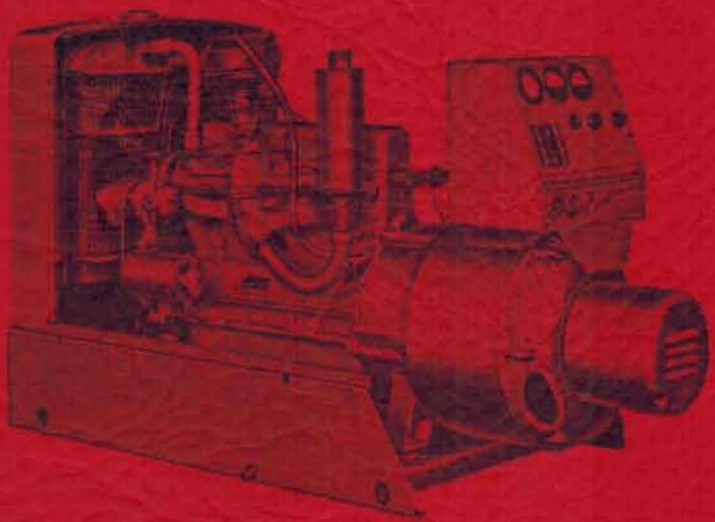
INSTRUCTION MANUAL

ONAN ELECTRIC GENERATING PLANTS

EC
Series



50 & 60 Cycle

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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 product of its manufacture to be free from defects in material and factory workmanship if properly installed, serviced and operated under normal conditions according to the Manufacturer's instructions.

Manufacturer's obligation under this warranty is limited to correcting without charge at its factory any part or parts thereof which shall be returned to its factory or one of its Authorized Service Stations, transportation charges prepaid, within ninety (90) days after being put into service by the original user, and which upon examination shall disclose to the Manufacturer's satisfaction to have been originally defective. Correction of such defects by repair to, or supplying of replacements for defective parts, shall constitute fulfillment of all obligations to original user.

This warranty shall not apply to any of the Manufacturer's products which must be replaced because of normal wear, which have been subject to misuse, negligence or accident or which shall have been repaired or altered outside of the Manufacturer's factory unless authorized by the Manufacturer.

Manufacturer shall not be liable for loss, damage or expense directly or indirectly from the use of its product or from any other cause. The Manufacturer makes no warranty whatsoever with respect to component parts which are warranted separately by their respective manufacturers.

The above warranty supersedes and is in lieu of all other warranties, expressed or implied, and no person, agent or dealer is authorized to give any warranties on behalf of the Manufacturer nor to assume for the Manufacturer any other liability in connection with any of its products unless made in writing and signed by an official of the Manufacturer.

IMPORTANT

RETURN WARRANTY CARD ATTACHED TO UNIT.

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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.

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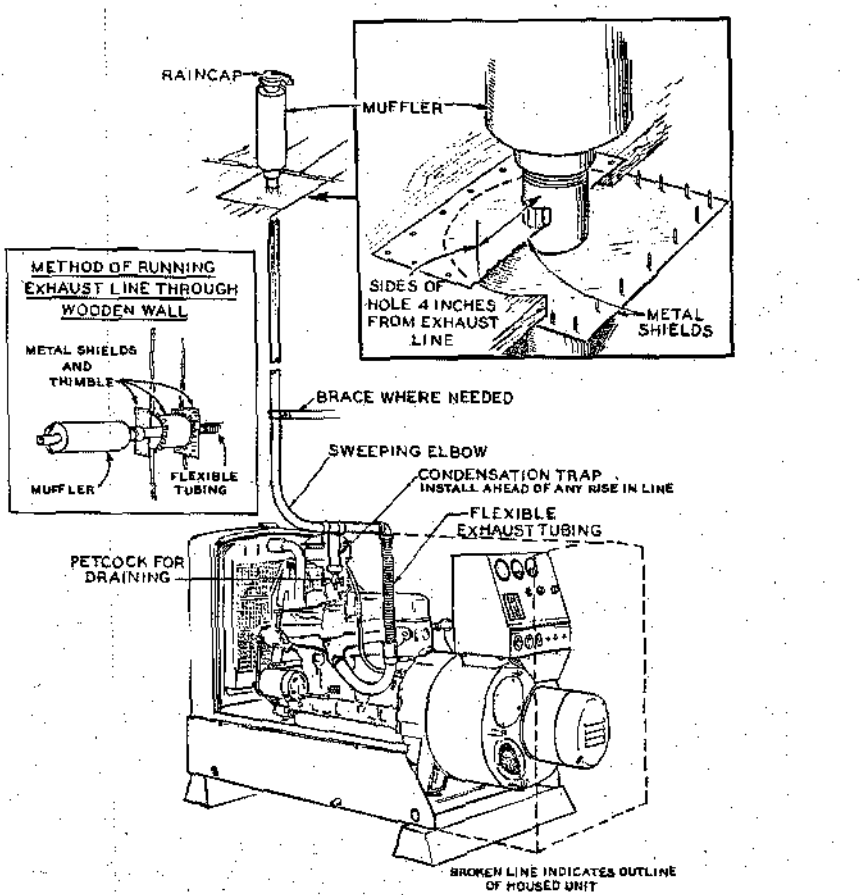
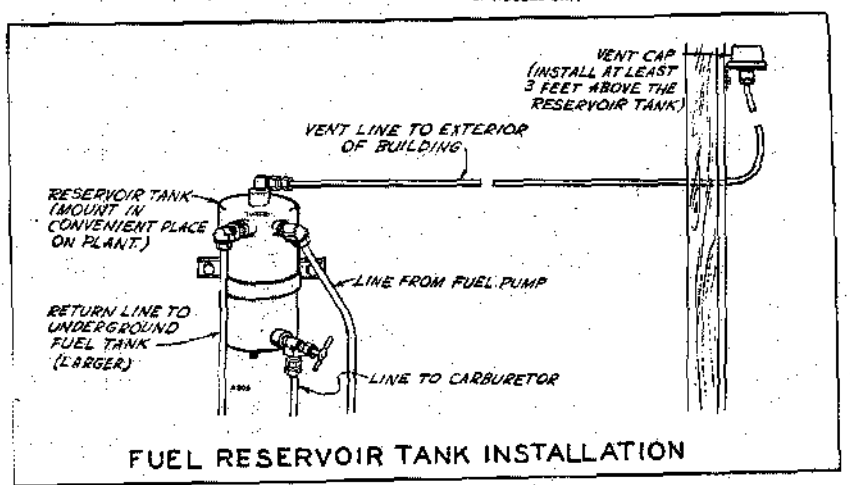




Typical Onan Standby Installation

THIS INSTALLATION IS A TYPICAL ONE. BEFORE INSTALLING CHECK REGULATIONS.

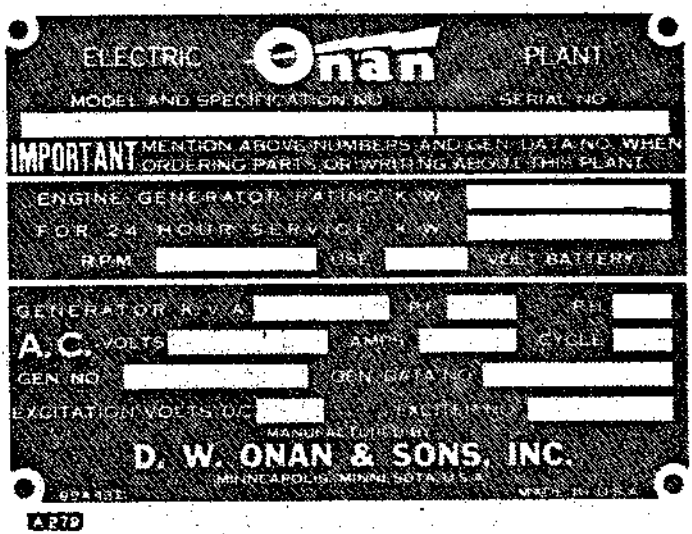
FIG. 1. TYPICAL INSTALLATION

INTRODUCTION

This instruction manual is supplied to assist in the proper installation, operation, and servicing of the EC series of electric generating plants. Unless otherwise indicated, these instructions apply to all standard plants of the EC 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.



AE7D

FIG. 2. ELECTRIC PLANT NAMEPLATE

Basic differences in the EC 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.

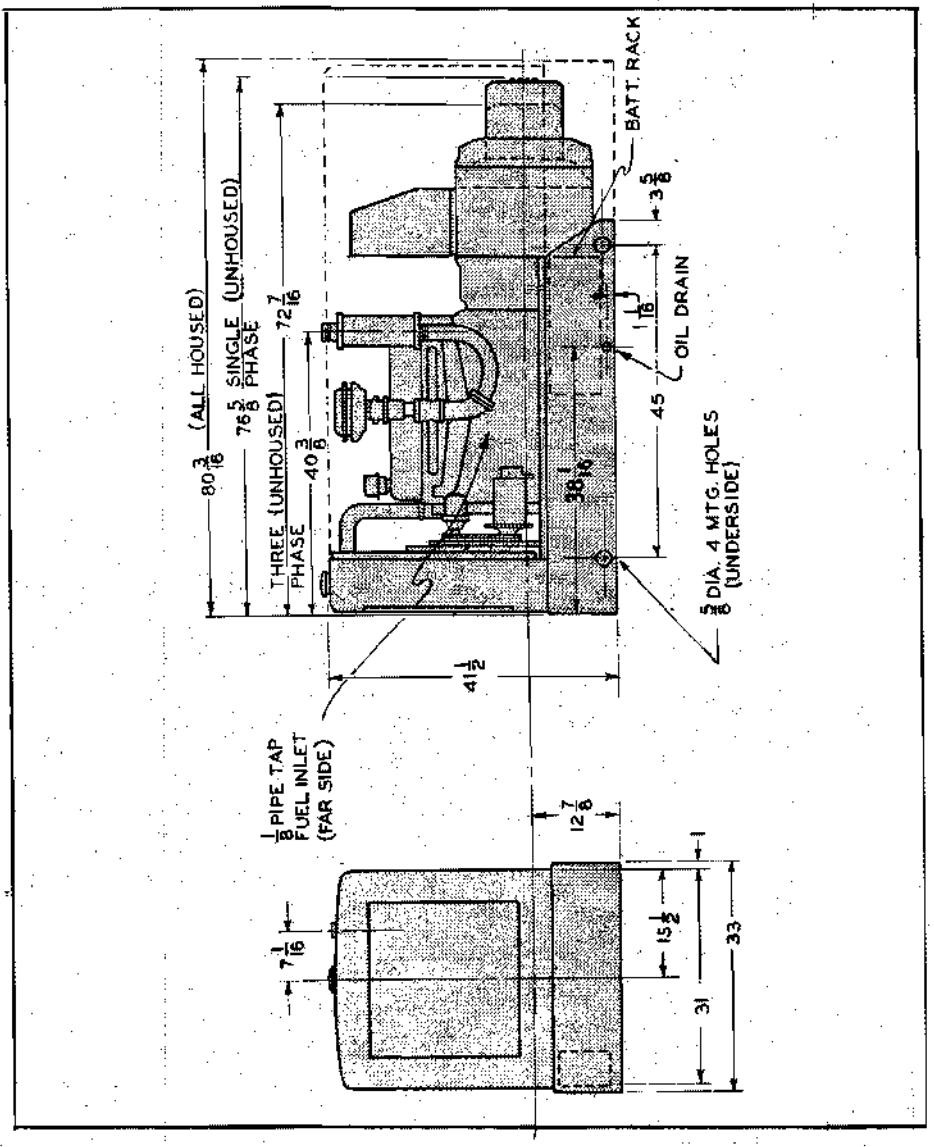


FIG. 3. PLANT INSTALLATION OUTLINE

ENGINE

The engine is a Ford industrial 6-cylinder over-head-valve engine. It is a water cooled, 4 stroke cycle, short-stroke design. 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 full flow oil filter, contributes to long engine life.

ENGINE DATA

Cylinder Bore (inches)	3.62
Piston Stroke (inches)	3.6
Piston Displacement	223 cu. in.
Compression Ratio	7.5 to 1

Piston - 3 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 6 quarts dry - 5 quarts refill - replaceable cartridge, full flow type oil filter.
Cooling - Capacity 16 quarts
Ignition - 12 volt battery - Firing order 1-5-3-6-2-4 Neg. Grd.

GENERATOR

The generator is actually two generators in one: the alternator, and the exciter. The alternator is an alternating current generator of the four pole, revolving field, voltage regulated type. It is rated at 0.8 power factor and is designed for high efficiency and excellent motor starting ability. Inter-connected amortisseur windings on all models allow greater load unbalance and permit parallel operation. The external voltage regulator provides for voltage regulation within ± 2%. A separate rheostat is provided for manual control of voltage in case of regulator failure. The frequency of the current is determined by the engine speed, which is controlled by the engine governor. Speed of the 60 cycle plant is approximately 1800 rpm, and speed of the 50 cycle plant is approximately 1500 rpm.

The exciter is a high ceiling voltage type matched to a quick response voltage regulator assuring a high stability excitation system. The exciter is a four pole, revolving armature, direct current generator which produces current for magnetizing the alternator field. The exciter is connected directly to the alternator and is removable.

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, and safety cut-off relay reset button. Safety devices include a high water temperature cut-off and over speed cut-off. A low oil pressure cut-off switch can be supplied at added cost. The complete electrical instrument panel for housed units includes a running time meter, ammeter (2 on single phase models), volt meter, phase selector switch (except single phase models), circuit breaker, voltage regulator rheostat, and manual voltage control rheostat. Unhoused models are supplied with a panel using only the voltmeter, voltage regulator rheostat, manual voltage control rheostat and output terminal block.

"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 base, 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 out doors, 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. The muffler outlet is 1-1/2 inch pipe size. 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. Use the short length of flexible exhaust tubing between the muffler outlet and any pipe extension. Avoid the use of 90 degree pipe elbows, if turns are necessary, as they tend to create undesirable back pressure in the exhaust line.

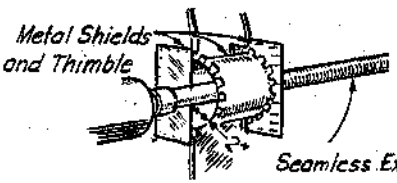


FIG. 4. EXHAUST THIMBLE

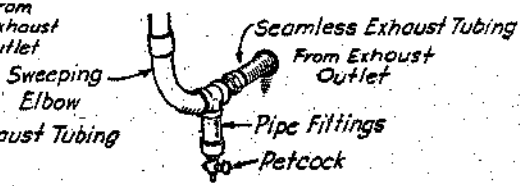


FIG. 5. CONDENSATION TRAP

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 be inclined upward from the plant, construct a condensation trap of pipe fittings and install it at the point where the upward pitch begins. Drain the trap periodically.

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 1/8" pipe. A proper adapter fitting must be used if other than a 1/8" pipe thread fitting is used on the fuel line.

"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 carburetor 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 fuel return line must be provided between the auxiliary tank and the main supply tank.*

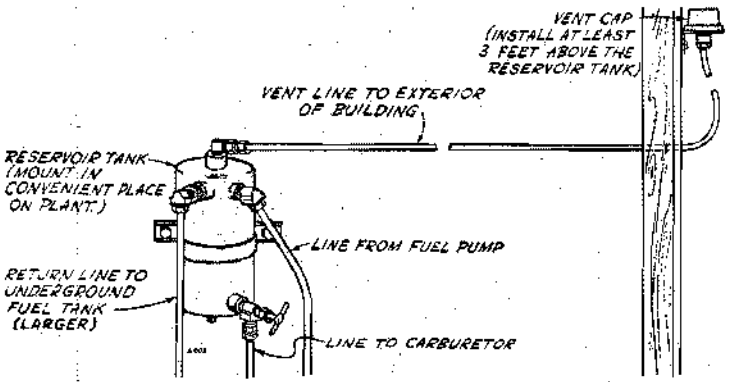


FIG. 6. DAY TANK INSTALLATION

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 13. 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. - A 12 volt, "long" type battery is required and is to be mounted inside the housing left side plate; beside the engine starter motor. Face the terminal posts of the battery toward the starter. Connect the starter cable to the positive (+) battery post, and the grounded cable to the negative (—) battery post. If the battery cable terminals are a tight fit for installation, spread the terminals slightly - do not pound them on to the battery posts. Tighten the terminals securely. A light coating of grease or asphalt paint on the battery terminals will help to retard corrosion.

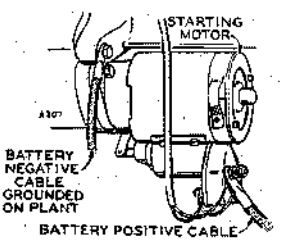


FIG. 7. BATTERY CONNECTION

If the plant will be operated consistently in temperature conditions above 90°F. (32°C.), such as in tropical or boiler room installations, reduce the battery specific gravity. Refer to UNUSUAL OPERATING CONDITIONS - HIGH TEMPERATURES.

LOAD WIRE CONNECTIONS. - Load wire connections are to be made to a large terminal block mounted inside the control box. Access to the terminal block is gained by removing the screws from the instrument panel and swinging the panel out on its hinge. Bring the load wires in through one of the knock-out sections provided in the side of the box. All wiring must be in accordance with national and local electrical codes.

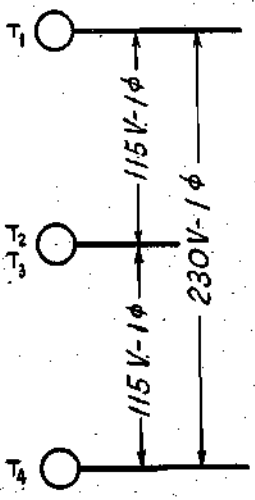


FIG. 8.

115/230 VOLT, SINGLE PHASE, 3 WIRE PLANT. - The load terminals are marked T1, T2-T3, and T4 from top to bottom. The T1 and T4 terminals are the "Hot" terminals; the T2-T3 terminal is the neutral(ground). For 115 volt service, connect the "hot" (black) load wires to the T1 and T4 terminals, and the neutral (white) wire to the T2-T3 terminal. Two 115 volt circuits are obtained. Remember that ONLY ONE HALF the rated capacity of the plant will be available on either of the two separate 115 volt circuits. Balance the load as closely as possible between the two circuits.

The two black wires will give one 230 volt circuit, with the rated capacity of the plant available, if no 115 volt current is used.

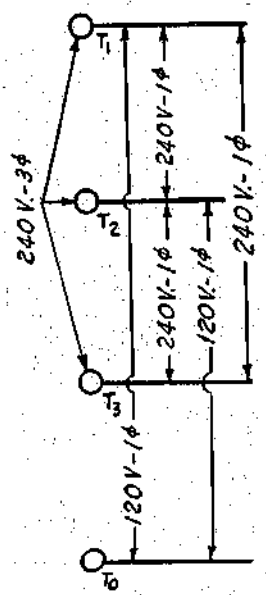


FIG. 9.

120/240 VOLT, 3 PHASE, 4 WIRE DELTA- CONNECTED GENERATOR PLANT. - This type of generating plant is specially designed so that two types of loading can be applied to the generator; regular 240 volt, 3 phase, 3 wire operation; or, combination 240 volt, 3 phase, 3 wire and 120/240 volt, 1 phase, 3 wire operation.

The load terminals are marked T1, T2, T3, and T0, from top to bottom. The T0 terminal is the center tap between T1 and T2. The T0 terminal of the generator is not grounded.

For 240 volt 3 phase 3 wire operation connect the three load wires to the three terminals T1, T2, and T3, one wire to each terminal post. For 3 phase, 3 wire operation, the T0 terminal is not used and is normally not grounded.

If it is desired to use combination single phase and three phase loads simultaneously, connect such single phase loads as follows:

For 120/240 Volt, 1 phase, 3 wire operation, terminals T1 and T2 are the "Hot" terminals; the T0 terminal is the neutral which can be grounded if desired. For 120 volt service, connect the "hot" (black) load wires to the T1 and T2 terminals, and the neutral (white) wire to the T0 Terminal. Two 120 volt circuits are thus obtained. The two black wires connected to T1 and T2 will give one 240 volt circuit.

Any combination of single phase and three phase loading can be applied to the generator simultaneously as specified above as long as no terminal current exceeds the rated current of the generator.

Combination single phase and three phase loads applied to a three phase generator are unbalanced loads which cause the phase voltages to be unequal. These unbalanced loads will not create voltage unbalance of the phase voltages of greater than 5 percent so long as no terminal current exceeds the rated current of the generator.

This generating plant may be used with an ONAN automatic line transfer control for standby plant operation. The T0 terminal of the ONAN automatic line transfer control is always grounded. Connecting the generating plant T0 lead to the line transfer T0 terminal grounds the generator.

If used in conjunction with an ONAN automatic line transfer control on a 3 phase 3 wire circuit, the line transfer T0 terminal should be left open and not used.

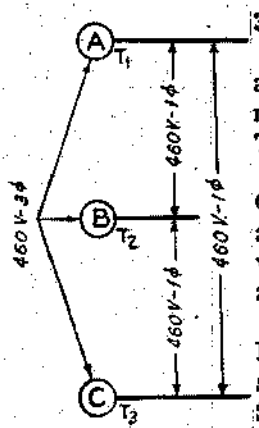


FIG. 10.

3 PHASE, 3 WIRE PLANT CONNECTIONS. - None of the terminals are grounded, Figure 10. For three phase current, connect a separate load wire to each plant terminal, T1, T2, T3, one wire to each terminal.

On connections for single phase current, connect separate load wires to each of any two plant terminals, one wire to each terminal. Three single phase load circuits are thus available.

If both single and 3 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 plant capacity. Divide the remainder by 3, and this is the load that may be taken from any one circuit for single phase current. For example, a 3 phase 10,000 watt load is used. This leaves 15,000 watts available for single phase, if the plant capacity is 25,000 watts. One third of this 15,000 watts is 5,000 watts, which is *the amount that may be taken from each of the 3 single phase circuits. Do not attempt to take all 15,000 watts in this example off one circuit, as overloading of the generator will result.*

120/208 VOLT, 3 PHASE, 4 WIRE WYE-CONNECTED PLANT. - The four wire plant is designed to produce single phase current of one voltage, and three phase current of different voltage. As shown on the plant nameplate, the single phase current is the lower voltage and the three phase current is the higher voltage.

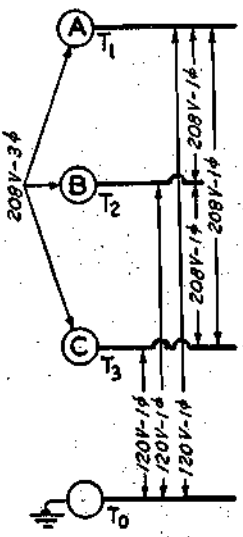


FIG. 11

The load terminals are marked T1, T2, T3, and T0 from top to bottom. The T1, T2, and T3 terminals are the "hot" terminals, and the T0 terminal is the ground terminal.

For three phase current, connect the three load wires to the terminals T1, T2, and T3, one wire to each terminal post. If a test run indicates reverse rotation of motors in the load circuit, reverse the connections of any two terminals.

For single phase current, connect the "hot" load wire to any one of the terminals T1, T2, or T3. Connect the ground wire to the T0 Terminal. Three single phase circuits are thus available.

NOTE!

When taking a single phase load off the plant, the single phase (line to neutral) voltage is 120 volts when the AC Voltmeter connected across the line (line to line) terminals reads 208 volts. On other 3 phase, 4 wire plants of different voltage rating this applies also except of course that the single phase (line to neutral) voltage will always be the lower voltage as specified on the nameplate when the voltmeter reads the higher (line to line) voltage as specified on the nameplate.

If both single and three phase current is used at the same time, use care not to over-load any one of the single phase circuits. Subtract the amount of the three phase load from the rated capacity of the plant. Divide the remainder by three to determine the amount of single phase load which may be connected to any single phase circuit.

REMOTE CONTROL CONNECTIONS. - A small four place terminal block is mounted on the bottom inside surface of the control box. To provide for remote control of starting and stopping, connect the START-STOP remote switch to this terminal block, Figure 12.

Connect the single, unmarked terminal of the switch to the No. 1 terminal of the plant. Connect the switch terminal marked OFF to the No. 2 plant terminal. Connect the switch terminal marked ON to the No. 3 plant terminal. The plant B + terminal is used only with line transfer equipment. If additional remote switches are installed, they must be connected in a parallel circuit: all OFF terminals together, etc.

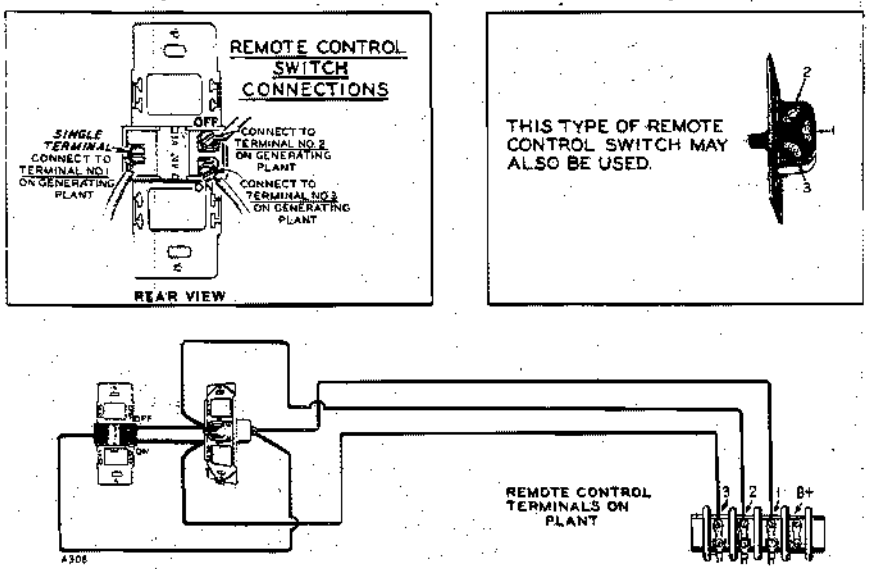


FIG. 12. REMOTE CONTROL CONNECTIONS

For remote control distances, #18 wire can always be used up to 75 feet in wire length. For greater distances, larger wire will be necessary, as indicated.

MAX. DISTANCE	WIRE SIZE
75 feet	#18
120 feet	#16
200 feet	#14

CRANKCASE OIL. - The oil capacity of the crankcase when "dry" (oil filter empty) is 6 U.S. quarts. Normal refill capacity is 5 U.S. quarts. Use MS or DG type heavy duty (detergent) type of oil. Select the proper SAE number of oil according to the lowest expected temperature.

TEMPERATURE	SAE NUMBER
Above 100°F.	50
above 32°F. (0°C)	30
32°F. (0°C.) to -10°F. (-23.3°C.)	10
Below -10°F. (23.3°C.)	5W

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.

AIR CLEANER. - Remove the air cleaner top and fill the reservoir cup, to the line indicated on the cup, with oil of the same SAE number as used in the crankcase. On housed plants, because of close top clearance, it is necessary to remove the air cleaner from the carburetor. Be sure the air cleaner is properly reinstalled before running the plant.

RADIATOR. - The capacity of the cooling system is 16 quarts (U.S. measure). Check to see that the radiator drain and the cylinder block drain is 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 antifreeze solution. Use the correct proportion of antifreeze, as recommended by the antifreeze manufacturer, to protect at least 10 degrees F. below the lowest expected temperature.

FUEL, GASOLINE. - Some special model plants are equipped with a mounted 20 gallon capacity fuel tank. Do not fill *the tank completely full of cold gasoline. Expansion of the gasoline as the plant warms up may cause the gasoline to overflow, creating a fire hazard, allow an inch or two of expansion space.*

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.

Observe the usual safety precautions when handling gasoline. Special precautions must be taken when the fuel tank is near the plant. Never fill the tank while the plant is running.

FUEL, NATURAL GAS. - If gas fuel is to be used, see that all fuel connections are leak proof. See that the line pressure at the regulator inlet does not exceed 5 pounds per square inch. In some localities, presence of foreign matter in the fuel may require the installation of a trap or filter. Consult the fuel supplier.

A special carburetor fitting is used on plants equipped for gas fuel operation. See that the float lock screw (FIG. 16.) is turned up tightly to prevent the float from vibrating inside the carburetor. If an emergency source of gasoline is also connected, see that the shut-off valve on the carburetor is closed. See that the electric choke is readjusted for gas operation as described in the paragraph on Carburetor-Gas in this manual.

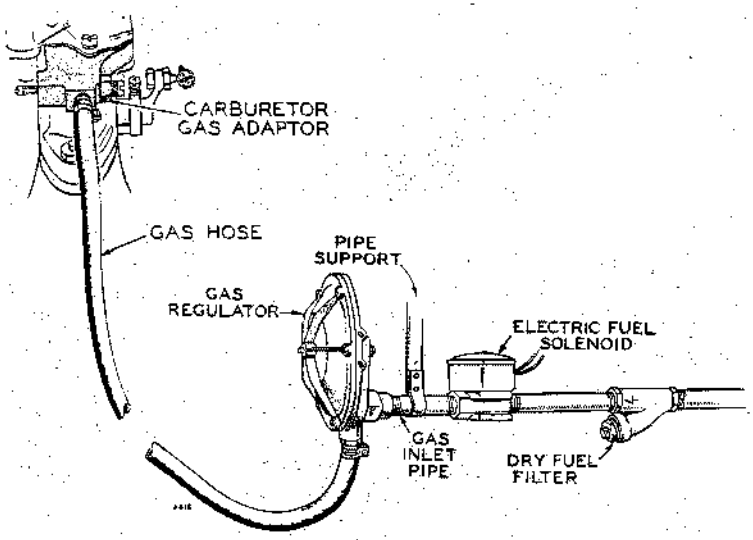


FIG. 13. GAS FUEL LINE CONNECTIONS

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 140° to 170°.

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 EC series plants are equipped with three 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 pressure drops to less than 15 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).

3. Overspeed Cut-off. - The overspeed cut-off is a centrifugal type switch mounted on the rear end of the generator which acts to stop the plant if the governor becomes inoperative due to a broken drive belt, etc. It is not adjustable.

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.

AMPERES. - The ammeter (two on single phase 3 wire models) indicates the amount of CONNECTED electrical load. On three phase models, the ammeter indicates the load connected to any one phase, as determined by the selector switch position. On single phase models, each ammeter indicates the amount of load connected to its respective circuit.

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. On single phase models, the voltage shown will always be the higher nameplate rating.

CIRCUIT BREAKER. - The circuit breaker is a safety device. The circuit breaker will open automatically and disconnect the load if the plant is severly overloaded. Correct the cause of overloading before again throwing the circuit breaker handle to the ON position. To disconnect the load, throw the circuit breaker handle to the OFF position.

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 excessive engine speed 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.*

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 one 30 minute period each week. 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.

X-RAY SERVICE. - When the generating plant is used for X-Ray service, a few departures from normal operating procedure are recommended.

1. Dummy Load - The heavy X-Ray load is on for only a very short period of time, in most cases for only a fraction of a second. The engine governor (and the engine itself) can not act fast enough to prevent a voltage and frequency drop when the X-Ray load is added, nor to prevent a corresponding upward surge when the X-Ray load is removed. If a dummy load of about 4 or 5 KW is on continuously, more satisfactory operation is obtained. The engine is placed in a more stable operating range where it is already pulling the 4 or 5 KW load before the X-Ray load is applied. The dummy load can consist of space heaters, or in warm weather, of similar resistor units.

2. Periodic Checks - Due to the exacting requirements of X-Ray service, the generating plant should be serviced and maintained to give peak performance. Particular attention should be given to proper ignition, governor, and carburetor servicing.

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 element at the same time (which will require an extra quart). 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 element) 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 antifreeze compound in the proportion recommended by the antifreeze manufacturer, protecting to at least 10 degrees F. below the lowest expected temperature. The capacity of the cooling system is approximately 16 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 antifreeze 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. 30 oil for temperatures above 32°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 element more frequently, as conditions require.

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, 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 it from the top of the carburetor. Disassemble the top section from the cup section and pour out the dirt laden oil. Clean reservoir cup and filter element with solvent, and allow to dry. Refill to the indicated level with clean oil and reassemble the cleaner. When reinstalling to the top of the carburetor, tighten just enough to assure that no air will leak in around the clamping point.

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 antifreeze 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, drain the crankcase and refill to the proper level after the FIRST 15 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.

Under normal temperature (above 32° F.) and operating conditions, change the crankcase oil every 100 operating hours.

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 FILTER. - The oil filter is a full-flow 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.

Under normal operating conditions, change the oil filter element each alternate crankcase oil change. However, under cold operating conditions or dusty and dirty conditions, change the filter element at each oil change.

Place a drip pan under the oil filter. Remove the center bolt and remove the filter housing and element as a unit. After discarding the dirty filter element and all the gaskets, clean the metal parts with solvent, making sure the radial holes in the center bolt are not clogged. Place a new gasket next to the head of the center bolt and insert the center bolt in the housing. Install the spring and retainer assembly over the center bolt (retainer facing the threaded end of bolt). Install a new gasket and element over the bolt.

With the openings in the diaphragm positioned at the top, install a new housing gasket in the crankcase recess. Position the filter and tighten the center bolt just enough to cause the filter housing to contact the gasket. Rotate the housing to assure even seating, then tighten the center bolt to 20-25 pounds-foot torque. 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. - Check the governor oil level. Remove the oil level plug (Fig. 28) and add oil, of the same SAE number as used in the crankcase, until the oil reaches the plug level. Do not overfill.

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. - Put two or three drops of oil in the battery charging generator oilers, one at each end of the generator. Do not over lubricate.

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 (see Figure 14.) 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 0.024" to 0.026" at widest separation. Apply a very small amount (about the size of a match head) of high temperature grease on the breaker cam surface. Put a few drops of oil in the oiler cup on the side of the distributor.

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 sandpaper. 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.

VALVE TAPPETS. - Remove the rocker arm covers and check the tappet clearances. Adjust as necessary to a clearance of 0.015 inch for the intake valves, and 0.019 inch for the exhaust valves. Tappets should be adjusted with the engine at operating temperature.

CAUTION

When replacing the rocker arm covers, tighten the cover nuts to only 2 to 2.5 lbs ft. torque. Over tightening the cover nuts will distort the cover.

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 antifreeze 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 main and idle adjusting needle valves (Fig. 14.). The main adjusting needle, at the bottom of the carburetor, affects the operation at the heavier load conditions. 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 adjustments should not be disturbed. If the adjustments have been changed, an approximate setting of 1-1/2 turn open for the idle needle and 1 turn open for the main needle will permit starting. Adjust temporarily for smoothest running. Allow the engine to thoroughly warm up before making final adjustment.

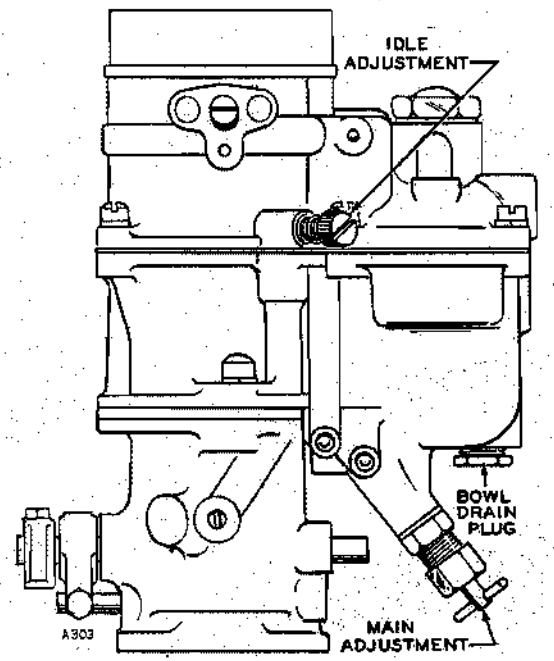


FIG. 14. GASOLINE CARBURETOR ADJUSTMENTS

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.

To adjust the main needle, apply a full electrical load (or as much as possible if full load can not be reached) and adjust the manual voltage control rheostat to maintain proper voltage as load is added. Turn the main needle in (clockwise) until the voltmeter reading begins to drop. Then turn the needle out (counterclockwise) to the point where the voltage returns to normal.

Remove the electrical load (adjusting the manual voltage control rheostat accordingly) and return the plant to automatic voltage regulation by turning the manual voltage control rheostat to its extreme counterclockwise position. Try various electrical loads. If the engine speed fluctuates at any load (a frequency meter or accurate tachometer can be used to check speed) turn the main adjusting needle out slightly. Do not turn out more than 1/2 turn beyond the original full load setting. If stable speed can not be obtained by such carburetor adjustment, a change in the governor sensitivity adjustment will probably be necessary.

ELECTRIC CHOKE. - A 12 volt electric choke with vacuum booster is used on all plants as shown in Figure 15A. 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 zero and the twelfth mark from the zero mark is labeled with an asterisk (*). The asterisk mark indicates the normal adjustment setting. A long raised line on the top 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 as shown in Figure 15A.

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).

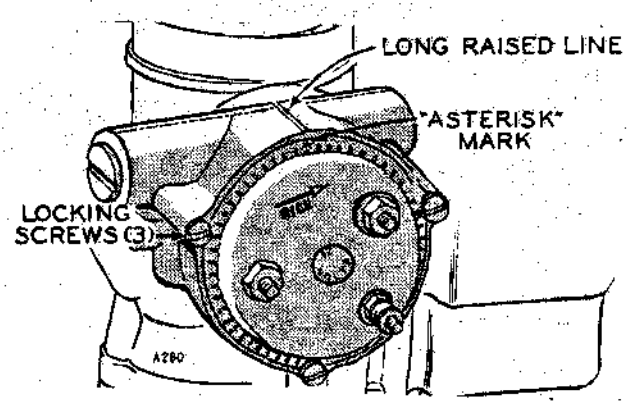


FIG. 15A. ELECTRIC CHOKE

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. When the engine is warm, the Zenith electric choke cannot give choking action immediately when the engine is stopped. 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 not sufficient to open the butterfly valve. However, as soon as the engine fires, the volume of air passing into the carburetor is great enough to overcome the weight of the counterweight and the butterfly valve snaps open to the vertical or fully open position. 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 Figure 15B. When the choke is properly adjusted the center line of the counterweight is 1/16" below the center line of choke shaft measured along the circumference of the counterweight, when the butterfly valve is in the closed position. 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:

(1) The butterfly valve freely closes when released.

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

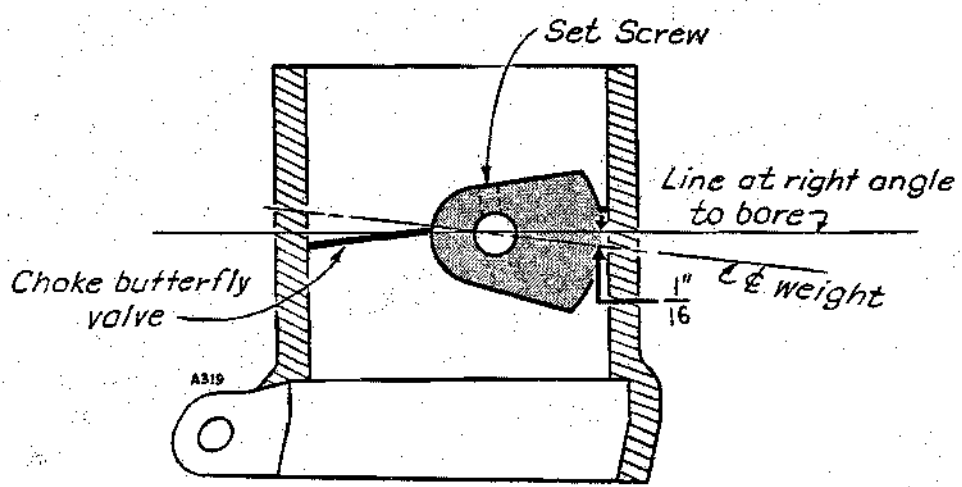


FIG. 15B. COUNTERWEIGHTED CHOKE ADJUSTMENTS

CARBURETOR, GAS.- If the plant is equipped for gas fuel, see that the gasoline shut off is closed and that the float lock screw at the bottom of the carburetor is turned upward to its limit. The electric choke must be adjusted so that the adjustable cover is turned 10 to 12 notches counterclockwise from the zero mark, as shown on Figure 16. When properly adjusted, the electric choke will be completely open even at very low temperatures.

With the "idle" adjusting screw turned inward to its seat, and with the plant operating at full load, turn the main gas adjusting screw in until the engine speed (or voltage) begins to drop. Then turn the adjusting screw out (counterclockwise) until the voltage returns to normal. Set the lock nut securely to prevent any change in the setting from vibration.

Remove the electrical load and repeat the adjusting process, using the "idle" adjusting screw.

With electrical load removed, adjust the throttle level stop screw so that there is 1/32 inch clearance between the screw end and the stop pin.

Gas-Gasoline conversion kits are available to convert your plant to this type of operation. Write to the factory for detailed information giving complete Model and Spec No. and Serial No. of your plant.

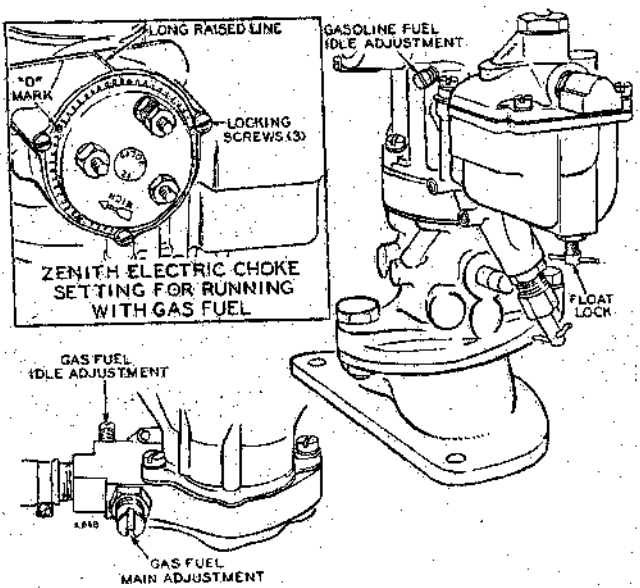


FIG. 16. GAS-GASOLINE CARBURETOR ADJUSTMENTS

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.

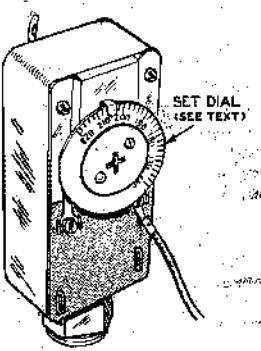


FIG. 17. HIGH WATER TEMPERATURE CUT-OFF SWITCH

FAN AND GENERATOR BELT ADJUSTMENT. - A separate belt is used to drive the fan and the generator. Reduced belt wear and more efficient operation of the fan and generator is thus obtained. The correct adjustment of these belts must be maintained to provide proper engine cooling and high generator output. The belts should be checked for cracks and wear occasionally and replaced when necessary.

To adjust the fan belt, loosen the fan bracket screws, then move the bracket up or down until a deflection of 1/2 inch is obtained between the crankshaft pulley and the fan pulley, with light thumb pressure on the belt(see Figure 18.).

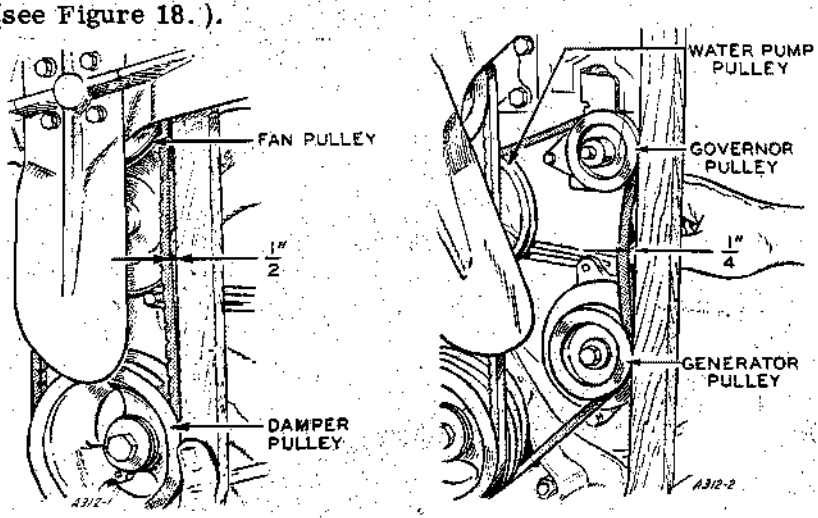


FIG. 18. FAN AND GENERATOR BELT ADJUSTMENTS

To adjust the generator belt, loosen the generator link clamp screw and the two generator mounting bolts. Move the generator toward or away from the engine until a deflection of 1/4 inch is obtained between the generator pulley and the governor pulley, with light thumb pressure on the belt.

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.

1. With the engine stopped, and tension on the governor spring, adjust the governor linkage length so that the carburetor stop lever clears the stop boss by not less than 1/32" as shown. See illustration GOVERNOR ADJUSTMENT.

2. Start the plant and allow it to reach operating temperature.

3. Adjust the speed. With no electrical load connected, adjust the speed screw to attain the proper no load (n.l.) 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.

Although the plant is rated at 80% power factor load, the speed and voltage regulation at full load may be made by connecting the type of load that corresponds with the application. At unity (1.0) power factor the KW rating is equal to 25 kilowatts.

4. If the plant tends to hunt (alternately increase and decrease speed) under load conditions, increase very slightly the distance between the governor main shaft and the sensitivity screw on which the spring link pivots. For best regulation keep the sensitivity screw up as closely as possible without causing hunting.

Any change in the setting of the sensitivity screw will require correcting the speed screw adjustment. Decreasing sensitivity by turning the screw clockwise causes a slight speed increase which can be corrected by turning the speed screw slightly counterclockwise to decrease spring tension.

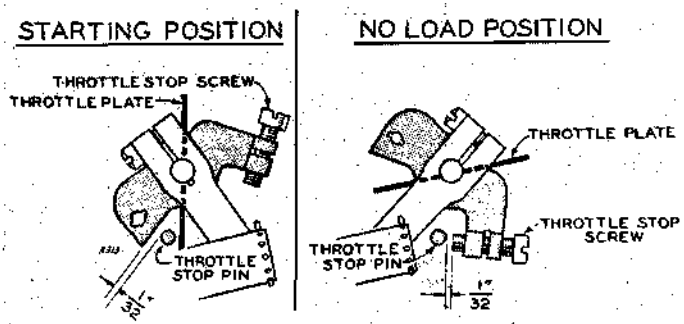


FIG. 19. GOVERNOR THROTTLE ARM STOP ADJUSTMENT

SPEED CHART FOR CHECKING GOVERNOR REGULATION

	SPEED RANGE LIMITS		SPEED SPREAD PREFERRED	(WITHIN RANGE) 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.

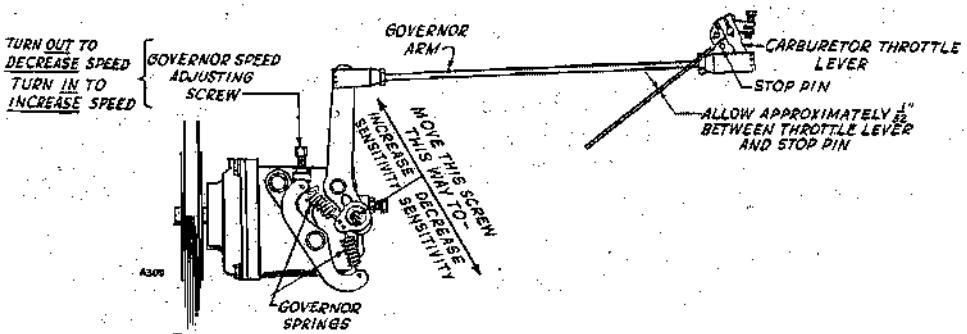


FIG. 20. GOVERNOR ADJUSTMENT

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.

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 21.), 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. See Figure 21. 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.

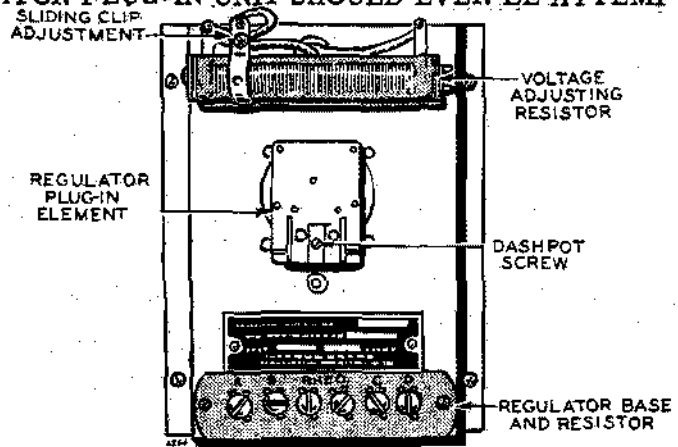


FIG. 21. REGOHM VOLTAGE REGULATOR ADJUSTMENT

VOLTAGE CHART

TYPE OF PLANT			VOLTAGE LIMITS	
VOLT	PHASE	WIRE	MAXIMUM NO LOAD VOLTAGE	MINIMUM FULL LOAD * VOLTAGE
115	1	2	117	113
230	1	2	234	226
115/230	1	3	234	226
120/208	3	4	212	204
120/240	3	4(DELTA)		
460	3	3	468	452
220/380	3	4	388	372
127/220	3	4	224	216
575	3	3	586	564
230/460	1	3	468	452
115	*3*	*3*	*117*	*113*

* *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 clockwise direction, in the firing order 1-5-3-6-2-4. The number one socket is identified by the number "1" on the cap.

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 0.025 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 0.025 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 22. 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.

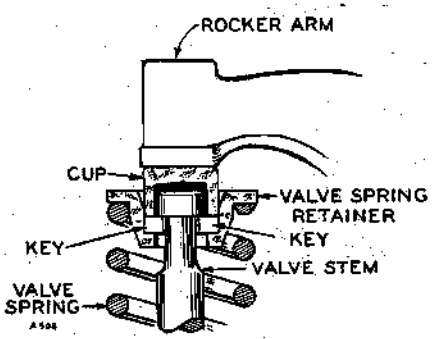


FIG. 22. VALVE ROTATORS

The rotator mechanism has a clearance between the valve tip and the rotator cap, as shown in Figure 22. 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. Regular service stations have gauges to check the rotator clearance and where the clearance is too large it can be reduced by grinding off the cap to decrease its depth. 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. In addition each key should be installed in its original position and not turned over. If it is necessary to use a new valve, new caps and keys should be installed.

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 0.015 inch and the exhaust valve stem clearance should be 0.019 inch. NOTE: The valves are arranged from front to rear in this order - E-I-I-E-I-E-E-I-E-I-I-E. Tighten the lock nut then check the clearance again.

VALVE TIMING. - The camshaft is driven by the crankshaft through a silent timing chain at the front of the engine. Proper valve timing is provided by installation of the timing chain as shown in Figure 23.

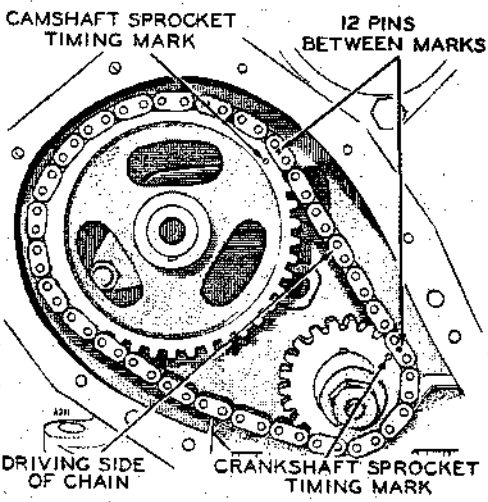


FIG. 23. TIMING CHAIN

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.

The crankshaft damper has six grooved timing marks. The first mark which goes past the pointer with rotation is the only mark which is to be used to time the engine. See Figure 24. The pointer is bolted to the front of the engine.

Connect the timing light high tension lead to the No. 1 spark plug and the other two leads to the proper battery terminals. If necessary, clean the dirt from the first timing mark, and chalk the mark and pointer to improve legibility.

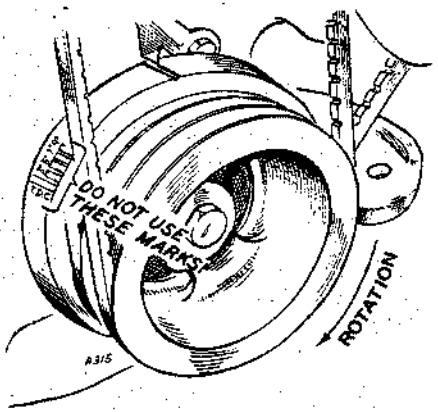


FIG. 24. IGNITION TIMING

Operate the engine at idle speed, and direct the liming light at the pointer, keeping the pointer in line with the center of the pulley and the light. The light should flash just as the first mark on the pulley lines up with the pointer. If the first mark on the pulley and the pointer do not line up, loosen the distributor body clamp, and rotate the distributor body until the first mark and the pointer are in line. (Note: Ignition timing is advanced by counterclockwise rotation of the distributor body, while clockwise rotation retards timing.)

TESTING COMPRESSION. - Operate the engine at idle speed for 30 minutes to be sure it is thoroughly warmed up. Turn off the engine and remove all of the spark plugs from the engine. Install a compression gauge in a spark plug hole, and crank the engine about four revolutions with the starter. Record the gauge reading for each cylinder. Chalk on the manifold works well. Compare the gauge

readings. The compression should be 125 pounds plus or minus 10 for each cylinder. The reading on all cylinders should be the same within 10 pounds.

If the compression pressure is low on two adjacent cylinders, the possibility of a leak between the two cylinders is indicated. Such a leak is usually caused by a head gasket which is not sealing properly. If the compression pressures on all cylinders are low, or vary a great deal, the cause of the trouble can be narrowed down by squirting a liberal quantity of engine oil through the spark plug holes on top of the pistons of the low reading cylinders. Then crank the engine a few revolutions to get the oil evenly distributed on the cylinder walls, and make a second compression test. If there is very little difference between the readings obtained in the two checks, sticking or poorly seating valves are indicated. However, if the readings on the low cylinders have improved considerably, it indicates the compression is being lost past the pistons and rings.

CYLINDER HEADBOLT TIGHTENING. - When replacing the cylinder head, first coat the cylinder head bolts with head gasket sealer and then tighten the head bolts in the sequence shown in Figure 25.

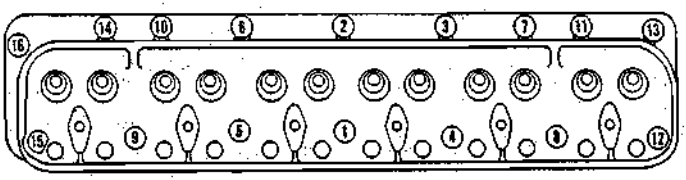


FIG. 25. CYLINDER HEAD BOLT TIGHTENING SEQUENCE

Tighten the head bolts in three progressive steps as shown below, using the proper torque as specified.

HEAD BOLT TORQUE SPECIFICATIONS

HEAD BOLT TIGHTENING STEPS	TORQUE (foot-pounds)
1 (Cold)	55
2 (Cold)	65
Final (Hot)	75

The final tightening of the headbolts should be made after the plant has been run for a minimum of 30 minutes at idle speed.

CONNECTING ROD, PISTON, PIN, AND RING MAINTENANCE. - Remove the cylinder heads and the oil pan. Remove any ridge at the top of the cylinder bore and clean the carbon from the piston and cylinder bore. Remove the connecting rod lock nuts and nuts. Pull the cap off the rod and push the connecting rod and piston out the top of the cylinder. (Be careful that the crankpin or the cylinder wall is not scratched when removing the piston and rod.) Be sure to mark the pistons for identification of the piston with the bore and rod for assembly purposes.

Remove the piston rings. Remove the piston pin retaining clips at each end of the piston pin, then remove the piston pin. Discard the retaining clips. Identify the bearing inserts for assembly with the same rod and cap, then remove the inserts.

NOTE: Each rod and bearing cap is numbered from 1 to 6 from the front to the rear end of the engine. The numbers on the rod and bearing cap must be on the same side when installed in their respective cylinder bores. If a connecting rod is ever transposed from one block or cylinder to another, the bearings must be fitted and the rod must be numbered to correspond with the new cylinder number.

Assemble the connecting rods to the pistons so that the oil squirt hole in the rod is positioned as shown in Figure 26. Install the piston pin through the piston and rod, then install the pin retainers by spiraling them into the piston with the fingers. Do not use pliers.

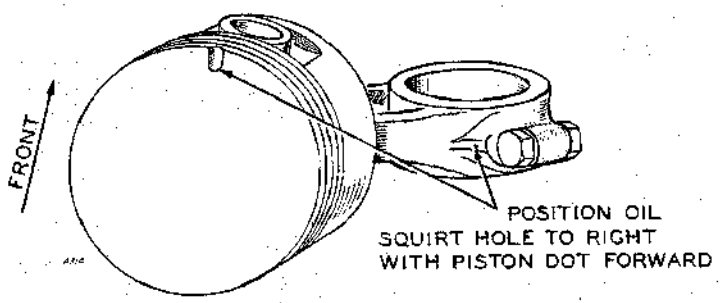


FIG. 26. PISTON AND CONNECTING ROD ASSEMBLY

Install the oil ring spacer in the oil ring groove, position the gap in line with either piston pin bore. Spiral the steel rail ring segment into the upper side of the oil ring groove, position the gap approximately 1 inch to the right side of the spring spacer gap.

NOTE: Firmly support the spring spacer during installation of the steel rails, being careful that the spring spacer ring ends are not overlapped. These ends must be butted together as this permits the spacer to be compressed during installation of the steel rails.

Spiral the remaining steel oil ring segment into position at the lower side of the oil ring groove. Position the gap approximately 1 inch to the left side of the spring spacer gap.

NOTE: Flex the oil ring assembly in its groove by compressing the ring with the fingers to be sure that the ring segments are free prior to installation in the cylinder bores.

Install the lower compression ring into its groove with the inside counterbore toward the top of the piston. Position the gap to the spark plug side of the cylinder bore. Install the upper compression ring with the word "TOP" toward the top of the piston. Position the gap to the side opposite the spark plug side of the cylinder bore.

Check the connecting rod bearing fit using the Plastigage method.

Oil the piston rings, piston, connecting rod bearings, and cylinder walls with light engine oil. Install a piston ring compressor on the piston, and insert the piston in the cylinder. Be sure to install pistons in the same cylinder from which they were removed, or to which they were fitted.
NOTE: Install the piston with the indentation in the piston head toward the front of the engine.
If a new piston and connecting rod is to be installed, be sure to stamp the cylinder number on the connecting rod and connecting rod cap. Push the piston into the cylinder. Turn the crankshaft throw to the bottom of its stroke. Oil the crankpin and push the piston all the way down until the rod bearing seats on the crankpin.

Install the bearing cap (line up the stamped numbers) and tighten the retaining nuts to 45-50 foot-pounds torque. Install new pal nuts, and tighten them to 3-3-1/2 foot-pounds torque (or finger tight plus 1/3 turn).

Be careful not to damage the crankpin journals with the connecting rod bolts when the piston is pushed all the way into the cylinder bore. Check the bearing fit using the Plastigage method.

OIL BATH AIR CLEANER. - Fill the reservoir up to the line indicated on the cup, with oil of the same SAE number as used in the engine oil base. Be sure the air cleaner is properly reassembled before running the plant.

THERMOSTAT REPLACEMENT AND INSPECTION. - The thermostat is located in the water outlet elbow at the front of the cylinder head. Proper operation of the thermostat is necessary to maintain efficient operation of the engine. If the thermostat becomes inoperative and the valve remains open, the engine will run too cold causing sludge and acids to accumulate in the crankcase. If the valve in a defective thermostat does not open, serious overheating will result.

To replace the thermostat, place a new water outlet elbow gasket on the cylinder head. Position the thermostat on the cylinder head with the butterfly valve facing forward and the marking "top" toward the top of the engine.

OIL FILTER CARTRIDGE REPLACEMENT. - The full-flow type oil filter cleans all of the lubricating oil before it enters the oil passages in the cylinder block. This type of filtration assures that all of the oil is cleaned before it can reach vital bearing surfaces. If the filter element should become clogged, lubrication of vital engine parts is assured by the by-pass valve located in the hollow center bolt. The by-pass valve allows a sufficient quantity of unfiltered oil to enter the engine to prevent any damage to the moving parts. A top-opening, anti-drain-back diaphragm is positioned in the cylinder block to prevent oil from draining out of the filter and back into the oil pan when the engine is stopped. This insures an immediate supply of oil to the bearings when the engine is started again.

The oil filter cartridge should be replaced every 100 hours, or if operating in below freezing temperatures or under severe dust conditions, whenever the oil on the dip stick is so black or dirty that the markings on the dip stick cannot be seen through the oil.

When changing the oil filter cartridge, place a drip pan below the filter. Remove the center bolt, then remove the filter housing and element as a unit. Discard the dirty filter element and all gaskets, then thoroughly clean all the metal parts in solvent. Make sure the holes in the center bolt are free of sludge and obstructions. Place a new gasket on the center bolt, then insert the center bolt in the housing. Make sure the tangs on the spring retainer are engaged in the spring, then drop the spring and retainer assembly over the center bolt. Install a new gasket and filter cartridge over the center bolt. NOTE: The pressed paper type of cartridge does not require a gasket above the spring retainer.

Make sure the holes in the anti-drain -back diaphragm are positioned at the top. Install a new gasket in the filter housing recess in the block. Position the filter assembly on the block, then tighten the bolt just enough to bring the filter housing in contact with the gasket. Rotate the housing slightly to assure even seating, then tighten the center bolt to 20-25 foot-pounds torque (approximately 3/4 to one additional turn).

Note: Be sure to check around the filter housing and center bolt for leaks with the engine warmed up and operating at fast idle speed.

CRANKCASE VENTILATOR. - The crankcase ventilating system permits clean, filtered air to circulate through the engine. As the air enters at the top of the engine through an oil wetted filter in the oil fill cap, the air moves through the engine and picks up oil vapor and blow-by gasses and carries them to the air cleaner.

Due to the reversed flow of cooling air over the engine the oil fill cap position should be reversed, so that the marking "FRONT" faces toward the generator end of the plant. This will enable the air scoop on the cap to better catch the air flow.

LUBRICATION. - Keep the crankcase filled with service MS or DG type oil of the correct SAE Number as recommended in the following chart:

VISCOSITY TO USE	AT ATMOSPHERIC TEMPERATURE
SAE - 50	Above 100°F.
SAE - 30	Above 32°F.
SAE - 10	32°F(0°C.)to-10°F.(-23.3°C.)
SAE - 5W	Below -10°F. (23.3 °C.)

ENGINE OIL RECOMMENDATIONS

The crankcase capacity is 5 quarts plus an additional quart if the oil filter is changed. After the break-in oil is replaced use an oil of the proper SAE number, according to the lowest temperature to which the plant will be exposed, as indicated in the table. The temperatures indicated are for conditions where the plant will be standing idle long enough to cool off to the surrounding temperature.

Type MS or DG oil is a detergent type oil. The use of a non-detergent type oil is not recommended.

Keep the crankcase oil level at or near the upper level mark on the oil level gauge, but never above it. Do not attempt to check the oil level while the plant is running. If the crankcase is overfilled, the connecting rods may strike the oil, causing improper lubrication and excessive oil consumption. Never allow the oil level to fall to the low level mark on the oil level gauge.

Maintenance Schedule

	Daily or Each 10 Hours	Each 50 Hours	Each 100 Hours	Each 1000 Hours
Oil Level	X			
Coolant Level	X			
Clean Air Cleaner Cap; Clean Sump if Necessary	X			
Check Governor Oil Level		X		
Clean Air Cleaner Sump and Filter Element		X		
Clean Crankcase Ventilating System (Oil Fill Cap)		X		
Check Battery Electrolite Level and State of Charge		X		
Compression Pressure			X	
Engine Tune-Up			X	
Adjust Valve Lash			X	
Lubricate Distributor and Inspect and Adjust Points			X	
Check Carburetor and Choke Adjustment			X	
Check Governor Adjustments			X	
Check Oil, Fuel, and Cooling Systems For Leaks			X	
Change Engine Oil*			X	
Change Oil Filter Element*			X	
Drain and Flush Cooling System				X
Remove and Clean Oil Pan and Inlet Screen				X

*Each 50 Hours in Freezing Temperatures

FIG. 27 MAINTENANCE SCHEDULE

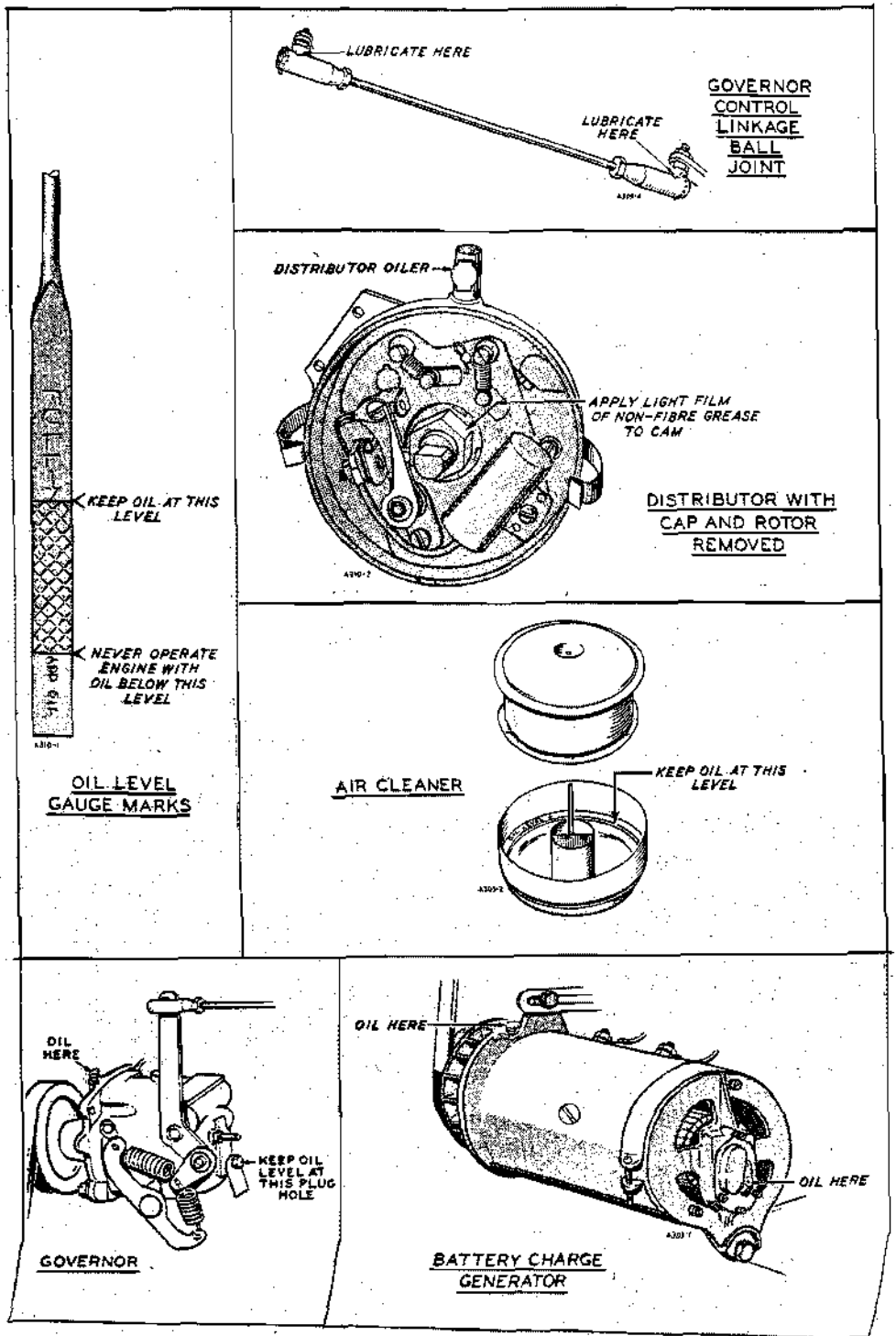


FIG. 28. LUBRICATION POINTS

The dip stick is located on the right hand side of the engine. It is preferable to check the oil level after the engine has been stopped for a period of time, such as over night. 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 parts shown in Figure 28 - lubricate at least every 100 operating hours or oftener as recommended under PERIODIC SERVICE. The same type of oil as used in the engine may be used to oil the distributor, and the battery charge generator. Pour a few drops of oil into the oil cup on the side of the distributor. Pour a few drops of oil into the oil cup on the top of the battery charge generator. Pour a few drops of oil into the hole at the end of the battery charge generator. 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.

See Figure 28 for illustration of lubrication points.

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.

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. 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.

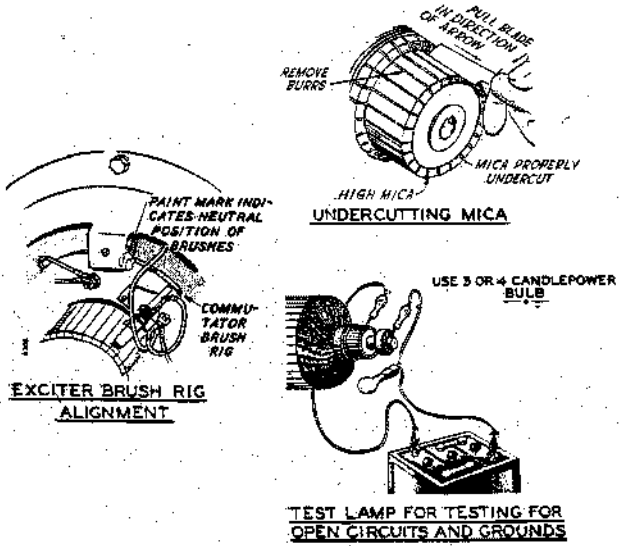
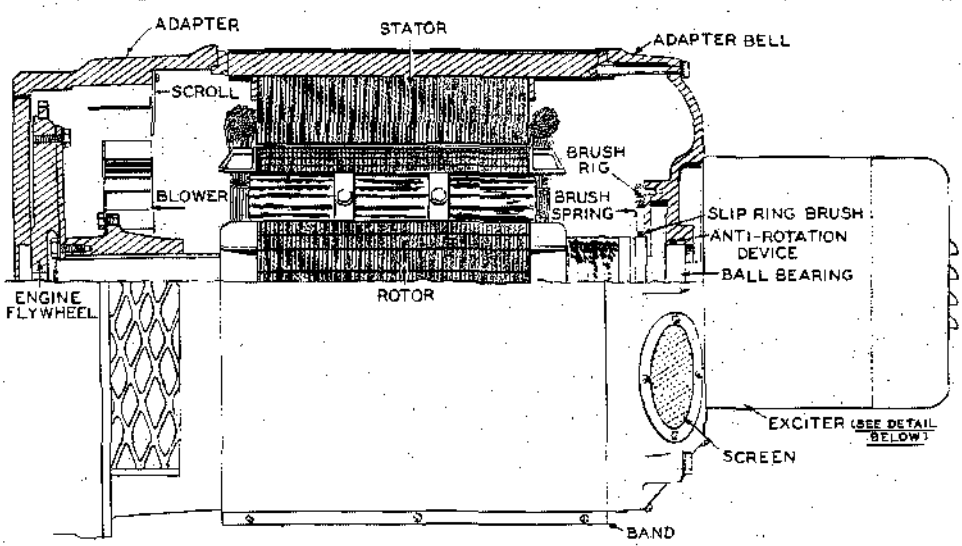
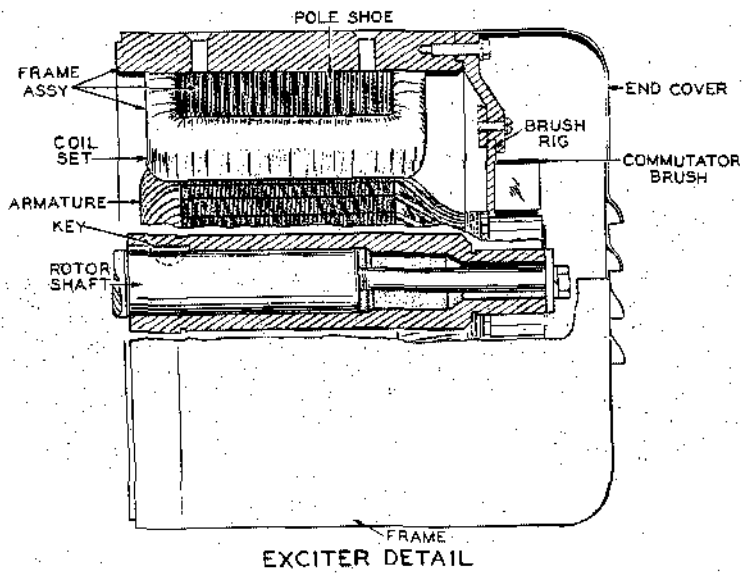


FIG. 29. GENERATOR MAINTENANCE

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.*





EXCITER DETAIL

FIG. 30. 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. See Figure 31.

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. Refer to the brush spring removal illustration Figure 31.

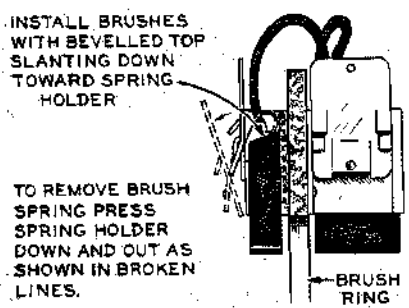


FIG. 31. BRUSH SPRING REMOVAL

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.

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.

TABLE OF CLEARANCES AND SPECIFICATIONS

GENERAL	
Horsepower @ r.p.m.	67.5 @ 1800
Taxable Horsepower	31.5
Bore (inches)	3.62
Stroke (inches)	3.60
Piston Displacement (cubic inches)	223
Compression Pressure @ Cranking Speed (p.s.i.)	125
Firing Order	1-5-3-6-2-4
Oil Capacity (qts.)*	5
Compression Ratio	7.5:1
Torque — Foot-Pounds @ r.p.m.	193 @ 1800
* Add 1 quart with filter change.	
CYLINDER BLOCK	
Cylinder Bore Diameter —Std. (inches)	3.6250-3.6274
Maximum Allowable Oversize Cylinder Bore(inch)	0.060
Allowable Cylinder Bore Out of Round - New Bore (Inch)	0.0005
Allowable Cylinder Bore Taper - New Bore (inch).	0.001
Main Bearing Bore Diameter (inches)	2.6912-2.6920
Camshaft Bearing Bore Diameter (inches)	2.0575-2.0585
Tappet Bore Diameter (inch)	0.500-0.501
CYLINDER HEAD	
Head Gasket Surface Flatness (inch)	0.004 overall
Valve Guide Bore Diameter - Intake & Exhaust (inch)	0.3430-0.3440
Valve Seat Width - Intake (inch)	0.060-0.080
Valve Seat Width - Exhaust (inch)	0.070-0.090
Valve Seat Angle	45°
Maximum Allowable Valve Seat Runout (inch)	0.002
CRANKSHAFT	
Number of Main Bearing Journals	4
Main Bearing Journal Diameter - Std. (inches).	2.4980-2.4988
Connecting Rod Journal Diameter - Std. (inches)	2.2980-2.2988
Main Bearing Journal Runout (inch)	0.002
Main Bearing Journal Out of Round (inch)	0.00025
Crankshaft End Play Controlled By Main Bearing Number	3
Maximum Connecting Rod and Main Bearing Journal Taper (inch)	*0.0005*
Maximum Connecting Rod Journal Out of Round (inch)	*0.00025*
Crankshaft End Play (inch)	*0.004-0.008*

PISTONS AND PISTON PINS

Piston Diameter - Std. (inches)	3.6241-3.6265
Piston to Cylinder Bore Clearance - at Bottom of Skirt (inch)	0.0006-0.0012
Piston Pin to Piston Clearance (inch)	0.0001-0.0003
Piston Ring Groove Width (inch) -	
Upper Compression	0.0955-0.0965
Lower Compression	0.0955-0.0965
Oil	0.1880-0.1890
Piston Pin Diameter - Std. (inch)	0.9120-0.9123
Oversize Piston Pins Available (inch)	0.001 and 0.002
Piston Pin Length (inches)	3.016-3.030
Piston Pin to Connecting Rod Bushing Clearance (inch)	0.0001-0.0003
Compression Rings Side Clearance (inch)	0.002-0.0035
Oil Ring Side Clearance (inch)	0.0015-0.0030
Piston Ring Gap Width - All (inch)	0.010-0.027
Piston Ring Gap Spacing	Stagger Gap

Service Piston Ring Sets Available-Std., 0.020, 0.030, 0.040, 0.060 O.S.

CAMSHAFT

Number of Bearings	4
Journal Diameter - Std. (inches)	1.9255-1.9265
Camshaft End Play	0.003-0.007
Journal Runout (inch)	0.005
Journal to Bearing Clearance (inch)	0.001-0.003
Bearing I.D. Installed in Block - Std. Bearing (inches)	1.9275-1.9285
Service Bearings Available	Std. and 0.015U.S.
Camshaft Lobe Lift - Intake and Exhaust (inch).	0.242

VALVE MECHANISM

Intake Valve Lash Setting-Hot (inch)	0.015
Exhaust Valve Lash Setting - Hot (inch)	0.019
Valves with O.S. Stems Available (inch)	0.003, 0.015, 0.030
Valve Stem to Guide Clearance - Intake (inch)	0.001-0.002
Valve Stem to Guide Clearance - Exhaust (inch).	0.002-0.003
Valve Spring Free Length (inches)	2.110-2.130
Valve Spring Pressure (pounds@ inches compressed)	54-62 @1.821 124-140 @1.505
Tappet to Tappet Bore Clearance (inch)	0.0005-0.002
Valve Stem Diameter - Std., Intake (inch)	0.3415-0.3425
Valve Stem Diameter - Std., Exhaust (inch)	0.3405-0.3415
Rocker Arm Bore Diameter (inch)	0.783-0.784
Rocker Arm Shaft O.D. (inch)	0.780-0.781

VALVE MECHANISM (CONT.)

Rocker Arm to Shaft Clearance (inch)	0.002-0.004
Maximum Push Rod Runout (inch)	0.020
Tappet Diameter - Std. (inch)	0.4990-0.4995

CONNECTING ROD

Piston Pin Bushing I.D. - Std. (inch)	0.9122-0.9125
Bearing Bore Diameter - Std. (inches)	2.4230-2.4238
Maximum Bearing Bore Out of Round (inch)	0.0004
Connecting Rod Length - Center to Center(inches)	6.258-6.262
Maximum Allowable Twist - Overall (inch)*	0.012
Maximum Allowable Bend - Overall (inch)*	0.004
Connecting Rod Side Clearance (inch)	0.003-0.009

* At ends of 8 inch arbor.

MAIN BEARINGS

Main Bearing to Crankshaft Clearance - No. 1, 2, and 3 (inch)	0.0005-0.0025
- No. 4	0.001-0.0029
Undersize Main Bearings Available (inch)	0.010, 0.020, 0.030, 0.040

CONNECTING ROD BEARINGS

Connecting Rod Bearing to Crank Pin Clearance (inch)	0.0007-0.0026
Undersize Connecting Rod Bearings Available (inch)	0.010, 0.020, 0.030

OIL PUMP

Oil Pump Capacity (G.P.M. @ r.p.m.)	9.2 @ 4000
Oil Pressure Relief Valve Spring Tension (pounds @ compressed length)	9.76-9.84 @ 1.56
Drive Shaft to Housing Bearing Clearance (inch).	0.0015-0.0029
Relief Valve Piston Clearance (inch)	0.0015-0.0035
Oil Pump Gears End Clearance (inch)	0.0015-0.0055
Driven Gear to Shaft Clearance (inch)	0.001-0.002

COOLING SYSTEM

Cooling System Capacity (quarts)	*16*
Water Pump Capacity (G.P.M. @ r.p.m.)	*23 @ 2000*
Thermostat Opening Temperature - Std. (°F).	*148-153*

COOLING SYSTEM (CONT.)

Thermostat Fully Open - Std. (°F)	173
Thermostat Opening Temperature - High Temp. (°F)	167-172
Thermostat Fully Open - High Temp. (°F)	192
Fan Belt Deflection (inch)	1/2
Generator Belt Deflection (inch)	1/4

FUEL PUMP

Pressure (p.s.i. @ r.p.m.)	4—5 @ 900
Volume (at idle speed)	1 pint in 45 seconds or less
Vacuum (inches Hg. @ r.p.m.)	6 @ 900

CARBURETOR

Fuel level - Below Power - Valve Mounting Surface (inch)	11/16 ± 1/32
Main Metering Jet (identification number)-	
0-5000 feet altitude	67
5000-10,000 feet altitude	65
10,000-15,000 feet altitude	63

SPARK PLUGS

GAP - (Gaseous Fuel)	0.018
Gap - 14 mm (Gasoline Fuel)	0.028-0.032
18 mm (Gasoline Fuel)	0.028-0.032
Torque - 14 mm (foot-pounds)	25-30
18 mm (foot-pounds)	15-20

DISTRIBUTOR

Contact Point Gap (inch)	0.024-0.026
Dwell Angle	35°-38°
Breaker Arm Spring Tension (ounces)	17-20
Initial Ignition Timing	20° B.T.D.C.

BOLT AND NUT TORQUE	Foot-Pounds
Main Bearing Cap Bolts	95-105
Cylinder Head Bolts (hot)	75
Oil Pan to Cylinder Block	12-15
Flywheel to Crankshaft	75-85
Exhaust Manifold to Cylinder Head	23-28
Intake Manifold to Cylinder Head	23-28
Oil Pump to Cylinder Block	30-35

BOLT AND NUT TORQUE (CONT.)	Foot-Pounds
Oil Pump Cover Plate	12-15
Oil Filter to Cylinder Block	20-25
Cylinder Front Cover	6-9
Water Outlet Elbow	23-28
Camshaft Sprocket to Camshaft	45-50
Damper to Crankshaft	85-95
Connecting Rod Nuts	45-50
Rocker Shaft Support to Cylinder Head	45-55
Valve Lash Adjusting Screw Lock Nut	30-35
Rocker Arm Cover	2.0-2.5
Push Rod Chamber Cover	2.0-2.5
Water Pump to Cylinder Block	23-28
Fuel Pump to Cylinder Block	12-15

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 antifreeze was left in the cooling system, check the level and add a 50-50 solution of water and the type of antifreeze originally used to bring the cooling liquid up to proper level. If desired, the antifreeze 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.
Excessive choking.	See that choke opens properly.
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.
EXCESSIVE OIL CONSUMPTION, LIGHT BLUE SMOKY EXHAUST	
Sludged rings, excessive bearing clearances, piston skirt collapsed, worn intake valve guides.	Replace worn parts.

POSSIBLE CAUSE	REMEDY
EXCESSIVE OIL CONSUMPTION, LIGHT BLUE SMOKY EXHAUST (CONT.)	
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.
Low oil supply.	Add oil.
Low oil pressure.	Refer to symptom of low oil pressure for remedies.
Oil badly diluted.	Change oil.

POSSIBLE CAUSE	REMEDY
ENGINE STOPS UNEXPECTEDLY	
Fuel tank empty.	Refill.
Fuel pump failure.	Repair or replace.
High water temperature.	See symptoms for engine overheating.
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 symptomof 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.
Valves hot.	Adjust tappet clearance.
Fuel stale or low octane.	Use good fresh fuel.
Lean fuel mixture.	Clean or adjust carburetor.

POSSIBLE CAUSE	REMEDY
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 ignition.
Poor choking.	If plant is cold, adjust choke. If plant is warm, pull up on choke arm momentarily, while cranking.
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.

POSSIBLE CAUSE	REMEDY
ENGINE RUNS BUT CURRENT DOES NOT BUILD UP (CONT.)	
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.
NOISY BRUSHES	
High mica between bars of commutator.	Undercut mica.

POSSIBLE CAUSE	REMEDY
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.