INSTRUCTION MANUAL

FOR

ONAN ELECTRIC GENERATING PLANTS

Series

HC

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

938-1 A A *Price $1.00* A Printed in U. S. A.

GENERAL INFORMATION

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

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

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

MANUFACTURER'S WARRANTY

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

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

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

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

RETURN WARRANTY CARD ATTACHED TO UNIT.

PLANT RUNNING HOURS
COMPARED TO AUTOMOBILE RUNNING MILES

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

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

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

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

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

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

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

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

This instruction manual is supplied to assist the operator in the proper installation and operation of the generating plant. Disregarding these instructions may lead to unnecessary trouble and expense. Keep this manual and the wiring diagram accessible for reference.

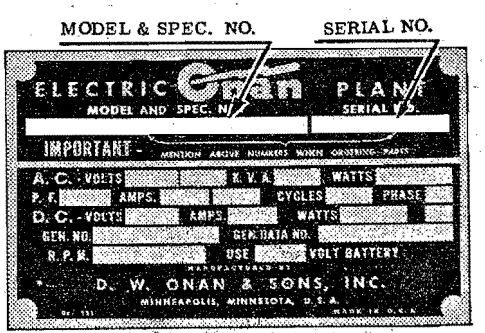
Each electric generating plant is given an acutal running test and is carefully checked under various electrical load conditions before leaving the factory, to assure that it is free of defects and will produce its rated output. Inspect the plant for any damage which may have occurred in shipment. Any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

The generating plant consists, basically, of an internal combustion engine and a self excited alternating current generator. The engine is a 4 cylinder gasoline burning type. The generator is a four pole, revolving armature type, directly connected to the engine. Accessories and controls suitable for a normal installation and according to the particular model are supplied. Housed models have a sheet metal housing for the plant and include an engine and electrical meter panel. Unhoused models are of the open construction with a box containing the necessary control parts mounted over the generator.

The radiator end of the plant is designated as "Front End" and the carburetor side is designated as "Left Side" of the plant by D. W. Onan & Sons Inc.

ALWAYS REFER TO THIS PLANT BY NAMEPLATE INFORMATION

TAKE THE INFORMATION STAMPED ON THE *PLANT* NAMEPLATE (NOT *ENGINE* NAMEPLATE).



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If it ever becomes necessary to contact the factory or an Authorized Service Station in regard to this generating plant, be sure to refer to the nameplate information as shown. This information must be known in order to properly identify the plant and to enable proper advice to be given.

This instruction manual is supplied with all generating plants of the HC Series. Instructions apply specifically to the standard models. Some details may not apply to special models. Some special installation or operating conditions may require the operator of this plant to modify these instructions. However, by following as closely as possible the recommendations as given in this book and by referring to the plant wiring diagram, the operator should have no difficulty in making a good installation and in properly operating the generating plant.

ENGINE DETAILS

The engine is a Continental Model F 162, specification 1360. It has 4 cylinders, L head, 3-7/16" bore, 4-3/8" stroke, 162 cu. inch total piston displacement, 6.8 to 1 compression ratio, 41.0 horse power at 1800 rpm.

The cooling system is approximately 10-1/2 quarts, U.S. standard measure. Full length water jackets surround the cylinder and valve seats. A belt driven, prelubricated, ball bearing water pump maintains circulation of the engine coolant. The temperature of the coolant is controlled by a thermostat and a by-pass. A pusher type fan forces cooling air out through the front of the radiator. The radiator cap is of the pressure type.

The crankcase oil capacity is 4 quarts (U.S. measure) plus approximately 1 pint used in the operation of the oil filter. A gear type oil pump supplies pressure lubrication to main, connecting rod, and camshaft bearings.

Main and connecting rod bearings are precision type replaceable liners. All valves are positive rotator type. Exhaust inserts are used. Valve tappets are adjustable. Firing order is 1-3-4-2. 60 cycle plants run at approximately 1800 rpm. 50 cycle plants run at approximately 1500 rpm. The engine speed is controlled by a flyweight type, gear driven governor.

The engine has a 12 volt battery ignition system which is radio noise suppressed and a 12 volt charging generator with charging rate automatically regulated.

The choke is automatic. Standard models burn gasoline fuel and have an up draft carburetor with an adjustable main jet. Special models are equipped to burn gas fuel (natural gas or liquid petroleum gas, depending upon the model).

GENERATOR DETAILS

AC GENERATOR

The alternating current generator is a revolving armature, self excited, inherently regulated type. The inherent design of the generator with saturated, 4 pole, shunt wound field, assures close regulation of voltage between no load and full load conditions. A special series winding in the field of the remote starting models permits the generator to be used as a starting motor. The armature, connected directly to the engine flywheel, is supported at the engine end by the engine rear main bearing, and at the outer end by a large ball bearing. 50 cycle generators operate at approximately 1500 rpm, and 60 cycle generators operate at approximately 1800 rpm.

CONTROLS

The housed plants will have the following as standard equipment; voltmeter, ammeter, circuit breaker, oil gauge, charge meter, water temperature gauge, start-stop switch and an electric hand crank switch.

The open plants will have the following as standard equipment; charge meter, oil gauge, water temperature gauge, start-stop switch and an electric hand crank swicth

OPTIONAL EQUIPMENT

"DAY" FUEL RESERVOIR TANK. - The "DAY" 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, thus insuring against starting failure due to a partially filled carburetor.

AUTOMATIC CONTROL. - The automatic control provides for automatic starting and stopping of the plant. When an electrical load is turned on, the generating plant starts and continues to run until the electrical load is turned off.

LINE TRANSFER. - The line transfer is designed particularly for standby service. Upon failure of the regular source of power, the line transfer disconnects the load from the regular power supply line, starts the plant, and connect the load line to the plant. The plant continues to run, regardless if load is connected or not, until the regular power supply is restored. The transfer control then disconnects the load line from the plant, stops the plant, and connects the load line to the regular power supply line.

IMPORTANCE OF PROPER INSTALLATION. - Satisfactory and dependable performance of the generating plant is dependent to a great extent upon the proper installation. Location and ventilation are important factors to consider in the plant installation.

LOCATION. - Locate the plant centrally in relation to the electrical load. For example, two buildings 500 feet apart are to be supplied with current from the generating plant. If the amount of the electrical load is approximately equal to each building, the ideal location for the generating plant would then be at a point midway between the two buildings. If most of the electrical load will be concentrated in one building, the generating plant should then be located in or near that building. Each installation differs in this respect.

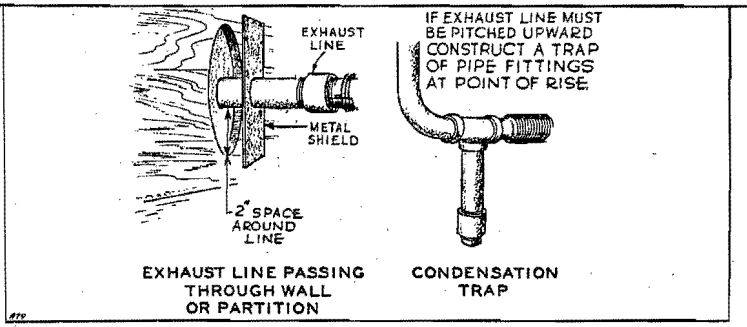
Avoid as much as possible the use of long electric lines. Long lines require larger size wire to avoid excessive voltage drop. Be sure to use large enough wire, taking into consideration distance, electrical load, and permissable voltage drop. Consult a licensed electrican if in doubt.

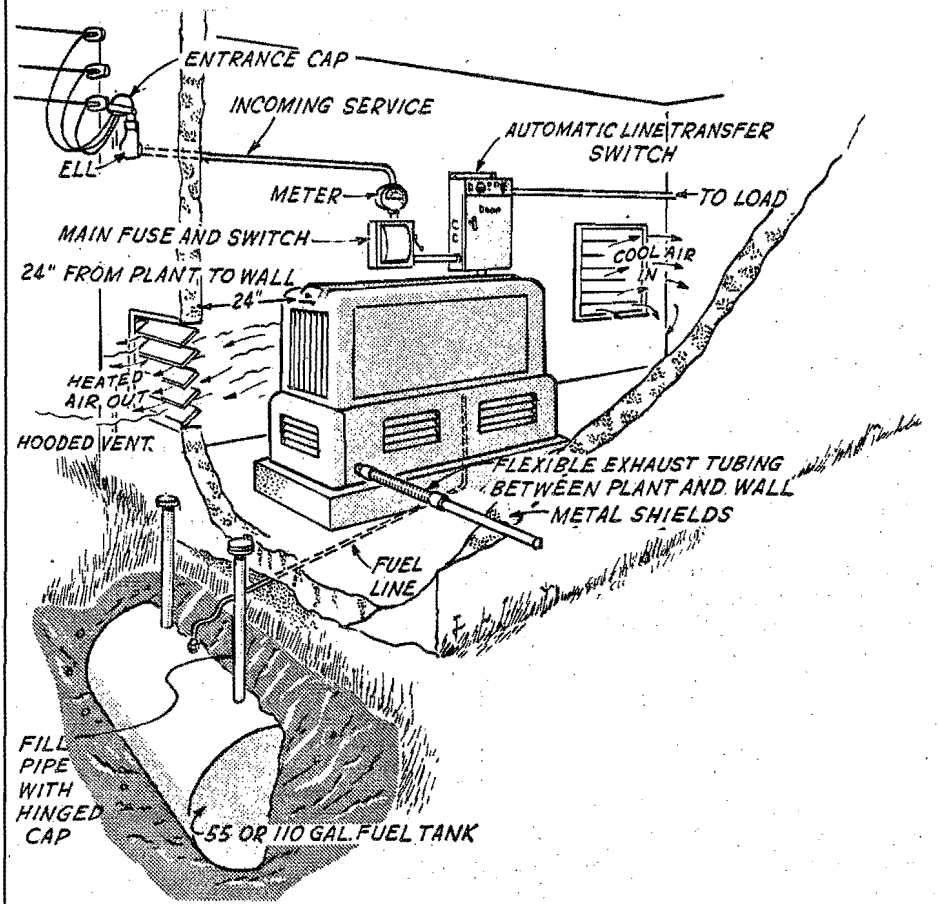
Select a site for the generating plant which will be dry, clean, and well ventilated. Choice of either a damp or dusty location will require more frequent inspection and servicing of the plant. If practicable, install the plant inside a building or covered vehicle for protection from extremes in weather conditions.

MOUNTING. - For permanent installations, a raised platform of concrete or heavy timber on which to mount the plant will be a convenience in servicing the plant. The plant may be bolted down in position if desired. Allow at least 24 inches of space on all sides of the plant for convenience in servicing.

If the plant is mounted in a mobile vehicle, be sure the plant is bolted securely in place so that it can not shift when in transit. The plant must be set approximately level when in operation.

VENTILATION. - The plant generates a considerable amount of heat which must be dissipated by proper ventilation. Engine heat is removed by a pusher type fan which blows cooling air out through the front of the radiator. For room or compartment installations, provide an opening at least as large as the radiator area for exit of the heated air. This opening should be directly in front of the radiator, and as close to the radiator as practicable. It may be necessary to construct a duct from the front of the radiator to the outdoors. In cold weather, some method of controlling the air flow should be provided, so that the temperature of the room can be kept at a normal point. Generator cooling air is discharged from the flywheel housing on the right side of the engine. Provide an outlet for this heated air. See that the air heated by





Typical Onan Standby Installation

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

the plant will not be recirculated to the plant. Provide for the free entry of fresh air. Consult the dealer or factory if special ventilation problems arise. The plant can be adapted to piping fresh cooling water through the engine.

EXHAUST. - Exhaust gases are deadly poisonous and must be piped outside if the plant is installed indoors. Excessive inhalation of exhaust gases may cause serious illness or death. The exhaust outlet is 1-1/2" standard pipe size. Use pipe at least as large as the outlet size for the first 10 feet and increase pipe diameter one size for each additional 10 feet in length. Avoid sharp turns as much as possible. If the line passes through an inflammable wall, shield the wall by passing the line through properly insulated metal collars. If the exhaust line is lengthy or rises from the plant muffler, provide a means of draining condensation periodically.

UNDERGROUND MUFFLER. - If exhaust noise from the standard muffler will be objectionable, an underground muffler may be constructed. Use a heavy 10 gallon or larger tank or drum. If the tank contained any inflammable material, be sure all fumes are exhausted before starting to work on it. Weld suitable pipe fittings to the tank, for inlet and outlet pipes. Perforate the bottom of the tank, for condensation to drain out. Bury the underground muffler in loose gravel. Extend the outlet pipe at least 24 inches above the ground and fit it with a gooseneck fitting to avoid entrance of rain or snow. If there is any possibility of an underground muffler filling with water at any time, the underground muffler can not be used.

FUEL SUPPLY, GASOLINE. - When installing a separate gasoline tank, the lift of the fuel to the fuel pump on the plant must not be more than 6 feet. The horizontal distance between the tank and the plant should not exceed 50 feet. If the fuel outlet of the tank is at the top of the tank, a drop or suction pipe must extend down to within an inch or two of the tank bottom. All connections between the fuel tank and the fuel pump must be tight. An air leak will prevent pumping of fuel to the plant.

Tanks of 55 gallon or 110 gallon capacity, and 25 or 50 ft. fuel lines for underground installation are available through the dealer from whom the generating plant was purchased. Observe local underwriters codes regarding the installation of any fuel tank.

The fuel pump inlet on the plant is for 1/4 inch inverted flare tubing connection. For some installations, it will be necessary to remove the inverted connection from the fuel pump elbow, which is threaded with standard 1/8 inch pipe thread.

NATURAL GAS OR VAPOR FUEL. - Some special model plants are equipped to burn LPG or natural gas fuel, and some are fitted with heat exchanger equipment. Any applicable gas codes must be complied with when connecting the plant to a source of gas fuel.

INSTALLING GARRETSON SECONDARY GAS REGULATOR. - This secondary regulator is designed to operate on an incoming line pressure of from 3 to 8 ounces. If the line pressure exceeds 8 ounces, a primary regulator must be installed and adjusted to reduce the line pressure before it enters the secondary regulator.

A fuel filter should be installed in the line, before the secondary regulator to prevent pipe scale and other impurities from entering the regulator.

The illustration shows how the parts are to be assembled to the regulator.

1. Assemble the 3/4" (B) and 1/8" (C) pipe plugs to the regulator.
2. Assemble the pipe nipple (K), elbow (D), and half nipple (E) as shown.
3. Some installations require a fuel filter. Install the filter in the incoming fuel line ahead of the regulator as shown.
4. Install the regulator to the 3/4 inch incoming fuel supply line. Turn the regulator to an upright position and support the supply line so as to serve as a mounting for the regulator.

To adjust the regulator see the section ADJUSTMENTS. No carburetor choking is required for this type of regulator.

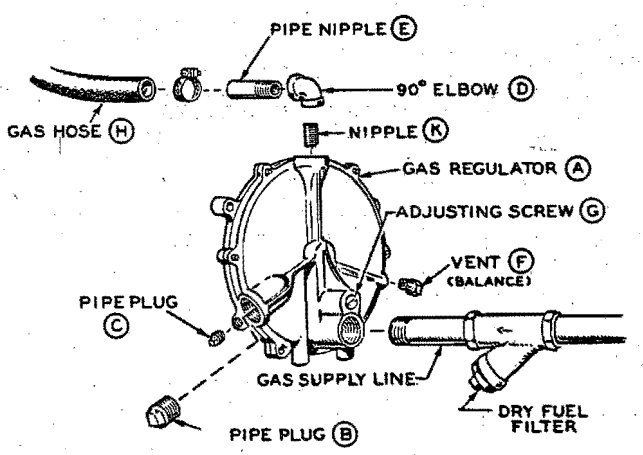


FIG. 2 - REGULATOR

BATTERY. - One 12 volt battery is required. Connect the battery cable attached to the start solenoid switch to the positive (+) post of the battery. Connect the battery cable which is grounded, to the negative (—) post of the battery. It may be necessary to spread the positive cable clamp slightly to make it fit over the post. Do not pound on the clamps to force them down on the posts. Tighten the clamps securely and coat lightly with light grease or vaseline to minimize corrosion deposits.

A "WET" (ready for use) starting battery is sometimes supplied with the plant. This battery is in a well charged condition when shipped from the factory. However, if the battery is not placed in service within 30 to 40 days, it may have become partly discharged. If such is the case, the battery should be given a freshening charge before being placed in service. If a "DRY" battery is supplied, it must be prepared for use according to the instructions given on the tag attached to the battery.

CONNECTING THE LOAD WIRES

HOUSED PLANTS. - The AC output terminal block, to which the load wires are to be connected, is located in the control panel. Be sure to use sufficiently large insulated wire. The connections must be made to conform to applicable electrical codes. Follow the directions for connecting to the plant terminals as given, according to the type of plant. Load connections are to be made to terminals marked M1, M2, M3 and M4.

115 VOLT, SINGLE PHASE, 2 WIRE PLANT. - One terminal post is grounded. The "M1" terminal post is "hot". Connect the neutral or ground load wire to the plant terminal post marked "M4". Connect the "hot" load wire to the plant terminal post marked "M1". Refer to A, Figure 3.

115/230 VOLT, SINGLE PHASE, 3 WIRE PLANT. - The terminals "M2" and "M3" are grounded. Terminals "M1" and "M4" are "hot". For 115 volt current connect the neutral load wire to the plant terminal post marked "M2" or "M3". Connect the "hot" load wire to either of the two outside terminals "M1" or "M4". Two separate 115 volt circuits are thus available with not more than 1/2 the total plant rating available on each circuit. Balance the load as closely as possible between the two circuits. Refer to C, Figure 3.

For 230 volt current, connect the load wires to the plant terminals "M1" and "M4", leaving the center "M2" and "M3" terimnals unused. Refer to B, Figure 3.

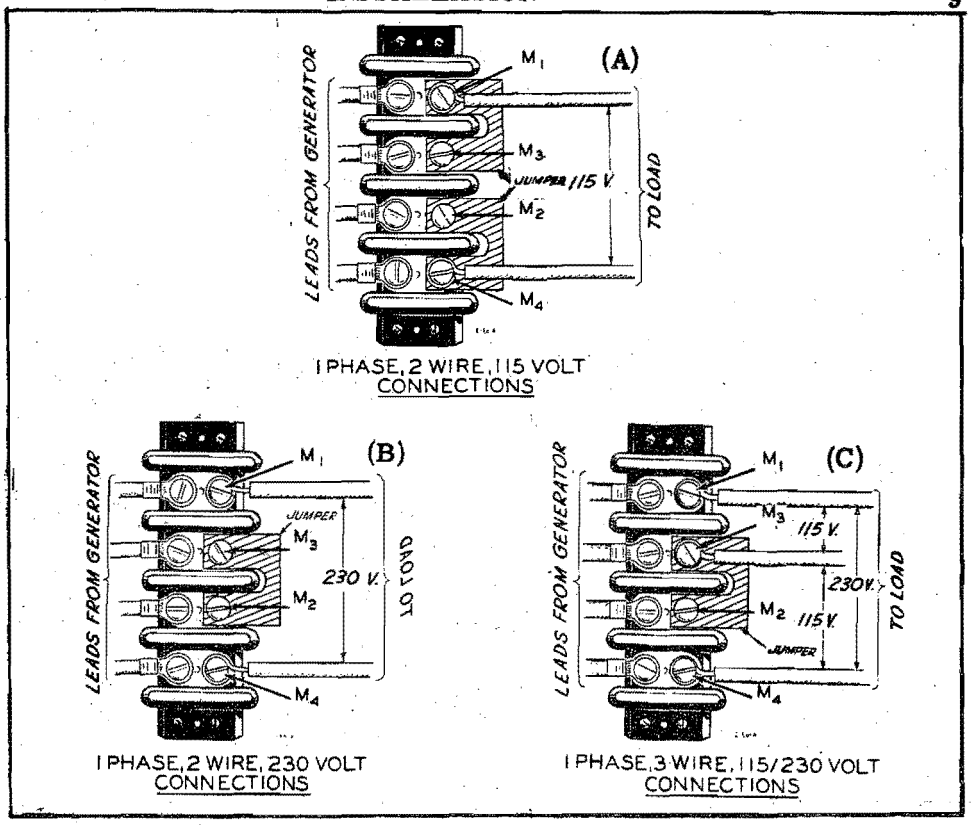


Fig. 3 Single Phase Plant

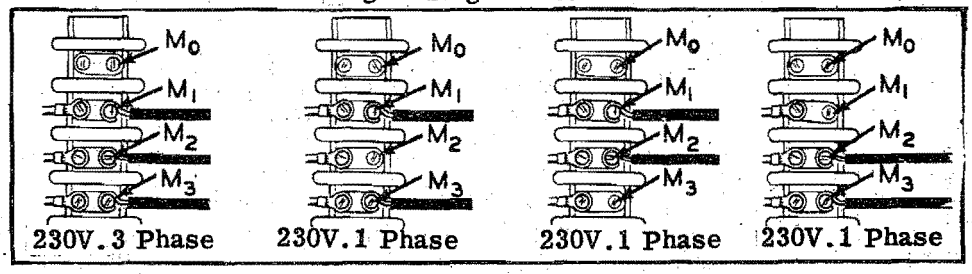


Fig. 4 Three Phase, Three wire

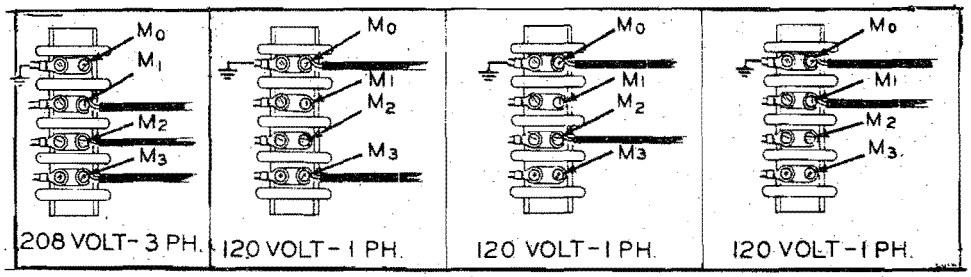


Fig. 5 Three Phase, Four Wire Plant

230 VOLT, THREE PHASE, 3 WIRE PLANT. - No terminal is grounded. For three phase current, connect a separate load wire to each plant terminal, "M1", "M2" and "M3", one wire to each terminal. Reversing the connections between any two terminals will reverse the direction of rotation of 3 phase motors. Use a phase sequence indicator to assure in-phase connection. Refer to Figure 4.

To obtain 230 volt, single phase current, connect separate load wires to each of any two plant terminals, one wire to each terminal. Three 230 volt, single phase circuits are thus available, with 1/3 the plant rating to each circuit. Balance the load as closely as possible between the circuits.

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 4,000 watt load is used. This leaves 6,000 watts available for single phase, if the plant capacity is 10,000 watts. One third of this 6,000 watts is 2,000 watts, which is the amount that may be taken from each of the 3 single phase circuits. Do not attempt to take all 6,000 in this example off one circuit, as overloading of generator will result.

120 VOLT, SINGLE PHASE /208 VOLT, THREE PHASE, 4 WIRE PLANT. - The "M0" terminal is grounded. For 120 volt, single phase current, connect the grounded load wire to the "M0" plant terminal, and the other load wire to any one of the other three terminals "M1" "M2" or "M3. Three 120 volt, single phase circuits are thus available, with 1/3 the plant rating to each circuit. Balance the load as closely as possible between the circuits. Refer to Figure 5.

For 208 volt, three phase current, connect a load wire to each of the three terminals "M1", "M2" and "M3" leaving the "M0" terminal unused. Reversing the connections between any two terminals will reverse the direction of rotation of 3 phase motors. Use a phase sequence indicator to assure in-phase connection.

For 208 volt, single phase current, connect separate load wires to each of any two insulated (three lower) terminals,one wire to each terminal. Three circuits are thus available, with 1/3 the plant rating to each circuit. Balance the load as closely as possible between the circuits. If both single and three phase current is used at the same time, see the directions for the three phase, three wire plant.

UNHOUSED PLANTS. - The AC output terminal block, to which the load wires are to be connected, is located in the control panel. Load wires must be of the proper size of insulated

wire, taking into consideration the distance involved and the amount of the load. The installation must meet requirements of electrical codes which apply in the locality. Connections must be properly made and insulated. Install an approved switch or other device for disconnecting the plant from the load. Consult a licensed electrician if in doubt.

115/230 VOLT, SINGLE PHASE, 3 WIRE PLANT. - Connect generator leads marked "M2" and "M3" together. This will be the "neutral" load connection lead. For 115 volt, 3 wire, connect the neutral (white) load wire to the "M2", "M3" terminal. Connect two separate black (hot) load wires, one to each of the "M1" and "M4" terminals. Two 115 volt circuits are thus available, one between "M1" and "M2", "M3" and the other between "M4" and "M2", M3". One half the capacity of the generator is available on each circuit. Do not attempt to take the entire generator capacity of 115 volt current from one circuit only, as the generator will be unbalanced and overloaded. Divide the load between the two circuits as equally as is practicable. Refer to C, Figure 3.

NOTE

If the full generator capacity is desired on a single 115 volt circuit, connect terminals "M1" and "M3" together, then "M2" and "M4" together. Connect one load wire to the "M1" "M3" terminal and the other load wire to the "M2", "M4" terminal. For 230 volt service, do not connect a load wire to terminals "M2", "M3" which must be connected together with a jumper bar. Connect one load wire to the terminal "M1", and the other load wire to the terminal "M4".

SINGLE PHASE 120 VOLT, 3 PHASE 208 VOLT, 4 WIRE PLANT. - For 120 volt, 1 phase current, connect the neutral (white) load wire to the terminal marked "M0". Connect a "hot" (black) load wire to either "M1", "M2, or "M3". Three separate 120 volt circuits are thus available: "M0"-"M1", "M0"-"M2", and "M0"-"M3". When using single phase current, not more than one third of the capacity of the generator is available on each of the three single phase circuits. Divide the load as equally as possible between the three single phase circuits. See Figure 5.

For 208 volt, 1 phase current, the "M0" terminal is not used. Connect separate load wires to any two of the "M1", "M2", or "M3" terminals. Three separate single phase circuits are available: "M1"-M2", "M1"-"M3", and "M2"-"M3". As when connected for 120 volts, the load should be divided between the three single phase circuits.

For 3 phase current the "M0" generator lead is not used. Connect the three load line wires to the terminals "M1", "M2" and "M3", one load

wire to each terminal. Reversing the connections between any two terminals will reverse the direction of rotation of 3 phase motors.

If both single phase and three phase current is used at the same time, use care not to overload or unbalance the generator. Subtract the amount of the three phase load from the total capacity of the generator. Divide the remainder by three to determine the amount of load which may be connected to each single phase circuit. Refer to the "housed plant" load connections for an example. Do not attempt to take the entire single phase load off one circuit, unless the load is a small one.

3 PHASE, 3 WIRE PLANT. - For a 3 phase current, connect the three load wires to the terminals "M1", "M2" and "M3, one wire to each lead. Reversing the connections between any two leads will reverse the direction of rotation of 3 phase motors. Refer to Figure 4.

For single phase current, connect a separate load wire to each of any two terminals. Three separate single phase circuits are thus available: "M1"-"M2", "M2"-"M3" and "M1"-"M3". Not more than one third of the generator capacity is available on each single phase circuit.

If both single and three phase current is used at the same time, follow the principles of load distribution as directed for the 4 wire plant.

REMOTE CONTROL CONNECTIONS

A small, four place terminal block marked "B+, 1, 2 and 3" is provided for connecting start-stop stations. The terminal block is located inside the control box. One or more remote control switches may be connected to this block for remote starting and stopping. Connect the switch terminals as illustrated, to the terminals No. 1, 2, and 3 on the terminal block. Terminal number 1 is used as a common ground, terminal number 2 connects to the stopping circuit of the plant and terminal number 3 connects to the starting circuit of the plant. The terminal marked B+, is to be used only with an automatic control installation. The wire length from the plant to the switch determines the wire size necessary. Use #18 wire up to 75 feet, #16 wire up to 120 feet, #14 wire up to 200 feet, and #12 up to 300 feet. If automatic line transfer equipment is to be connected, follow the directions supplied with the equipment.

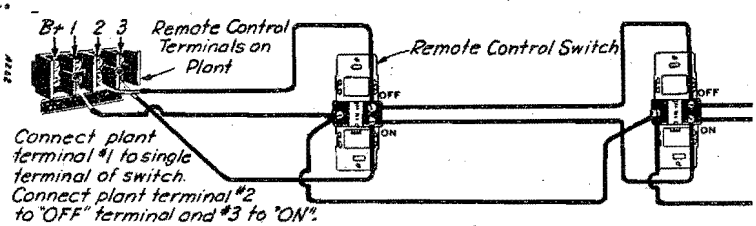


FIG. 6 - REMOTE CONTROL CONNECTIONS

RESERVOIR TANK (OPTIONAL). - A reservoir fuel tank, commonly called a "DAY" tank, may be installed, as illustrated. Fuel from this tank flows by gravity to the carburetor to replace any fuel lost by evaporation and insures quick starting after an idle period.

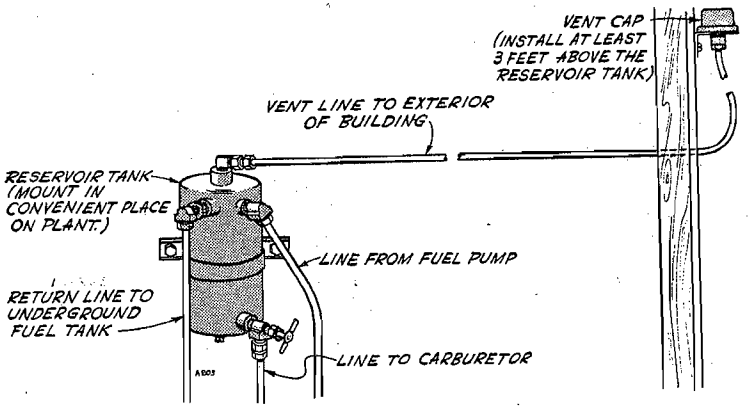


FIG. 7 - RESERVOIR FUEL TANK

CITY WATER COOLED PLANTS. - The engines powering these special model plants are cooled by passing a controlled flow of fresh cool water through the engine cooling system. The plumbing requirements will vary according to the particular installation. If water impurities exist (such as calcium, alkali, iron, etc.) in a ratio great enough to eventually restrict the cooling system, install a filtering device to purify the water before entering the engine.

A chemical process, which protects from rust and mineral caking, is available. Details concerning this Model A "Aqua-Clear" process may be obtained from Sudbury Laboratory Inc., Box 487, South Sudbury, Massachusetts, U.S.A.

PREPARATION FOR OPERATION. - Before putting the plant in operation, supply it with fuel, oil, and water (or anti-freeze liquid). Comply with the following instructions.

LUBRICATION. - Fill the crankcase with 4 quarts (U.S.Measure) of a good quality heavy duty oil classified by the American Petroleum Institute as Service "DG" or, as marketed by most manufacturers, "MS/DG". The use of service "DS" is satisfactory, but its higher cost is not justified. Approximately 1 pint of oil remained in the oil filter when the crankcase was drained at the factory. Do not use an oil heavier than SAE number 20 in a plant being put into service the first time. After the first oil change, use an oil of the proper SAE number, according to the lowest temperature to which the plant will be exposed, as indicated in the following table. The temperatures indicated are for conditions where the plant will be standing idle long enough to cool off to the surrounding temperature.

TEMPERATURE	SAE NUMBER OF OIL
Above 32°F. (0°C.)	30
32°F. to 0°F. (0°C. to -18°C.)	10
Below 0°F. (-18°C.)	5W or 10W (As required for engine starting).

If SAE number 5W oil is not obtainable for use in temperatures below 0°F., use diluted number 10W oil as directed under ABNORMAL OPERATING CONDITIONS - LOW TEMPERATURES.

The use of a heavy duty (detergent) type of oil will help to increase the life of pistons and rings. If a change to a detergent type oil is made after using non-detergent oil in this plant, allow not more than one third the usual operating hours between the next two oil changes. Thereafter, change the crankcase oil at the regular periods, as recommended under PERIODIC SERVICE.

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.

Place a drop of non-gummy oil on each of the ball joints of the governor to carburetor control linkage.

AIR CLEANER. - Remove the bottom cup of the air cleaner and fill to the "OIL LEVEL" mark with oil of the same SAE number as that used in the crankcase. Be sure the bottom cup is properly reinstalled.

FUEL, GASOLINE. - The fuel pump inlet is provided with a fitting for 1/4" inverted flared tubing. If necessary to replace the inlet fitting with another type, be sure the replacement fitting has 1/8" pipe threads to fit the fuel pump inlet.

If the plant is equipped with a fuel tank mounted inside the plant housing, the tank capacity is 15 gallons, U.S. Measure. 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. The gasoline level gauge is attached to the gas tank cap. Remove the gas tank cap to check the amount of fuel in the tank. Do not fill the tank when the plant is running.

Use fresh, clean "regular" grade gasoline. Do not use premium grade gasoline. If highly leaded gasoline is used, more frequent carbon and lead removal, valve grinding and spark plug servicing will be necessary. However, do not use a low octane fuel, such as "stove gas".

FUEL, GAS. - If the plant is equipped to burn gas fuel, observe provisions of local gas codes in connecting to a source of gas fuel. The Garretson regulator furnished with the plant is a secondary or atmospheric type, capable of handling line pressure up to 8 ounces. If the pressure exceeds 8 ounces, install a primary type regulator in the line to reduce the pressure to 8 ounces or less.

RADIATOR. - The capacity of the cooling system is 10-1/2 quarts U.S. Measure. Be sure both drain cocks are closed. Use clean, alkali free (soft) water. Clean rain water may be used. The use of a rust and scale preventative in the cooling system is recommended.

If the plant will be exposed to freezing temperatures, use a standard anti-freeze solution. Use the correct proportion of anti-freeze as recommended by the anti-freeze manufacturer, depending upon the lowest temperature to which the plant may be exposed. To avoid loss of anti-freeze through the radiator overflow pipe, due to expansion of the coolant as the plant warms up, fill only to between 1 or 2 inches below the bottom of the filler neck.

After the instructions under INSTALLATION and PREPARATION have been carefully complied with, the plant should be ready for operation. However, before starting the plant, carefully study the sections headed OPERATION and ABNORMAL OPERATING CONDITIONS immediately following.

PRELIMINARY. - Before starting the plant, be sure that it has been properly installed and prepared for operation. Turn on the fuel supply and check for leaks, correcting any that may be found. Be sure that no electrical load is connected to the generating plant.

STARTING THE PLANT ELECTRICALLY. - Set the ignition toggle switch at the ELECT. START position. Press the START switch to electrically crank the engine. On a plant being started for the first time, or one which has run out of gasoline, it will be necessary to allow the engine to crank long enough to allow the fuel pump to become full and to pump gasoline to the carburetor. Do not crank steadily, but in periods of approximately five seconds each, with five seconds intervals between crankings.

When the carburetor receives sufficient fuel, the plant should start. Carburetor choking is automatic. As the engine starts to fire, hold the START switch in contact until the plant has picked up running speed.

After the first start, the plant should start within a few seconds of cranking. Failure to start promptly is usually an indication of trouble in the fuel or ignition systems, and the cause of the trouble should be found and corrected.

NOTE

Sometimes, when the plant is stopped for a short time and an attempt to restart is made while the engine is still hot, it may be necessary to pull up on the automatic choke arm momentarily while cranking. The engine starts at full open throttle position, and so may require some choking under certain hot conditions.

If the generating plant is equipped for the use of gas fuel as well as gasoline fuel, the automatic choke control mounted atop the exhaust manifold is fitted with a lock device. See that the operating arm of the automatic choke is locked in the down position, so that the choke can not operate. NO CHOKING IS NECESSARY WHEN OPERATING ON GAS FUEL, AND THE CARBURETOR CHOKE VALVE SHOULD BE WIDE OPEN.

Turn on the gas fuel supply and press the START switch. Release the START switch when the plant reaches running speed. The plant was test run on 1000 BTU gas, and if a different BTU content gas is used, it may be necessary to readjust the carburetor gas adjustment valve slightly to assure smooth and economical operation. See the section headed ADJUSTMENTS.

STARTING THE PLANT MANUALLY. - If the starting battery lacks sufficient power to crank the

engine, or the engine can not be cranked electrically for some other reason, the plant can be started manually.

To start the plant manually, see that the fuel system is ready for operation, as explained under STARTING ELECTRICALLY. Throw the ignition switch to the HAND START position. Engage the hand crank and crank the engine, using a quick upward pull on the crank handle. Do not "spin" the crank. The automatic choke provides full choking action only when the START switch is in contact, so it is necessary to block or hold up the choke arm for a few preliminary crankings. After the plant starts and has reached running speed, throw the ignition toggle switch to the ELECT. START position.

STANDBY SERVICE. - When the generating plant is used for standby service, upon failure of a regular source of electrical power, it is essential to start the plant regularly. If practicable, start the plant once each week and allow to run for approximately 30 minutes. The generating plant should never be allowed to stand for more than a week without such a "dry" run.

If the plant will start but does not continue to run, start the plant manually with the ignition switch in the HAND START position. If the plant continues to run with the ignition switch at the HAND START position, but stops when the switch is thrown to the ELECT. START position, trouble is indicated in one of the relays or a loose connection. Failure of the battery charging generator to deliver current to the stop relay will also prevent the plant from running with the ignition switch at the ELECT. START position.

CAUTION. - KEEP THE IGNITION TOGGLE SWITCH AT THE ELECT. START POSITION AT ALL TIMES EXCEPT WHILE ACTUALLY STARTING THE PLANT MANUALLY OR WHEN MAKING TESTS. WHEN THE SWITCH IS AT HAND START POSITION THE PLANT CAN NOT BE STOPPED REMOTELY NOR BY PRESSING THE STOP SWITCH AT THE PLANT. IF THE SWITCH IS LEFT AT THE HAND START POSITION WHEN THE PLANT IS NOT RUNNING, THE BATTERY MAY BECOME DISCHARGED!

CHECKING THE OPERATION, HOUSED PLANTS. - After the plant starts, allow the engine to reach operating temperature. Check the level of the coolant in the radiator, as the thermostat may have allowed an air pocket to from, thus preventing complete filling. Add coolant to bring the level to the proper point, if necessary. The oil pressure should be between 20 and 30 pounds, the coolant temperature approximately 150° to 180° F. (65° to 82°C.), and the battery charge rate between 2 and 20 amperes, depending upon the charge condition of the battery.

When the plant is not in operation, the water temperature gauge will register 212°F. The oil pressure gauge and charge ammeter will register zero. If it is desired to check the water temperature when the plant is not running, throw the ignition switch to the HAND START position while making the observation. Be sure to return the switch to the ELECT. START position after making the observation. While the plant is running, the various gauges are automatically in operation when the ignition switch is at ELECT. START position.

Connect a load to the plant by throwing the circuit breaker handle to the ON position. If the plant tends to surge, it is an indication the engine needs additional warm-up before connecting a heavy load.

The electrical meters indicate the output voltage and the amount of load connected to the output terminals. At no load, the voltage should be slightly above the nameplate rating, and with a full load the voltage should be slightly below the nameplate rating.

If the voltmeter reading fluctuates, investigate for possible fluctuating load conditions before attempting any adjustments on the plant carburetor or governor.

The circuit breaker will open automatically and disconnect the load if the plant is severely 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.

CHECKING THE OPERATION, UNHOUSED PLANTS. - The unhoused plant is not equipped with the instrument panel supplied on the housed plant. The absence of the various instruments does not affect the efficiency of the plant in any way, but does impose upon the operator the responsibility of becoming sufficiently familiar with the performance of the plant to recognize any abnormal condition before damage may be done.

HIGH WATER TEMPERATURE SWITCH. - The high water temperature switch is standard equipment on the HC series plants. If the engine water temperature rises to a dangerous point, the cut-off switch operates to automatically ground out the ignition, having the same effect as pressing the stop button on the plant. The engine must cool off approximately 10°F. before it can be restarted, after the cut-off switch has operated. Before attempting to start the plant after the cut-off switch has operated, determine and correct the cause of the high temperature.

LOW OIL PRESSURE SWITCH. - Some plants are equipped with a low oil pressure cut-off switch. On these plants, if the engine oil pressure falls to approximately 6 pounds, the cut-off switch operates to ground out the ignition, stopping the plant.

Determine and correct the cause of the low oil pressure before attempting to again start the plant.

EMERGENCY OPERATION

If a burned out relay, switch, or other temporary difficulty prevents normal operation of the plant with the ignition switch at the ELECT. START position, the plant may be run with the switch at the HAND START position. This is purely an emergency measure and should be resorted to only if necessary. All relays, etc. are cut out of the engine control circuit. Keep a careful check on the plant while operating under these conditions.

STOPPING THE PLANT. - If practicable, disconnect the electrical load. Press and hold the STOP switch firmly. The switch is a momentary contact type and must be held at STOP position until the plant completely stops. The ignition switch must be at the ELECT. START position, as pressing the STOP button will have no effect if the switch is at the HAND START position.

LOW TEMPERATURES

Lubrication, fuel, and the cooling system require special attention at temperatures below 32°F. (0°C.).

CRANKCASE OIL. - If the plant must be started after standing unused in temperatures between 32°F. (0°C.) and 0°F. (-18°C.) use a good quality oil of SAE number 10 in the crankcase. For temperatures below 0°F. (-18°C.) use SAE number 10W, or number 5W if necessary for engine cranking. Use heavy duty detergent type oil.

If number 5W oil is not obtainable, dilute number 10W oil with not more than 1 part of kerosene to 4 parts of oil. Do not put diluted oil into the engine until ready to start the plant. Thoroughly mix the oil and kerosene just before pouring into the engine. Immediately start the plant and run for at least 10 minutes to thoroughly circulate the mixture through the engine. Always use a mixture of the same proportions when adding oil between changes. When using diluted oil, change the oil every 25 operating hours and check the oil level frequently. Use undiluted oil again as soon as temperature conditions permit.

CAUTION

Always drain the oil only when the engine is warm.
Drain the oil filter when changing to a lighter oil.
Add sufficient oil to compensate for that used to fill the filter.

AIR CLEANER. - If congealed oil or frost formation within the air cleaner restricts the air flow, remove and clean the air cleaner. Reassemble and use the air cleaner without oil until conditions permit the use of oil in the normal manner. Do not use diluted oil in the air cleaner.

COOLING SYSTEM. - The coolant must be protected if there is any possibility of its freezing. Use any good anti-freeze solution, in the porportion recommended by the anti-freeze manufacturer for the lowest temperature to which the plant will be exposed. The capacity of the cooling system is 10-1/2 quarts, U.S. Measure.

If the water temperature gauge shows the engine to be operating too cool, a portion of the radiator surface may be covered to raise the coolant temperature to normal. Avoid overheating. Set the high water temperature cut-off switch 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 and the type of anti-freeze used. Check the anti-freeze solution frequently.

If the cooling system is drained to prevent freezing, BE SURE TO REMOVE THE RADIATOR CAP in order to prevent formation of a vacuum in the cooling system, which would prevent complete draining. Open both the radiator and the cylinder block drain cock.

FUEL, GASOLINE. - Fresh, clean, winter "regular" grade gasoline is an aid to easy starting in cold weather. Moisture condensation can cause considerable trouble from ice formation in the fuel system. Do not fill the fuel tank entirely full of cold gasoline, as expansion may cause it to overflow. However, moisture condensation will be reduced if the tank is kept as full as practicable.

BATTERY. - Check the charge condition of the battery frequently, to be sure that it is kept in a well charged condition. A discharged battery will freeze at approximately 20°F. (-7°C.) and may be permanently damaged. A fully charged battery will not freeze at -90°F. (-67°C.).

HIGH TEMPERATURES

COOLING SYSTEM. - If the plant is to be operated in abnormally high temperatures (above 100°F., or 38°C.), provide sufficient air circulation for proper cooling. Keep the cooling system clean and free of rust and scale. See that the high water temperature cut-off switch is correctly set. Keep the radiator well filled, the fan belt tension properly adjusted, and the crankcase oil level at, but not above the full mark on the oil level gauge.

NOTE

For best cooling effects for housed plants, keep the door panels in place on the plant when it is in operation. Do not obstruct the flow of air to the plant.

Use SAE number 30 oil for temperature up to 100°F. (38°C.) and SAE No. 40 for higher temperatures. Check the oil level frequently, and change the crankcase oil at least every 50 hours. Keep the electrolyte level in the battery up to normal.

BATTERY. - For a usual plant installation, follow the instructions for Battery under INSTALLATION. If the installation agrees with the following description, prepare the battery to assure long battery life by REDUCING BATTERY SPECIFIC GRAVITY.

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

The cranking power of the battery is also reduced when electrolyte is diluted to reduce acid activity and thus lengthen battery life. If temperature is consistently above 90°F. (32.2°C.) adjust the electrolyte as instructed below.

1. Fully charge the battery. DO NOT BRING AN OPEN FLAME OR BURNING CIGARETTE NEAR THE BATTERY ON CHARGE BECAUSE THE GAS RELEASED DURING THE CHARGING IS VERY INFLAMMABLE.

2. While battery is on charge, use a hydrometer or filler bulb to siphon off all of the electrolyte above the plates in each cell. Do not attempt to pour off ! Dispose of the removed electrolyte. AVOID SKIN OR CLOTHING CONTACT WITH ELECTROLYTE.

3. Fill each cell with pure distilled water.

4. Recharge the battery for one hour at a 4 to 6 ampere rate.

5. Use a reliable battery hydrometer, to test each cell. If the specific gravity is above 1.225, repeat steps number 2, 3 and 4 until the highest specific gravity 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

Keep the plant as clean as practicable. Service the air cleaner as frequently as conditions require. Keep the radiator fins clean and free of obstructions. Keep the generator commutator and slip rings and brushes clean. See that all brushes ride freely in their holders. Keep oil and gasoline supplies in air tight containers. Install a new oil filter element as often as necessary to keep the oil clean. Change the crankcase oil more frequently as necessary, before the normal time has elapsed between changes.

GENERAL. - Follow a definite schedule of inspection and servicing to assure better performance and longer life of the plant at minimum expense. Service periods outlined below are for normal service and average operating conditions. For extreme load conditions, or abnormal operating conditions, service more frequently. Keep a record of the hours of operation each day to assure servicing at the proper periods. The running time meter records the TOTAL number of hours the plant has been in operation.

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 often enough to assure a continuous fuel supply. Do not fill the tank while the plant is running.

RADIATOR. - Check the level of the coolant and, if necessary, add sufficient liquid to bring the level up to within one or two inches of the bottom of the filler neck. In freezing weather, if a non-permanent type anti-freeze is used, check the protective strength of the coolant. The cut-off switch will not protect against evaporation.

AIR CLEANER. - Check the oil level in the air cleaner cup and add sufficient oil to bring it to the indicated level. Clean out and refill the oil cup if dusty conditions prevail.

CRANKCASE OIL LEVEL. - Check the oil level as indicated on the bayonet type oil level gauge. Do not allow the engine to operate with the oil level close to the low level mark on the gauge. Add sufficient oil of the proper SAE number to bring the level to the upper level mark, but do not overfill the crankcase.

CLEANING. - Keep the plant as clean as possible. A clean plant will give longer and more satisfactory service.

WEEKLY SERVICE

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

CRANKCASE OIL. - Add crankcase oil as necessary, or change the oil after 50 operating hours. If the plant has been operating with diluted oil, change the oil after 25 hours operation. Drain the oil filter can to coincide with each oil change and drain the oil while hot. Never flush with kerosene.

GENERAL LUBRICATION. - Put a little powdered graphite oil on each of the governor to carburetor link ball joints. Put several drops of oil in the oil holes at each end of the battery charging generator.

AIR CLEANER. - Clean the air cleaner filter element and cup thoroughly in gasoline or other suitable solvent. Allow to dry, or use compressed air to dry. Refill the cup to the indicated level with clean oil of the same SAE number as that used in the crankcase, except as noted under ABNORMAL OPERATING CONDITIONS.

FAN AND GENERATOR BELT. - Check the tension of the fan belt. Adjust to permit about 3/4" play when pressure is applied midway between the pulleys. Install a new belt if the old one is badly worn.

BATTERY. - See that the battery connections are clean and tight. Keep the electrolyte level approximately 3/8" above the plates by adding only clean water which has been approved for use in batteries. In freezing weather, run the plant at least 20 minutes after adding water to mix the water with the electrolyte.

SPARK PLUGS. - Clean the spark plugs and check the electrodes gap. Keep the gap adjusted to 0.025". More frequent spark plug service may be necessary if leaded gasoline is used. If hard starting occurs when using gaseous fuel, correct the spark plug gap as shown in the Table of Clearances.

IGNITION. - Check the ignition contact points. If they are only slightly burned or pitted, resurface them on a fine stone. Install new contact points if the old ones are badly burned. Keep the gap adjusted as shown in the Table of Clearances. Excessive burning or pitting of the points usually indicates a faulty condenser, which should be replaced with a new one.

MONTHLY SERVICE

If the plant is operated more than 200 hours a month, perform the MONTHLY SERVICE operations every 200 hours.

GASOLINE SUPPLY. - If the plant has a mounted tank, drain the gasoline from the tank. Remove the fitting at the bottom of the tank and flush the gas tank to remove all sediment. Replace fitting and fuel line.

Remove the pipe plug at the bottom of the carburetor and drain the bowl of any sediment which may have accumulated. Remove the fuel pump bowl and clean the screen and sediment recess.

Turn on the gasoline supply and inspect for leaks, correcting any found.

IGNITION. - Place a light coating of grease on the breaker cam of the unit.

EXHAUST SYSTEM. - Inspect all exhaust connections carefully. Make any necessary repairs.

OIL FILTER. - Engine condition, hours of running time, accumulation of sludge in the filter can, and a crankcase oil change to a different SAE number are determining factors for the necessity of changing the oil filter element. Oil discoloration is normal with heavy duty detergent oils. Clean out the oil filter and install a new element. The new filter element will absorb approximately one pint of oil when the plant is started up. After a short running period, stop the plant and check the crankcase oil level. Add oil as necessary to bring the oil up to the proper level.

ENGINE COMPRESSION. - Check the compression of each cylinder, using a compression gauge. A difference of more than 10 pounds pressure between cylinders or uniformly low compression indicates a compression loss which should be corrected. High compression is an indication of excessive carbon or lead deposits in the combustion chambers. Compression reading of 115 lbs. or over at battery cranking speed is considered good compression.

CRANKCASE BREATHER HOSE. - To assure proper crankcase ventilation, this hose must not be restricted by sludge accumulation. Engine condition will greatly determine necessity for periodic inspection and cleaning of the hose.

CARBON (OR LEAD) REMOVAL. - In some cases, lead deposits build up around valves and in the combustion chamber very rapidly. Burned valve faces or seats may soon result, leading to poor compression and a noticeable loss of power. When using the average automotive gasoline, remove the engine cylinder head each 200 operating hours. Carefully clean all carbon and lead deposits from the combustion chamber, paying particular attention to the valves. If valves do not seat perfectly, a valve grind job should be done. If carbon and lead deposits are removed frequently enough, the frequency of necessary valve grinding jobs can be substantially reduced.

These engine have "positive-rotor" type valves. Consequently under ideal operating conditions necessary periods might be extended but never exceeding 500 hours.

GENERATOR. - Check the condition of the commutator, slip rings and brushes. In service, the commutator and slip rings acquire a glossy brown color, which is a normal condition. Do not attempt to maintain a bright metallic, newly machined finish. If the commutator or slip rings become heavily coated, clean with a lint free cloth.

Slight roughness may be remedied by lightly sanding with #00 sandpaper. Clean out all carbon and sandpaper dust.

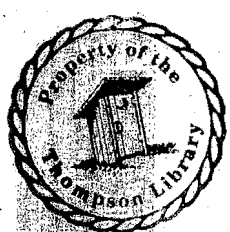
When brushes are worn so that the top of the brush is below a point midway between the top and bottom of the brush holder, replace the brushes with new ones. Brushes must ride freely in their holders, and spring tension should be uniform.

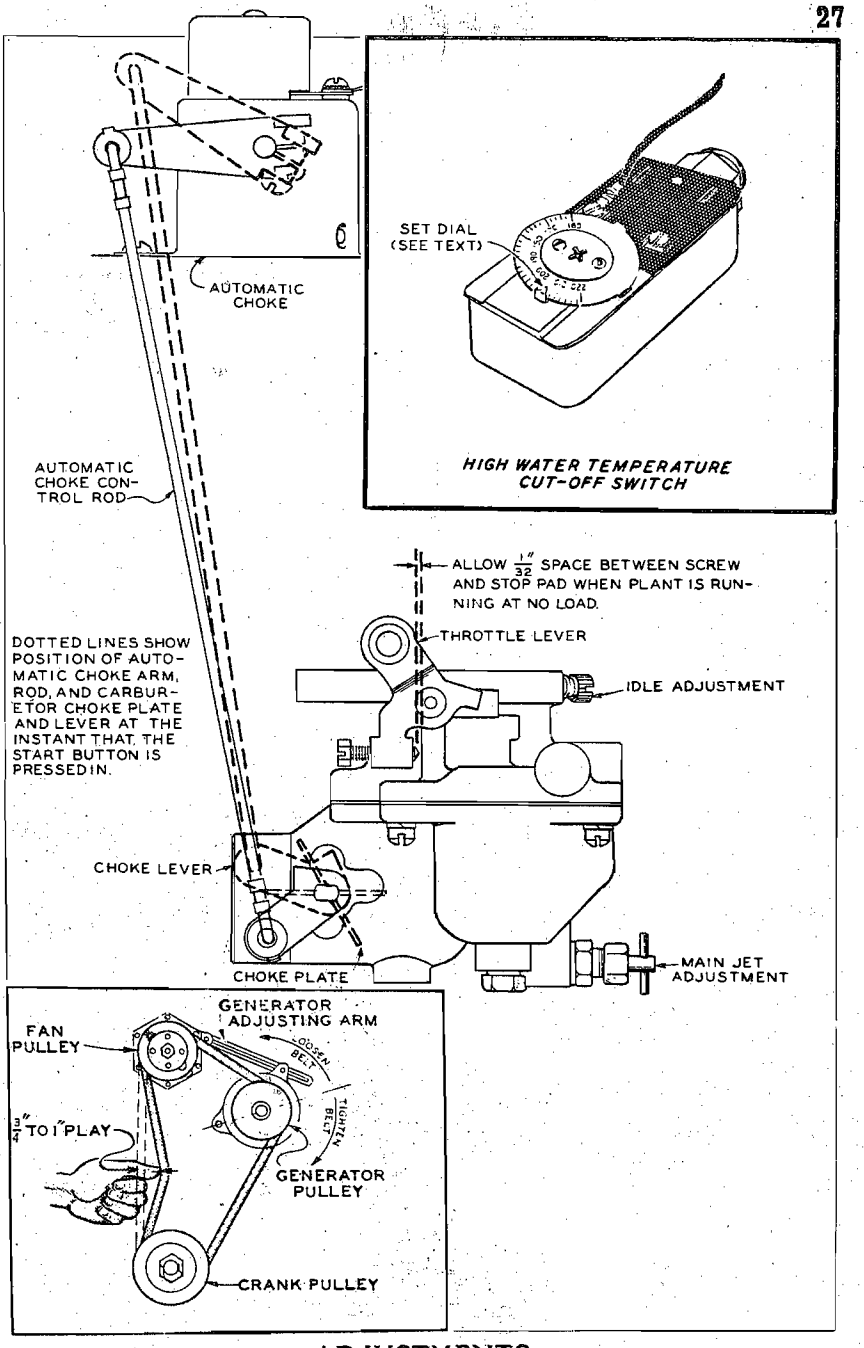
Check the brush rig for proper alignment of the reference marks on the brush rig and its support.

Refer to the MAINTENANCE and REPAIR section for generator service details.

GENERAL. - Thoroughly inspect the plant for oil or water leaks, loose electrical connections, and loose bolts or nuts. Make any necessary repairs.

GENERATOR BEARING. - The generator bearing is a double shield type which does not require lubrication.





ADJUSTMENTS

CARBURETOR, GASOLINE ONLY. - The carburetor should require no servicing other than keeping it clean and free of sediment. When cleaning jets and passages, use compressed air or a fine, soft copper wire. Be sure that all gaskets are in their proper places when reassembling.

Changes in the type of gasoline used, or in operating conditions may necessitate a readjustment of the carburetor. Before readjusting the carburetor, make sure that the ignition system, valves, and other parts of the fuel system are operating properly. The main jet adjustment is at the bottom of the carburetor and should be adjusted with a full load on the plant, and with the plant at operating temperature.

Turn the adjusting needle in (clockwise) until the voltage, as shown on the AC VOLTMETER drops noticeably. Turn the screw slowly out (counterclockwise) until the voltage rises to normal, and the engine runs smoothly. If it is necessary to open the adjustment more than one half turn beyond the point where normal voltage is attained in order to obtain smooth operation, a readjustment of the governor may be necessary. Check the operation at various loads.

After the plant has been adjusted for load operation, disconnect the load and adjust the idle adjustment screw in the same manner. This adjustment is usually not as critical as the main jet adjustment. The throttle lever idling stop screw should be adjusted so that there is 1/32" space between the screw end and the throttle stop when the plant is operating at no load.

CARBURETOR, GAS OR VAPOR AND GASOLINE COMBINATION. - A change in the BTU rating of the fuel used will probably necessitate readjusting the gas adjustment screw valve at the bottom of the carburetor. With a full load on the plant, turn the adjusting valve in (clockwise) until the voltage as shown on the AC voltmeter drops noticeably. Turn the screw slowly out (counterclockwise) until the voltage rises to normal and the engine runs smoothly. If it is necessary to open the adjustment much beyond the point where normal voltage is attained in order to obtain smooth operation, a readjustment of the governor may be necessary. Keep 1/32" clearance between the throttle stop and the throttle stop screw.

CARBURETOR GAS ONLY. - Adjust this carburetor the same as the gas-gasoline carburetor adjustments.

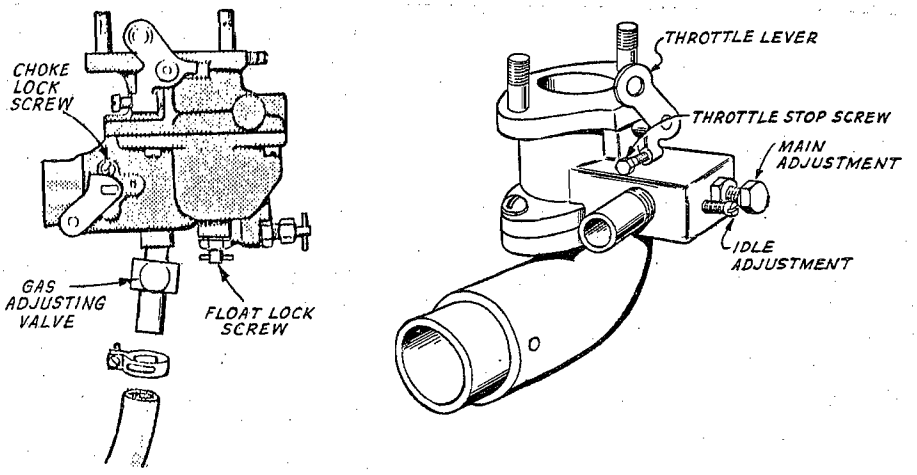
REGULATOR. - The regulator must be adjusted to the incoming line pressure before the regulator can be connected to the carburetor.

Open the fuel shut-off valve in the gas supply line. Blow into the open vent or balance hole in the regulator to allow fuel to flow past the regu-

lator valve.

Place a soap bubble over the open end of the pipe nipple located on top of the regulator.

Turn the adjusting screw out or counterclockwise making the soap bubble grow larger. Then turn the screw in until the soap bubble will hold. Assemble the vent to the vent hole in the regulator then connect the rubber hose between the carburetor and the regulator.



GAS - GASOLINE GAS - ONLY

FIG. 9 - CARBURETORS

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. The switch will not operate if the ignition switch is at the HAND START position.

FAN AND GENERATOR BELT ADJUSTMENT. - The belt tension is determined by the position of the battery charging generator. To readjust the belt tension, loosen the generator adjusting arm bolt and nut slightly. Move the generator toward the engine to loosen the belt, or away from the engine to

tighten the belt. Adjust to permit 3/4" to 1" play in the belt when pressure is applied at a point midway between the fan and crankshaft pulleys. Be sure to retighten the adjusting arm screw and nut when the adjustment is completed. Too tight a belt will wear out rapidly and cause excessive strain on the water pump and battery charging generator bearings. A belt which is too loose will slip, causing rapid belt wear, inefficient cooling, and possible low battery charge rate.

AUTOMATIC CHOKE. - The choke control should not need seasonal adjustments, but may be adjusted in the following manner. Turn the shaft of the control to the position where a 3/32" diameter rod may be passed down through the hole in the end of the shaft opposite the lever. Engage the rod in the notch in the edge of the mounting flange. Loosen the lever clamp screw just enough to allow the lever to be turned slightly. To adjust the choke for a richer mixture, pull the lever upward. To adjust for a leaner mixture, push the lever downward. Retighten the lever clamp screw and remove the rod from the hole in the shaft. Check to see that when the lever is lifted up to the limit of its travel, the carburetor choke valve is completely closed, and when the lever is pushed down, the carburetor choke valve is wide open. For gas or vapor operation, the choke arm should be locked in the wide open position.

MANIFOLD HEAT ADJUSTMENT. - This valve speeds up engine warm-up. It does not aid engine starting. Normally a slightly longer engine warm-up time is better than altering the valve adjustment. The valve must work freely.

Under certain atmospheric conditions, such as cold and damp weather, it may be necessary to change the setting of the manifold heat control valve. Moisture in the air may condense and freeze as it passes into the carburetor, causing ice formation in the carburetor venturi. Ice formation would cause low power output. To increase the heat deflected to the intake manifold and carburetor venturi, loosen the heat control valve sector lock nut and turn the shaft counterclockwise to the desired position. This loosens the tension on the operating spring which allows exhaust heat to be deflected for a longer period of time. In very cold weather it may be necessary to turn the valve counterclockwise to the limit of its travel. Under extreme conditions it may be necessary to install an auxiliary air heater around the manifold to deflect more heat to the carburetor air intake.

GOVERNOR. - The governor controls the engine speed, and therefore the voltage and frequency of the generator output. 60 cycle plants are adjusted at the factory to a maximum no load speed of 1920 rpm. 50 cycle plants are similarly adjusted to 1560 rpm. maximum. These are maximum figures, and may sometimes be as low as 1710 rpm for 60 cycle or 1440 for 50 cycle plants. A voltmeter or frequency meter (preferably both) should be connected to the generator

output in order to correctly adjust the governor.

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 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 for 3 phase plants, 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 the KVA rating.

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.

SPEED CHART FOR CHECKING UNIT REGULATION

		SPEED RANGE LIMITS		SPEED SPREAD (WITHIN RANGE) PREFERRED	LIMITS	
		MAX.	MIN.	F. L. * to N. L.	MAX.	MIN.
FOR ALL 60 CYCLE PLANTS	CYCLE→	64	57	59.5 - 60.5	3	0
	RPM→	1920	1710	1785 - 1815	90	0
FOR ALL 50 CYCLE PLANTS	CYCLE→	52	48	49.5 - 50.5	3	0
	RPM→	1560	1440	1485 - 1515	90	0

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

5. If hunting occurs at NO LOAD, screw the small bumper spring screw in until the hunt is stopped, but not far enough to increase the engine speed. CAUTION: Be sure all load is removed when adjusting the bumper screw.

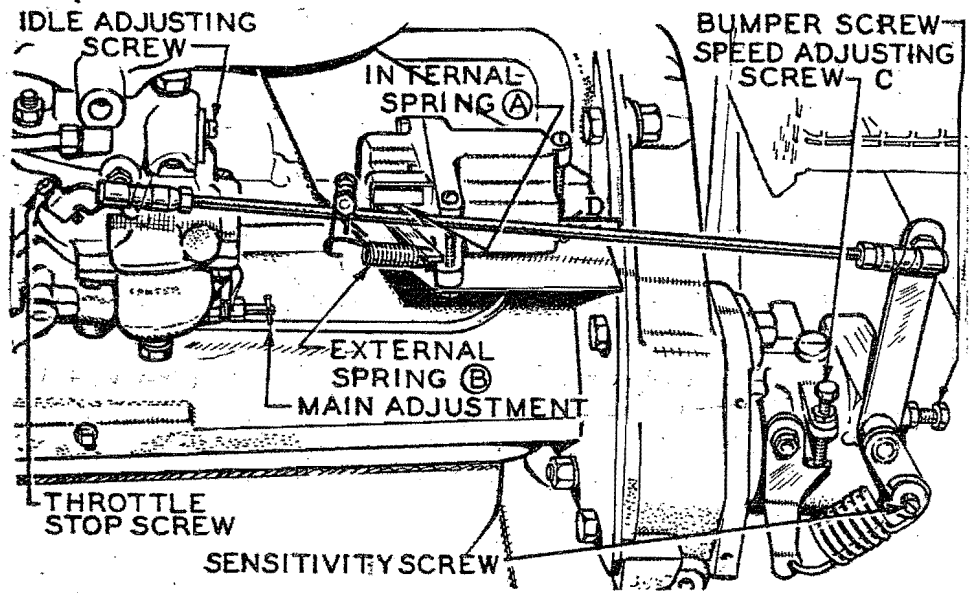


FIG. 10 - GOVERNOR ADJUSTMENT

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 probably that the engine is low on power and should be repaired as necessary.

Recheck the ac output voltage.

ADJUSTMENT - GOVERNOR BOOSTER

1. The HC series are equipped with an auxiliary speed booster device, operating by intake manifold vacuum. The speed booster is adjusted to increase governor action as the load on the generator is increased. The booster serves to maintain or increase the speed at the heavier loads, thus resulting in more nearly constant voltage.

The booster is mounted between the carburetor and the governor, and is operated by engine vacuum which passes through a tubing between the booster and the manifold. When the plant is operating at about half load or less, the engine vacuum is sufficient to cause the diaphragm to overcome the tension of the internal booster spring (A). Under these con-

conditions, there is no tension on the booster external spring (B) and the booster does not affect the governor operation.

As the load on the plant is increased, the engine vacuum becomes less, the booster internal spring tension overcomes the pull of the diaphragm, and tension is put on the booster external spring. The tension on the external spring "helps" the regular governor spring in its function, thus causing a slight increase in engine speed as the load is increased.

2. With the plant operating at no load, disconnect the booster external spring (B), Fig. 10. Turn the speed adjusting nut (C) to obtain a frequency reading of 60 cycles for a 60 cycle plant (50 cycles for a 50 cycle plant). The voltage should be within the limits shown in the table below, according to the rated plant voltage shown on the plant name-plate.

TABLE FOR GOVERNOR ADJUSTING LIMITS

Plant Rated Voltage	No Load Volts (Maximum)	Minumum Full Load Volts Without Booster	Maximum No Load To Full Load Volt Drop with Booster
115/230	124 or 248	112 or 224	10 or 20
230 3 Ph. 3 Wire	248	*220	22
460 3 Ph. 3 Wire	496	*438	44
120/208 3 Ph. 4 Wire	224 (3 Phase)	*202 (3 Phase)	20
220/380	409 3 Phase	*360 3 Phase	36

* - 3 Phase Full Load Voltages shown are with .8 Power Factor Load.

3. Connect a full electrical load to the generator. As the electrical load is connected, the governor should act smoothly and quickly to keep the voltage within the limits in the table. However, there should be not more than a spread of 3 cycles between the no load frequency and the full load frequency. For example: if the frequency was 60 cycles at no load, then the full load frequency should be not less than 57 cycles. If the cycle spread is more than 3 cycles, turn the sensitivity screw, Fig. 10, in (clockwise) a half turn. This will, in turn, necessitate a slight compensating speed nut adjustment. Repeat the process until the cycle spread is within 3 cycles and voltage is within the limits shown in the table.

4. Check the performance under various loads. The governor should react to each load change quickly and smoothly. It is normal for the frequency (and voltage) to drop below the lower limit for a few seconds when a sudden heavy load is connected, but then should stabilize within the limit. It is also normal for the frequency (and voltage) to rise temporarily above the upper limit upon removing a heavy load.

5. If the frequency fluctuates or refuses to stabilize when under a constant load condition, the governor is perhaps too sensitive. Turn the sensitivity screw out (counterclockwise) a partial turn at a time until the governor stabilizes. It will then be necessary to again adjust the speed nut to bring the frequency within the proper limits.

6. After long service, the governor mechanism parts may become worn enough to prevent correct governor adjustments. If the engine and generator are otherwise in good condition and all other adjustments are properly made, but governor action is still erratic, inspect for worn parts. Remove the governor to inspect the shaft-and-yoke assembly, and other internal parts.

7. If governor adjustment will not correct an excessive drop in cycles at full load, engine power may be low. Check the compression, etc., making repairs as necessary. If governor adjustment will not correct a fluctuating speed condition, the carburetor adjustment may be too lean. Refer to ADJUSTMENTS; CARBURETOR.

8. After satisfactory performance has been attained under various loads, the booster can be connected. With the plant operating at no load, connect the booster external spring, Fig. 10. Adjust the bracket on the governor link just to the position where there is no tension on the spring.

9. Now connect a full electrical load to the generator. The frequency should stabilize at a point of 1 cycle LOWER THAN the no load frequency. For example: if the no load frequency is 61 cycles, the frequency under full load should be 60 cycles. If there is a drop in the frequency of more than 1 cycle, increase the internal spring tension. Adjust the tension of the internal spring by pulling out on the spring bracket (D), and moving the pin to a different hole.

10. With the booster disconnected, a maximum drop of 3 cycles from no load to full load is normal. With the booster in operation, a drop of 1 cycle from no load to full load is normal.

11. The effect of the booster is limited by the general condition of the engine. The booster can not compensate for a loss in engine vacuum caused by leaky valves, worn piston rings, etc.

12. If there is tension on the external spring Fig. 10, when the plant is operating at no load or light load, it may be due to improper adjustment, a leak in the booster diaphragm, tubing or an obstructed vacuum line.

GENERAL. - Refer to the SERVICE DIAGNOSIS section for assistance in locating and correcting troubles which may occur. Should a major overhaul become necessary, the plant should be carefully checked and all necessary repairs made by a competent mechanic who is thoroughly familiar with modern internal combustion engines and revolving field generators.

ENGINE

TAPPET ADJUSTMENT. - The tappet adjustments may be made after removing the valve chamber cover. The tappets are the adjustable screw type, requiring three wrenches to adjust. See the illustration, TAPPET ADJUSTMENT.

The tappets should be adjusted with the engine hot and with each respective piston at Top Dead Center on the compression stroke. Set the tappets in firing order sequence, turning the hand crank 1/2 revolution to put the next piston at Top Dead Center. Firing order is 1, 3, 4, 2.

Adjust the tappets to 0.014" clearance for both the intake valves and the exhaust valves. If possible, make a final check with the engine running at a slow idle, and at operating temperature. Make certain that the lock nut on each tappet adjusting screw is tightened securely after the adjustment is completed.

VALVE SERVICE. - The proper seating of the valves is essential to good engine performance. If any one valve is leaking, service all valves. Each valve, its guide, piston top, the cylinder head and top of the block should be thoroughly cleaned of all carbon deposits. Replace with a new one any valve of which the stem is worn or the head is warped or badly burned. The intake valve face angle is 30° and the exhaust valve face angle is 45°.

All old valves to be reused should be ground and reassembled to their original seats. Grind only enough to assure a perfect seal. Be careful to remove all traces of grinding compound from valves and seats. Lightly oil valves and guides before reassembly.

Both the intake valves and the exhaust valves are of the "Positive Roto" type, each valve having a cap under the end of the stem. When reassembling, install the cap on the end of the valve stem before installing the spring retainer locks. Note that the valve spring retainer locks have a very slight taper. The thinner edge of the lock must face upward. Be sure two locks are properly installed on each valve stem. If the valves are properly installed, it will be possible to turn them in their guides when the valves are wide open, but only in one direction.

Set all the tappet clearances after the valves have been reassembled. When tightening the cylinder head nuts, start at the center and work outward and towards the ends. Tighten cylinder head nuts to a tension of 80 pounds foot torque. See the paragraph IGNITION TIMING for instructions on proper installation of the magneto and its drive shaft.

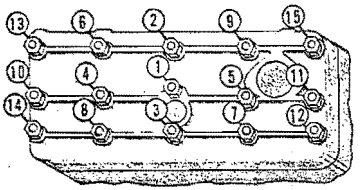


FIG. 11 - CYLINDER HEAD TIGHTENING SEQUENCE

To prevent distortion, tighten the cylinder head in the sequence shown above. "Snug up" twice before a third and final tightening.

When the engine is started, allow it to thoroughly warm up and carefully check the tappet clearances, making any necessary corrections with the engine running at a slow idle. After approximately 10 hours operation, again check the tappets, making any necessary adjustments. Tappets set too tightly may cause burned or warped valves and cutting of the camshaft and tappets.

TIMING GEARS. - The crankshaft and camshaft timing gears are keyed to their respective shafts. The camshaft gear is fastened with a large hexagon nut and locking washer. The gears may be removed with a gear puller. Always install both gears new when either needs replacing, never one only. The crankshaft gear has one tooth punch-marked, which must mesh with the two teeth punch-marked on the camshaft gear. See the illustration, TIMING GEARS.

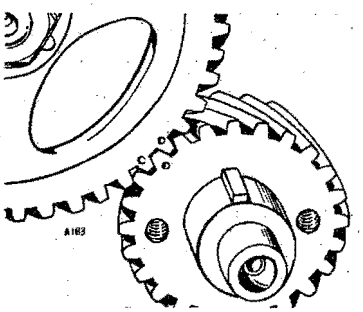


FIG. 12 - TIMING GEARS.

IGNITION TIMING. - The correct timing is the setting which gives the best performance under full rated load conditions.

Crank the engine until the number 1 piston is coming up on the compres-

sion stroke. Continue slowly to crank the engine until the flywheel mark IGN is in the center of the inspection hole located on the flywheel housing on the right side of the engine.

If the distributor drive shaft has been removed, install it properly engaged with its drive member. Install the distributor to the cylinder head. The distributor shaft is off-set to insure proper engagement when the distributor rotor points toward the front of the engine. If the rotor fails to point to the #1 tower, the distributor drive shaft must be lifted up, rotated, and reinstalled to the correct position.

See that the distributor ignition points gap, at full separation, is same as shown in the Table of Clearances. Loosen the distributor adjusting clamp screw and turn the distributor body counterclockwise to close the ignition points. Use a series type timing light, if available. Slowly turn the distributor clockwise until the ignition points just separate. At this point the timing is correct for average operating conditions. To advance the timing, turn the distributor body slightly in a clockwise direction, or to retard timing turn it counterclockwise. Keep the spark advanced as far as possible without causing a "ping".

To help determine if parts have been correctly installed, refer to the following conditions which should prevail when the piston in #1 cylinder is at top dead center (#1D.C.); Number 4 exhaust valve will have just closed as viewed through the spark plug hole. The slot in the oil pump drive shaft which drives the distributor drive shaft will be almost parallel to the "front to rear" direction of the engine. The distributor rotor will be at #1 tower and will point toward the front of the engine. The flywheel marks will align with the inspection hole.

PISTON RING REPLACEMENT. - The piston and connecting rod assemblies are removed from the top of the cylinder. Three compression rings and one oil control ring are used on each piston. Check the cylinders for an out-of-round or tapered condition, reboring for oversize pistons if necessary. Any ridge worn at the top of the bore should be removed, even if not reboring. Fit each ring to its individual cylinder, being sure that the gap between the ends of the ring, when in the cylinder, is within the limits described. The ring gap is .007 to .017". The compression rings are interchangeable, one groove to the other. Fit the proper ring in each ring groove on the piston, with the ring gaps spaced an equal distance around the piston. The wide oil control ring fits the bottom piston ring groove. Be sure the ring grooves are clean and free of carbon deposits, and the oil holes are open before installing the rings on the piston. The rings should have between 0.0015" and .002" clearance in their grooves. Replacement rings of the tapered type will be marked "TOP" or identified in some other unmistakable manner, and this mark must be installed toward the top of the piston.

PISTON PINS. - The hardened piston pins are selected in production to obtain a 0.0004" loose fit in connecting rod pin bushing, and a light push fit in piston boss. Maintain these clearances to fit oversize piston pins. When reinstalling old pistons, be sure that they are installed in their original cylinder, and in the same position relative to the numbered side of the connecting rod. When reassembling, make sure that the snap ring at either end of the pin is tightly in place.

CONNECTING RODS. - (See note "Bearing Caution"). - The steel backed connecting rod lower end bearings are readily replaceable. When removing the connecting rods, note the markings on the camshaft side of the rods and caps, so as to reassemble in the original manner. Notches machined in the connecting rod halves receive matching projections stamped into the steel backs of the bearing shells. If a shell becomes worn, discard both shells for that rod and install new ones. The shells are designed to provide a clearance of 0.0002" to 0.0022". Never attempt fitting a bearing by scraping or filing of either the cap or upper half of the rod. Be sure that rods and caps as well as bearing shells are perfectly clean and free of oil when inserting the shells. Oil on the back of the shell will prevent proper seating of the shell in the rod or cap. Oil the crankshaft journal after the bearing has been firmly seated in the rod.

The sides of the connecting rod crank ends are not babbitt lined. It is of vital importance that the side play clearance of 0.006" to 0.010" be maintained. Be sure that piston and connecting rod assemblies are properly aligned before installation.

MAIN BEARINGS. (See Note "Bearing Caution"). - The crankshaft main bearings are of the same type as the connecting rod bearings. Front, intermediate, or rear bearing shells are not interchangeable between the other locations. Bearing caps are numbered on the camshaft side and are doweled to assure proper reassembly. The same general directions given for fitting the connection rod bearings should be observed in fitting the main bearings. The clearance when installed should be 0.0002" to 0.0024". The rear face of the front main bearing takes the end thrust of the crankshaft. The crankshaft end play should be 0.003" and is regulated by a shim pack to the rear of a removable thrust collar behind the crankshaft gear. When servicing the crankshaft or related parts always make sure that all oil holes in the shaft are open and clean.

BEARING CAUTION: Certain engines are equipped with MORAINE DU-REX-100 main bearings and (or) connecting rod bearings. After a few hours of operation the bearing becomes a leaden gray in color and develops minute craters, almost cellular in appearance. THIS APPEARANCE IS A NATURAL CHARACTERISTIC OF THIS TYPE BEARING AND IN NO WAY INDICATES FAILURE. Reasons for necessary bearing replacement are: Worn bearings, causing a noticeable

drop in oil pressure; Damaged bearings, due to deep scratches or gouges; Loss of babbitt overlay, due to lubrication failure, overheating or other abnormal conditions. Before replacing bearings, clean them thoroughly but NEVER USE ABRASIVES which may become imbedded. Improved performance is gained by this bearing.

CAMSHAFT. - Provided that proper lubrication is supplied, the camshaft and its bearings should never require servicing. If the cams are cut by too close adjustment of the tappets, they can be reconditioned by careful honing if not too badly scored.

The camshaft bearings are bushings which are line reamed, after installation in the crankcase. The installation of new camshaft bearings is not practicable without the proper line reaming equipment. Clearances are given in the Table of Clearances.

WATER PUMP. - The water pump on this engine is a centrifugal, self sealing, prelubricated ball bearing type. To dismantle the pump, follow this procedure.

1. Remove the four screws that mount the water pump assembly to the engine.
2. Remove the screws that hold the end plate on the back of the water pump assembly.
3. Use a suitable puller to remove the pulley from the impeller shaft.
4. Remove the lock ring that retains the bearing at the pulley end.
5. Press the impeller shaft out of the body casting from the rear of the water pump. This frees the impeller.
6. Tap the shaft seal out by inserting a plug through the front of the casting. Tap out the seal gently to prevent any damage to the seal.
7. Reverse the disassembly steps in order to assemble the pump. Note that the impeller hub is assembled to the impeller shaft with the fins facing the water pump seal.

LUBRICATION SYSTEM. - A gear type oil pump supplies oil under pressure through drilled passageways to the crankshaft main, lower connecting rod bearings, camshaft bearings, timing gears, and valve tappets. When ever the engine is disassembled for service, make sure that all oil passages are clean and unobstructed. Thoroughly clean the engine oil pan and the oil pump strainer screen. An oil pressure relief valve is adjusted at the factory to give a pressure of 20 to 30 pounds at the governed speed, with the engine oil hot. The oil pressure relief adjustment is reached by removing a large hexagon shaped plug in the side of the crankcase close to the fuel pump. Oil pressure may be increased by adding plunger washers or reduced by removing plunger washers. Never attempt to adjust the oil pressure without first testing with a gauge which is known to be accurate. Also refer to LOW OIL PRESSURE, first, under SERVICE DIAGNOSIS. Be sure the gauge is not defective. Too high or too low pressure may be caused

by a sticking plunger. Remove the assembly and clean thoroughly. Continued low oil pressure indicates excessively worn bearings.

TORQUE WRENCH DATA
(Limits in Pounds Ft. Torque)

Cylinder Head - 7/16"	70-75
Main Bearing Caps and Connecting Rods 3/8"	35-40
Flywheel - 3/8"	35-40
Manifolds - 3/8"	25-30
Gear Cover, Water Pump, Front and Rear End Plates, Oil Pan - 5/16"	15-20

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 engine operates, and figure out the probable cause of any irregular operation. Then locate the trouble by a process of elimination. In many instances, a symptom indicating trouble in one unit may be caused by improper function of a closely related unit or system. Remember that the cause usually is a SIMPLE ONE, rather than a mysterious and complicated one.

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

TABLE OF CLEARANCES AND SPECIFICATIONS

	MINIMUM	MAXIMUM
Valve Tappets - Intake - Warm Engine, Preferably Idling.	0.014"	
Valve Tappets - Exhaust - Warm Engine, Preferably Idling.	0.014"	
Valve Seat Angle - Intake.	30°	
Valve Seat Angle - Exhaust.	45°	
Valve Stem Clearance in Guide - Intake - Desired.	0.0015"	
Valve Stem Clearance in Guide - Exhaust - Desired.	0.0045"	
Crankshaft Main Bearing (Desired .001").	0.0002"	0.0024"
Crankshaft Main Bearing Journal Size.	2.249"	2.250"
Connecting Rod Bearing (Desired .001").	0.0002"	0.0022"
Crankshaft Rod Bearing Journal Size.	1.9365"	1.9375"
Connecting Rod Side Play.	0.006"	0.010"
Camshaft Bushings - #1 and 3.	0.002"	0.004"
Camshaft Bushing - #2.	0.003"	0.0045"
Camshaft Bearing Journal Dia. #1.	1.8715"	1.8725"
Camshaft Bearing Journal Dia. #2.	1.7457"	1.7465"
Camshaft Bearing Journal Dia. #3.	1.2465"	1.2475"
Camshaft End Play.	0.0005"	0.0015"
Piston (Alum. Alloy) to Cylinder, 002" thick, 1/2" wide feeler.	5 to 10 lb. pull	
Cylinder Bore Size.	3.4375"	3.4395"
Piston Pin in Rod Bushing(Desired .0004").	0.0002"	0.0006"
Piston Pin in Piston.	Light Push Fit	
Ring Gap, 3 Top Grooves.	0.007"	0.017"
Ring Gap, Bottom Groove.	0.007"	0.017"
Distributor Points Gap - 12 volt battery ignition.	0.020"	
Spark Plug Gap - Comm 5		
For Gasoline Fuel Operation.	0.025"	
For Gaseous Fuel (LPG or Natural Gas) Operation - When necessary to aid starting.	0.015"	0.018"
Ignition Timing - at Cranking Speed.	17° advance	
Firing Order.	1 - 3 - 4 - 2	
Cylinder Head Nut - Torque.	80 lbs. ft.	
Oil Capacity - Excluding Filter.	4 U.S. Qts.	
Oil Pressure at 1800 RPM.	20#	30#
Oil Recommendation - High Viscosity, Heavy Duty Detergent		
Over 32°F.	SAE 30	
32°F. to 0°F.	SAE 10	
Below 0°F.	SAE 10W or 5W	
AC Generator Maximum Permissible Run-out at Rotor Bearing.		0.010"

GENERATOR

GENERAL. - The generator normally requires little maintenance other than the regular PERIODIC SERVICE operations, which should never be neglected. Some generator tests are simple to perform, do not require major disassembly, and require only a continuity type test lamp set. Other tests require special equipment and extensive disassembly of the generator. Partial disassembly, and removal of the generator is necessary in order to make certain engine repairs.

GENERATOR REMOVAL. - To disassemble the generator for removal, first remove the brush springs and brushes. Disconnect field coil and other lead wires which connect to the brush rig, to permit removal of the end bell and brush rig as an assembly. Be sure to tag each wire and its connection point as it is disconnected, to assure correct reconnection.

After removing the end bell mounting screws, carefully tap the end bell straight backward until it becomes free of the armature bearing. Place blocking under the rear of the engine, remove the screws which attach the generator frame to the engine rear, and carefully pull the frame assembly straight back over the armature. Use care not to allow the frame to drag or catch on the armature laminations.

To remove the armature, carefully block up the armature and remove the screws mounting its drive disc to the engine flywheel. Slide the armature away from the engine.

COMMUTATOR AND COLLECTOR RINGS. - The mica insulation between the commutator bars, or segments, was originally undercut to a depth of 1/32 inch below the commutator surface. After a long period of service, the surface of the commutator may become worn down level with the mica. This condition would cause noisy brushes, sparking of the brushes, and pitting of the commutator. The mica should again be undercut to 1/32 inch depth. Remove the brush springs and pull all the brushes out of their guides. After tagging any leads disconnected (to assure correct reconnection) remove the end bell. With a mica undercutting tool, or an improvised tool fashioned from a hack saw blade (Fig. 13), carefully cut the mica between all of the commutator bars down to the 1/32 inch depth. Use care to avoid scratching the surface. Remove any burrs which may be formed along the edges of the bars, and clean all spaces between bars completely free of any metallic particles, Fig. 14.

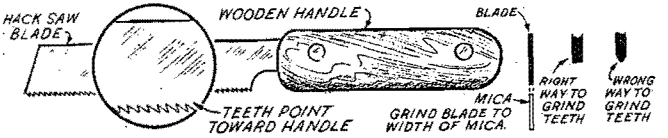


FIG. 13 - MICA UNDERCUTTING TOOL

If some unusual operating condition should cause the surface of the commutator or collector rings to become grooved, out of round, pitted, or rough, it will be necessary to remove the armature and turn the damaged commutator or collector rings in a lathe, to "true" the surface. Before centering the armature in the lathe, remove the ball bearing to prevent getting any dirt into it. After turning smooth, be sure to undercut the commutator mica as previously described. When the armature is reinstalled, reduce the run-out at the bearing end as much as possible before installing the end bell.

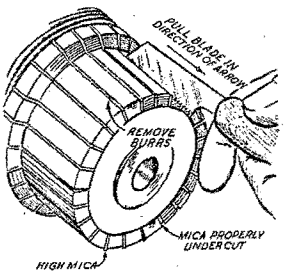


FIG. 14 - UNDERCUTTING MICA

BRUSH RIG. - It is unnecessary to loosen or remove the brush rig from the end bell for average generator servicing. However, if the brush rig has been loosened or removed for any reason, the brush rig must be returned to its exact original position. This original position was marked at the factory in the test run and must be maintained as long as the original brush rig and armature are continued in service. The position can be identified by a mark across the outer edge of the brush rig supporting ring, which mark must align with the marked support in the end bell. Improper positioning of the brush rig will cause excessive arcing of the brushes, burning of the commutator, low generator output, and possible serious damage to the generator windings from over-heating.

GENERATOR WINDINGS TEST PROCEDURE

Some generator tests do not require complete disassembly of the generator, and can be performed with the use of a continuity type test lamp set. Other tests require extensive generator disassembly and the use of an armature growler or other equipment usually found only in an electrical repair shop.

NOTE

Individual coils of the field coil set can be installed. Full instructions for installation are included with replacement coils, and must be carefully followed. Proper installation of individual coils can best be done by a qualified service shop.

It is seldom practicable to make internal repairs of generator windings. However, an external lead wire can be repaired as necessary.

FIELD COIL TESTS. - To test the field coils for an open circuit or a grounded circuit, use a test lamp set. As each lead wire is disconnected, tag it and its connection point, to assure correct reconnection.

If the plant is an electric cranking model which uses the generator as a cranking motor, the field coils are wound with two separate windings to each coil. The series (cranking) winding is of very heavy wire and its leads, marked S1 and F +, are easily identified. The shunt field leads are marked F + and F —. Temporarily connect the two F + leads together, for test purposes.

OPEN CIRCUIT TEST. - To test for an open circuit, connect one test lamp lead to the F + coil terminals, and the other test lamp lead to the F — coil lead. If the test lamp fails to light, an open circuit in the shunt winding is indicated. Repeat the test, between the S1 and F + terminals. If the test lamp fails to light, an open circuit in the cranking winding is indicated.

If an indicated open circuit can not be isolated in an external lead, or in a loose terminal, a more thorough test of individual coils will be necessary. Consult a qualified service shop.

GROUNDED CIRCUIT TEST. - To test the field windings for a grounded circuit, connect one test lamp lead to a bare metal part of the generator frame. Connect the other test lead to the coil terminals F +. If the test lamp lights, a grounded circuit is indicated. If inspection locates the ground in an external lead, repair as necessary. To locate a grounded coil, remove the screws mounting one of the pole shoes to the generator frame. Push the pole shoe and coil away from contact with the frame. If the ground is thus eliminated (test light goes out), the ground has been isolated at the loosened coil. Repeat as necessary until the grounded coil is located. Usually, the grounded point of the coil can be easily identified and the insulation repaired at the point of damage.

SHORT CIRCUIT TEST. - A short circuit test requires the use of special equipment and testing of individual coils. A sensitive ohmmeter can be used to test the resistance of each coil winding. If one coil winding shows an ohmmeter reading of more than 10% LESS than the average reading of the other three coils, that coil is short circuited. On electric cranking models, care must be taken not to confuse the cranking winding with the shunt winding.

ARMATURE TESTS. - The armature is wound with two separate windings, dc and ac. The dc winding produces direct current for exciting the field, and for charging the starting batteries on the electric cranking models. The ac winding produces the alternating current output of the generator. Replace a defective armature with a new one.

GROUNDED CIRCUIT TEST. - Use a test lamp set to test both armature windings for a grounded circuit. Connect one test lamp lead to a bare metal point on the armature shaft. Connect the other test lead to the commutator surface. If the test lamp glows, the dc portion of the armature is grounded. Repeat the test, contacting the collector rings. If the test lamp glows, the ac portion of the armature is grounded. Replace a grounded armature with a new one.

AC WINDING, OPEN CIRCUIT TEST. - Use a test lamp set to test the ac winding for an open circuit. If the generator is the 115/230 volt, single phase model there are TWO ac windings. Contact the test lamp leads to the two collector rings nearest the ball bearing. If the test lamp fails to light, an open circuit in that winding is indicated. Repeat the test in the same manner, contacting the two collector rings nearest the commutator. If the test is made between the two middle collector rings, the test lamp should not glow - if it does, a short circuit between the two windings is indicated.

If the generator is a 3 phase, 3 wire model, contact one test lead to the collector ring nearest the commutator (no winding is connected to the ring next to the bearing). Contact the other test lead to the next two collector rings, in turn. If the test lamp fails to light on either test, an open circuit is indicated.

If the generator is a 3 phase, 4 wire model, contact one test lead to the collector ring nearest the bearing. Contact the second test lead to each of the next 3 collector rings, in turn. If the test lamp fails to light on any of the 3 tests, an open circuit is indicated.

AC WINDING, SHORT CIRCUIT TEST. - An armature growler is required for making an ac winding short circuit test. Follow the test procedure recommended by the growler manufacturer.

DC WINDING, OPEN OR SHORT CIRCUIT TEST. - An armature growler is required to make a satisfactory test. Follow the test procedure recommended by the growler manufacturer.

CONTROL BOX EQUIPMENT. - The control box equipment requires no maintenance other than keeping it dry, free of dust, and all connections electrically tight. If any of the control box equipment fails to function properly, replace the defective part with a corresponding new part. Repairs or adjustments on such parts are seldom practicable.

Always disconnect the starting battery before working on any control box equipment. Tag or otherwise mark each lead and its connection point before disconnecting it, to assure correct reconnection. Check carefully for loose or broken connections, or for damaged insulation.

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, 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, condenser, etc., or retime ignition.
Clogged carburetor.	Clean jets.
Clogged fuel screen.	Clean.
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.
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 bearings.	Replace.
Sludge on oil screen.	Remove and clean.
Badly worn oil pump.	Replace.
Defective oil pressure gauge.	Replace.

POSSIBLE CAUSE	REMEDY
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.
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 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	
Worn piston rings.	Install new piston rings.
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.

POSSIBLE CAUSE	REMEDY
EXCESSIVE OIL CONSUMPTION, LIGHT BLUE SMOKY EXHAUST (Cont.)	
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, 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.	Adjust choke. Install needed carburetor parts, adjust float level.
Choke not open.	See that choke opens properly.
Dirty 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 symptoms of low oil pressure for remedies.
Oil badly diluted.	Change oil.
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.

POSSIBLE CAUSE	REMEDY
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 symptoms of low pressure for remedies.
Oil badly diluted.	Change oil.
PINGING SOUND WHEN ENGINE IS RAPIDLY ACCELERATED OR HEAVILY LOADED	
Carbon in cylinders.	Remove carbon.
Spark too early.	Retime ignition.
Wrong spark plugs.	Install correct plugs.
Spark plugs burned or carboned.	Install new plugs.
Valves hot.	Adjust tappet clearance.
Fuel stale or low octane.	Use good fresh fuel.
Lean fuel mixture.	Clean or adjust carburetor.
ENGINE CRANKS TOO STIFFLY	
Too heavy oil in crankcase.	Drain, refill with lighter oil.
Engine stuck.	Disassemble and repair.
ENGINE WILL NOT START WHEN CRANKED	
Faulty ignition.	Clean, adjust, or replace breaker points, plugs, condenser, etc. or retime ignition.

POSSIBLE CAUSE	REMEDY
ENGINE WILL NOT START WHEN CRANKED (Cont.)	
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.
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 commutation 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.

POSSIBLE CAUSE	REMEDY
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.
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.

POSSIBLE CAUSE	REMEDY
ENGINE OVERHEATING (Cont.)	
Radiator obstructed.	Clean radiator.
Ignition timing late.	Adjust ignition timing.
Improper ventilation.	Provide for better air change.

PREPARING UNITS FOR STORAGE OR EXTENDED OUT-OF-SERVICE PERIODS. - Electrical generating sets are often taken out of service for extended periods of time. Too often 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 by this method:

Shut off the fuel supply at the tank and allow the unit to run until it stops from lack of fuel. The fuel system will then be free of gasoline except for the tank.

If the fuel tank will be subjected to temperature changes, fill the tank nearly full to lessen chances of condensation forming within the fuel tank.

Drain the oil from the oil base while the engine is warm. Replace the drain plug. See that the oil filler cap is in place. Attach a warning tag that oil has been drained.

If the cooling system does not have anti-freeze and rush inhibitor, drain the entire cooling system. Be sure to drain both the radiator and the block.

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 over slowly by hand to lubricate the cylinders. 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.

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.

Plug the exhaust outlet with a wood plug to prevent entrance of moisture or foreign matter.

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 can not 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 TO SERVICE 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 mater.

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 the plug from the exhaust outlet.

Remove, clean and adjust spark plugs. While the plugs are out, crank the engine over several times by hand 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 by hand to distribute the oil. Replace the spark plugs and gaskets.

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

Refill the cooling system with clean, fresh water.

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

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

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

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.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