INSTRUCTION MANUAL

FOR

ONAN ELECTRIC GENERATING PLANTS

Series

HR

D. W. ONAN & SONS INC. • MINNEAPOLIS 14, MINN.

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GENERAL INFORMATION

THE PURPOSE OF THIS BOOK. This instruction book is furnished so that the operator may learn of the characteristics of the plant. A thorough study of the book will help the operator to keep the plant in good operating condition so that it will give efficient service. An understanding of the plant will also assist the operator in determing the cause of trouble if it occurs.

KEEP THIS BOOK HANDY. Such simple mistakes as the use of improper oil, improper fuel, or the neglect of routine servicing may result in failure of the plant at a time when it is urgently needed. It is suggested that this book be kept near the plant so that it may be referred to when necessary.

SERVICE. If trouble occurs and the operator is unable to determine the cause after a thorough study of this book, or if he is unable to determine what repair parts are required, needed information will be furnished upon request. WHEN ASKING FOR INFORMATION, BE SURE TO TO STATE THE MODEL, SPEC., AND SERIAL NUMBERS OF THE PLANT. THIS INFORMATION IS ABSOLUTELY NECESSARY AND MAY BE OBTAINED FROM THE NAMEPLATE ON THE PLANT.

MANUFACTURER'S WARRANTY

The manufacturer warrants each new engine or electric plant to be free from defects in material and workmanship. Under normal use and service our obligation under this warranty is limited to the furnishing of any part without charge which, within ninety (90) days after delivery to the original user shall be returned to us or our authorized service station with transportation charges prepaid and which our examination shall disclose to have been defective.

Our liability in case of defective workmanship, material or any costs incurred in remedying any claimed defective condition in any unit or such unit having been repaired, altered or which installation and service recommendations have not been complied with, is limited strictly to the proper adjustment authorized by the factory.

This warranty does not include or cover standard accessories used, such as carburetors, magnetos, fuel pumps, etc., made by other manufacturers. Such accessories have separate warranties made by the respective manufacturers. Repair or exchange of such accessories will be made by us on the basis of such warranties.

This warranty is in lieu of all other warranties expressed or implied.

IMPORTANT

RETURN WARRANTY CARD ATTACHED TO UNIT.

PLANT RUNNING HOURS COMPARED TO AUTOMOBILE RUNNING MILES

The engine of your generating plant makes as many revolutions in one hour, as the average automobile engine does when the car travels a distance of 41 miles.

100 running hours time on a generating plant engine is equivalent in total RPM to approximately 4100 running miles on an automobile.

Compare the running time of your generating plant engine with the number of miles traveled by an automobile. The oil in an auto is checked every one or two hundred miles (3 to 5 hrs. running time) and changed every 1000 to 1500 miles (28 to 42 hrs.) whereas in a generating plant or stationary power engine, the oil should be checked every 6 to 8 running hours (250 to 350 miles) and changed every 50 to 100 operating hours (2000 to 4000 miles) depending on operating conditions.

About every 5,000 to 10,000 miles (120 to 250 hours), services have to be performed on an auto, such as checking ignition points, replacing spark plugs, condensers, etc. Similarly on your generating plant engine, these same services have to be performed periodically except the change period is reckoned in hours. 10,000 miles on an auto is equivalent to about 250 running hours on your plant engine.

To arrive at an approximate figure of comparative generating plant running hours as against automobile engine running miles, multiply the total number of running hours by 41 to find the equivalent of running miles on an automobile.

Your generating plant engine can "take it" and will give many hours of efficient performance provided it is serviced regularly.

Below is a chart showing the comparison between a generating plant engine running hours and an automobile running miles.

	GENERATING PLANT RUNNING HOURS	AUTOMOBILE RUNNING MILES		GENERATING PLANT RUNNING HOURS	AUTOMOBILE RUNNING MILES
DAILY AVERAGE	1 Hr.	41 Mi.		30 Hrs.	1,230 Miles
	4 Hrs.	164 Mi.	MONTHLY AVERAGE	120 Hrs.	4,920 Miles
	6 Hrs.	246 Mi.		180 Hrs.	7,380 Miles
	8 Hrs.	328 Mi.		240 Hrs.	9,840 Miles
	7 Hrs.	287 Mi.		365 Hrs.	14,965 Miles
WEEKLY AVERAGE	28 Hrs.	1,148 Mi.	YEARLY AVERAGE	1,460 Hrs.	59,860 Miles
	42 Hrs.	1,722 Mi.		2,190 Hrs.	89,790 Miles
	56 Hrs.	2,296 Mi.		2,920 Hrs.	119,720 Miles

NOTE: Electric generating plants do not operate economically when used to power electric refrigerators and will add from 4 to 8 operating hours per day in addition to the regular lighting load.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

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INTRODUCTION

This instruction manual is supplied to assist in the proper installation, operation, and servicing of the Continental Engine Model R602 of the HR series of electric generating plants. Unless otherwise indicated, these instructions apply to all standard plants of the HR series. Some details of these instructions may not apply to special models having modifications specified by the purchaser. The use of auxiliary or special equipment, special installation requirements, or unusual operating conditions may require some deviation from these instructions. However, by using the instructions and recommendations given in this manual as a general guide, it will be possible to make a good installation, and to properly operate and maintain the plant.

Each electric generating plant is given an actual running test and is carefully checked under various electrical load conditions before leaving the factory, to assure that it is free of defects and will produce its rated output. Inspect the plant carefully for any damage which might have occurred in shipment. Any part so damaged must be repaired or replaced before putting the plant in operation.

If it should become necessary to contact the factory or an Authorized Service Station in regard to this generating plant, always give the Model and Spec. Number, and Serial Number, as shown on the plant nameplate. This information is essential in order to properly identify the plant so that proper advice can be supplied.

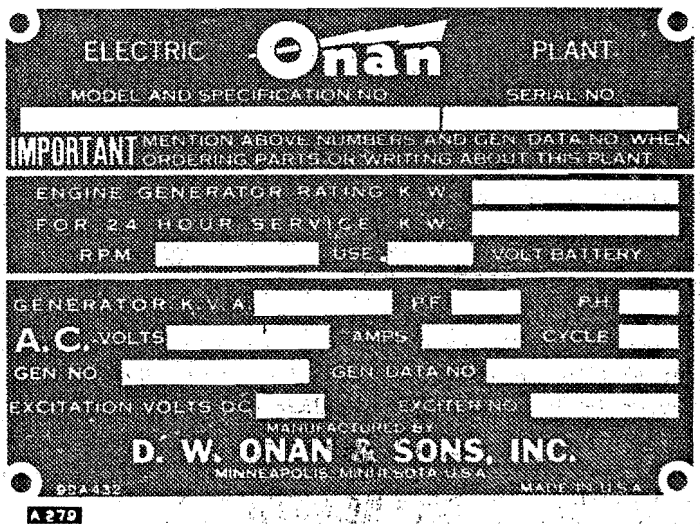


FIG. 1 - ELECTRIC PLANT NAMEPLATE

Basic differences in the HR series of plants are indicated by a letter A, B, etc. ending the model number as given on the plant nameplate.

The plant is a complete electric power plant, consisting of an internal combustion engine, a self excited electric generator directly connected to the engine, and a control and instrument panel. The engine end of the plant is designated as the front end, and right and left sides are determined when facing the front end.

ENGINE

The engine is a Continental Model R602,6-cylinder over-head-valve engine. It is a water cooled, 4 stroke cycle. Full length water jackets around each cylinder, in conjunction with a high velocity flow of coolant, contribute to efficient engine cooling. Full pressure lubrication, with a shunt type oil filter, contributes to long engine life.

ENGINE DATA

Cylinder Bore (Inches)	4-7/8"
Piston Stroke (Inches)	5-3/8"
Piston Displacement	602 cu. in.
Compression Ratio	6.0 to 1

Piston - 5 ring, hard Chrome plated top ring.
Connecting Rod Bearings - Replaceable precision type.
Main Bearings - Replaceable precision type.
Valves - Overhead, rotating type.
Tappets - Adjustable push rod clearance.
Lubrication - Capacity 18 quarts dry - replaceable cartridge, Shunt type oil filter.
Cooling - Capacity 64 quarts.
Ignition - 12 volt battery - Firing order 1-5-3-6-2-4- Neg. Grd.

GENERATOR DETAILS

The air cooled generator has two main components; the alternator and the exciter.

The alternator is a revolving field type alternating current generator. The generator rotor is connected directly to the engine flywheel and turns at engine speed. The rotor is a four pole type and must operate at approximately 1800 rpm for the 60 cycle plants. The alternating current is generated in the stator winding of the alternator and is taken to the AC output terminals inside the metal box on the generator. The outboard end of the rotor is supported by a lubricated ball bearing. The stator end bell casting, which might be called an adapter bell to distinguish it from the exciter end bell, houses this stator bearing, as well as the slip ring brush rig which serves to feed exciter current through

the rotor. Hand holes in the adapter bell provide access to the slip ring brushes and to the constant-pressure type brush springs for servicing.

The separate exciter is a stationary field, direct current generator. The output of the exciter is used to create a magnetic field in the rotor. The exciter armature shaft is tapered and keyed to the outboard end of the rotor shaft.

The generator is specifically designed for high efficiency and excellent motor starting ability. The external voltage regulator gives extremely close (2%) voltage reglation. The manually operated field rheostat may be used to control voltage for emergency operation if the automatic regulator should fail. The frequency of the current is determined by the engine speed, and is regulated by the engine governor. The output rating is at 0.8 (80%) power factor load. The rated capacity for 60 cycle plants is 75,000 watts (75KW). The rated capacity for 50 cycle plants is reduced to 60KW due to lower engine speed.

CONTROLS

The control box, located at the rear of the plant, mounts engine operating instruments and electrical meters, etc. according to the particular model. The engine instruments for the standard plant include: electric water temperature gauge, electric oil pressure gauge, battery charge rate ammeter, start-stop switch. Safety devices include a high water temperature cut-off and a low oil pressure cut-off switch. The complete electric instrument panel for housed units includes a running time meter, ammeter, AC volt meter, DC volt meter, phase selector switch, circuit breaker, frequency meter, voltage regulator rheostat, and manual voltage control rheostat.

"DAY" FUEL RESERVOIR TANK. - The "DAY" fuel reservoir tank provides a reservoir of gasoline fuel which feeds by gravity to the carburetor. Gasoline tends to slowly evaporate from the carburetor during shut-down periods. If the shut-down is of lengthy duration, such as in standby service, the evaporation may be enough to prevent ready starting. The "DAY" tank keeps the carburetor full for an extended time, thus insuring against starting failure due to a partially filled carburetor.

LINE TRANSFER. - A complete line of automatic line transfer controls are available, designed especially for standby service. Upon failure of the regular source of electric power, the line transfer disconnects the load lines from the regular power supply lines, starts the plant, and connects the load lines to the plant. The plant continues to run, regardless if electrical load is connected or not, until the regular power supply is restored. When power is restored, the line transfer then disconnects the load lines from the plant, stops the plant, and connects the load lines back to the regular power supply lines.

UNDERGROUND FUEL TANK. - Fuel tanks of 55, 110, or 250 gallon capacity are available for underground use. Fill and vent pipes, and a suction tube extending to within an inch or two of the tank bottom are supplied. Provision for a fuel return line connection (necessary when "DAY" reservoir tank is used) is also provided.

LOCATION. - If the generating plant is to be installed in a permanent location, choose a site for the plant that will be more or less centrally located in relation to the electrical load. Plan to avoid running wiring for a long distance. For standby installations, the usual location is close to the main fuse or entrance box. Check local regulations concerning standby installations.

The selected site for the plant should be in a clean, dry, well ventilated location, preferably heated in extremely cold weather. Choice of either a damp or exceptionally dusty location will require more frequent inspection and servicing of the plant

MOUNTING. - The plant should be mounted on a raised concrete or heavy timber case, for ease in draining oil and other periodic servicing. Allow at least 24 inches clearance space on all sides of the plant for access in servicing. Though not a requirement for permanent installations, the plant may be bolted down if desired.

If the plant is to be used for mobile service, mounted in a truck or trailer, it must be bolted securely in place so that it can not shift while in transit. Make provisions for access to the plant for servicing. Extra support for the vehicle floor may be necessary, to prevent the mounting bolts from tearing loose on rough roads or in turning sharp corners.

VENTILATION. - The plant creates a considerable amount of heat which must be removed by proper ventilation. In a large room or outdoors, cooling will be no problem. However, if the plant is installed inside a small room or compartment, provide separate air inlet and outlet openings.

Cooling air travels from the rear of the plant towards the front end. Locate the compartment air inlet opening where most convenient, preferably to the rear of the plant. The inlet opening should be at least as large as the radiator area.

Engine heat is blown out through the front of the plant by a pusher type fan. The cooling air outlet should be directly in front of the radiator, and as close as is practicable. The opening should be at least as large as the radiator area, preferable larger. Where the opening size must be held to the minimum, a duct of canvas or sheet metal may be used between the radiator grill on the plant and the compartment air outlet. The duct will prevent recirculation of heated air.

Generator cooling air is drawn in at the rear end and discharged at the bottom forward end of the generator. The heated air is then picked up and discharged through the engine radiator.

In cold weather, a means of restricting the air flow can be provided, to keep the compartment temperature at a normal point.

EXHAUST. - The engine exhaust gases are deadly poisonous and must be piped outside any room or other enclosure. Use pipe as large as the exhaust connection on the engine. Use pipe at least as large as the muffler outlet for the first ten feet. Increase the size of the pipe one pipe size for each ten feet of additional length. Avoid the use of 90 degree pipe elbows, if turns are necessary, as they tend to create undesirable back pressure in the exhaust line.

Insulate or shield the exhaust pipe if there is danger of any one touching it, or if it must be run close to any wall or other material that is not completely fire proof. If the exhaust line must pass through a combustible wall or partition, provide insulated shield collars for the line. The wall openings must be at least 4 inches larger on all sides than the exhaust line.

FUEL SUPPLY, GASOLINE. - When an underground fuel tank is installed, the total lift of fuel from tank to fuel pump inlet should not be more than 6 feet. The horizontal distance between the tank and plant should not be more than 50 feet. Most fuel tanks for underground use have the fuel outlet at the tank top, requiring a drop or suction tube extending down to within an inch or two of the tank bottom. All fuel line connections between the tank and the plant fuel pump must be air tight. Any air leak will prevent pumping of fuel to the plant. The fuel pump inlet opening is threaded for 1/4" pipe. A proper adapter fitting must be used if other than 1/4" pipe thread fitting is used on the fuel line. A priming lever is attached to the fuel pump.

'DAY" FUEL RESERVOIR TANK. - In standby service, the generating plant may stand unused for many days. In this period of shut-down, sufficient gasoline may evaporate from the carburetor to lower its fuel level considerably. Prolonged cranking may then be necessary to pump enough gasoline into the car-

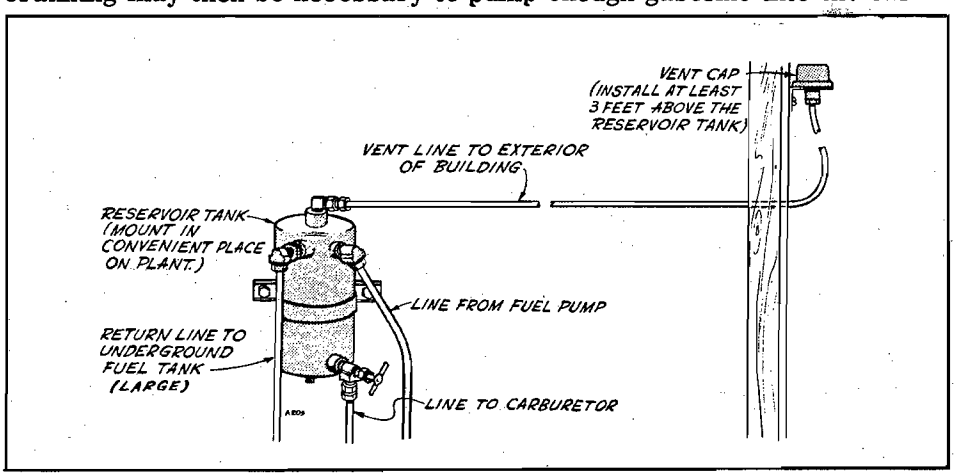


FIG. 2 - DAY TANK INSTALLATION

buretor for the engine to start. Where automatic, unattended starting after extended shut-down is necessary, an auxiliary gravity feed fuel tank should be installed. Fuel from this tank flows by gravity to the carburetor, thus replacing any fuel lost through evaporation and promotes quick starting after an idle period. Note that a large fuel return line must be provided between the auxiliary tank and the main supply tank.

FUEL, NATURAL GAS OR LPG. - If the plant is equipped for the use of natural gas (or LPG), connect the gas fuel line to the gas pressure regulator as shown in Figure 00. The position of the gas pressure regulator is important and it must be installed as shown in the illustration. Local regulations may require the installation of a fuel solenoid valve and filter.

BATTERY CONNECTION. - Cables for making connections between the plant and the battery are supplied with all plants even though the starting batteries are not. If necessary, spread the cable lug open slightly. Do not use a hammer to drive the cable lugs onto the battery terminal posts, because the battery may become damaged. Cable lugs should make clean full contact on the battery terminal posts to prevent loss of current at this point. Coat lugs and terminal posts with a thin coating of vaseline to help prevent corrosion.

If a single 12 volt battery is used, connect the long battery cable with the larger lug from the positive (+) post on the battery to the outside terminal on the starter. Connect the other long cable from the negative (—) post on the battery to the starter mounting stud as illustrated. The short jumper cable is not used with a single 12 volt battery. Secure cable connections at all points.

If two 6-volt batteries are to be connected in series to form a 12-volt battery, connect the short jumper cable from the negative (—) post of one battery to the positive (+) post of the second battery. Then make the longer cable connections as described in the foregoing paragraph.

Batteries should always be installed on a wooden or metal rack to permit a free circulation of air around the battery.

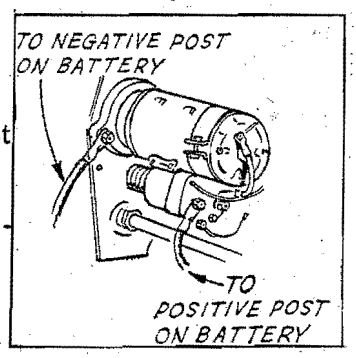
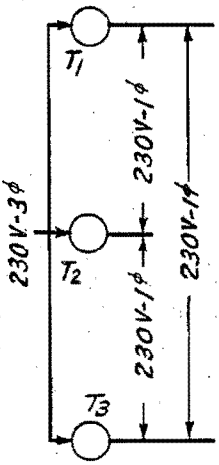


FIG. 3 - STARTER

CONNECTING THE LOAD WIRES. - Connect the AC load wires to the terminal lugs inside the sheet metal box on the generator. Observe electrical code specifications. Be sure to provide a switch for disconnecting all electrical load from the plant. Connect the load line wires to the terminal lugs according to the following directions, depending upon the type of plant. Properly fuse each circuit.

230 VOLT, 3 PHASE, 3 WIRE PLANT

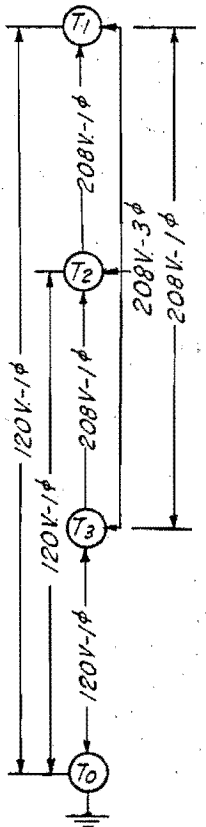
No terminal is grounded. For three phase current, connect separate load wires to each plant terminal "T1", "T2", "T3", one wire to each terminal. Reversing the connections between any two terminals will reverse the direction of rotation of 3 phase motors. If phase sequence is important, as when paralleling plants, be sure to check the phase sequence before connections are completed.



To obtain 230 volt, single phase current, connect separate load wires to each of any two plant terminals. Three 230 volt single phase circuits are thus available, with not more than 1/3 of the plant rated capacity for each circuit. Balance the load as closely as possible among the circuits.

If both single phase and three phase current is to be used at the same time, use care not to overload any one circuit. Subtract the amount of the 3 phase load from the rated capacity of the plant. Divide the remainder by 3, and this is the maximum load that can be taken from any one circuit for single phase current use. For example, a 75,000 watt plant is used, with a 45,000 watt 3 phase load connected. This leaves 30,000 watts available for single phase use. Divide the 30,000 watts by 3, giving 10,000 watts available on each single phase circuit. Do not attempt to take all 30,000 watts off one circuit; distribute the load equally over the three single phase circuits.

120 VOLT, SINGLE PHASE/208 VOLT, THREE PHASE PLANT



The terminal marked "T0" is grounded. For 120 volt, single phase current, connect the "neutral" (white) load wire to the "T0" terminal. Connect the "hot" (black) load wire to any one of the other three terminals, "T1", "T2" or "T3". Three separate 120 volt, single phase circuits are thus available. Do not attempt to take more than 1/3 the rated capacity of the plant from any one circuit. Balance the load as closely as possible among the three circuits.

For 208 volt, three phase current, connect a separate load wire to each of the plant terminals "T1", "T2", and "T3", leaving the "T0" terminal unused. Reversing the connections between any two terminals will reverse the direction of rotation of 3 phase motors. If phase sequence is important, as when paralleling plants, check the phase sequence before making final connections.

For 208 volt, single phase current, connect separate load wires to each of any two terminals "T1", "T2", or "T3". Do not use the "T0" terminal. Three separate single phase circuits are available: "T1" and "T2", "T1" and "T3", "T2" and "T3". Do not attempt to take more than 1/3 the rated capacity of the plant from any one circuit. Balance the load as closely as possible among the three circuits.

If both single and three phase current are used at the same time, follow the principles of load distribution as given for the 3 phase, 3 wire plant.

460 VOLT or 575 VOLT, 3 PHASE, 3 WIRE PLANT

Follow the principles of connection as given for the 230 volt, 3 phase, 3 wire plant.

120/240 VOLT or 220/380 VOLT, 3 PHASE, 4 WIRE.

Follow the principles of connection as given for the 120 volt, single phase/208 volt, 3 phase, 4 wire plant.

REMOTE CONTROL CONNECTIONS. - A small 4 place terminal marked "REMOTE-DC OUTPUT" is located inside the control box. If automatic or line failure controls are to be connected, follow the directions for connections as supplied with the control equipment. The terminal block is marked "B+, 1, 2, 3.".

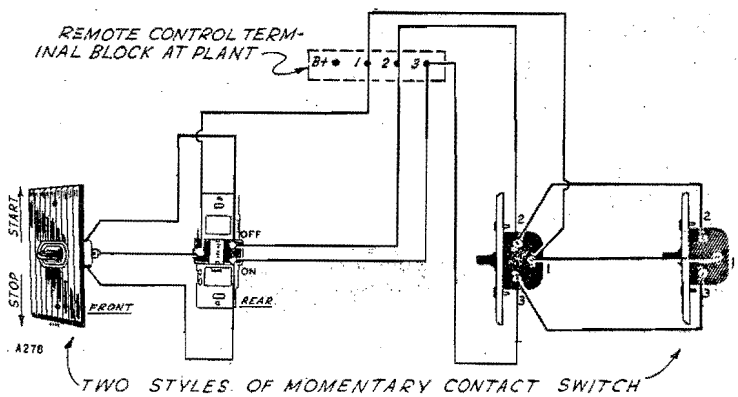


FIG. 5 - REMOTE CONTROL CONNECTIONS

Connect the remote control switch to the terminal block on the plant by running a wire from "OFF" on the switch to #2 terminal on the block. Connect "ON" to #3 on the block. The remaining wire is to be run from the last vacant terminal on the switch to #1 on the terminal block.

A remote control switch is supplied with the remote starting type plant. This switch and additional switches may be installed at convenient points.

The wire length from the plant to the switch determines the wire size necessary. Use #18 wire up to 85 feet, #16 wire up to 135 feet, #14 wire up to 215 feet, and #12 wire up to 350 feet.

AUTOMATIC CONTROLS. - Separately mounted automatic controls can be connected to the generating plant. Before buying and installing such a control, the purpose should be analyzed in order to select the correct type desired. One type of control serves to start and stop the plant according to load demand where there is no commercial power. Another type of control starts and stops the plant and transfers the load during an interruption of commercial power. Automatic controls should be used when even a short interruption of commercial power is serious or in locations where there is no attendant to throw a hand-operated switch. These controls serve various other functions, and literature and advice covering the particular application should be requested from D.W. ONAN & SONS or any of its Authorized Distributors, Dealers, or Parts and Service Centers.

CRANKCASE OIL. - The oil capacity of the crankcase when "dry" (oil filters empty) is 18 U.S. quarts. The "dry" oil filters take 4 quarts of oil. Select the proper SAE number of oil according to the lowest expected temperature. Use detergent oil classified by the American Petroleum Institute as Service "DG' or, as marketed by most manufacturers, "MS/DG".

The use of Service "DS" is satisfactory, but its higher cost is not justified.

TEMPERATURE	SAE NUMBER
Above 50°F.	40
20°F. to 50°F.	30
0°F. to 20°F.	20W

The use of a heavy duty (detergent oil keeps dirt and sludge particles in suspension so that they are removed when the oil is drained and the filter is changed.

NOTE

When adding oil between changes, always use oil of the same brand. When mixed together, detergent oils of different manufacturers sometimes form chemical compounds harmful to engine parts.

TO CHECK THE OIL. - Shut the engine off and allow it to stand for 2 minutes. This will allow the oil to drain down from the valve chamber. The oil reading on the bayonet gauge will show the oil level.

If the oil level reads at the lower mark on the bayonet gauge, add oil to bring the reading to the top mark.

If the engine stands for any length of time the oil level will read about 2" above the top mark. This is normal as the oil has drained down from the filters.

AIR CLEANER. - Remove the air cleaner bottom and fill the reservoir cup, to the disk indicated on the cup bottom, with oil of the same SAE number as used in the crankcase. Be sure to lock the cup in place when replacing.

RADIATOR. - The capacity of the cooling system is 64 quarts (U.S. measure). Check to see that the radiator drain and the cylinder block drain are closed. Fill the radiator to within an inch or two of the bottom of the filler neck. Use clean soft (alkali free) water, such as clean rain water. The use of a good rust and scale inhibitor is recommended.

If the plant will be exposed to freezing temperatures (below 32°F. or 0° C.), use a standard anti-freeze solution. Use the correct proportion of anti-freeze, as recommended by the anti-freeze manufacturer, to protect at least 10 degrees F. below the lowest expected temperature.

FUEL, GASOLINE. - Use fresh, "regular" grade of gasoline. Do not use a highly leaded "premium" grade of gasoline. The use of highly leaded gasoline will require more frequent lead removal, valve, and spark plug servicing. The engine is designed to operate at highest efficiency and economy when using "regular" grade gasoline. However, do not use a low octane fuel, such as "stove gas". The use of such fuel may cause serious damage to the engine.

FUEL, NATURAL GAS. - Follow national and local codes on installing fuel pipes. Be sure that all connections are leak proof.

The secondary regulator requires a line pressure from 4-6 ounces. If the line pressure is more than 6 ounces a primary regulator must be installed in the line to reduce the pressure before it enters the secondary regulator.

In some localities, presence of a foreign matter in the fuel may require the installation of a trap or filter in the line. Consult the fuel supplier.

GENERAL. - Before putting the plant into operation for the first time, be sure that it has been properly installed, and that all requirements under PREPARATION have been met. Check the following points:

1. See that no electrical load is connected to the generator (throw the circuit breaker to the "OFF" position).

2. See that the "VOLTAGE REGULATOR RHEOSTAT" knob is at its approximate perpendicular or mid-adjustment point.

3. See that the "FIELD RHEOSTAT AND VOLTAGE REGULATOR SWITCH" knob is at its extreme COUNTERCLOCKWISE position.

STARTING THE PLANT. - For electric starting, press the "START-STOP" toggle switch in the "START" direction, holding in contact to crank the engine. On the initial start, or if the plant has run out of fuel, extensive cranking may be necessary to pump fuel to the carburetor and fill it. The carburetor is automatically choked, and as soon as the carburetor is sufficiently full, the plant should start. As the engine begins to fire, hold the START switch in contact until running speed has been reached.

Inhibitor oil was sprayed into the cylinders after the factory test run, and it may be necessary to remove the spark plugs and clean them with gasoline before the plant will start the first time. Dry the plugs thoroughly before reinstalling them.

If gas fuel is used, the carburetor choke must be adjusted as described under the paragraph Carburetor-Gas. On the initial start, it will probably be necessary to press the priming button on the gas pressure regulator momentarily. Do not overprime.

CHECKING OPERATION. - After the plant starts, check the engine instruments immediately. See that all are indicating normally, as outlined below. On the initial run, allow the plant to reach operating temperature, then check the coolant level in the radiator. The thermostat may have permitted an air pocket to form, thus preventing complete filling.

NOTE

Inhibitor oil was sprayed inside the cylinders after the factory test run. On the initial run there will be a considerable amount of smoke in the exhaust gases, until the inhibitor oil is burned out.

Throw the circuit breaker handle to the ON position, to connect electrical load to the plant. If the plant tends to surge slightly, it is usually an indication that additional warm up is needed before connecting a heavy load. Continued surging after warm up indicates needed adjustments of the carburetor or governor. Refer to the ADJUSTMENT section.

The engine instruments are furnished on all standard plants. Their function and normal readings or positions are as follows:

OIL. - The oil pressure gauge registers the engine oil pressure while the engine is running. Normal operating pressure is 40 to 60 lbs. at operating temperature, some what higher until the plant warms up.

TEMPERATURE. - The water temperature gauge registers the coolant temperature during operation. Normal operating temperature is 150^{o} to 170^{o}.

AMPS. - The ammeter indicates the battery charge or discharge current in amperes. The rate of charge during operation depends upon the charge condition of the battery. Under normal conditions, the charge rate will be 5 to 10 amperes when the plant starts. The rate will gradually fall to almost zero as the battery becomes fully charged.

EMERGENCY STOP RELAY. - The stop relay button must be pushed to de-energize the stop relay when one of the safety devices has operated to stop the plant. Investigate the cause for the emergency stop before again starting the plant.

START-STOP. - The start-stop switch is a normally open, momentary contact switch. Push the switch up to start, and down to stop the plant.

SAFETY STOPPING DEVICES. - The HR series plants are equipped with two safety devices which operate to stop the plant under certain conditions which could cause serious damage.

1. High Water Temperature Cut-Off. - The temperature cut off is a thermostatic type switch, mounted on the engine, which acts to stop the plant if the coolant temperature rises too high. A dial adjustment permits setting the switch for various temperatures. Refer to ADJUSTMENTS.

2. Low Oil Pressure Cut-Off. - The oil pressure cut-off is a pressure operated switch, mounted on the engine, which acts to stop the plant if the oil pres-

sure drops to less than 9 pounds. It is not adjustable. The low oil pressure cut-off switch is Optional Equipment. (NOTE: When the plant is equipped with a low oil pressure cut-off switch, a time delay relay is also furnished. The time delay relay is used as a pilot relay which is in series with the ground lead between the low oil pressure cut-off switch and the Emergency Stop Relay. The time delay relay does not close its contacts until approximately 5 seconds after energization of its coil, thus allowing the engine oil pressure to build up and open the grounding connection of the low oil pressure cut-off switch).

If one of the safety devices has operated to stop the plant, it is necessary to press the "EMERGENCY STOP RELAY" reset button before the plant can be started again in a normal manner.

The electrical meters and controls vary with the different models. Their description and normal function are as follows:

RUNNING TIME. - The running time meter registers the number of hours, to 1/10th, that the plant has actually run. It provides a convenient means of keeping a regular servicing schedule.

VOLTS. - The voltmeter indicates the a.c. voltage of the generator circuit. On three phase models, voltage of one phase only, as determined by the selector switch position, will be shown. On four wire, three phase models, only the three phase voltage (higher nameplate rating) will be shown.

CIRCUIT BREAKER. - The circuit breaker is a safety device. In case of a severe over-load, the circuit breaker will automatically trip to the "OFF" position, disconnecting the load terminals from the generator output. When the circuit breaker handle is at the "ON" position, the load terminals are connected to the generator output. The circuit breaker can be used as a manual connect-disconnect switch.

SELECTOR SWITCH. - The selector switch is provided on three phase models only. Its setting determines which phase of the generator circuit is indicated on the ammeter and voltmeter.

REGULATOR RHEOSTAT. - The voltage regulator rheostat position determines the REGULATED voltage. Normal setting is with the arrow on the knob pointing straight up.

COMBINATION FIELD RHEOSTAT AND VOLTAGE REGULATOR SWITCH. - The field rheostat is provided for EMERGENCY use only, in case of failure of the voltage regulator. Normal setting of the knob is extreme counterclockwise. When turned slightly clockwise, the voltage regulator is disconnected and voltage MUST be manually controlled.

ENGINE CONTROL OPERATION. - A brief description of the function of the various engine control circuits will enable the operator to more easily understand their operation.

When the Start Button is pushed to start position, battery current is fed to the Start Solenoid Relay, its contacts close and feed battery current to the Start Solenoid; its contacts close and feed battery current to the Starting Motor which cranks the engine. The Start-Disconnect relay, which is in the cranking circuit, opens its contacts and disconnects the cranking circuit, when it becomes energized by the charging generator voltage as the charging generator comes up to speed.

When the Start Button is pushed, the Start Ignition Relay is energized, connecting the battery across the ignition circuit. As soon as the battery charging generator comes up to speed, as the engine is cranking, enough voltage is generated to close the Ignition Relay (Labeled Stop Relay on the Wiring Diagram). The ignition relay remains operated as long as the plant is operating. To stop the plant, operation of the Stop Push Button grounds the coil of the Ignition Relay; disconnects the ignition circuit and stops the plant.

The ignition circuit goes thru the normally closed contact of the Emergency Stop Relay. If either high water temperature or low oil pressure occurs, the Emergency Stop Relay coil connected to the charging generator becomes energized, disconnects the ignition circuit, and stops the plant. (This also occurs if the plant is equipped with a low oil pressure cut-off switch.) When the Emergency Stop Relay is energized, the normally open contacts close connecting the hold in coil circuit to the battery positive. When this occurs, the cause of the plant shut-down should be determined first, before attempting to start the plant again. Whenever the Emergency Stop Relay has operated, the Emergency Reset Switch must be operated before the plant can be started.

When the start button is pushed to start position, the Anti-Dieseling Solenoid Start Relay is energized, its contacts close feeding current to the Anti-Dieseling Solenoid. The energized solenoid pulls the plunger in,which in turn opens the butterfly valve in the carburetor. The Anti-Dieseling Solenoid will remain in operation as long as the unit is run-

ning. When the stop button is pushed to stop, the Anti-Dieseling Solenoid becomes de-energized. A spring attached to the solenoid plunger pulls the plunger out which closes the butterfly valve thus shutting off the air supply to the cylinders and prevents dieseling from taking place.

STANDBY SERVICE. - When the plant is used for standby service (failure of a commercial or other regular source of power), it is essential to "exercise" the plant regularly. If practicable, start and run the plant for approximately 15 minutes every day or two. If a fuel reservoir tank (see INSTALLATION) is used, the length of time between exercise periods can be considerably lengthened. However, an exercise run at least once a week is recommended.

VOLTAGE REGULATOR. - Normally, the voltage regulator does not require attention during successive operating periods. The voltage regulator is an automatic device for controlling the output voltage of the generator. Its action provides the same effect as is obtained by hand operation of a rheostat on a manually controlled generator.

The voltage regulator knob position determines the regulated voltage of the generator output. The regulator was adjusted at the factory to give the rated voltage with the knob arrow pointing straight up. The voltage can be lowered or raised approximately 10% by turning the adjusting knob. Turn counterclockwise to lower the voltage; or clockwise to raise the voltage. The regulator will keep the voltage at its set value regardless of changes in temperature, load, or power factor. If the voltage can not be set at the desired point by knob adjustment, a change in the regulator resistor setting may be required. Refer to ADJUSTMENTS.

FIELD RHEOSTAT. - The field rheostat provides for manual control of output voltage and should be used ONLY in case of voltage regulator failure. When the FIELD RHEOSTAT knob is turned to its normal extreme counterclockwise position, an integral switch provides for automatic voltage regulator operation. However, turning the FIELD RHEOSTAT knob slightly clockwise, disconnects the automatic voltage regulator and the generator voltage MUST be manually controlled by knob operation.

When manual voltage control is necessary, turn the FIELD RHEOSTAT knob from its extreme counterclockwise position just enough to cause the integral switch to cut out the regulator. Start the plant and adjust the rheostat knob to obtain the proper voltage.

The voltage of the generator will drop somewhat as it warms up, necessitating a rheostat adjustment. The rheostat setting must also be changed as the electrical load on the generator is changed, to keep the voltage at a safe operating point. As electrical load is increased, the voltage will drop, and it will be necessary to turn the rheostat knob clockwise

to raise the voltage back to normal. Likewise, as electrical load is removed the voltage will rise, and a counterclockwise adjustment of the rheostat knob is necessary to lower the voltage. Keep in mind that any substantial change in the amount of load connected to the generator calls for a compensating readjustment of the rheostat knob.

STOPPING THE PLANT. - The plant is stopped by pushing the control panel switch or a remote control switch to the STOP position. If practicable, disconnect all load before stopping the plant.

LOW TEMPERATURES

CRANKCASE OIL. - For cold weather operation, select the SAE number of the crankcase oil according to the lowest temperature expected before the next scheduled oil change. See PREPARATION. When changing to a lighter oil for cold weather, change the oil filter elements at the same time. After changing to a lighter oil, always run the plant for a few minutes to circulate the lighter oil through the engine.

If an unexpected temperature drop takes place, use caution in attempting to start the plant after a shut down period. Do not attempt to start a plant that is so "stiff" that it will not crank properly. Congealed oil may not flow readily, resulting in lack of lubrication to vital parts and causing serious damage. In an emergency, apply heat directly to the engine oil pan to warm the oil. When the oil is sufficiently fluid, start the plant and allow it to thoroughly warm up. Stop the plant and change the oil (and oil filter elements) to the proper SAE number.

RADIATOR. - If there is a possibility of the temperature falling below 32°F. (0°C.) the coolant must be protected against freezing. Use a good anti-freeze compound in the proportion recommended by the anti-freeze manufacturer, protecting to at least 10 degrees F. below the lowest expected temperature. The capacity of the cooling system is approximately 64 U.S. quarts.

Set the high water temperature cut-off switch (See ADJUSTMENTS) to operate at a temperature several degrees below the boiling point of the anti-freeze solution used, taking into consideration the altitude at which the plant is operating.

If the cooling system is drained to prevent freezing, be sure to remove the radiator cap while draining. Failure to remove the cap may form a vacuum in the cooling system, preventing complete draining. Be sure that the cylinder block drain cock is fully opened for complete draining of the radiator.

GASOLINE FUEL. - Use fresh, clean, winter grade (not highly leaded premium) gasoline for best starting in cold weather. If the fuel tank is subject to considerable temperature variations, keep the tank nearly full in order to cut down condensation of moisture inside the fuel tank. Such condensation can cause trouble by ice formation in the fuel system. Avoid filling the tank entirely full of cold gasoline. Expansion of the fuel as it warms up may cause it to overflow and create a fire hazard.

GAS FUEL. - Certain types of LPG fuel do not vaporize readily at low temperatures. Heat exchanger equipment may be necessary. Consult the fuel supplier if lowered performance is observed at low temperatures.

BATTERY. - Check the charge condition of the starting battery often enough to assure that it is always in a well charged condition. The charging circuit is designed to keep the battery well charged in normal service, but frequent starting with short operating periods may cause the charge condition to drop to a point where there will not be enough power to crank the engine at low temperatures.

The cranking power of a battery drops to about 40% of its normal power at 0°F., and the cranking load is greatly increased. If practicable, remove the battery to a warm place during shut down periods in extremely cold weather. It takes but a few minutes to connect the battery for starting, and its cranking power will be much greater if warm.

IGNITION. - The ignition system must be in good condition for prompt starting in cold weather. The distributor breaker points and condenser, and the spark plugs are particularly important. See that the breaker points are in good condition (not burned or pitted) and are properly adjusted.

HIGH TEMPERATURES

LUBRICATION. - As indicated under PREPARATION, use SAE No. 40 oil for temperatures above 50°F. Keep the oil level at or near the FULL mark on the level indicator. However, do not over fill the crankcase. Use the same SAE number oil to service the air cleaner.

COOLING. - A constant supply of fresh air must be provided for proper cooling. See that nothing obstructs the flow of air to the plant, and see that the radiator air outlet flow is not obstructed in any way. Keep the radiator well filled. Use a good rust inhibitor to keep the cooling system clean and free of rust and scale formation. See that the fan belt tension is properly adjusted. Be sure the high water temperature switch is properly adjusted (see ADJUSTMENTS).

BATTERY. - Check the level of the electrolyte frequently. Add approved water as often as necessary to keep the level at the point recommended by the battery manufacturer.

NOTE

REDUCING BATTERY SPECIFIC GRAVITY FOR LONGER BATTERY LIFE

Standard automotive type storage batteries will self discharge very quickly when installed where the ambient temperature is always above 90°F., such as in a boiler room, or in tropical climates. To lengthen battery life, dilute the electrolyte from a normal 1.275 specific gravity reading at full charge to a 1.225 reading.

The cranking power of the battery is reduced somewhat when the electrolyte is diluted, but if the temperature is consistently above 90°F., the reduced cranking power will hardly be noticed, and lengthened battery life will be a distinct advantage. Adjust the electrolyte as follows:

1. Fully charge the battery. Do not bring an open flame or burning cigarette near the battery during charging, as the gas released during charging is highly inflammable.

2. While the battery is still on charge, use a hydrometer or filler bulb to draw off all the electrolyte above the plates in each cell. DO NOT ATTEMPT TO POUR OFF!! Avoid skin or clothing contact with the electrolyte. Dispose of the removed electrolyte.

3. Refill each cell with pure distilled water, to the recommended level.

4. Continue charging for one hour at a 4 to 6 ampere rate.

5. Use a reliable hydrometer to test each battery cell. If the specific gravity is still above 1.225, repeat steps 2, 3, and 4 until the reading of the fully charged battery is not over 1.225. Most batteries require repeating steps 2, 3 and 4 two times.

DUST AND DIRT

AIR CLEANER. - Clean the air cleaner and change its oil as frequently as the conditions require. The air cleaner function of trapping air borne dust and dirt is very important in promoting longer engine life.

RADIATOR. - Keep the radiator cooling fins clean and free of dust, chaff, leaves, etc. Clogged cooling fins will reduce the effective cooling area of the radiator and may result in improper cooling.

GENERAL. - Keep the entire plant as clean as practicable. Wipe off accumulations of dust, dirt, and spilled oil. Keep the generator commutator, slip rings, and brushes clean. Keep supplies of fuel and oil in air tight containers. Change the crankcase oil, and the oil filter elements more frequently, as conditions require.

Follow a definite schedule of inspection and servicing to assure the best performance and long life of the plant. Service periods outlined below are for average service and normal operating conditions. Under unusual service or abnormal operating conditions, service the plant more frequently. Keep a record of the hours the plant is operated each day to assure servicing at the proper time.

	HOURS OF OPERATION					
	Daily	50	100	200	500	1000
Oil level.	X					
Coolant.	X					
Air cleaner cup and filter.	X					
Crankcase vent cap.		X				
Battery electrolyte level.		X				
Oil-charge generator, start motor.			X			
Change engine oil.			X			
Change oil filter element.			X			
Lubricate distributor.			X			
Inspect and adjust points*.			X			
Fan belt tension			X			
Clean spark plugs*.			X			
Magneto points*.				X		
Compression pressure.					X	
AC-DC generator brushes*.					X	
Charging generator brushes*.					X	
Tappet clearance.					X	
Starting motor brushes.					X	
Inspect commutator.					X	
Grind valves*.					X	
Clean carbon.					X	
Remove and clean oil pan and oil pump inlet screen.						X
Flush cooling system.						X
AC-DC generator bearing.						X
Clean carburetor. □						X
Complete reconditioning.	5000 Hours					

* - Replace as Required.
□ - Service as Required.

If it is necessary to remove parts for inspection and gaskets are disturbed, they should be replaced with new ones.

When brushes are replaced be sure the commutator and slip rings are in good condition.

Recommended Fuel: Use a regular grade of gasoline. If a high lead content is used, it will be necessary to remove the lead deposits more frequently.

GENERAL. - Follow a definite schedule of inspection and servicing to help in keeping the plant in good running condition, and to keep operating expenses to a minimum. Service periods outlined in this section are for normal service and operating conditions. For extreme conditions, such as continuous heavy duty, extremely high or low temperatures, etc., service more frequently. For periods of little use, service periods can be lengthened accordingly. Keep a record of the operating hours each day to assure servicing at the proper intervals.

DAILY SERVICE

If the plant is operated more than 8 hours daily, perform the DAILY SERVICE operations every 8 hours.

FUEL. - If the plant is operated on gasoline fuel, check the fuel supply often enough to avoid running out of fuel. If the plant stops from lack of fuel, it will be necessary for the fuel pump to first pump enough fuel to the carburetor to permit starting again. This may require considerable cranking, or working the primer lever on the pump, depending upon the distance of fuel lift from the tank to the fuel pump.

CRANKCASE OIL. - Check the oil level, on the level indicator. Do not allow the oil level to fall below the "ADD OIL" mark on the indicator. Add oil, of the proper SAE number, as necessary to bring the level to or near the "FULL" mark on the indicator. Do not over fill.

AIR CLEANER. - Service the air cleaner as often as required by the operating conditions. Under extremely dusty conditions, it may be necessary to clean the air cleaner and renew its oil several times during a day's operation. Under dust-free conditions, every 100 hours or even less frequent servicing may be sufficient.

To service the air cleaner, remove the cup by turning it to the left. Lift out the fin section in the cup, then pour out the oil. Wipe the reservoir cup clean and replace the fin section.

Fill the cup to the raised button on the bottom of the fin section. Replace the cup to the air cleaner by lifting the cup upwards and turning to the right to lock it in place.

RADIATOR. - Check the level of the coolant in the radiator, and add liquid as necessary to bring the level up to normal. If freezing weather prevails, and a non-permanent type anti-freeze is used, test the protective strength of the solution. The high water temperature switch will not protect against evaporation.

CLEANING. - Keep the plant clean as practicable. A clean plant is easier to service and will give better service. Wipe off spilled oil, dust, dirt, etc.

WEEKLY SERVICE

If the plant is operated more than 50 hours a week, perform the WEEKLY SERVICE operations every 50 hours.

CRANKCASE OIL. - With a new (or reconditioned) engine, use SAE #20 oil for the FIRST 20 HOURS OF OPERATION. Drain and refill the crankcase again after the next 50 hours of operation. If the plant is operating under temperature conditions of 32°F., (0°C.) or lower, continue to change the crankcase oil at 50 hour intervals.

CRANKCASE BREATHER. - Remove the oil fill cap and clean in a good solvent. Oil the wire mesh with engine oil. Under severe dust conditions, service more frequently.

OIL FILTERS. - The oil filter is a shunt type, and if allowed to become filled with sludge to the point where no oil can flow through it, a by-pass valve opens to provide lubrication to the engine.

Change the oil filter elements each time the oil is changed.

Place a drip pan under the oil filter. Remove the center bolt and remove the filter housing. After discarding the dirty filter element and gasket, clean the metal parts with solvent, making sure the radial holes in the center bolt are not clogged. Place a new gasket in the filter base recess. Replace the new element and cover and tighten the bolt. Overtightening the center bolt may cause distortion of the filter housing and cause oil leakage. Check for oil leakage after the engine has warmed up.

GOVERNOR LINKAGE. - Inspect the ball joints of the governor arm and carburetor throttle linkage. Keep these points free of dust. Lubricate with a "dry" type of lubricant, such as powdered graphite. If a "dry" lubricant is not obtainable, use only a light machine oil of non-gumming quality.

BATTERY GENERATOR. - Has sealed bearings and does not require any lubrication.

STARTER. - The starting motor does not require lubrication.

BATTERY. - See that the battery connections are clean and tight. Corrosion at the terminals can be removed by flushing with a weak baking soda and water solution. Flush clean with clear water and dry thoroughly. A light coating of grease or asphalt paint on the battery terminals will retard such corrosion.

Keep the electrolyte at the proper level above the plate separators by adding clean water which has been approved for use in batteries. In freezing weather, run the plant for at least 20 minutes after adding water, to mix the water with the electrolyte and prevent its freezing.

SEMI-MONTHLY SERVICE

If the plant is operated more than 100 hours semi-monthly, perform the following operations every 100 operating hours.

FUEL SYSTEM. - Remove the drain plug at the bottom of the carburetor to drain off any sediment. Install the plug securely. Remove the filter bowl and screen from the fuel pump, clean thoroughly, and replace. After servicing is completed, inspect carefully against leaks.

SPARK PLUGS. - Remove the spark plugs, clean them, and adjust the gap according to the dimensions given in the TABLE OF CLEARANCES. Replace with a new one any plug which will not pass a standard compression firing test.

DISTRIBUTOR. - Examine the distributor breaker points. If burned or pitted, replace with a new set. See that the point gap is set at 0.019" to 0.021" at widest separation. Apply a very small amount (about the size of a match head) of high temperature grease on the breaker cam surface. Turn the grease cup, located on the side of the distributor, one turn inward.

COMPRESSION TEST. - Use a compression gauge to test the engine compression. Low compression on one cylinder may indicate a leaking valve. Unusually high compression on all cylinders may indicate a build-up of lead deposits, necessitating removal of the cylinder heads and scraping deposits out. Normal new engine compression with the throttle wide open, engine at operating temperature, all spark plugs removed, and the battery fully charged, is approximately 125 pounds plus or minus 10 for each cylinder.

EXHAUST. - Inspect all exhaust connections carefully for leaks. Tighten or make any other necessary repairs.

GENERATOR. - Check the condition of the exciter commutator and brushes, and the alternator slip rings and brushes. Remove the exciter end cover to reach the commutator. Remove the blank cover and ventilator plates to reach the alternator slip rings. In service, the commutator and slip rings acquire a glossy brown color, which is a normal condition. Do not attempt to maintain a bright, newly machined appearance. Wipe clean with a dry, lint-free cloth. Slight roughness or heavy coating may be remedied by lightly sanding with #00 sand-

paper. Do not use emery or carborundum cloth or paper. Wipe out all carbon and sanding dust.

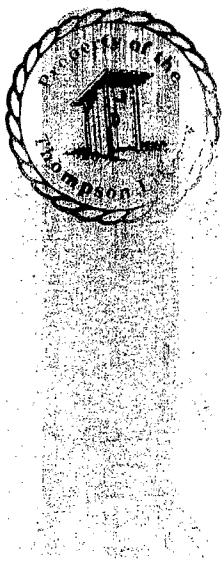
Brushes will eventually wear too short to perform their function. Brush wear will be more rapid under dusty conditions. Replace brushes only when worn to 1/2 inch in length, or if damaged. Refer to the MAINTENANCE section. Never apply any kind of lubricant to the brushes, commutator, or slip rings.

The generator bearing is a permanently sealed, prelubricated type. It requires no lubrication service.

SEMI-YEARLY SERVICE
(Approximately 1200 operating hours)

COOLING SYSTEM. - Drain the cooling system. Flush thoroughly and if necessary, use a good cleaning solution. Refill, using a good rust inhibitor or anti-freeze containing inhibitor.

OIL PAN. - Remove the engine oil pan and clean thoroughly of all sludge, etc. Do this at a time to coincide with a regularly scheduled oil change.



CARBURETOR, GASOLINE. - The carburetor has an idle adjusting needle only (Fig. 6). The main jet is fixed and cannot be adjusted. The idle adjusting needle, at the side of the carburetor, affects the operation at the light and no load conditions.

Under normal circumstances, the factory carburetor adjustment should not be disturbed. If the adjustment has been changed, an approximate setting of 1-1/2 turn open for the idle needle will permit starting. Allow the engine to thoroughly warm up before making final adjustment.

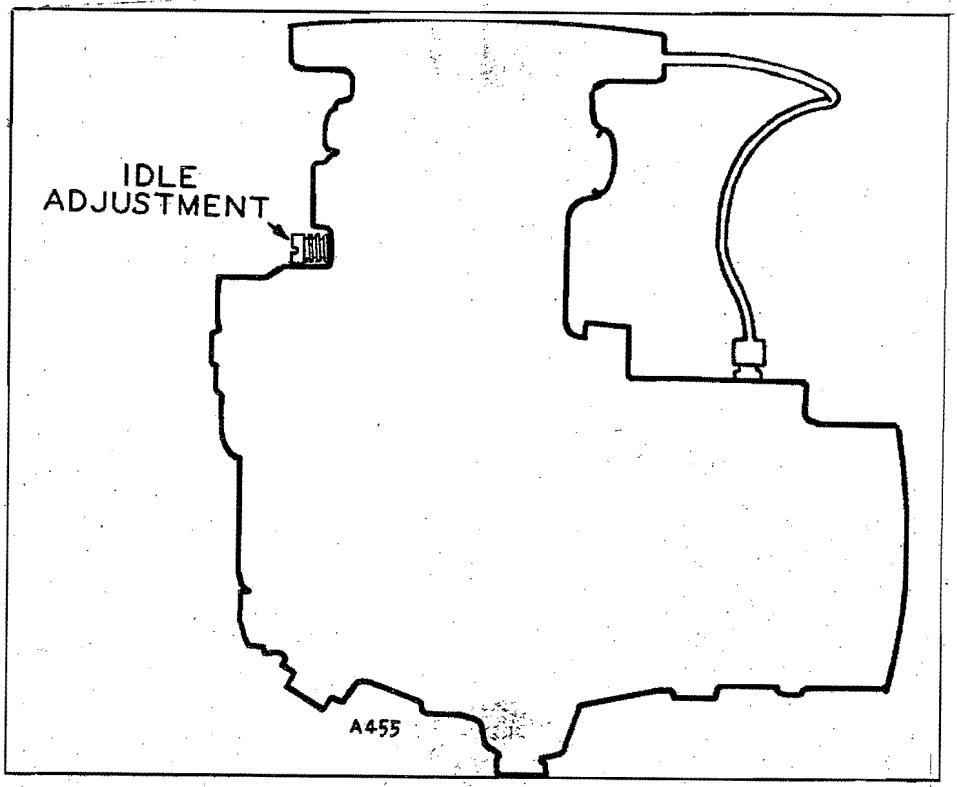


FIG. 6 - GASOLINE CARBURETOR ADJUSTMENT

With no electrical load connected, turn the manual voltage control rheostat (not the regulator rheostat) gradually clockwise until the voltmeter reading reaches the rated voltage. Slowly turn the idle adjusting needle out (counterclockwise) until the voltmeter reading drops slightly. Then turn the needle in (clockwise) gradually to the point where the voltage returns to normal.

ELECTRIC CHOKE. - A 12 volt electric choke is used on all plants as shown in Figure 7 . The adjustable choke cover is held in place by the three outer screws. The perimeter of the cover is divided into sections by small raised marks. One of the marks is

labeled with an asterisk (*). The asterisk mark indicates the normal adjustment setting. A long raised line on the side of the choke housing is used as the reference mark. The normal setting for the choke is made when the asterisk mark lines up with the reference line.

If over-choking occurs, loosen the three locking screws and turn the choke cover slightly to the left (counterclockwise). Do not turn very far. One or two notches will usually be sufficient. Tighten the three locking screws. To increase the choking action, turn the choke cover slightly to the right (clockwise).

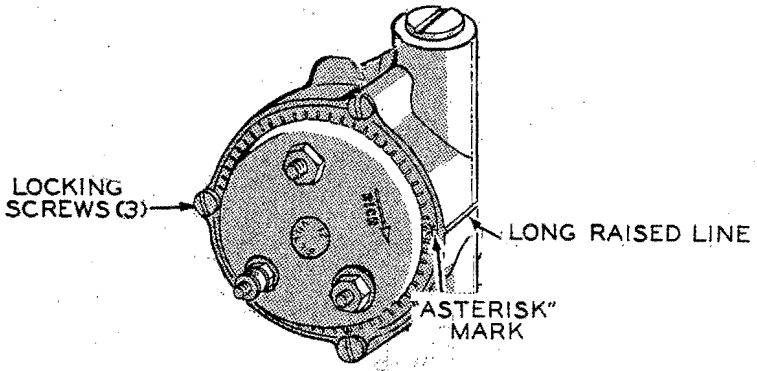


FIG. 7 - ELECTRIC CHOKE

COUNTERWEIGHTED CHOKE, GAS OPERATION. - All units built to operate on gas fuels are equipped with a special counterweighted choke to aid starting when the engine is warm. The Zenith electric choke must be locked in a wide open position when a gas fuel is used. The counterweighted choke provides choking action immediately when the engine stops regardless of whether the engine is warm or not. This choke is mounted in a special adapter which is located between the carburetor and the air cleaner. The counterweight is mounted on the end of this choke shaft so that when the engine is not running the butterfly valve is automatically pulled shut by the action of the counterweight. When the engine is cranking the volume of air passing into the carburetor is sufficient to open the butterfly valve. The counterweight choke remains in the fully open position as long as the engine is running. As soon as the engine stops, the counterweight automatically pulls the butterfly valve shut.

The correct adjustment of the counterweighted choke is shown in the illustration. The choke is properly adjusted when the counterweight will close the butterfly valve when the engine is not running. The counterweight is held on the choke shaft by an Allen head set screw. The operation of the counterweighted choke should be checked after adjustment by determing that:

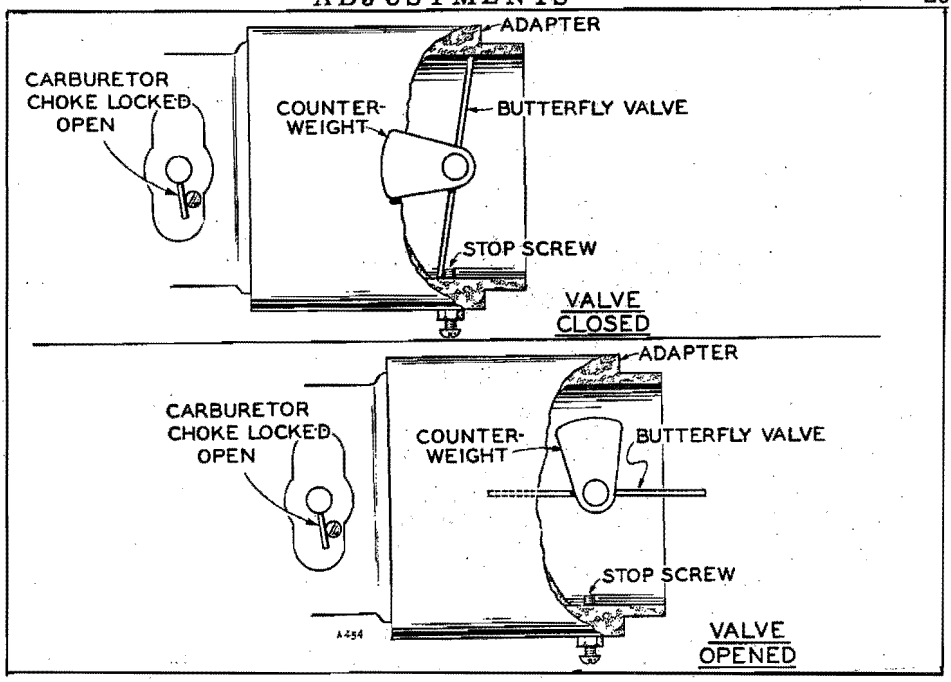


FIG. 8 - COUNTERWEIGHTED CHOKE ADJUSTMENTS

(1) The butterfly valve freely closes when released.

(2) The butterfly valve snaps open as soon as the engine fires.

CARBURETOR, GAS. - Some plants are equipped to use gas fuel. Such plants have a special gas-gasoline carburetor, and a gas flow regulator. Be sure the installation conforms to local regulation, installing a fuel filter and a solenoid valve if required.

For gas operation, the carburetor float lock screw A must be turned up, and the choke pin B locked in its downward position. The gas adjusting valve C may require slight readjustment, depending upon the BTU rating of the gas fuel to be used. (If the valve setting has been accidentally changed, set it at 1/2 to 3/4 turn open to start the engine). Allow the engine to warm up to operating temperature and make a final adjustment under full load condition. Open the valve slowly until the engine begins to run unevenly, then turn the valve in just to the point of smooth operation at full load.

For gasoline operation, turn the float lock screw A down, and turn the choke lock screw in so that the pin B can turn to the horizontal position. When the plant warms up, the choke pin assumes the vertical position, indicating that the choke is fully open.

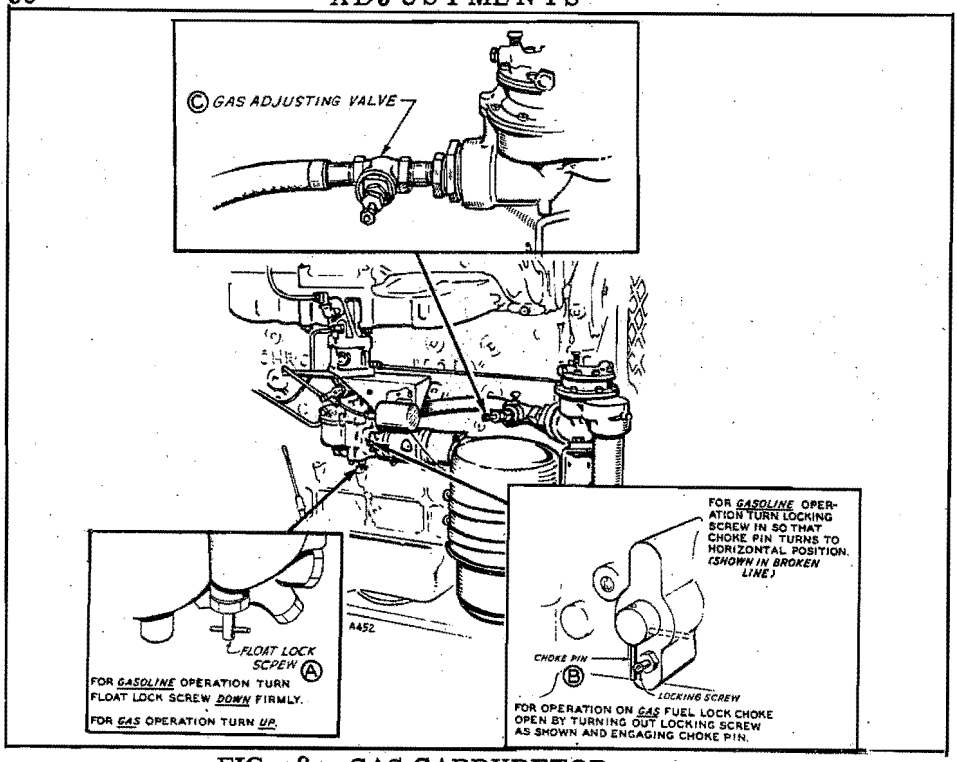


FIG. 9 - GAS CARBURETOR

HIGH WATER TEMPERATURE SWITCH. - The high water temperature switch operates to stop the engine if the coolant temperature rises too high. This prevents overheating, which could cause serious damage to engine parts. The engine may be started again when the coolant temperature drops approximately 10°F. The dial adjustment should be set to operate at a temperature several degrees below the boiling point of the coolant, taking into consideration the altitude at which the plant is operating. Lower the setting 3°F. for each 1000 feet above sea level. The dial was set at 205°F. at the factory. Do not set the switch to operate at too low a temperature or the engine may be stopped before it reaches operating temperature.

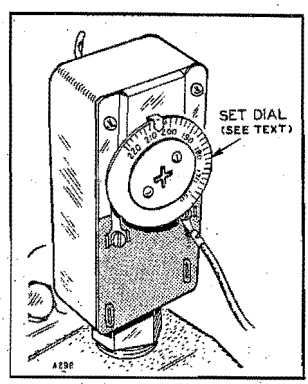


FIG. 10 - HIGH WATER TEMPERATURE CUT-OFF SWITCH

GOVERNOR. - The governor controls the speed of the engine, and therefore the frequency of the current. Plant speed affects a.c. output voltage. Either a tachometer or frequency meter may be used to check engine speed for proper governor adjustment.

Start the plant and allow it to reach operating temperature.

Adjust the speed. With no electrical load connected, adjust the speed screw to attain the proper no load speed as shown in the speed chart. Apply a full rated load at 0.8 power factor and again check the speed. Be sure the voltage is safe for the load applied. An incorrect speed drop from full load to no load necessitates a sensitivity adjustment.

If the plant tends to hunt (alternately increase and decrease speed) under load conditions, increase very slightly the distance between the eye of the sensitivity screw and its support. For best regulation keep the sensitivity screw in as close as possible without causing hunting. Any change in the setting of the sensitivity screw will require correcting the speed screw adjustment.

SPEED CHART FOR CHECKING GOVERNOR REGULATION

	SPEED RANGE LIMITS		SPEED SPREAD (WITHIN RANGE) PREFERRED	LIMITS	
	MAX.	MIN.	F. L. * to N. L.	MAX.	MIN.
FOR ALL 60 CYCLE PLANTS	CYCLE 63	59	59 - 61	3	1.5
	RPM 1890	1770	1770 - 1830	90	45
FOR ALL 50 CYCLE PLANTS	CYCLE 53	49	49 - 51	3	1.5
	RPM 1590	1470	1470 - 1530	90	45

* Speed Regulation for Full Rated Load is at 0.8 Power Factor.

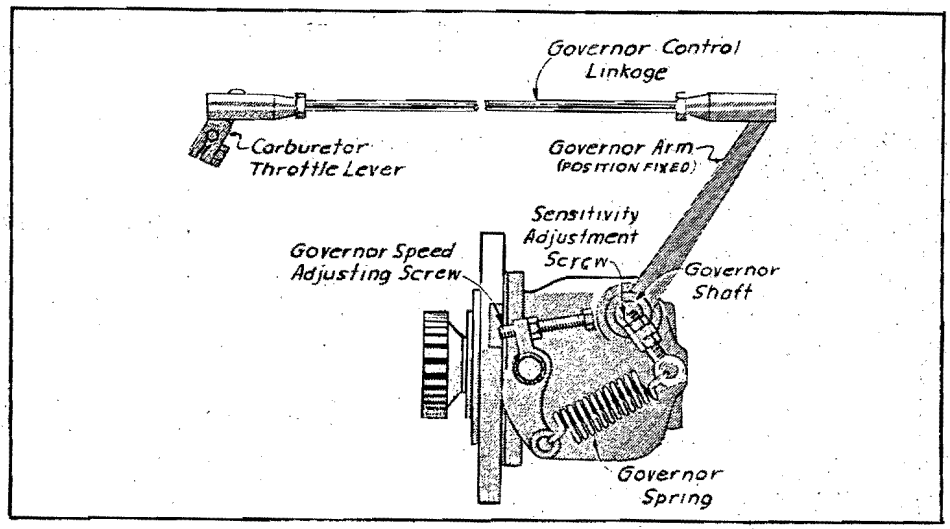


FIG. 11 - GOVERNOR ADJUSTMENT

Be sure that all lock nuts are tightened as adjustments are completed. The governor can not operate properly if there is any binding, sticking, or excessive looseness in the connecting linkage or carburetor throttle assembly. A lean fuel mixture, or a cold engine may cause hunting. If the voltage drop is excessive when a full load is applied, and adjustments are correctly made, it is probable that the engine is low on power and should be repaired as necessary.

Recheck the a.c. output voltage.

ANTI-DIESELING CONTROL OPERATION. - When the engine is operating hot and the ignition is turned off to stop it, any gasoline reaching the cylinders will ignite and keep it running; creating what is called a "dieseling" condition. To prevent this "dieseling" condition from occuring, a butterfly valve is located in the carburetor and connected to a spring and to the anti-dieseling solenoid. As soon as the plant stops, the spring pulls the carburetor butterfly valve shut, stopping any further fuel and air flow to the engine. The carburetor butterfly valve is automatically opened by the anti-dieseling solenoid as soon as the engine starts cranking. (NOTE: On some wiring diagrams, the anti-dieseling solenoid is called the governor solenoid and the anti-dieseling solenoid start relay is called the governor solenoid start relay). (NOTE: The anti-dieseling solenoid must be manually operated (Held in the operated position by hand) when the Hand Crank-Remote switch is at the "Hand Crank" position in order to have it hold in when the battery is low.)

AC VOLTAGE REGULATOR ADJUSTMENT PROCEDURE. - See also the instructions REGULATING THE VOLTAGE under Operation section of this manual. This procedure will be necessary only after installation of new parts or after disturbing the setting of original parts. Reference to the plant wiring diagram will be helpful.

Be sure engine speed is correct before attempting to correct output voltage by adjusting the a.c. voltage regulator.

1. Turn the Manual Field Rheostat slightly clockwise to place it in the RHEOSTAT ON position.

2. Adjust the manual rheostat to obtain an exciter voltage of 70 volts. Use a d.c. voltmeter across two adjacent d.c. brushes (A1 and A2).

3. Set the DC brushes. With the brush rig loosened shift it to the position which gives the highest voltage. The peak d.c. exciter voltage gives the peak a.c. output voltage. This brush rig position will be the same as neutral position resulting in the least arcing at the brushes.

4. Turn the Manual Field Rheostat all the way counterclockwise to the REGULATOR ON position.

5. Set the regulator rheostat at approximately the middle of its rotation.

6. Set the adjustable resistor, which is mounted either separately or on the regulator base (see Figure 00), to obtain the rated AC voltage. Very little movement of the sliding clip will be necessary. Be sure to retighten the clip after the adjustment is completed.

7. The adjustable range of the regulator rheostat should be not less than 10% above and 10% below rated AC voltage.

8. Refer to the VOLTAGE CHART and regulate the a.c. output voltage as instructed under REGULATING THE VOLTAGE under OPERATION section of this manual.

REGOHM VOLTAGE REGULATOR DASHPOT ADJUSTMENT. - If a hunting voltage condition exists, after the governor has been adjusted, the voltage regulator dashpot must be adjusted. To adjust the voltage regulator dashpot, proceed as follows:

1. Remove the louvered cover from the regulator box.

2. Remove the clamping bar from the metal cover of the regulator plug-in-unit.

3. Remove the cover, held in place by two screws at the top.

4. Turn the slotted screw at the center, until the hunting just stops.

IMPORTANT

THIS IS THE ONLY ADJUSTMENT THAT WILL BE NECESSARY AND NO ADJUSTMENT TO ANY OTHER PART OF THE REGULATOR PLUG-IN-UNIT SHOULD EVER BE ATTEMPTED.

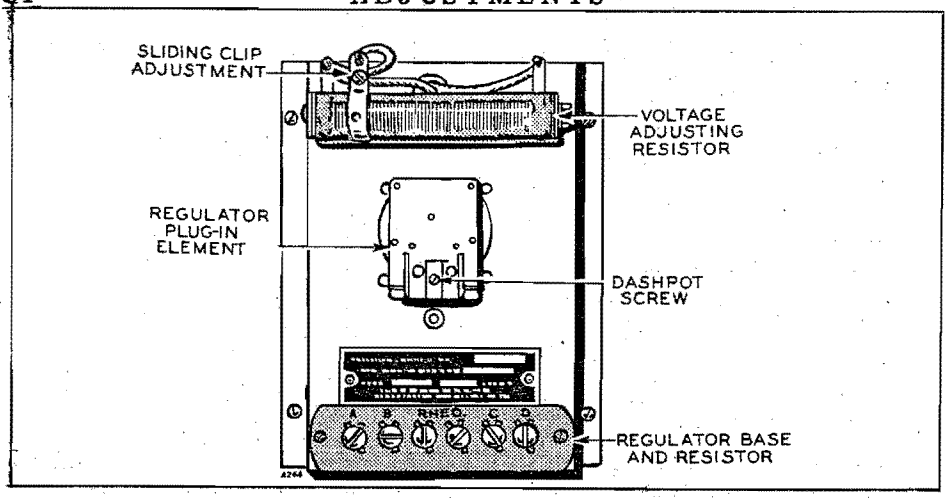


FIG. 12 - REGOHM VOLTAGE REGULATOR ADJUSTMENT

VOLTAGE CHART

TYPE OF PLANT			VOLTAGE LIMITS	
VOLT	PHASE	WIRE	MAXIMUM NO LOAD VOLTAGE	MINIMUM FULL LOAD * VOLTAGE
230	3	3	234	226
120/208	3	4	212	204
120/240	3	4(Delta)	244	236
460	3	3	468	452
575	3	3	586	564

* Voltage Regulation for Full Rated Load is at 0.8 Power Factor.

DISTRIBUTOR POINT GAP. - The proper condition, alignment, and point gap adjustment are important factors governing engine performance and long point life. They should be cleaned and inspected every 100 hours of operation. Points should be replaced whenever a burned condition or excessive metal transfer between the points exists. The distributor points and the inside of the distributor cap should be cleaned with a stiff bristle brush using a good solvent such as chloroform or carbon tetrachloride.

Do not use a file, sandpaper, or emery cloth to clean or remove pits from distributor points. Any abrasion of the point surfaces only causes them to burn faster.

NOTE: If it is necessary to replace the distributor cap or spark plug wires, insert the wires in the proper cap sockets in a counterclockwise direction, in the firing order 1-5-3-6-2-4. The number one

socket is closest to the engine from the radiator end.

To check the distributor point gap, crank the engine with the starter until the movable arm rubbing block rests on a high point of the cam, then check the point gap with a 0.020 inch feeler gauge. If the point gap requires adjustment, loosen the point assembly lock screws, insert the blade of a screw driver in the adjustment slots, and turn it to obtain a 0.020 inch gap. Tighten the lock screws; then recheck the point gap.

VALVE SERVICE. - The engine is equipped with the "FREE" ROTO type valves (also known as the release type valve rotators) see Figure 13. The valve rotates by using a special valve spring retainer and cap. While the valve is lifted, it is free to rotate due to natural vibration and turbulence of the exhaust gases and this scuffing action prevents the formation of any troublesome deposits.

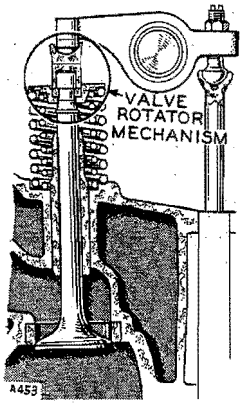


FIG 13 - VALVE ROTATORS

The rotator mechanism has a clearance between the valve tip and the rotator cap. This clearance is required to obtain positive freedom of the valve during the lift cycle. Wear occurs principally on the keys and clearance should be checked at each reconditioning. Wear tends to increase the clearance and cause increased valve lash. The rotator parts tend to become matched parts within each assembly as they wear in. For this reason it is highly desirable to keep the parts from each assembly separate during the servicing operation and to reassemble them with their original valve wherever possible.

Maintaining the proper clearance between the end of the valve stem and the rocker arm is one of the most important factors governing long engine life and top performance. It is recommended that the valve clearance be checked and adjusted when necessary every 100 hours. The engine must be at normal operating temperature before adjusting the valve clearance. The intake valve stem clearance should be 0.018 inch and the exhaust valve stem clearance should be 0.024 inch.

VALVE TIMING. - Proper valve timing is provided by having the timing gears correctly timed. The camshaft gear has center punch marks on two teeth. The crankshaft has a center punch mark on one tooth. Assemble the gears so that the marked tooth on the crankshaft gear goes between the two marked teeth on the camshaft gear.

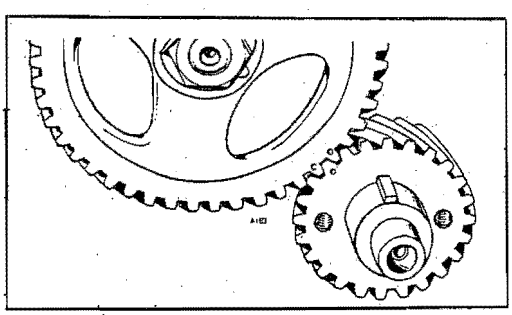


FIG. 14 - TIMING GEARS

IGNITION TIMING. - Whenever the distributor points are replaced or adjusted, the ignition timing should be checked and adjusted if necessary. Proper adjustment of ignition timing must be maintained to obtain maximum engine power output and best possible fuel economy.

Crank the engine over to bring No. 1 piston up on the compression stroke. Continue to crank the engine very slowly until the ignition mark on the flywheel is directly under the pointer in the flywheel housing. The grease cup should face away from the engine.

Remove the distributor cap and place the distributor into the adapter. Turn the rotor cap to point to the front of the engine. The distributor should drop slightly as the two shafts engage. The rotor cap should point to the No. 1 tower on the distributor cap.

The rotor rotates counterclockwise and the firing order is 1-5-3-6-2-4.

See that the distributor points gap, at full separation, is as shown in the Table of Clearances. Loosen the distributor adjusting clamp screw and turn the distributor counterclockwise to close the ignition points. Slowly turn the distributor clockwise until the ignition points just separate. At this point the timing is correct for the average operating conditions. Tighten the clamp screw. Keep the spark advanced as far as possible without causing a "ping".

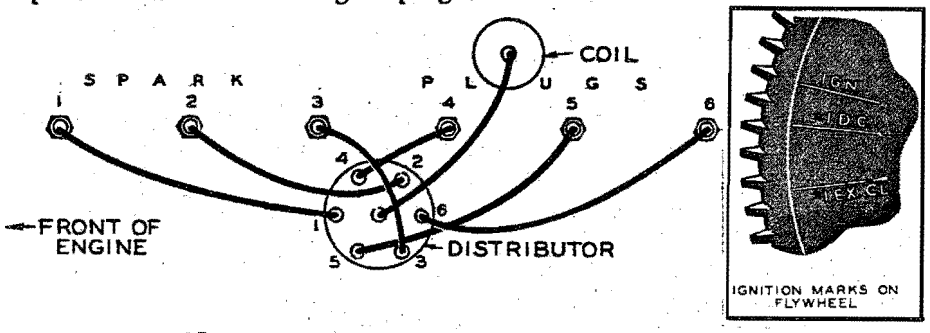


FIG. 15 - IGNITION TIMING

CYLINDER HEADBOLT TIGHTENING. - When replacing the cylinder head, first coat the cylinder head bolts with head gasket sealer and then tighten the head bolts starting in the center and work to both ends of the head.

TORQUES IN FOOT POUNDS

Cylinder Heads - 1/2".	100 - 110
Main Bearings and Rods - 1/2".	85 - 95
9/16.	100 - 110
Flywheel - 5/8".	145 - 155
Flywheel Housings - 1/2".	80 - 90
Gear Cover, Water Pump - 5/16".	15 - 20
Front & Rear End Plates- 3/8".	25 - 30
Oil Pan - 7/16".	50 - 55
1/2".	80 - 90

The dip stick is located on the carburetor side of the engine. It is preferable to check the oil level after the engine has been stopped for a 2 minute period of time. This allows the oil in the overhead valve system to drain back into the crankcase, permitting a more accurate measurement of the quantity.

Oil the following parts at least every 100 operating hours or oftener as recommended under PERIODIC SERVICE. Grease the water pump using a grease gun. Turn the grease cup on the side of the distributor 3/4 of one turn. The ball joints of the governor to carburetor control linkage should be lubricated with powdered graphite or a light non-gumming oil. Apply a light film of non-fibre, high melting point grease to the distributor cam.

NOTE!

DO NOT USE ENGINE OIL ON THE DISTRIBUTOR CAM, IT WILL SPATTER ON THE POINTS AND CAUSE THEM TO BURN RAPIDLY.

When the engine is new, check the oil level often (at least every 2 or 3 hours) until a pattern on oil consumption during break-in is established.

TROUBLE SHOOTING. - A good rule to follow in locating engine trouble is to never make more than one adjustment at a time. Stop and think how the motor operates, and figure out the probable cause of any irregular operation. Then locate the trouble by a process of elimination. In many instances, a symptom indicating trouble in one unit may be caused by improper function of a closely related unit or system. Remember that the cause usually is a SIMPLE ONE, rather than a mysterious and complicated one.

If a general tune-up is found necessary, perform necessary operations in this sequence: Spark Plugs; Battery and Ignition Cables; Distributor; Ignition Timing; Valve Clearance; and Carburetor.

TABLE OF CLEARANCES

	MINIMUM	MAXIMUM
Valve, Intake.		.018"
Valve, Exhaust.		.024"
Valve face and seat angle, Intake.		.030"
Valve face and seat angle, Exhaust.		.045"
Valve stem in guide - Intake.		.0015"
Valve stem in guide - Exhaust.		.0035"
Camshaft End Play.	.005"	.009"
Crankshaft End Play.	.004"	.006"
Piston Pin in Rod.		.0003"
Piston Pin in Piston.		.0002" ±
Distributor Point Gap (Full separation).		.020"
Spark Plug Gap - Gasoline Fuel.		.025"
Spark Plug Gap - Gas Fuel.		.018"

GENERATOR

GENERAL. - The generator normally requires little maintenance other than the PERIODIC SERVICE.

COMMUTATOR AND SLIP RINGS. - After a long period of service, the surface of the commutator may become worn to such an extent as to cause the mica insulation between the commutator bars to extend above the level of the bars. This condition would cause noisy brushes and would soon lead to excessive brush sparking and pitting of the commutator bars. High mica should be undercut to a depth equal to the distance between bars, or approximately 1/32". Remove the brush springs and the brushes. Tag the leads to insure correct replacement. Remove the end bell. With a tool fashioned from a hack saw blade, carefully undercut the mica. Be sure to remove any burrs which may have been formed when undercutting, and see that spaces between bars are completely free of any metallic particles.

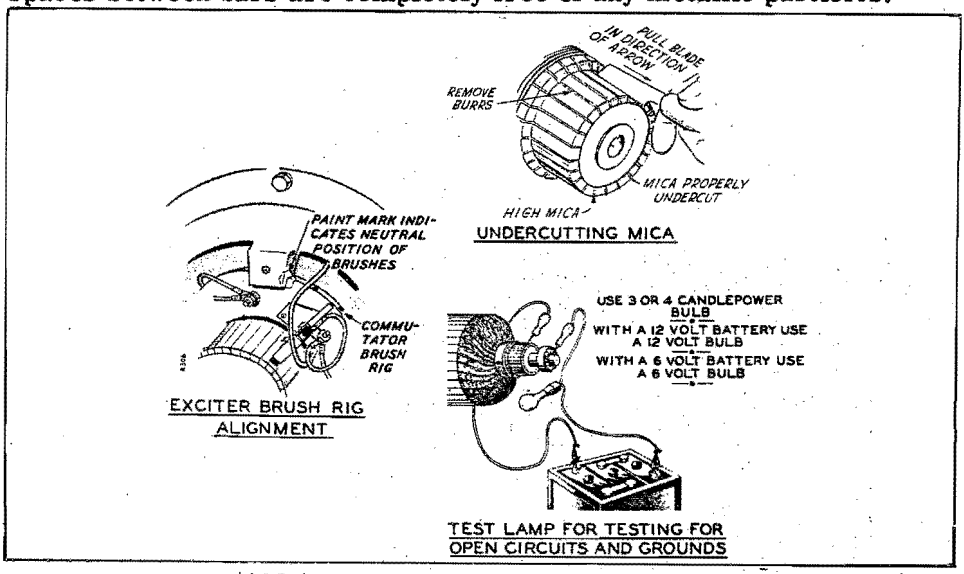


FIG. 16 - GENERATOR MAINTENANCE

Should dusty operating conditions cause the surface of the commutator or slip rings to become grooved, out of round, pitted, or rough, it will be necessary to remove the rotor and turn the commutator or slip rings down in a lathe. It will be necessary to remove the generator frame before the rotor can be removed. After the commutator is turned down, the mica between bars must be undercut as described above. When the rotor is reinstalled, align it as carefully as possible before installing the frame, end bell, and end bell cover.

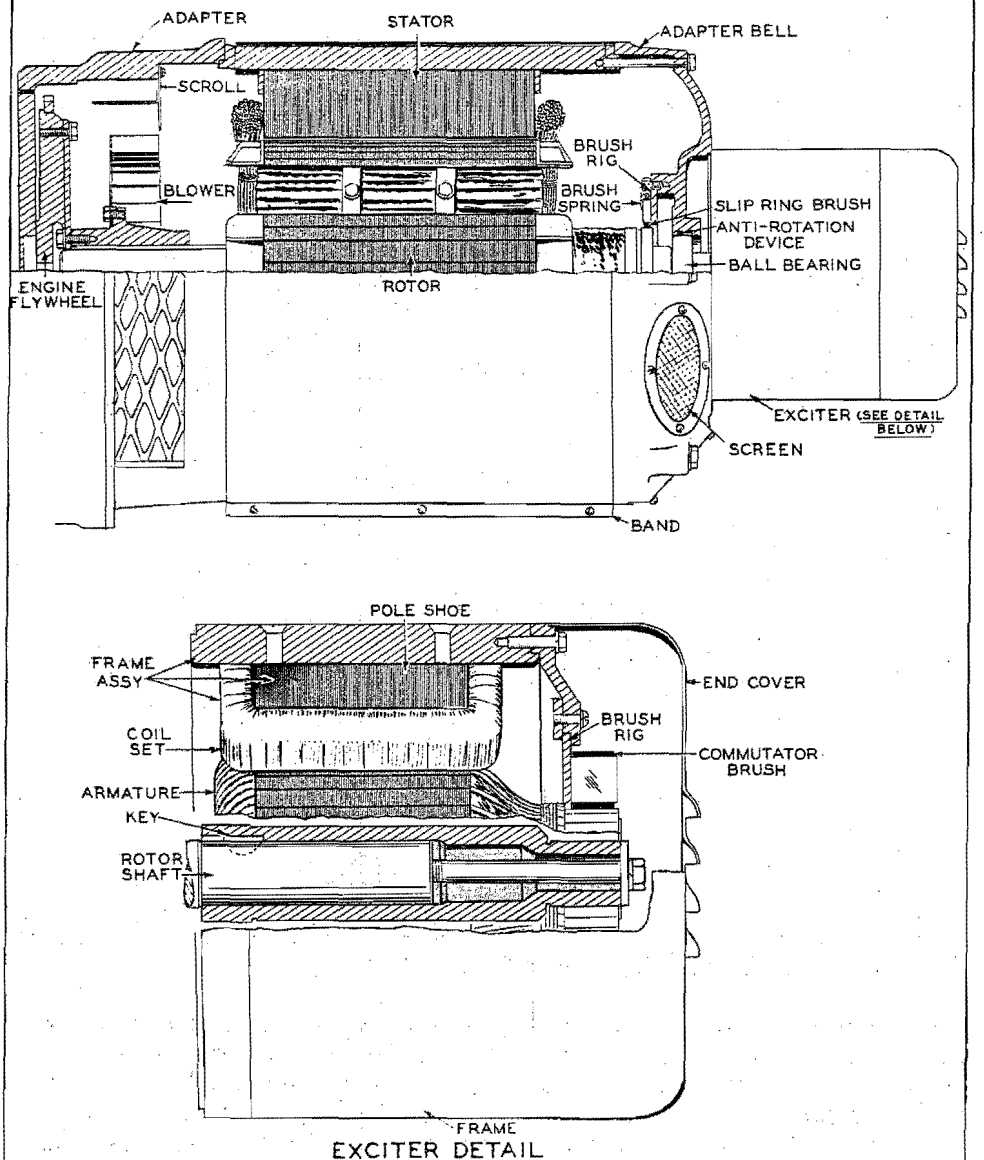


FIG. 17 - GENERATOR ASSEMBLY

BRUSH RIG. - It is unnecessary to remove the brush rig from the end bell when servicing the generator. If it has been removed mistakenly, line up the paint mark on the outer edge of the brush rig with the mark on the brush rig support in the end bell. A deviation from the proper positioning of the brush rig will lead to excessive arcing of the brushes, burning of the commutator, low generator output, and possible irreparable damage to the generator windings due to overheating. Any defective condenser should be replaced with a new one of the same capacity.

BRUSHES. - Install new brushes when the old ones are worn so that the top of the brush is below a point midway between the top and bottom of the brush guide. Do not continue to use brushes that are worn too short. It is recommended that only a moderate load be applied to the generator until the new brushes have been "run in", to eliminate excessive sparking.

Each brush spring is attached permanently to a brass support which is detachable from the brush guide. These springs are designed to provide constant pressure as brushes wear shorter. To unslip the spring support from the brush guide, push it toward the commutator or slip-ring and away from the brush guide.

Use care not to damage the spring by bending it against the spring support. Correct spring tension is 9 to 13 ounces. It is difficult to accurately measure the spring tension in the field, or to determine if a spring has become fatigued. Under normal conditions the springs may never require replacement, but after long usage or if they appear damaged, replacement is good preventive insurance. When replacing a brush in its guide, be sure that the low side of the beveled top edge is toward the spring support side of the brush guide.

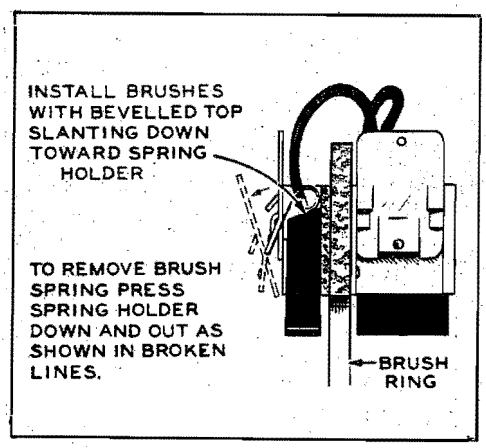


FIG. 18 - BRUSH SPRING REMOVAL

GENERATOR WINDINGS. - Use a continuity type test lamp set to test for grounded or open circuits in the generator windings. Be sure that all brushes are lifted away from contact with the commutator and slip rings, and that generator leads to the control panel are disconnected. When disconnecting leads, tag them to facilitate correct replacement. Disconnect condenser leads from brush terminals to avoid mistaking a defective condenser for a grounded lead.

Use an armature growler to test the exciter armature for an internal short circuit. Exciter or alternator field coil windings may be tested for an internal short circuit by comparative ohmmeter readings.

If one or more exciter coils test defective, install a new set of field coils. If an alternator stator winding tests defective, install a new stator assembly. If a rotor winding tests defective, install a new rotor assembly. Leads may be repaired as necessary.

GENERATOR DISASSEMBLY AND ASSEMBLY. - To remove the exciter, unclip the brush springs and lift all brushes. It is not necessary to remove the brush rig from the end bell. Disconnect the exciter lead to the stator brush rig. The exciter is held to the adapter bell by cap screws. Remove the screws and carefully work the frame assembly off to avoid damaging the exciter armature. An armature through stud mounts the exciter armature to the tapered and keyed outboard end of alternator rotor shaft.

To remove the alternator, first remove the exciter and exciter armature. Disconnect leads that go from the control box to the engine at the engine end and tag them to insure proper reassembly. Unclip the alternator brush springs and lift the brushes. It is not necessary to remove the brush rig from the adapter bell. Leave the control box attached to the alternator stator. Detach from the engine and remove as an assembly, the entire alternator stator, adapter to engine casting, brush rig and adapter bell casting. When removing the stator avoid damaging the rotor. The rotor is attached to the engine flywheel by means of a drive disc which pilots in the flywheel. Two 1/4-20 tapped holes are provided in the drive disc to facilitate the removal of the rotor by inserting screws to push the disc out.

To reinstall the alternator, reverse the procedure for removal and comply as follows: The matching surfaces of the engine flywheel and the rotor drive disc must be free from nicks and dirt. Snug up the rotor mounting screws and check for excessive run-out at the bearing while rotating with the hand crank. Excessive run-out, if not due to a nick or dirt on the disc or flywheel, can usually be corrected by turning to the highest point, then applying sufficient pressure or striking with a heavy soft faced hammer on the laminations toward the "low" side. Recheck and repeat as necessary and perform a final check after screws are tightened.

CONTROLS

CONTROL PANEL EQUIPMENT. - If any of the control panel equipment fails to function properly, the defective part should be replaced with a corresponding new unit rather than to attempt repairs on the old part. Disconnect the battery whenever servicing any control panel equipment. Keep all connections tight and clean.

REGOHM REGULATOR MAINTENANCE. - No maintenance is required on the voltage regulator. The cover should always be kept on the regulator. The regulator should not be cleaned or lubricated nor should any adjustment be attempted on the mechanism inside the cover except the dashpot adjustment. The component parts of the regulator base assembly should be kept free of dust, grease and moisture. If faulty operation occurs, the circuit of the generator and load should be checked first. If the cause of the faulty operation can be definitely traced to the voltage regulator, return it to the factory for inspection and repair. When the voltage regulator is returned to the factory, remove the wires connected to the terminals marked A, B, RHEO, and D, C. Return the entire base assembly, consisting of the resistors, plus the regulator plug in unit to an ONAN Authorized Service Station or the factory.

GENERAL. - Electrical generating sets are often taken out of service for extended periods of time. In many cases they are left to stand idle without being protected against possible damage from rust and corrosion or the elements. The factory recommends that any unit to be removed from service for 30 days or more be protected as follows:

FOR ONE MONTH:

1. While the engine is running treat the upper cylinders by spraying M 4834 A Engine Preservative Oil (SAE 10) or equivalent into the carburetor air intake for about two minutes. Open the throttle for a short burst of speed, then shut off the ignition and allow the engine to come to a stop while continuing to spray M 4834 A into the air intake.

2. Leave the spark plugs installed and cover all openings into the engine with dust-proof caps or shields.

3. Drain the oil, water, and gasoline.

4. Spray the flywheel and ring gear with a mixture of one part M 4850 Bodies Anti-Rust Oil, and one part M 4970, Stoddard Solvent or equivalent.

FOR INDEFINITE PERIOD:

1. Drain the crankcase completely and refill with M 4834 A Engine Preservative Oil (SAE 10) or equivalent. Attach a warning tag that oil has been drained.

2. Run the engine until it is completely out of gasoline, then restart and run it on M 534 H or equivalent unleaded, undyed gasoline for at least 10 minutes.

3. While the engine is still running, treat the upper cylinders by spraying M 4834 A into the carburetor air intake for about two minutes. Open the throttle for a short burst of speed, shut off the ignition and allow the engine to come to a stop while continuing to spray M 4834 A into the air intake.

4. Drain the oil, and gasoline. Drain the water at the bottom of the radiator and toward the rear of the cylinder block.

5. Remove all grease and oil from the exterior surfaces of the engine.

6. Remove each spark plug and pour two tablespoonfuls of rust inhibitor oil (Use SAE 50 motor oil as a substitute) into each cylinder. Crank the engine to lubricate the cylinder walls thoroughly. Stop the engine with the TC (top center) mark on the flywheel indicating

at least one piston is at top center position. Replace the spark plugs.

7. Seal all openings in the engine and accessories with M 6471, Non-hydroscopic Adhesive Tape or equivalent. Mask off all areas to be used for electrical contact.

8. Make sure all surfaces are dry, then spray all taped openings, all engine accessories including ignition wiring, and all exterior surfaces of the engine with M 4858 B, Insulation Compound-Ignition, or equivalent.

Clean the generator brushes, brush holders, commutator and collector rings by wiping with a clean cloth. Do not coat with lubricant or other preservative.

Remove, clean and replace the air cleaner.

Wipe all exposed parts clean and coat with a film of grease all such parts liable to rust.

Oil the governor to carburetor linkage with SAE 50 oil.

Where batteries are likely to be exposed to freezing temperatures, they must be removed and stored where there is no danger of freezing. A fully charged battery can withstand very low temperatures but an idle battery gradually loses its charge and may become discharged to the point where it will freeze. An idle battery should be given a freshening charge about every 40 days.

If the battery is not removed, disconnect the cables from the unit. Arrange the cables so that the lugs cannot come in contact with each other or with metal parts.

Provide a suitable cover for the entire unit, particularly if it will be exposed to the elements.

RETURNING THE UNIT AFTER EXTENDED OUT-OF-SERVICE PERIODS. - Remove all protective coatings of grease from external parts. Wipe the entire unit clean of accumulated dust or other foreign matter.

Inspect the unit carefully for damage and for other conditions requiring attention. Service as needed. Keep the side panels and top plate on the housing except while servicing. They help direct the cooling air properly and reduce radio interference.

Remove all the masking tape.

Remove, clean and adjust spark plugs. While the plugs are out, crank

the engine over several times to distribute oil over the cylinder walls. If the cylinders are dry, put a tablespoonful of oil into each cylinder and turn the engine over several times to distribute the oil. Replace the spark plugs and gaskets.

Examine all fuel, oil and water lines and connections. Service as needed.

Refill the cooling system with clean, fresh water.

If anti-freeze was left in the cooling system, check the level and add a 50-50 solution of water and the type of anti-freeze originally used to bring the cooling liquid up to proper level. If desired, the anti-freeze solution can be drained and the cooling system refilled with clean, fresh water.

Refill the crankcase and air cleaner with the correct amount and grade of oil.

Check carefully for leaks of water, fuel or oil after servicing the unit. Correct any leaks before starting the unit.

CAUTION

> On the initial start (starting the plant for the first time after it has been installed or taken out of storage) check the oil pressure immediately. Long storage periods may cause the oil pump to lose its prime.

Connect the battery cables to the unit. Carefully recheck to make sure the unit is ready for operation. Then start the unit in the regular manner as described under OPERATION in the instruction manual. Always connect the ground cable lastly.

POSSIBLE CAUSE	REMEDY
GENERATOR OVERHEATING	
Overloaded.	Reduce load.
Brush rig out of position.	Be sure to line up marks.
VOLTAGE DROPS UNDER HEAVY LOAD	
Engine lacks power.	See remedies for engine missing under heavy load.
Poor compression.	Tighten cylinder head and spark plugs. If still not corrected, grind the valves. Replace piston rings, if necessary.
Faulty carburetion.	Check the fuel system. Clean, adjust or replace parts necessary.
Restricted air cleaner.	Clean and refill.
Carbon or lead in cylinder.	Remove carbon.
Restricted exhaust line.	Clean or increase the size.
ENGINE MISFIRES AT LIGHT LOAD	
Carburetor idle adjustment set wrong or clogged.	Adjust, clean if needed.
Spark plug gaps too narrow.	Adjust to correct gap.
Intake air leak.	Tighten or replace gaskets.
Faulty ignition.	Clean, adjust, or replace breaker points, plugs, condenser, coil, etc., or retime ignition.
Uneven compression.	Tighten cylinder head and spark plugs. If still not corrected, grind valves. Replace piston rings, if necessary.
Worn intake valve stems or guides.	Replace valves or guides.

POSSIBLE CAUSE	REMEDY
ENGINE MISFIRES AT HEAVY LOAD	
Spark plugs defective.	Replace.
Faulty ignition.	Clean, adjust, or replace breaker points, plugs, condensers, coil, etc., or retime ignition.
Clogged carburetor.	Clean jets.
Clogged fuel screen.	Clean.
Valve lash too tight.	Adjust.
Defective spark plug cables.	Replace.
ENGINE MISFIRES AT ALL LOADS	
Fouled spark plug.	Clean and adjust.
Defective or wrong spark plug.	Replace.
Sticking valves.	Clean stems and guides.
Broken valve spring.	Replace.
Defective ignition wires.	Replace.
Defective or improperly adjusted points.	Adjust or replace breaker points.
Defective ignition condenser.	Replace.
Improper valve lash.	Adjust.
LOW OIL PRESSURE	
Oil too light.	Drain, refill with proper oil.
Oil badly diluted.	Drain, refill with proper oil.
Oil too low.	Add oil.
Oil relief valve not seating.	Remove and clean, or replace.
Badly worn engine bearings.	Replace.

POSSIBLE CAUSE	REMEDY
LOW OIL PRESSURE (Cont.)	
Sludge on oil inlet screen.	Remove and clean screen.
Badly worn oil pump.	Repair or replace pump.
Defective oil pressure gauge.	Replace engine or panel unit.
HIGH OIL PRESSURE	
Oil too heavy.	Drain, refill with proper oil.
Clogged oil passage.	Clean all lines and passages.
Oil relief valve stuck.	Remove and clean.
Defective oil pressure gauge.	Replace engine or panel unit.
PLANT STARTS BUT DOES NOT CONTINUE TO RUN	
Start button released too soon.	Hold in contact longer.
Defective charging generator.	Repair.
Defective panel equipment.	See Controls.
ENGINE BACKFIRES AT CARBURETOR	
Lean fuel mixture.	Clean or adjust carburetor.
Clogged fuel screen.	Clean screen.
Intake air leak.	Replace flange gaskets, tighten carburetor.
Poor fuel.	Refill with good, fresh fuel.
Spark too late.	Retime ignition.
Spark plug wires crossed.	Install wires correctly.
Intake valves leaking.	Grind or replace.

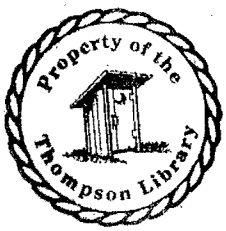
POSSIBLE CAUSE	REMEDY
EXCESSIVE OIL CONSUMPTION, LIGHT BLUE SMOKY EXHAUST	
Sludged rings, excessive bearing clearances, piston skirt collapsed, worn intake valve guides.	Replace worn parts.
Oil leaks from engine or connections. This does not cause smoky exhaust.	Replace gaskets or leaking tubing. Tighten screws and connections.
Oil too light or diluted.	Drain, refill with correct oil.
Too large bearing clearance.	Replace bearings.
Oil pressure too high.	Refer to symptoms of high oil pressure for remedies.
Engine misfires.	Refer to symptoms of engine misfires.
Faulty ignition.	Clean, adjust, or replace breaker points, plugs, condenser, coil, etc., or retime ignition.
Unit operated at light or no load for long periods.	No remedy needed.
Too much oil.	Drain excess oil.
BLACK, SMOKY EXHAUST, EXCESSIVE FUEL CONSUMPTION, FOULING OF SPARK PLUGS WITH BLACK SOOT, POSSIBLE LACK OF POWER UNDER HEAVY LOAD	
Fuel mixture too rich.	Be sure all jet gaskets are in place and tight; float needle valve gasket is in place and tight. Adjust choke. Install needed carburetor parts, adjust float level.
Choke not open.	See that choke opens properly.
Dirty carburetor air cleaner.	Clean, refill to proper level.
LIGHT POUNDING KNOCK	
Loose connecting rod bearing.	Replace.

POSSIBLE CAUSE	REMEDY
LIGHT POUNDING KNOCK (Cont.)	
Low oil supply.	Add oil.
Low oil pressure.	Refer to symptom of low oil pressure for remedies.
Oil badly diluted.	Change oil.
ENGING STOPS UNEXPECTEDLY	
Fuel tank empty.	Refill.
Fuel pump failure.	Repair or replace.
High water temperature.	See symptoms for engine over-heating.
Defective ignition.	Check the ignition system. Repair or replace parts necessary.
DULL METALLIC THUD, IF NOT BAD, MAY DISAPPEAR AFTER FEW MINUTES OPERATION. IF BAD, INCREASES WITH LOAD	
Loose crankshaft.	Replace bearings, unless one of the next three remedies permanently corrects the trouble.
SHARP METALLIC THUD, ESPECIALLY WHEN COLD ENGINE FIRST STARTED	
Low oil supply.	Add oil.
Low oil pressure.	Refer to symptom of low pressure for remedies.
Oil badly diluted.	Change oil.
PINGING SOUND WHEN ENGINE IS RAPIDLY ACCELERATED OR HEAVILY LOADED	
Carbon in cylinders.	Remove carbon.
Spark too early.	Retime ignition.
Wrong spark plugs.	Install correct plugs.
Spark plugs burned or carboned.	Install new plugs.

POSSIBLE CAUSE	REMEDY
PINGING SOUND WHEN ENGINE IS RAPIDLY ACCELERATED OR HEAVILY LOADED (Cont.)	
Valves hot.	Adjust tappet clearance.
Fuel stale or low octane.	Use good fresh fuel.
Lean fuel mixture.	Clean or adjust carburetor.
ENGINE CRANKS TOO STIFFLY	
Corroded terminals.	Clean and tighten terminals.
Too heavy oil in crankcase.	Drain, refill with light oil.
Weak battery.	Test and recharge or replace battery.
Engine stuck.	Disassemble and repair.
Defective cable.	Install new cable.
ENGINE WILL NOT START WHEN CRANKED	
Faulty ignition.	Clean, adjust, or replace breaker points, plugs, condenser, coil, etc., or retime ignition.
Lack of fuel or faulty carburetion.	Refill the tank. Check the fuel system. Clean, adjust, or replace parts necessary.
Clogged fuel screen.	Clean.
Cylinders flooded.	Crank few times with spark plugs removed.
Poor fuel.	Drain, refill with good fuel.
Poor compression.	Tighten cylinder head and spark plugs. If still not corrected, grind the valves. Replace piston rings, if necessary.
Wrong timing.	Retime ingition.
Poor choking.	If plant is cold, adjust choke. If plant is warm, pull up on choke arm momentarily, while cranking.

POSSIBLE CAUSE	REMEDY
ENGINE RUNS BUT CURRENT DOES NOT BUILD UP	
Poor brush contact or dirty commutator or slip rings.	See that brushes seat well, are free in holders, are not worn too short, and have good spring tension.
Open circuit, short circuit or ground in generator	See GENERATOR, replace part necessary.
CURRENT UNSTEADY BUT ENGINE NOT MISFIRING	
Speed too low.	Adjust governor to correct speed.
Poor commutator or brush contact.	See that brushes seat well on commutator and slip rings, are free in holders, are not worn too short, and have good spring tension.
Loose connections.	Tighten connections.
Fluctuating load.	Correct any abnormal load condition causing trouble.
TAPPING SOUND	
Tappet clearance too great.	Adjust or replace tappets.
Broken valve spring.	Install new spring.
HOLLOW CLICKING SOUND WITH COOL ENGINE UNDER LOAD	
Loose pistons.	If noise only slight and disappears when engine warms up, no immediate attention needed. Otherwise replace worn parts.
VOLTAGE LOW AT FAR END OF LINE BUT NORMAL NEAR POWER UNIT	
Too small line wire for load and distance.	Install larger or extra wires or reduce load.
MOTORS RUN TOO SLOWLY AND OVERHEAT AT FAR END OF LINE BUT OK NEAR POWER UNIT	
Too small line wire for load and distance.	Install larger or extra wires or reduce load.

POSSIBLE CAUSE	REMEDY
NOISY BRUSHES	
High mica betweeen bars of commutator.	Undercut mica.
EXCESSIVE ARCING OF BRUSHES	
Rough commutator or rings.	Turn down.
Dirty commutator or rings.	Clean.
High mica.	Undercut mica.
Brush rig out of position.	Line up marks on brush rig and support.
ENGINE OVERHEATING	
Low water in radiator.	Refill radiator.
Overloaded.	Remove part of load.
Improper lubrication.	See Low Oil Pressure.
Radiator obstructed.	Clean radiator.
Ignition timing late.	Adjust ignition timing.
Improper ventilation.	Provide for better air change.
STARTER WILL NOT CRANK ENGINE	
Discharged battery.	Test and recharge or replace battery.
Corroded terminals.	Clean and tighten terminals.
Loose connections.	Tighten connections.
Defective starter relay.	Clean contacts if necessary. Replace switch if necessary.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