OPERATOR'S
INSTRUCTION
BOOK

FOR

Kahlenberg

MARINE OIL ENGINES

KAHLENBERG BROS. CO.
TWO RIVERS, WISCONSIN
U. S. A.

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INTRODUCTION

1—Foreword—Kahlenberg oil engines are carefully built with high grade material and workmanship. Being simple in construction and easy to operate, they give long and reliable service with a minimum of attention.

This booklet will enable the engineer to become familiar with the general care and operation of his engine. It is not, however, intended to cover in detail all phases of installation and operation, for after all, actual experience on the job is the best guide.

A complete parts list with illustrations is furnished with each engine and should be referred to for details of construction or when ordering repair parts.

Operators of Kahlenberg engines should at all times feel free to write the factory for information concerning their engines. In writing always mention the serial number of the engine and the horsepower.

2—Operating Principle—The Kahlenberg Oil Engine operates on the two stroke or two cycle system with all events taking place in two strokes of the piston, or during one revolution of the crankshaft. When the piston has reached its highest or top dead center position, the fuel is sprayed into the combustion chamber by the fuel injection pump, where it is gasified and, with the heat of compression, ignites.

The piston then starts downward on the expansion or power stroke and just before reaching its lowest position, it uncovers the exhaust ports through which the burned gases are expelled.

The intake ports are also uncovered and the air, compressed in the crankcase by the piston on its downward stroke, enters the cylinder. This fresh air is then compressed as the piston travels upward.

PART ONE

GENERAL INSTALLATION

3—**Foundation**—The engine foundation must be strongly built and firmly fastened to the hull. The main engine timbers should be extended ahead and aft of the engine as far as possible. Blue prints for laying out the foundation are furnished with each engine and should be carefully checked and followed.

4—**Alignment**—After the engine is placed on the foundation, care should be taken to see that the two halves of the flange coupling connecting the engine and propeller shaft come together evenly without being forced. This can be tested by trying a thickness gauge at points between the flanges. After the engine is in service, the alignment should be checked and corrected occasionally.

5—**Exhaust Piping**—The exhaust pipe should not be smaller than the pipe flange furnished with the engine. It is essential to have a clean and free exhaust line to eliminate back pressure. Use flanged unions so the pipe can be easily taken apart. If a stack is fitted, run the exhaust pipe up to the top of the stack or a little higher in order to avoid objectionable drumming noise.

6—**Water Piping**—In general, the size of water pipes should be the size of the inlet and outlets on the engine. Make provision for draining them thoroughly in cold weather. The over-flow pipe from the bearing water jackets should be brought up to about six inches above the top of the forward cylinder head cap, bent down, and then led overboard. This will prevent the water draining out of the cylinders when the engine is stopped.

7—**Fuel Tanks and Fuel Piping**—The fuel tanks should be placed high enough so that the fuel will flow by gravity to the fuel injection pumps on the governor. The bottom of the tanks must therefore be at least three or four inches higher than the suction valves on the fuel pumps. Tanks placed too high should also be avoided.

If the tanks are too low to allow the fuel to flow to the fuel pumps, an auxiliary fuel pump should be used and will be furnished as an extra. The fuel is pumped into a fuel oil tank placed in the engine room from which it flows by gravity to the engine. The tank can be furnished from the factory or can be easily made in any sheet metal shop from our blue prints. Use shellac on fuel line joints.

8—**Air Piping**—Owing to the varied conditions under which engines and air tanks are installed, there is no fixed arrangement for piping, although by referring to the blue prints furnished with the engine, a general idea as to the piping layout can be obtained. Air pipes should be as large as the openings in the tanks. If long pipes are used, increase the size. The tanks may be located in any convenient place or position. Air valves should be "Jenkins" soft disc air service valves or equal, and all joints should be made with a mixture of litharge and glycerine mixed to a consistency of cream.

9—**Fume Manifold Piping**—The fume manifold is mounted on the cylinder heads and is used to conduct the torch gases out of the engine room when starting. A pipe (usually made of galvanized sheet iron) should be attached to the manifold and led through the roof to the atmosphere.

10—**Wiring**—When the electric starting system is used, the wiring diagram furnished should be carefully followed. Place the battery near the engine so that all connections will be as short as possible. The terminals should be scraped clean and all connections made tight.

11—**Air Whistle**—If the whistle does not blow properly, it should be removed, the sounding plate unscrewed, and the air holes cleaned. The whistle valve should be opened slowly to avoid shrieking. If necessary a heavy spring can be used to prevent quick opening.

12—**Propeller**—When placing propeller on shaft, heat the hub slightly and then draw nuts up tight. If this is not done, the nuts and propeller may work loose.

PART TWO

LUBRICATION

13—General Lubrication—One of the most important factors in the life and care of any engine is proper lubrication—remember, wherever there is friction, there MUST be lubrication. In starting a new engine the first and foremost requirement is to see that all bearings and other engine parts are free from grit and foreign matter; second, that all parts are properly lubricated.

14—Mechanical Lubricators—Each engine is equipped with two mechanically operated lubricators mounted on the after cylinder. The starboard or exhaust side lubricator forces oil to the cylinders and pistons. The lubricator on the port or intake side supplies oil to the crankpins and main bearings. Each feed is visible and can be adjusted by turning the adjusting screw located directly opposite. Remove the cover and clean the sediment from the bottom of the lubricators once each year.

15—Caution—Operators are cautioned to turn the hand cranks of both lubricators from twenty to forty times before starting the engine. When an engine stands idle, the oil drains out of the bearings, cylinders, etc. making it necessary to turn the hand cranks on the lubricators before starting and force oil to these parts. Also, never pour oil of any kind into the crank cases; it is not necessary and will cause the engine to over speed or race which may result in serious damage. On large engines, fitted with crank case drains, connect the outlets to a small tank or other receptacle and open the drain cocks just sufficiently to allow the oil to blow out while the engine is in operation.

16—Adjusting Mechanical Lubricators—After the engine has been sufficiently "limbered up" during a month or two of running, the lubricators can be adjusted to supply the normal amount of oil for the size engine, as shown by the lubrication chart on page 9. Follow out the piping carefully to determine which of the feeds lead to the crank pins. Note that the crank pins require more oil than the main bearings.

17—Main Bearing Lubrication—The main bearings or journals should be lubricated with a good quality clean light machine oil which can be purchased for considerably less than the heat resisting Diesel cylinder oil. For the rate of feed to each bearing refer to the lubrication chart on page 9.

18—**Crank Pin Bearing Lubrication**—The oil for the crank pins is supplied by the port side lubricator, and passes through a special fitting mounted on the engine base just forward of each crank case. A tube located at this point directs the oil into an oil ring which is fastened on the crankshaft web. Centrifugal force, developed by the rotation of the crankshaft, forces the oil from this ring through drilled passages to the crank pin. Crank pins require more oil than the main bearings. For the rate of feed refer to the lubrication chart on page 9.

19—**Thrust Bearing Lubrication**—The thrust bearing is lubricated by the port side lubricator. This feed should be set to deliver about the same amount of oil that is fed to the main bearings.

20—**Cylinder Lubrication**—The cylinders and pistons are supplied with oil under pressure by the starboard side lubricator, and both have oil grooves to distribute the oil. For the rate of oil feed required see lubrication chart on page 9. Use a high grade heat resisting Diesel engine cylinder oil.

21—**Wrist Pin Lubrication**—The wrist pin bearings are lubricated by the starboard lubricator which also supplies oil to the cylinders. The oil enters on the forward side of each cylinder and is collected in a pocket at the end of the piston pin as the piston travels upward. A drilled passage leads from this pocket to the center of the pin. For the rate of feed see lubrication chart on page 9.

22—**Governor Driving Gear Lubrication**—The governor gear case, located at the bottom of the governor, should be kept three quarters full of light machine oil. The level will drop to half full when the engine is running. Drain the case and refill with clean oil once a month.

23—**Fuel Pump Driving Cam Lubrication**—The governor oil case, located above the fuel pumps and in which the governor cam, fuel pump rocker arms, and tappets operate, should be kept filled with light machine oil. Drain once a month and refill with clean oil.

24—**Lubrication of Miscellaneous Governor Parts**—The round casing at the top of the governor, enclosing the governor weights, has an oil channel at its top. Oiling here lubricates the fulcrum pins of the governor flyweights. The governor main spring adjusting nut has an opening on top through which the governor spindle and cam shifter are lubricated. These and other moving parts on the governor should be oiled with machine oil once each hour.

25—Reverse Gear Lubrication—The reverse gear is lubricated through several openings on the outside of the clutch drum just ahead of the brake band. Remove any one of these plugs and, using the cast iron funnel provided, pour in one pint of clear machine oil each day. (2 pints on large engines). See chart on page 9.
A small amount of oil each day is better than a larger quantity less frequently. Also lubricate the levers, pins, etc. on the outside of the clutch occasionally. The service given by a reverse gear depends on the lubrication. Do not neglect it.

26—Lubricating Oil—We do not recommend any particular brands of lubricating oil, but have tested the following and found same satisfactory. Oils of equal characteristics sold by other oil companies will be found entirely suitable.

Gulf Refining Company Products:
For Cylinders—Gulf Diesel Engine Oil, Heavy.
For Bearings—American Red Engine Oil.

Vacuum Oil Company Products:
For Cylinders—Gargoyle D. T. E. Oil, Extra Heavy.
For Bearings—Artic Oil C., Heavy.

Texas Oil Company Products:
For Cylinders—Texaco Ursa Oil.
For Bearings—Texaco Cetus Oil.

Standard Oil Company (Indiana) **Products:**
For Cylinders—Polarine Medium Heavy No. 30.
For Bearings—Superla Dynamo, or Junior Red Engine Oil.

Sinclair Refining Company Products:
For Cylinders—Rubilene Heavy.
For Bearings—Cordymo Oil.

Atlantic Refining Company Products:
For Cylinders—Atlantic Diesel Engine Oil.
For Bearings—Atlantic Red Engine Oil.

Tide Water Oil Company Products:
For Cylinders—Tycol Heavy.
For Bearings—Tycol 112.

27—Lubrication Chart—

ENGINE PARTS	LUBRICATED BY	GRADE OIL USED	AMOUNT RECOMMENDED		
			20-24 H. P.	30-36- 45- 54 50-60- 60- 70 75-90-100-120	135-150 180-200
Main Journals	Port Side Lubricator	Machine Oil	½ Drop *	1 Drop *	2 Drops *
Crank Pins	Port Side Lubricator	Machine Oil	1 Drop *	2 Drops *	3 Drops *
Thrust Br'g	Starboard Lubricator	Machine Oil	½ Drop *	1 Drop *	2 Drops *
Cylinders	Port Side Lubricator	Diesel Cyl. Oil	½ Drop *	1 Drop *	1 Drop *
Wrist Pins	Starboard Lubricator	Diesel Cyl. Oil	½ Drop *	1 Drop *	1 Drop *
Eccentrics	Drip Oiler	Machine Oil	5 Drops per Minute	6 Drops per Minute	8 Drops per Minute
Gov. Lower Oil Case	Oil Bath	Machine Oil	Keep ¾ Full	Keep ¾ Full	Keep ¾ Full
Gov. Upper Oil Case	Oil Bath	Machine Oil	Keep Full	Keep Full	Keep Full
Reverse Gear or Clutch	Oil Bath	Machine Oil	1 Pint Every Day	1 Pint Every Day	2 Pints Every Day
Miscel. Parts	Hand Oiling	Machine Oil	Every Hour	Every Hour	Every Hour

(*) Number of drops from each feed per revolution of the lubricator shaft.

PART THREE

OPERATION

GENERAL INSTRUCTIONS

28—**Cleaning**—After the installation is completed, all parts on the engine should be carefully cleaned to remove dirt, grit, and foreign matter.

29—**Oiling**—Read the foregoing chapter on **Lubrication** carefully and inspect each part to see that it is properly oiled and that both lubricators and also the two oil cases on the governor are filled with the correct lubricating oil. See lubrication chart on page 9.

30—**Removing Air from Fuel Lines**—Before starting a new engine and whenever fuel lines are disconnected or the fuel drained from the engine thereafter, all air must be removed from the fuel lines. To do this disconnect the union nuts at each fuel nozzle. Work each fuel pump by hand until a solid stream of fuel without air bubbles is obtained. If pumps do not pump fuel, loosen the hexagon caps over the pump valves and tighten again when the fuel appears at the nozzles.

31—**Priming the Cylinders before Starting**—Read paragraph 30 above. To prime the engine before starting, press each fuel pump primer cap down hard three or four times as far as the plunger will go. Note the pressure required on each pump to force the fuel through the nozzles. Prime only enough to insure satisfactory starting. Too much priming will cause the engine to speed up and race when started. If the engine has been running and is still warm, little or no priming is required. See paragraph 79, page 29.

32—**Compressed Air**—Compressed air for the first start can usually be obtained by filling the small tank at a local garage or other source, and with large engines especially, the shipyard supply can be used. Before using hand driven emergency compressors, a small amount of oil should be poured in the cylinder above the piston. Pump the small air tank up to 150 lbs. pressure and proceed to start the engine.

After the first start is made, the starting air is supplied by the compressor on the engine, and it should not be necessary to again resort to the auxiliary compressor, except in case of emergency. Remember, use compressed air only for starting. Do NOT use oxygen or acetylene or anything of like nature under any conditions.

33—**Cleaning Air Lines**—Disconnect air inlet copper tube on the air distributor and blow all dirt out of pipes with air pressure.

34—**Heating Engines not Equipped with Electric Starting**—Open flap doors on cylinder head cap and turn fume manifold down into position. Fill small torch fuel tank with kerosene or fuel oil and open air connection to tank and torches. To start torches first open slightly the air valve (nearest operator). Then while the fuel valve is being opened slightly, light with match or hand torch and adjust to blue flame. When firing tube is bright red, engine is ready to start. After the engine is started, turn torches off by first closing the fuel valve and then the air valve. Also close all valves on torch tank. Leave fume manifold down.

35—**Electric Starting**—Before closing switches, always see that there is a small spark at the point of contact. This indicates that current is flowing and that the plugs and connections are in good order. Prime the engine before closing the switches. After the current has been on for about thirty seconds, proceed to start the engine according to directions for starting.

The exact length of time the current should be on before starting varies and must be determined by the operator. In cold weather more priming and a greater length of time will be required. Leave the plugs on for a minute or two until the engine fires regularly. Pull in the clutch and put the engine under load as soon as possible. With large engines especially it is good practice to run at half speed or so at the dock for a short time before casting off, to warm up the engine and see that everything is working properly. If one of the cylinders does not fire properly, the corresponding switch should be thrown in again for a short time. Do not continue to pump fuel into a cylinder if it does not fire. Shut off the fuel pump and allow the plug to heat. The trouble may be due to a low battery charge or a loose or corroded connection.

36—**Barring Engine Over by Hand**—Do not insert the bar in flywheel to turn engine over by hand without first moving throttle lever 303 Fig. 12, , page 27 forward to closed position to shut off the fuel. Before starting two cylinder engines, flywheel must be barred over until No. 1 piston is slightly over center. To do this turn flywheel until the flywheel key on the crankshaft is slightly over top center towards the starboard (to start ahead). An arrow, located on the rim of the flywheel, may be brought in line with the

pointer, which is attached to the governor oil case. **Caution! Do not forget to remove turning bar.**

37—Before Starting Any Engine—First go over the engine carefully, see that all parts are properly oiled, lubricators filled, nozzles spraying fuel, clutch lever in neutral, air damper lever up, air inlet valves in rear of each cylinder open and valve stems free to move in and out. Open main throttle lever, open auxiliary control, open fuel valves from tanks, open sea cock, and don't forget to turn hand cranks on each lubricator at least forty times. CAUTION: After starting a new engine for the first time or when starting one on which the pistons just have been pulled, stop the engine after ten or fifteen minutes running. Take off the crankcase plates and feel of the crank pin bearings to make sure they are cool.

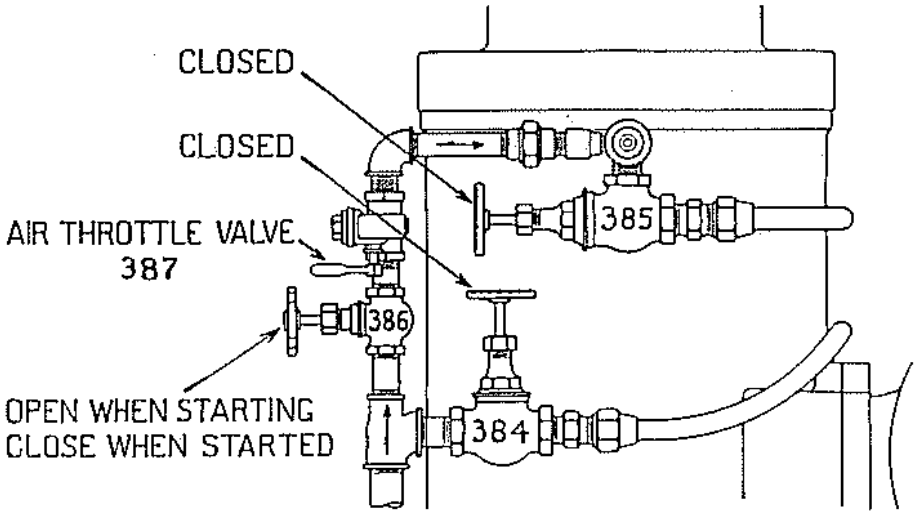

Fig. 1—Valves Set for Emergency Air Starting System.
(Also for starting two cylinder engines without air distributor)

When starting with the emergency system or when starting two cylinder engines not equipped with an air distributor, the air valves should be set as shown above. For starting directions refer to paragraph 38 below and paragraph 45 on page 15.

38—Starting Two Cylinder Engines Not Equipped with Air Distributor—Read paragraph 37 above; then proceed as follows:

1. Bar engine over to starting position. CAUTION: see paragraph 36, page 11.
2. Close electric switches or start torches.
3. Prime engine. See paragraph 31, page 10.
   If starting with electric plugs, prime engine before closing switches.
4. Open air valve 386 shown on Fig. 1 above.

5. Give air throttle valve 387, shown on Fig. 1, page 12 a quick pull.
6. After engine is started, follow instructions in paragraph 41, page 14.

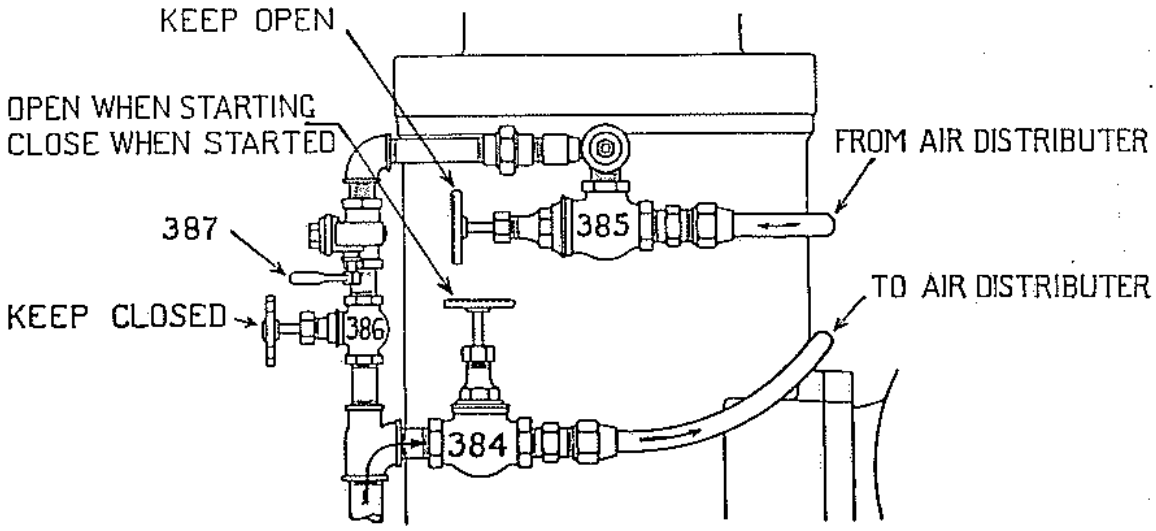

Fig. 2—Valves Set for Starting with Air Distributor.

In starting all three and four cylinder engines and also two cylinder engines equipped with air distributors, the air valves should be set as shown above. For starting directions refer to paragraphs 39 and 40 below.

39—Starting Two Cylinder Engines Equipped with Air Distributor—Read paragraph 37, page 12.

1. Bar engine over to starting position. See paragraph 36, page 11. Usually this is not necessary after engine is well limbered up.
2. Close electric switches or start torches.
3. Prime engine. See paragraph 31, page 10.
   If starting with electric plugs, prime engine before closing switches.
4. Set air valves in accordance with Fig. 2 above.
5. Open air throttle valve to turn engine over.
6. After engine starts, follow instructions in paragraph 41, page 14.

40—Starting Three and Four Cylinder Engines—Read paragraph 37, page 12.

1. Close electric switches or short torches.

2. Prime engine. See paragraph 31, page 10.
   If starting with electric plugs, prime engine before closing switches.

3. Open air valve 384 shown on Fig. 2, page 13.

4. Move air starting lever on air distributor forward from its central or stop position.

5. After engine is started, follow instructions in paragraph 41 below.

41—After Engine is Started:

1. Immediately close air damper shown on Fig. 6, page 20 to choke engine and prevent racing due to priming. Open to running position as soon as engine has burned the priming charge.

2. Adjust auxiliary throttle hand wheel shown on Fig. 12, page 27 to speed desired and put timing lever 304 shown on Fig. 12, page 27 ahead in correct ahead running position. Make sure cooling water is passing through engine.

3. Open switches and make sure each cylinder is firing.

4. "Pull in clutch" and get engine under load as soon as possible. Under ordinary conditions it is good practice to run the engine with clutch in at one-half or three-quarter speed at the dock for a few minutes to warm up and see that everything is in working order.

5. Close main air valves 384 and 386 shown on Fig. 2, page 13.

6. After starting a new engine for the first time, run the engine slowly for ten or fifteen minutes. Then stop and feel of the connecting rod bearings, as explained in the last part of paragraph 37.

42—To Slow Down:

1. Move auxiliary throttle hand wheel shown on Fig. 12, page 27 forward until desired speed is reached—tighten in position by turning clamping wheel to right.

2. Close air damper shown on Fig. 6, page 20 slightly.

43—To Run Neutral or Idle:

1. Place auxiliary throttle hand wheel shown on Fig. 12, page 27 in position for speed desired.
2. Put air damper lever Fig. 6, page 20 down to partially closed position, or lower, wherever engine runs best.
3. If engine misfires with timing lever 304 Fig 12, page 27 in normal running position, advance to idling position. Under certain conditions and with certain grades of fuel it may be necessary to place the timing lever in the center of the quadrant or a little aft of center when idling.
4. If cooling water is very cold, close sea cock slightly to keep cylinder heads warm when idling. Open again when running under load.

44—Reversing on Compressed Air: (Applies to 3 and 4 cylinder engines only).

1. Open air lines and valves to air starter as shown on Fig. 2, page 13. See that air inlet valves at the rear of each cylinder are open (with locking wheels forward).
2. Bring throttle lever 303 shown on Fig. 12, page 27 forward on quadrant to stop engine.
3. When engine stops open throttle and move air starter lever on air distributor aft for astern running (move forward for ahead running).
4. If full power is required astern, the timing lever 304 shown on Fig. 12, page 27 should be moved aft of central position.
5. Control speed of the engine with auxiliary throttle hand wheel shown on Fig. 12, page 27.

45—Emergency Starting System—At any time if necessary, all three and four cylinder engines (also two cylinder engines equipped with air distributor) may be started without using the air distributor by following the method used in starting two cylinder engines not having air distributors. See paragraph 38, page 12 and Fig. 1, page 12.

PART FOUR

DRAINING ENGINES IN COLD WEATHER

46—In cold weather all water jackets and other parts on the engine, as well as the piping, must be drained. See Fig. 3 below, and Fig. 4, page 17. List of parts requiring attention is as follows:

Cylinders
Exhaust manifolds
Circulating water pump
Bilge pump
Bearing water jackets
Thrust bearing
Water piping

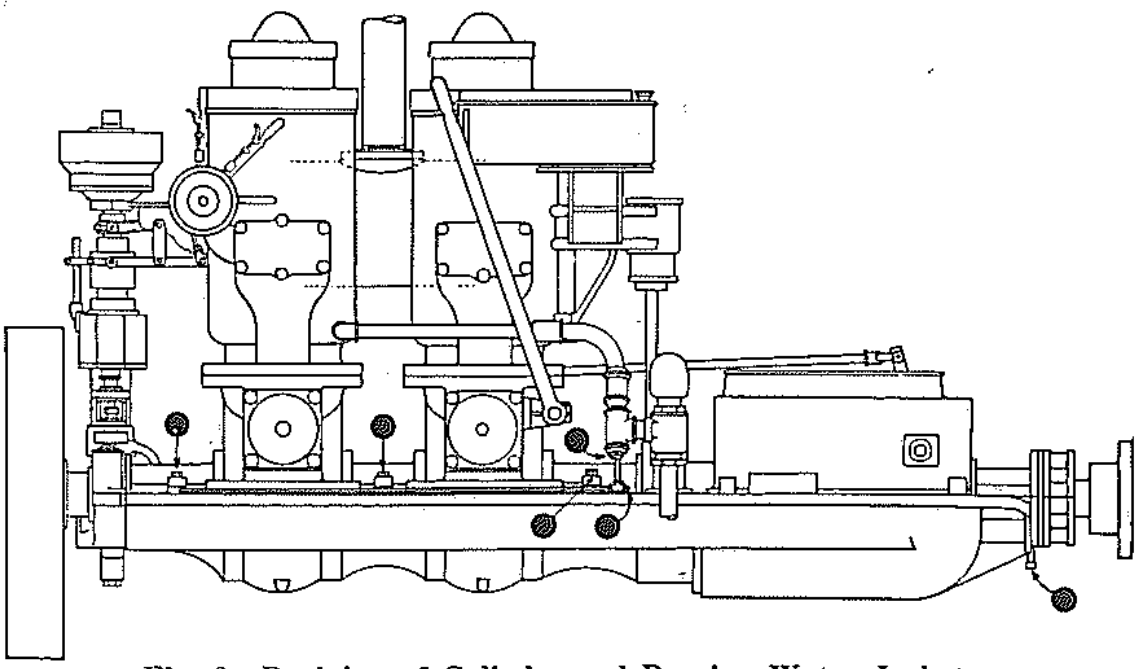

Fig. 3—Draining of Cylinder and Bearing Water Jackets.

The engine must be drained in cold weather at all points indicated above. Also see Figs. 4 and 5 and read directions for draining engines in paragraphs 46 to 53 inclusive on pages 16, 17, and 18.

47—**Draining Cylinders**—Remove drain plug in circulating water pump discharge pipe shown on Fig. 3 above. Open water cocks on cylinder heads to relieve air if necessary, so water will flow.

48—**Draining Exhaust Manifolds**—Remove plugs shown in Fig. 4, page 17 at rear end of **each** exhaust manifold. An oil drain plug is also provided on each manifold. Do not mistake these for the water drain plugs.

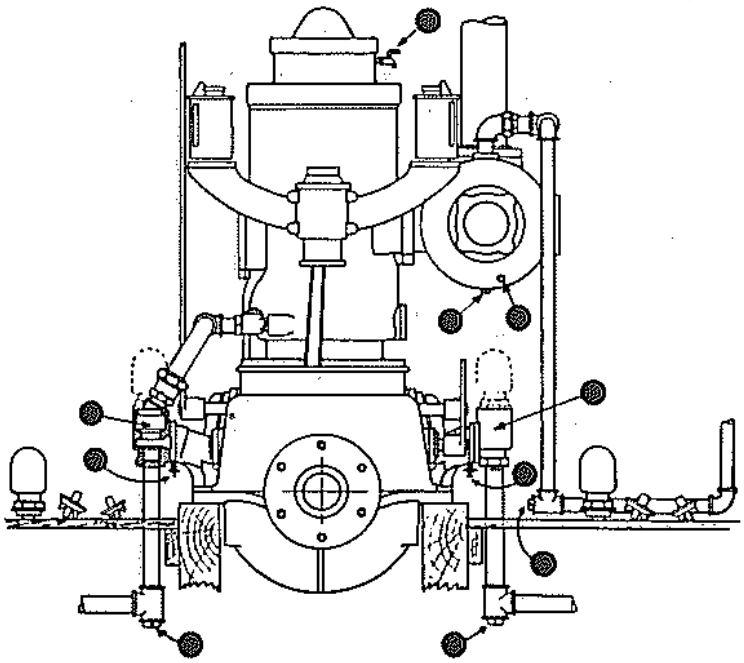

Fig. 4—Draining of Water Pumps, Piping and Exhaust Manifolds.
After draining cylinders, remove the valves from both water pumps as shown above and open drain cock under each pump. Also drain BOTH exhaust manifolds and all water piping on the boat. See paragraphs 46 to 53 inclusive on pages 16, 17, and 18.

49—Draining Circulating Water Pump—Take off air chamber, lift out both valves and drain the pump body by opening the drain cock located under the pump, all as shown in Fig. 4 above.

50—Draining Bilge Pump—Drain in same manner as circulating pump.

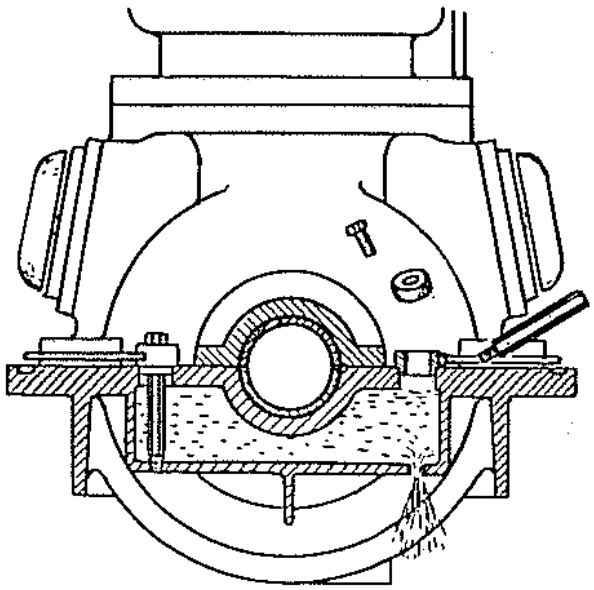

Fig. 5—Draining of Bearing Water Jackets.
The screw, cap, and the long brass plug must be removed from EACH bearing jacket (on operating side of engine only) as shown above.

51—Draining Bearing Jackets—Each bearing water jacket must be drained separately. Remove cap and take out the long bronze plug at **each** bearing, as shown in Fig. 5, page 17. Note that it is only necessary to remove the plugs on the operating side of the engine. In addition drain the long copper pipe leading from the water pump to the forward bearing by removing the small plug in the tee near the pump.

52—Draining Thrust Bearings—On large engines with water cooled thrust bearings take off the drain pipe cap, located directly under the thrust bearing, as shown in Fig. 3, page 16.

53—Draining Piping—All water piping on the boat should also be carefully drained.

PART FIVE

GENERAL SERVICE INSTRUCTIONS

54—**Reverse Gear Base**—The reverse gear base is fitted with tapped drain holes at the bottom. Pipe plugs may be screwed in these holes to close them if necessary to prevent bilge water reaching the reverse gear, etc.

55—**Crank Cases**—Oil should not be poured into the crank cases, as it is not required. Clean them out instead every two or three months.

56—**Crank Case Air Valves**—At the same time the crank cases are cleaned, the air breathing valves should also be examined and cleaned if necessary. In reassembling, care must be taken to see that the bronze discs are not pinched. They fit loosely in the grooves, and when assembled correctly can be freely moved sidewise.

57—**Crankshaft**—Flywheel hubs, governor driving gears, eccentric hubs, etc. are shrink fits on the crankshaft and must be pulled off with a heavy screw puller. When replacing they should be heated evenly just enough to expand and slip easily over the crankshaft. Steel governor gears may be heated in hot water. When a crankshaft is to be removed, care should be taken to see that the oil tubes, through which the oil enters the crank pin oil rings, are withdrawn far enough to clear the oil rings; otherwise the tubes will be bent and require replacement.

58—**Main Bearings**—The main bearings can be easily removed without disassembling the engine. By taking off the bearing cap, the top part of the bearing and the crankshaft are immediately exposed. The lower half of the bearing may then be rolled out from under the crankshaft by using a wood block and a hammer. Turn the engine over slowly while driving.

59—**Air Seal Rings**—Bronze collars or seal rings are placed on the crankshaft at each end of the center bearings and on the inside end of the end bearings. Their purpose is to prevent the air, compressed in the crankcase, from passing through the clearance in the bearing into the adjacent crankcase and blowing out the lubricating oil. The rings are a sliding fit on the crankshaft and are held against the crankcase by four springs. Replacement or inspection is seldom, if ever, required.

60—Cylinders—Due to the design and good combustion, cylinder wear is reduced to a minimum, and the engine will run for years without reboring. For distributing the oil around the cylinder wall, an oil groove is provided. This must be inspected and cleaned each time the pistons are pulled. Before replacing pistons, always crank lubricators by hand to see that the oil feeds are working properly. Each cylinder has a water jacket clean-out plate located under the exhaust port. Remove these plates occasionally and flush out any sand or sediment which may have accumulated.

61—Zinc Plugs—The cylinder clean-out plates on engines for use on salt water are fitted with zinc plugs which help to counteract the galvanic or corrosive action of salt water on the iron of the cylinders. The zinc may be easily renewed.

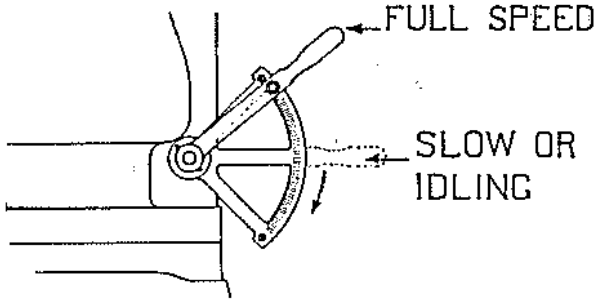

Fig. 6—Intake Air Damper Lever.

The various positions of the air damper lever are shown above and are explained in paragraph 62 below.

62—Intake Air Dampers—Each cylinder is provided with a damper valve in the intake air passage. The valves are controlled by a single lever located directly below the speed controls. See Fig. 6 above. This lever should always be up when the engine is running at full speed, and may be closed slightly when running slow. When the engine is idled or operated with clutch in neutral, place the lever in the half way position or below this. The exact location varies with conditions, and the engineer should determine the position at which the engine runs best when idling.

63—Bearing Water Cooling—Cooling water, which is circulated through the water jackets under each main bearing, maintains a very low average bearing temperature, and since oil is more effective in a cool running bearing than one operating at a so-called normal heat, only a minimum quantity of lubrication is required. The bearing jackets must be drained in cold weather. Follow instructions in paragraph 51, page 18. See Fig. 3, page 16 and Fig. 5, page 17.

64—**Thrust Bearings**—The ahead thrust of the propeller is taken up by a roller type thrust bearing (except on 20 and 30 H. P. engines). The reverse thrust is absorbed by a bronze collar. Both are arranged for adjustment, which is made as follows:

Loosen forward and aft clamp collars. Push reverse gear stub shaft as far forward as it will go, mark the shaft at edge of bearing, then pull the shaft back as far as it will go and make another mark. Push the shaft forward one half the distance between the marks and tighten clamp collars. This adjustment is made to prevent the propeller thrust from being transmitted through the reverse gear to the crankshaft.

65—**Cylinder Heads**—To remove cylinder heads, first take off the cylinder head cap, cylinder head nuts, disconnect pipes, etc. Then by reaching through the hole inside the cylinder head, place two blocks of wood (or two cylinder head nuts) on the top of the piston. Insert the bar in the fly wheel and turn the engine over so that the piston comes up and forces the head off. In replacing see that the gasket surfaces are clean. Cylinder head and cylinder head cap nuts should be drawn up evenly. Each cylinder head is fitted with a cock or plug which may be opened in case steam collects in the water jackets, and is also used to relieve air when draining cylinder water jackets. It is good practice to run the engine idle at the dock for a short time before stopping to allow the water to flow through the jackets, thus cooling the cylinders and heads.

66—**Pistons and Piston Rings**—Although not always necessary, it is good practice to remove the pistons and clean them thoroughly once each year, especially if the engine has been in hard service. A stuck or carboned piston ring will cause a sharp metallic click to be heard in the cylinder at all speeds. After the cylinder heads have been removed, scrape out the carbon from the cylinder walls above the piston carefully so the piston will come out easily. Do not take the rings off the piston. To do so distorts the rings. In cleaning pistons use kerosene or fuel oil and move the rings back and forth in the grooves to work the carbon out. When replacing pistons, follow instructions in paragraphs 68 and 69, page 22.

67—**Wrist Pins**—Wrist pins seldom require replacement or even inspection. If necessary to remove, proceed as follows: Take out the two lock screws located inside the piston. Then using a hammer drive out the pin, driving on the small diameter end.

68—Connecting Rods and Wrist Pin Bushings—On engines up to 100 H. P. inclusive, the connecting rod is fitted with a solid bronze wrist pin bushing. Larger engines have adjustable wrist pin bearings. Both are fitted with considerable clearance and end play at the factory to allow for heat expansion, and this should not be mistaken for wear. Stamped on the foot of each connecting rod will be found the serial number of the engine and the number of the cylinder. When the piston and connecting rod are assembled and placed in the cylinder correctly, these numbers should face the operating side of the engine, that is, the side on which the control levers are located. Both halves of the crank pin brasses are likewise numbered, and when assembled correctly all numbers should be in line and facing the operating or port side. See Fig. 7 below.

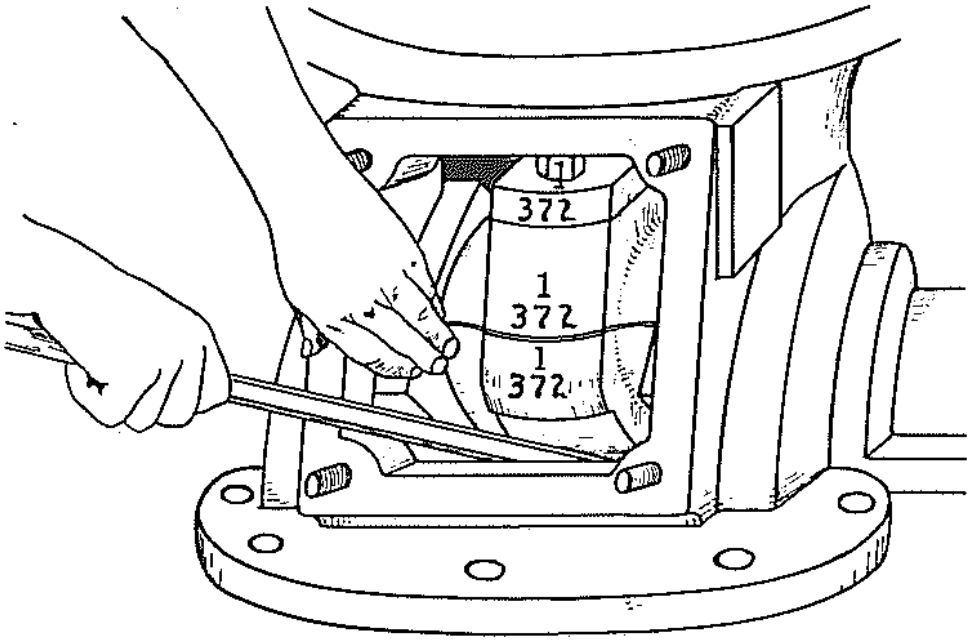

Fig. 7—Testing Crank Brasses for Proper Clearance.

Sufficient "up and down play" must be provided. Read paragraph 69 below. When correctly assembled, the numbers stamped on each part should be in line as shown and facing the operating side of the engine.

69—Crank Brasses—The crank pin bearings or brasses are made of bronze, lined with high grade bearing metal properly grooved, and are lubricated by a simple and positive ring oiling system which is fully described in paragraph 18, page 7. Before putting in the crank brasses, always turn the crank pin to lower center, operate the lubricator by hand, and observe the flow of oil from the oil hole in the center of the crank pin. After reassembling, try the brass for up and down movement using a bar as a pry to raise and lower the crank brass and connecting rod as shown in Fig. 7 above.

The up and down movement or play should not be less than ten thousands of an inch, or about the thickness of an ordinary post card which can be used as a shim. Also try brass to make sure there is plenty of end play or movement sideways. It is important that the brass be adjusted so it can move freely sideways and also up and down. Note that the crank brass parts are numbered the same as the connecting rod, and when assembled correctly, these numbers should be in line and facing the port side or operating side of the engine as shown in Fig. 7, page 22.

70—Governor Construction—The governor is of the vertical centrifugal type, driven by two smooth running spiral gears and is a complete self-contained fuel injection and speed regulating unit. It consists of two parts, the upper unit and lower unit. The upper unit, which includes everything above the rocker arm case, is easily removed and may be returned to the factory for overhauling. Likewise, the lower unit, or pedestal and drive shaft assembly, may be taken off the engine and sent in for repairs whenever necessary.

71—Governor Action—By extending or withdrawing the single cam used to drive the fuel pumps, the governor changes the fuel pump stroke, and consequently the speed of the engine a corresponding amount. As only one cam is used, the strokes of all pumps are changed at the same instant and exactly the same amount. None of the cylinders can receive more fuel than the others, and wear, if any, on the cam affects all pumps the same. This results in good speed regulation and smooth running.

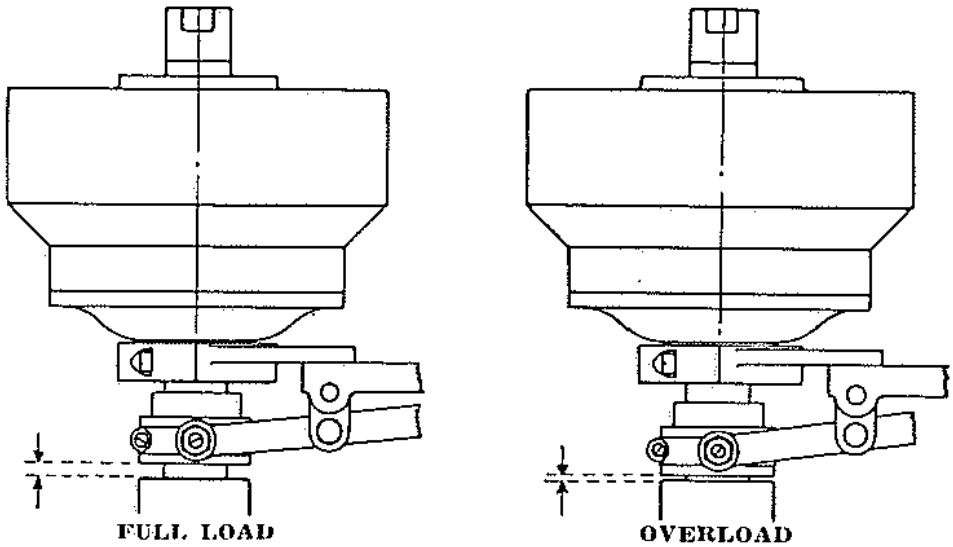

Fig. 8—Position of Governor Sleeve at Full Load and Overload.
The position of the governor throttle sleeve shown above indicates the amount of load on the engine. At full speed the sleeve should "float" up as shown above. Under no conditions should an engine be operated continuously with the throttle sleeve down at an overload. See paragraph 72 on page 24.

72—Speed Adjustment—For example, if the engine runs at 350 R.P.M. and it is desired to increase the speed to 365 R.P.M., the adjustment on the governor is made by turning the knurled adjusting screw 265 shown in Fig. 12, page 27, and increasing the tension on the speed regulating spring 264 until the desired speed is obtained.

The position of the governor throttle sleeve, which part moves up and down as the speed of the engine varies, indicates the load on the engine. When this sleeve is down in its lowest position, the engine is operating at its greatest overload. See Fig. 8, page 23. When it is between five-sixteenths and three-eighths inches up from its lowest position, the engine is operating at its full load, and the governor is said to be floating. Under no conditions should an engine be allowed to run continuously with the throttle sleeve down or at an overload as in Fig. 8. The remedy is to slacken the speed slightly by moving the auxiliary throttle control lever forward or put on a propeller of smaller diameter or of less pitch.

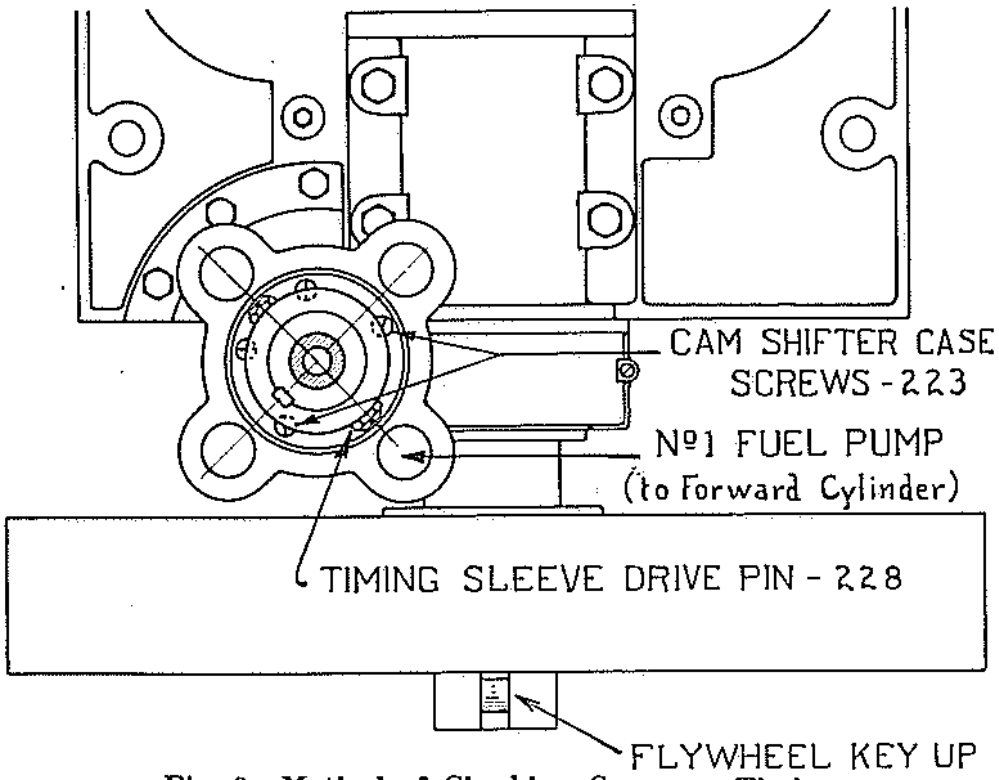

Fig. 9—Method of Checking Governor Timing.

When governor driving gears are meshed correctly and the flywheel key is on upper center, the two screws 223 farthest apart will be at equal distances from the center of number one fuel pump exactly as shown. See paragraph 73 below.

73—Governor Driving Gears—A zero mark (0) is placed on one tooth of the bronze gear. Mesh this tooth between the two zero (0) marked teeth on the steel gear. To check the timing, turn fly wheel

until the fly wheel key is up (No. 1 piston will also be on upper center). If gears are meshed correctly, the center of the opening between the two number 223 cap screws farthest apart will be directly opposite the center of No. 1 fuel pump; also one of the two number 228 timing sleeve drive pins will be directly opposite No. 1 fuel pump, all as shown in Fig. 9, page 24.

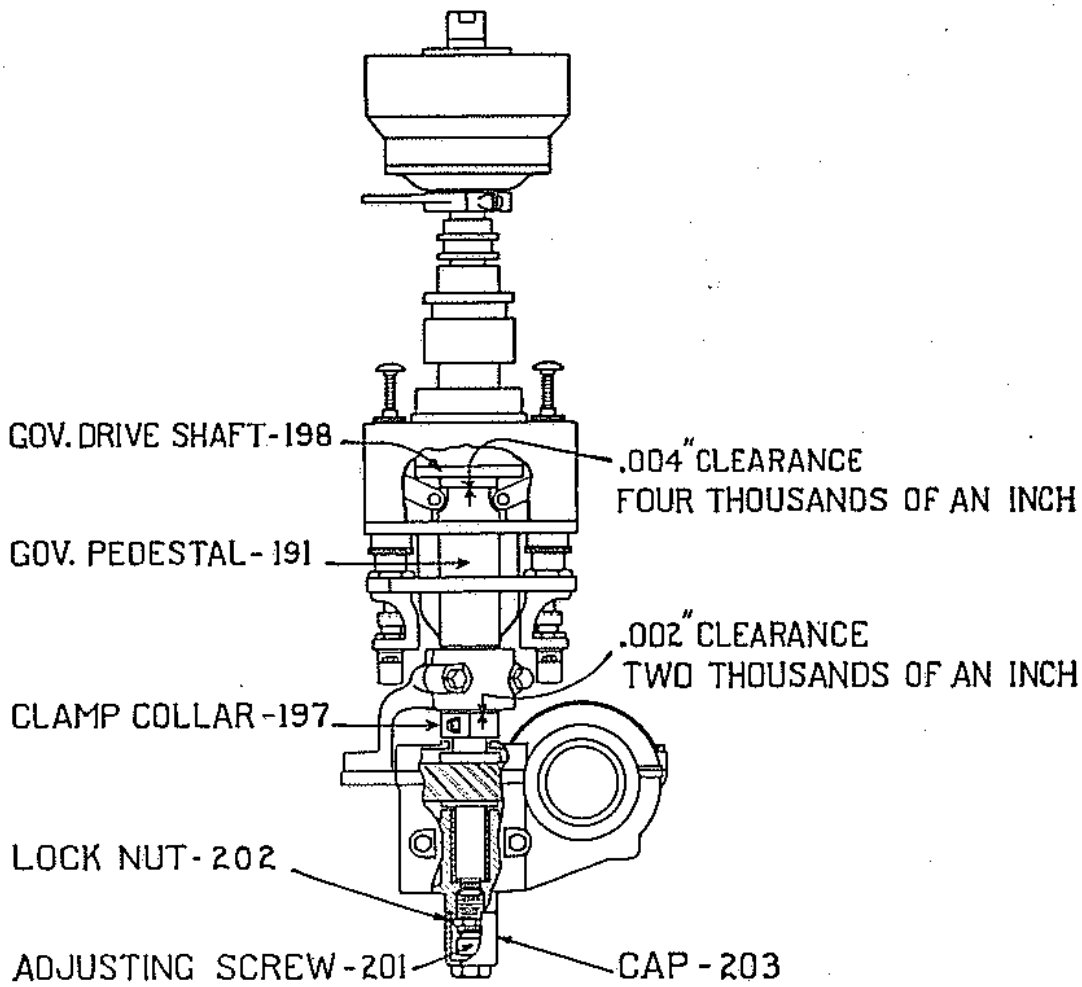

Fig. 10—Vertical Adjustment of the Governor.
The clearances shown above should be checked and if necessary readjusted once each year. Refer to paragraph 74 below.

74—Vertical Adjustment of Governor, Etc.—When assembled in the governor pedestal, the governor drive shaft should be given approximately six thousandths of an inch total end play which is obtained by adjusting the position of the thrust collar 193 clamped on the shaft. See Fig. 10 above. After the lower unit of the governor is bolted on the engine, make the vertical adjustment by turning the governor step bearing adjusting screw 201 up until a four thousandths inch thickness gauge can be inserted between the top of the governor pedestal and the under-side of the drive shaft flange.

With this adjustment made and a total of six thousandths of an inch end play in the shaft, there will, therefore, be about two thousandths clearance between the governor thrust collar and the bottom of the governor pedestal. This adjustment should be checked every year.

In reassembling the lower part of the governor, the space in the rear of the governor gear box cover should be packed with waste or oakum, as shown in Fig. 11 below, and melted paraffin poured over the waste to seal it.

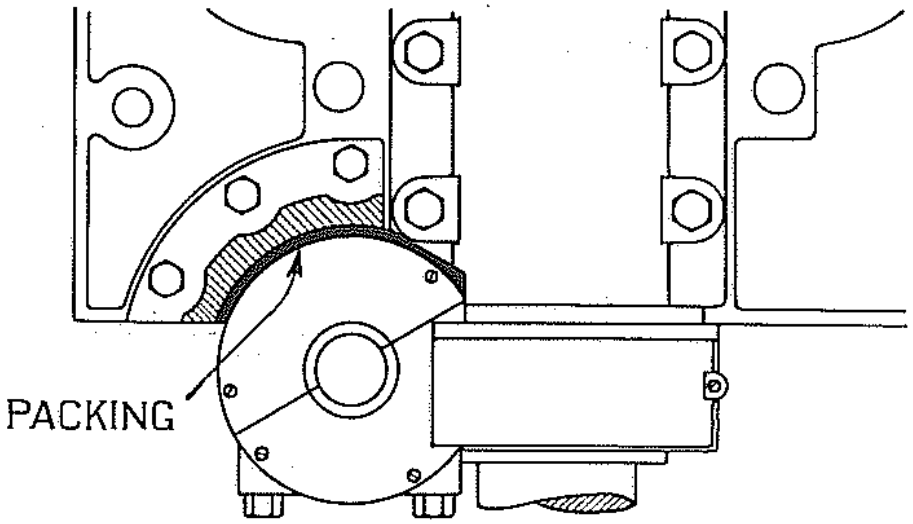

Fig. 11—Governor Gear Case Cover Packing.
The space at the rear of the governor gear case cover should be packed with waste or oakum and melted paraffin poured over to act as a seal. See paragraph 74 on page 25.

75—Throttle Lever—The throttle lever is the outside one of the twin control levers. See Fig. 12, page 27. To stop the engine, the throttle lever is moved forward. This withdraws the cam, shortens the stroke of the fuel pumps and puts them out of action, causing the engine to stop.

For ordinary running the throttle lever is left in the wide open position (farthest back) and the speed controlled entirely with the auxiliary throttle lever. (See instructions for direct reversing, paragraph 44, page 15.

76—Auxiliary Throttle Control Lever—For normal running, the speed of the engine is controlled by the auxiliary throttle lever or hand wheel. When this lever is used, the engine operates under complete governor control at all speeds.

To adjust the auxiliary control spring 348 shown in Fig. 12, page 27, proceed as follows: With engine stopped, place throttle

lever and the auxiliary throttle lever in wide open position. Tighten nut No. 346 until spring No. 348 is just beginning to start to pull. If the engine does not run slow enough at slow speed, slightly increase the tension on the outside spring No. 348A.

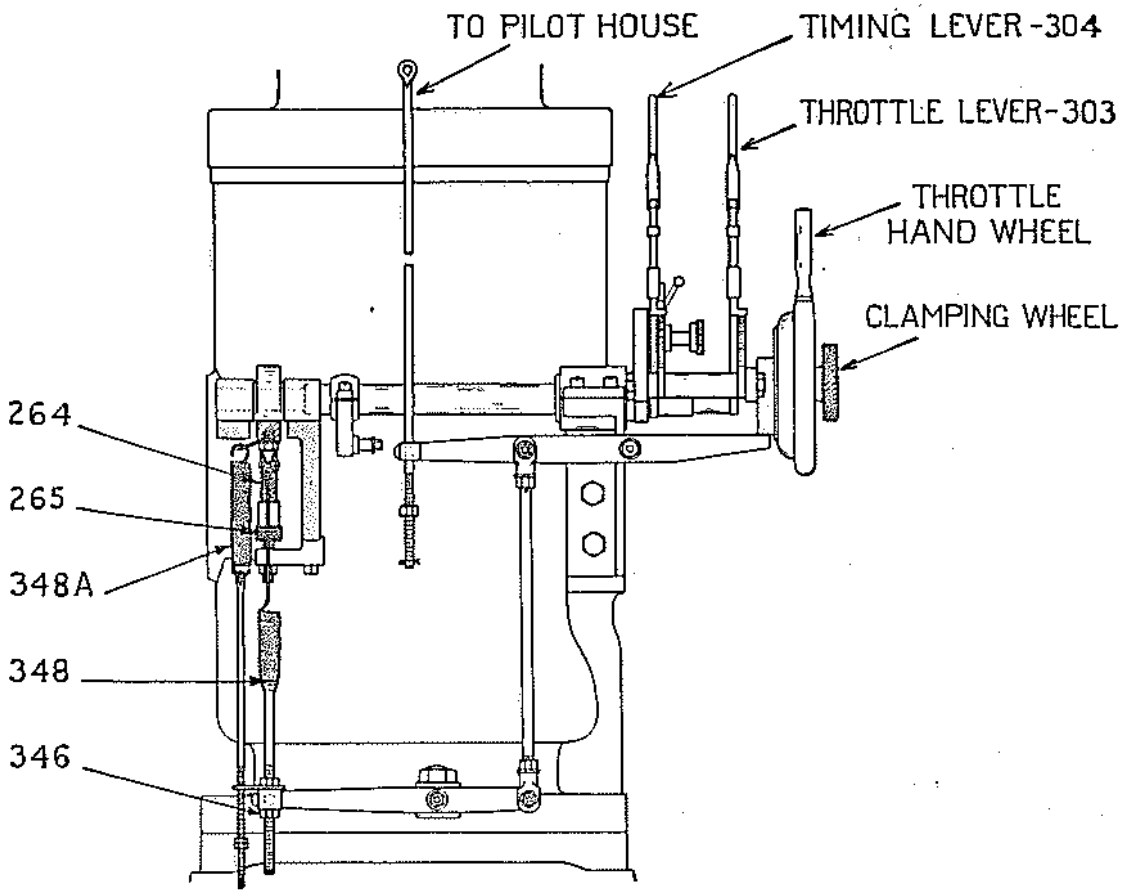

Fig. 12—Engine Controls and Speed Adjustments.

Speed is controlled by the throttle hand wheel. The throttle lever is used to stop the engine and the timing lever advances or retards the injection timing. For adjustment of the levers and speed regulating springs refer to paragraph 76 on page 26.

77—Injection Timing Lever—This is the inside one of the twin control levers shown in Fig. 12 above, and changes the timing of the fuel injection in relation to the piston stroke in a manner similar to the spark control on a gasoline engine. Moving the lever forward advances the timing; moving it aft retards the timing.

For normal running ahead, move the lever forward until the engine begins to knock slightly in the cylinders—this is the most economical and best running position. When operating idle with clutch in neutral for long periods, the timing may usually be left in normal ahead position or advanced to farthest forward position, or wherever engine runs best. Under certain conditions it may be

necessary to retard the timing lever to the center of the quadrant when idling for long periods.

78—**Fuel Injection Pumps**—The fuel pumps are separate units. Replacement can be easily made by removing the fuel pipes and two cap screws and without disturbing the adjustment of the pump stroke. The amount of stroke is set at the factory and is locked by small screw 301, shown in Fig. 13 below. To check the fuel pump stroke proceed as follows:

Place all control levers in wide open position. Bar the engine over by hand slowly until you are sure the pump plunger has reached its lowest position. The opening or distance (A), Fig. 13 is the amount of pump stroke. Use a gauge made as shown in Fig. 13 with dimension (A) corresponding to the fuel pump stroke given for the engine in the table on page 29.

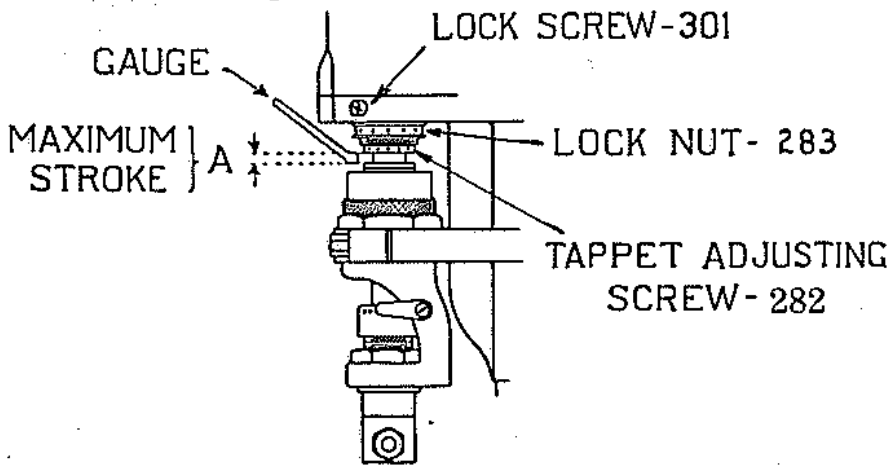

Fig. 13—Fuel Pump Stroke Adjustment.

The stroke is set at the factory with standard gauges, and the parts are then locked in position. Readjustment is seldom required. If necessary, follow directions in paragraph 78 above. Fuel pumps may be changed or replaced without affecting the stroke.

If adjustment is necessary, remove the locking screw 301, loosen locking nut 283, using a small punch, and turn tappet adjusting screw 282. Caution: Do not burr lower face of part 282 with punch. Tighten locking nut and try gauge. Continue until stroke is correct. Turn engine over slightly and again locate the lowest position of the plunger. Then reinsert the gauge and check the adjustment. Do this several times to be sure the stroke is correct, then replace and tighten locking screw 301.

If replacement of the governor spindle, cam, or any of the rocker arms, rollers, tappets, etc. is made, the maximum strokes of the fuel pumps should be checked and readjusted if necessary.

Occasionally fuel pump plungers will tend to stick in the packing and not return properly thus affecting the starting and running of the engine. The trouble is usually overcome by loosening the packing gland, oiling the plunger, or replacing the packing. Occasionally a pump will be attached improperly or the two cap screws pulled too tight causing the plunger to bind in the guide bushing. Plungers, worn at the packing gland enough to cause excessive sticking, should be replaced.

The fuel pumps should be kept in good working order by oiling the plunger and tappets frequently. To do this turn the knurled casing down as shown in Fig. 13. After oiling, turn the casing up again to protect the working parts from dust and dirt. If the plunger leaks considerably, the packing should be replaced. It is also good practice to grind the fuel pump valves occasionally. If not possible to return the pumps to the factory for overhauling, proceed as follows: Remove pump from engine. Take off the hexagon caps directly over the suction and discharge valves, and remove the springs. Regrind the valves with a very fine grade of valve grinding compound, using a screw driver to rotate the valve. Clean all grinding compound and foreign matter out of the pump and barrel. Blow out with compressed air, if available, and replace packing if necessary. In reassembling the valves, be sure the small spring is replaced on the top of each valve.

Each rocker arm is held in contact with the fuel pump tappet by two small retaining springs. Occasionally one or more of these springs after long use will be found broken resulting in missing and uneven running of the engine, especially when idling. To make replacement remove the screws underneath the rocker arm oil case and raise the case enough to reach the springs.

TABLE OF FUEL PUMP STROKES

20-24 H. P.—write factory.	60-70 H. P.— 1/8 Inch.
30-36 H. P.— 1/8 Inch.	75-90 H. P.— 3/16 Inch.
45-54 H. P.— 1/8 Inch.	100-120 H. P.— 3/16 Inch.
50-60 H. P.— 3/16 Inch.	135-150 H. P.—13/64 Inch.
	180-200 H. P.—13/64 Inch.

79—Fuel Pump Priming—Each fuel injection pump has a hand primer located on top of the oil casing directly over the pump. These are used to operate the fuel pumps by hand to prime the cylinders before starting. If the fuel pumps are operating satis-

factorily, the pressure required to force the fuel through the nozzles can readily be felt. By depressing the primer and turning it slightly to the right, any pump can be stopped and the cylinder put out of action. See paragraph 31, page 10.

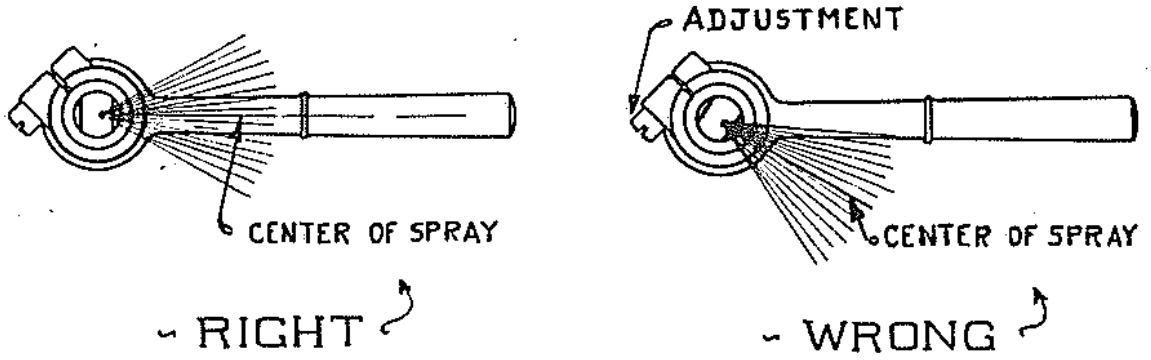

Fig. 14—Handle Adjustment on Movable Type Spray Nozzle.
After spray tips are inserted in the nozzle body the handle must be loosened and then adjusted so that the center of the spray will be directly in line with the handle. Both right and wrong adjustments are shown above. Read paragraphs 80 below.

80—Fuel Injection Nozzles—The injection nozzles consist essentially of a spring loaded check valve and a spray tip. To readjust the spray after taking the tip apart, turn the adjusting screw in as far as it will go; then unscrew it one full turn and tighten lock nut. All spray nozzles are sent out from the factory with the above adjustment. Under certain conditions and with various grades of fuel, some owners prefer to set their nozzles with a three quarter turn.

When replacing spray tips in nozzles, see that the flat seat at the threaded joint is clean and hold the tip between the jaws of a vise to prevent burring. The small check valve in the nozzle may require grinding after several years of service in which case, if possible, the entire nozzle should be returned to the factory for inspection and overhauling. The valve may be reground with a fine grade of valve grinding compound.

When starting engines equipped with movable spray nozzles (Type D), the spray must be directed toward the electric plug or the firing tube by moving the nozzle handle. After the engine is started, the handle or lever is brought back to the central or full load position so that the spray then passes downward through the center of the combustion chamber.

This type of nozzle requires a spray tip having a hole drilled at an angle and whenever changing or replacing tips, the handle must

be carefully readjusted so the hole points towards the handle and will direct the spray in an exact line with the handle, all as shown in Fig. 14, page 30. The two hold-down nuts on the nozzle should be tightened evenly, but never so tight that the nozzle cannot be easily moved with the hand. If the joint leaks, see that the seats are clean, and, if necessary, regrind with fine valve grinding compound.

81—**Fuel Service Pump**—Beyond occasional repacking of the plunger the fuel service pump requires little attention. Horizontal ball check valves should be used. If the pump tends to lose its suction, examine the valves and plunger for wear and the suction line for leaks. On some installations where the distance is great, it may be necessary to fit a foot valve in the suction pipe.

82—**Main Fuel Strainer**—All fuel for the engine passes through the main fuel strainer located on the forward end of the engine base near the fly-wheel. The strainer cup contains a fine mesh Monel Metal screen strainer of large area inside of which fits another strainer of slightly coarser mesh. The fuel enters from the bottom and passes through the inside strainer, and then through the fine outside strainer to the fuel pumps. Both strainers should be removed and cleaned frequently as the engine will tend to lag and slow up when they are clogged. The inside of the strainer also acts as a water settling chamber, and the water which accumulates here should be drained frequently by opening the small drain cock provided for this purpose. Drain the bottom of the fuel tanks occasionally to remove water.

83—**Pressure Fuel Oil Strainers**—A patented fuel strainer which filters the fuel under pressure just before it passes through the nozzle, is provided in each fuel pump discharge line to prevent any possibility of foreign matter clogging the spray nozzles. The strainer requires no attention other than inspection and cleaning once each year.

84—**Circulating Water Pump**—The circulating water pumps are of the plunger type with all parts made of bronze. A good grade of cotton packing (braided) should be used. Ordinary candle wicking if braided is also satisfactory. By unscrewing the air chamber, the valves are exposed and may be lifted out. If the pump valves tend to hammer, open the small air suction cock on the side of the valve chamber slightly. The more this valve is opened, the more

air will be admitted to the pump and its capacity reduced correspondingly. Therefore keep the valve as nearly closed as possible.

85—**Water Regulating Valves**—A valve for controlling the flow of cooling water is provided on each cylinder. To properly adjust these valves, proceed as follows: When the engine is under way, open the valves on all cylinders fully (slot in line with flow). Then by feeling of the brass overflow pipes on the cylinder heads, determine which cylinder is running coolest. Without changing the adjustment on the other valves, close the valve on this cylinder (usually the forward one) slightly. Continue until the temperatures are uniform. When the adjustment is properly made, the valve on the after cylinder on most installations will be fully open, and the one on the forward cylinder, closed the most. Once the valves are set, readjustment is seldom required.

86—**Bilge Pump**—Bilge pump parts are interchangeable with those of the circulating pump. A screen should be fitted to the end of the suction line to prevent dirt from entering the pump. On some installations it is also desirable to install a check valve or foot valve at the end of the suction pipe. To relieve the air if the pump becomes air bound, open the small cock at the top of the air chamber. The bilge pump may also be connected to a sea cock and by means of suitable valves and by-passes arranged to take the place of the circulating pump in an emergency. When the water is extremely warm during the summer months, both pumps can be used to supply cooling water to the engine.

87—**Air Compressor**—The water cooled air compressor, mounted on the after cylinder, is placed in operation by moving the small suction valve control lever. If the compressor loses capacity after long use, the valve springs should be replaced. It may also be found necessary to regrind the valves occasionally using fine valve grinding compound. The piston and rings will run for many years without replacement.

88—**Air Distributor**—The air distributor, which controls the flow of compressed air to each cylinder when starting or air reversing, is mounted above the governor and consists of a rotating valve and control disc operated by a lever. (Disc and lever are not used on two cylinder engines).

To remove the distributor, disconnect the copper air pipes and take out the cap screws with which the air distributor bracket is

fastened to the governor bracket. In reassembling, note that the lower end of the air distributor shaft is stamped with a zero (0). See Fig. 15 below. The coupling through which the shaft is driven, is also marked with a zero (0) as is the top of the governor shaft. When the three zeros are in line (one above the other), the distributor is timed correctly.

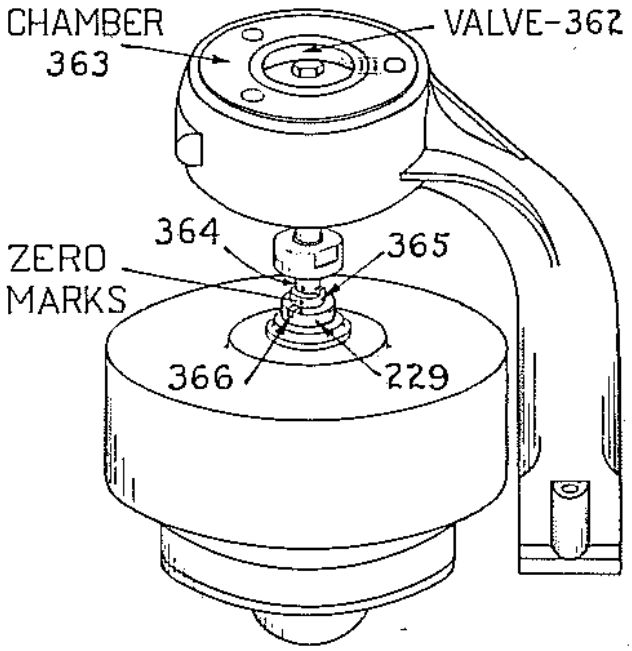

Fig. 15—Timing of Air Distributor.

Zero marks are stamped on the coupling, spindle, and governor shaft. When the three zeros are in line, as shown, the distributor rotary valve is timed correctly. See paragraph 88 on page 32.

The rotary valve 362 has a figure 1 stamped on its upper face. This mark should be opposite the figure 1 on the distributor chamber when the fly wheel key is up on dead center, all as shown on Fig. 15. This method may also be used to check distributor timing.

In case the engine does not turn over smoothly on air, see that the locking wheels on the air inlet valves located at the rear of each cylinder are not holding the valves closed. Try each valve to see that the valve stem is free and moves inward the full distance. Also make sure that valve 385 shown in Fig. 2, page 13 is open. When not maneuvering, the air pressure should be released from the distributor by closing the main air valve.

Occasionally, due to improper manipulation of the controls or extremely low starting air pressure, several cylinders will become filled with air ("air bound") and the engine will not turn over. It

is then necessary to open the relief valves and allow the trapped air to escape.

The air distributor spindle or shaft which rotates the distributing valve, is driven from the governor through key 366 shown in Fig. 15. This key is designed to shear off if the free rotation of the valve is interfered with. Replacement can be easily made by using any suitable piece of square steel.

The entire air distributor assembly, like the upper and lower units of the governor, can be removed and sent to the factory for overhauling.

89—Air Inlet Valves—These valves, located on the aft side of each cylinder and through which the starting air enters, are fitted with knurled locking wheels which may be screwed back to lock the valve stems. The valves seldom require attention, but if one should leak, it can be closed by means of the locking wheel. A knurled nut is fitted to the end of the valve stem and enables the valve to be rotated and reseated while the engine is running. These valves should be removed and reground whenever required using fine grinding compound.

90—Emergency Starting—In case of damage to the air distributor, the engine may be started by the emergency or one cylinder starting system. See Fig. 1, page 12 and paragraph 38 page 12 for directions.

91—Air Tanks—The tanks used on Kahlenberg engines are of steel with riveted and copper brazed seams. Unless labeled otherwise, they are built for a working pressure of 200 lbs. per square inch. Both the inside and outside are heavily galvanized. It is good practice to inspect the tanks once each year and drain off any water or oil which may have accumulated.

92—Exhaust Ports—The exhaust ports should be inspected frequently to see that they are open and free from carbon. To do this remove the small hand hole plates located on the outside of the exhaust manifold opposite each cylinder. Use an iron bar bent in the form of a hook to remove the carbon. There are four exhaust port openings to each cylinder, all of which must be clean. Caution: If the ports are blocked, the engine cannot exhaust properly and will lag, lose power, and overheat. Special tools for cleaning can be ordered from the factory. On a new engine, operators should in-

spect the ports once each week until they know just how frequently inspection and cleaning are required.

93—Electric Plugs—The wire coil or resistance element on an electric plug can be easily replaced. To do this pull the old wire out carefully with pliers, insert the new coil and fasten tight, using a small center punch. The insulation seldom requires attention or replacement. Plugs may be returned to the factory for coil replacement at small cost. When removing electric plugs use the special socket wrench furnished. When replacing apply a mixture of graphite and oil to the threads.

94—Generator—When generator repairs or adjustments are necessary, they should be made by an authorized service station of the generator manufacturer, if it is not convenient to ship the generator to us. For the wiring refer to the special diagram furnished with each engine. Keep both terminals on the battery (especially the positive) clean by scraping the contact surfaces frequently. Badly corroded terminals prevent the proper flow of electric current. Keep battery filled with distilled water.

95—Reverse Gear and Clutch—The following covers Reverse Gears and Clutches of Kahlenberg manufacture. For other type gears on old engines refer to special instructions issued.

Ahead Adjustment—Remove locking screw and locking clip on the slotted adjusting collar at the rear end of the clutch drum. Turn the collar one notch ahead (right hand thread) and try clutch by moving operating lever ahead. If tight enough, the operating fingers on the clutch will release with a snap noise when the lever is moved back from the ahead position.

Reverse Adjustment—The nuts on the two adjusting rods at the top of the brake band should be turned slightly, each the same amount, and then locked in position by means of the lock nuts provided. When the lever is placed in reverse position, the brake band should be sufficiently tight to hold the clutch from revolving, as slipping here will cause undue wear on the band and clutch drum and reduction of the propeller speed astern. If adjustment is correctly made, the clutch lever will remain in astern position until again moved forward. If not, the clutch is adjusted too tight in the reverse. Do not lean on the clutch lever when running ahead, this only wears out the bronze carrier yoke or collar on the sliding sleeve.

TROUBLE CHART

Troubles	Possible Causes	Numbers of Reference Paragraphs
ENGINE DOES NOT START	Air in fuel lines.	30
	Cylinders not primed.	31-79
	Fuel pump plunger sticking.	78
	Throttle lever in stop position.	37-75
	Auxiliary throttle lever in slow position.	37-76
	Fuel tank empty.	
	Fuel tank not properly vented.	
	Valve in fuel pipe from tank closed.	
	Fuel pumps shut off.	79
	Water in fuel.	
	Water in cylinders.	
	Water in exhaust manifold.	
	Starting air pressure too low.	88
	Inside of firing tube clogged with carbon.	
	Firing tube not hot enough.	34
	Battery low.	35
	Electric plug defective.	35-93
	Fuse defective.	35
	Loose battery connection.	10-35-94
	Battery terminals corroded.	10-35-94
	Spray nozzle defective.	80
	Spray nozzle improperly adjusted.	80
ENGINE MISSES OR DOES NOT IDLE	Fuel pump plunger sticking.	78
	Spray nozzle defective.	80
	Timing lever not in best position.	43-77
	Air damper lever not in proper position.	43-62
	Cooling water too cold.	43
	Speed too low.	43-76
	Tappet retainer springs broken.	78
	Fuel pump plunger packing leaks excessively.	78
	Fuel pump valves leaking.	78
	Fuel pump valve springs defective.	78
	Fuel pipe joints leaking.	7
	Dirt in fuel pump or nozzle.	78-80
	Piston rings stuck in grooves.	66
	Water in fuel.	82
	Water in cylinders.	
	Poor compression.	
	Fuel tank not sufficiently high.	7
	Fuel tank too high.	7
	Fuel strainers clogged.	82
	Fuel pump strokes incorrect.	78
ENGINE RACES WHEN STARTING	Engine primed too much.	31-79
	Air damper not closed immediately after starting.	41
	Auxiliary throttle lever not closed immediately.	41

TROUBLE CHART

Troubles	Possible Causes	Numbers of Reference Paragraphs
ENGINE LACKS POWER, SLOWS UP. OVERLOADED, OVERHEATING	Exhaust ports blocked with carbon.	92
	Water pump air cock wide open.	84
	Water valves on cylinders improperly adjusted.	85
	Injection timing lever not advanced far enough.	77
	Air damper lever not in open position.	62
	Speed control springs not adjusted properly.	76
	Defective spray nozzle.	80
	Fuel Strainer clogged.	82-83
	Air breathing valves clogged.	56
	Piston rings stuck in grooves.	66
	Propeller too large.	72
	Sea water too warm.	86
	Cylinder water jackets blocked with sand	60
	Leaky water pump suction pipe.	
	Water pump valves not seating properly.	84
	Water pump valve spring broken.	84
	Cylinders improperly lubricated.	20
	Compression poor.	
	Sea cock or strainer clogged.	
	Sea cock or piping too small.	6
	Sea cock improperly located.	
	Propeller shaft turns hard, fouled.	
	Exhaust pipe too small or too long.	5
	Exhaust pipe contains elbows.	5
	Improper muffler causes excessive back pressure.	
	Fuel pump strokes improperly adjusted.	78
ENGINE KNOCKS IN CYLINDERS	Injection timing advanced too far.	77
	Exhaust ports blocked with carbon.	92
	Air damper lever down in closed position.	62
	Spray nozzle valve leaking.	80
	Spray nozzle tip or valve defective.	80
	Defective fuel pump.	78
	Engine overheated or overloaded.	72-84
	Piston rings stuck in grooves.	66
	Connecting rod bearing burned out.	69
	Engine not firing on all cylinders.	35
ENGINE DOES NOT TURN OVER PROPERLY ON COMPRESSED AIR	Air distributor drive key sheared off.	88
	Air distributor not timed correctly.	88
	Air pressure too low.	91
	Obstruction in air pipes.	33
	Engine on dead center.	37
	Engine "air bound"—cylinders blocked with air.	88
	Air inlet valves closed or blocked.	89-37
	Air valve 385 closed.	88

TROUBLE CHART

Troubles	Possible Causes	Numbers of Reference Paragraphs
WATER PUMP POUNDS	Air cock not opened sufficiently. Wrist pin or bushing worn. Connection head loose in plunger. Eccentric strap worn.	84
AIR COMPRESSOR LOSES CAPACITY	Suction valve spring weak. Discharge valve spring weak. Valves require regrinding. Obstruction in discharge pipe. Discharge pipe too long. Discharge pipe too small.	87 87 87 8 8

DON'TS

1. Don't forget to thoroughly oil all moving parts and to turn the lubricators by hand before starting so you are satisfied that the oil has reached all bearings.
2. Don't forget to open the sea cock.
3. Don't attempt to start engine with valves in fuel line from tank closed.
4. Don't fail to see that everything is ready before making a start.
5. Don't wipe moving parts of engine while it is in operation.
6. Don't forget to close air damper for a while immediately after starting to prevent engine racing.
7. Don't forget to work the hand primers until you have a solid flow of oil at the nozzle unions before attempting to make the first start.
8. Don't forget to drain cylinders, exhaust manifold, bearing water jackets, and all pipes, pumps, etc. in cold weather.
9. Don't make any changes on your engine or allow a so called "Expert" to make them.
10. Don't forget that the lubricators must be filled at regular intervals, and other moving parts oiled while running.
11. Don't neglect to clean and thoroughly wipe the engine after your trip.

12. Don't attempt to start engine with throttle lever closed.
13. Don't forget to close throttle lever (stop position) when you turn the engine over by hand with bar.
14. Don't forget the flap doors on the cylinder head caps should be open on a regular run and closed when operating slow.
15. Don't forget that each bearing has a water jacket and each must be drained separately in cold weather.
16. Don't forget to close bearing water valve immediately after engine is stopped if there is a possibility of the water in the cylinders draining through the bearings.
17. Don't forget that if engine does not start promptly there is a possibility of the firing tube being clogged, a fuel pump not working properly or no fuel reaching the cylinders.
18. Don't, above all, change the stroke of the fuel pumps. The maximum stroke should not be more than that given on page 29.
19. Don't forget, it is best to allow the engine to run idle a short time before stopping after a long run.
20. Don't, under any conditions use anything but compressed air for starting.
21. Don't forget to clean the exhaust ports frequently.
22. Don't pour oil in the crank cases. Clean them out instead.
23. Don't waste your compressed air. If the engine does not start promptly, stop and look for the trouble.
24. Don't use air from all tanks when starting. Keep at least one in reserve. Close the valve on an empty air tank before opening the other valves.
25. Don't wash your engine down with a hose. If you do the water will get into the eccentrics and governor parts and cause excessive wear.
26. Don't forget, if your engine loses power, that the exhaust ports may be clogged, the main fuel strainer blocked with dirt, or something wrong with the supply of cooling water.
27. Don't forget Don't No. 8.
28. Don't forget Don't No. 13.

PART SIX

REPAIR PARTS

96—Parts Booklet—A complete repair parts booklet with illustrations of engine parts is furnished with each engine and should be referred to when ordering repairs. Copy of the parts list will gladly be sent to any owner or operator of a Kahlenberg engine, providing the request is accompanied by information as to the number of the engine, horsepower, and the name of the present owner.

97—Ordering Repair Parts—In ordering repair parts, always give complete information so there will be no delay in forwarding the shipment. Give the quantity, the part number of each item wanted, the name of the part, and the shop number and horsepower of the engine. Also specify if shipment is to be forwarded by express, parcel post, or freight.

If ordering by telegraph, the code word may be used instead of the number and name of each part. This will simplify and reduce the cost of your telegram.

98—Repair Parts Department—In marine service, the prompt shipment of replacement parts is of the utmost importance. Delays cost money. We therefore make every effort to ship all parts at the earliest possible moment. In fact, the majority of repair orders leave the plant within an hour or two after arrival. There is no red tape. You are assured your order **will** receive our immediate attention. Small parts shipped to us for repairs in most cases can be returned the same day they are received.

We call attention that such vital parts as the air distributor, upper part of the governor, the lower part of the governor, fuel pumps, spray nozzles, water pumps, air compressor heads, etc., can be taken off the engine as complete units and can easily be shipped to the factory or to our distributors for overhauling while the boat is not in use. They will then be in first class shape and ready for continuous service when the boat is again placed in operation.