INSTRUCTION MANUAL

FOR

ONAN ELECTRIC GENERATING PLANTS

10EL SERIES

ALTERNATING CURRENT MODELS

SPECIFICATIONS
G-H-J-K

. W. ONAN & SONS INC. MINNEAPOLIS 14. MINN.
)4-8 ******

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 determining 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 state the Model, Spec., and Serial numbers of the plant. This information is absolutely necessary and may be obtained from the nameplate on the plant.

MANUFACTURER'S WARRANTY

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

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

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

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

IMPORTANT--RETURN WARRANTY CARD ATTACHED TO PLANT.

TABLE OF CONTENTS

SUBJECT	PAGE NO.
Description	
Engine	1
Generator - AC Plant, DC Plant	2
Controls	2
Installation	
Location, Mounting, Ventilation, Exhaust	3
Underground Muffler - Fuel Supply, Gasoline	5
Fuel Supply, Gas - Batteries	6
Connecting the Load Wires, Housed Plants	6
Remote Control Connections	8
Connecting the Load Wires, Unhoused Plants	8
Remote Control Connections	10
Preparation	
Lubrication - Radiator	11
Fuel	12
Operation	
Starting	13
Checking the Operation	14
Connecting Electrical Load	14
Meters	14
High Water Temperature Switch	15
Low Oil Pressure Switch	15
Emergency Operation	15
Stopping the Plant	15
Abnormal Operating Conditions	
Low Temperatures	16
High Temperatures - Dust and Dirt	17
Periodic Service	
Daily Service, Weekly Service	18
Monthly Service	19
Semi-Yearly Service	20
Adjustments	
Carburetor	21
Automatic Choke	22
High Water Temperature Switch	22
Fan Belt Adjustment	22
Governor	23
Maintenance and Repair	
Engine	24
Table of Clearances	29
Generator	31
Service Diagnosis	
Probable Cause - Remedy	34
Special Instructions for Voltage Regulator Operation	39

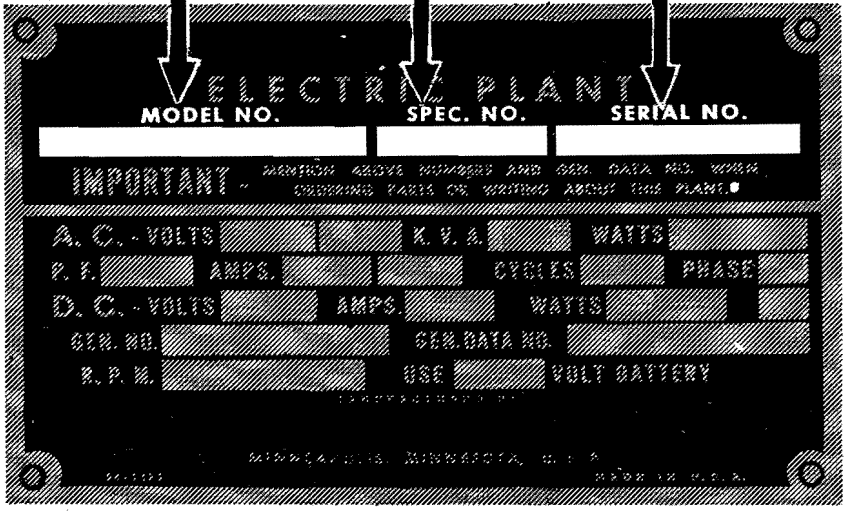
LIST OF ILLUSTRATIONS

SUBJECT	PAGE NO.
Typical Standby Installation	4
Exhaust Line	5
Connecting Load Wires - Housed Plants	
115 or 230 Volt, 1 Phase, 2 Wire Plant	6
115/230 Volt, 1 Phase, 3 Wire Plant	7
230 Volt, 3 Phase, 3 Wire Plant	7
120 Volt, 1 Phase/208 Volt 3 Phase, 4 Wire Plant	7
Remote Control Connections	8
Connecting Load Wires - Unhoused Plants	
115/230 Volt, 1 Phase, 3 Wire Plant	9
120 Volt, 1 Phase/208 Volt 3 Phase, 4 Wire Plant	9
3 Phase, 3 Wire Plant	10
Remote Control Connections	10
Carburetor Adjustment	21
Fan Belt Adjustment	22
Governor Adjustment	23
Water Pump-Timing Gear Marks	27
Removing Cylinder Sleeve	28
Installing Cylinder Sleeve	28
Care of Commutator and Brushes	29
Generator Assembly	29

Important !

Always GIVE THESE NUMBERS WHEN ORDERING REPAIR PARTS OR REQUESTING SERVICE INFORMATION FOR YOUR UNIT !

WRITE IN NUMBERS SHOWN ON PLANT NAMEPLATE



EL D

This 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. Each electric generating plant is given an actual running test and is carefully checked under various electrical load conditions before leaving the factory, to assure that it is free of defects and will produce its rated output. Inspect the plant 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 electric generator. Accessories and controls suitable for a normal installation and according to the particular model are supplied.

This instruction manual is supplied with all generating plants of the EL 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 using the instructions and recommendations given in this book as a general guide, the operator should have no difficulty in making a good installation, and in properly operating the generating plant.

If it ever becomes necessary to contact the factory or an Authorized Service Station in regard to this generating plant, be sure to furnish 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.

ENGINE

The engine is a Ford Model 8NNN-1004, 4 cylinder, L head, water cooled type. A gear type oil pump supplies full pressure lubrication to main, camshaft, and connecting rod bearings. Main and connecting rod bearings are replaceable. Cylinders have dry type replaceable liners. Pistons are aluminum.

ENGINE SPECIFICATIONS

BORE ..... 3-3/16"	HORSEPOWER - 1800 rpm 29
STROKE ..... 3-3/4"	FUEL ..... GASOLINE (NATURAL GAS EQUIP. AVAILABLE)
PISTON DISPLACEMENT 120 Cu. In.	COOLING ..... WATER
COMPRESSION RATIO 6.5:1	NO. CYLINDERS 4

The Ford engine used in this generating plant is an improved model of an efficient engine. The new distributor is easily accessible for servicing. The flywheel is marked for easier and more accurate timing. The newly designed cylinder head provides more power and fuel economy. The new aluminum pistons are cam ground to allow a closer fit, resulting in quiter operation and better oil economy. Engine life is increased by the use of chrome compression top rings on the pistons. The one piece valve guides simplify valve servicing. Camshaft lobes have been redesigned to increase engine efficiency. The new oil pump provides more positive lubrication. The cylinder block water passages are redesigned to provide more uniform cooling.

GENERATOR - AC PLANT

The alternating current generator is a revolving field type, with built in exciter. The alternator field and exciter armature are made into a single rotor unit. The exciter is a direct current generator which supplies current for charging the starting batteries and for creating a magnetic condition in the revolving field of the alternator. A separate winding in the exciter field enables the exciter to be used as a powerful motor for cranking the engine. The alternating current is taken directly from the stator winding of the alternator to the output connections.

The generator voltage and frequency are proportional to engine speed, which is closely regulated by the engine governor. Speed is approximately 1800 r.p.m. for 60 cycle plants and 1500 r.p.m. for 50 cycle plants. The inherent design of the generator provides close voltage regulation between no load and full load conditions, making it unnecessary to use any external voltage regulation methods for average applications.

GENERATOR - DC PLANT

The direct current (DC) type plant generator is of the compound wound type, and has 4 interpoles for sparkless commutation. The generator is self excited. The engine governor closely regulates engine speed, and so the generator voltage. The inherent design of the generator provides exceptionally close voltage regulation between no load and full load conditions.

CONTROLS

The controls necessary for proper operation of the plant are located at the generator end of the plant. The housed type plant has a panel for the instruments and control parts. The unhoused type plant has a control box mounted directly over the generator. Alternating current (AC) plants may be connected for remote control of starting and stopping, or automatic equipment may be connected.

NOTE

The unhoused type of plant is not equipped with the instrument panel supplied on the housed type of plant. The absence of the various instruments does not affect the efficiency of the plant in any way, but does inpose 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.

SPECIAL INSTRUCTIONS FOR VOLTAGE REGULATED PLANTS

For instructions regarding operation of the voltage regulated plants, refer to the special instructions at the end of this book, following the Service Diagnosis section.

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 at 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 electrician if in doubt.

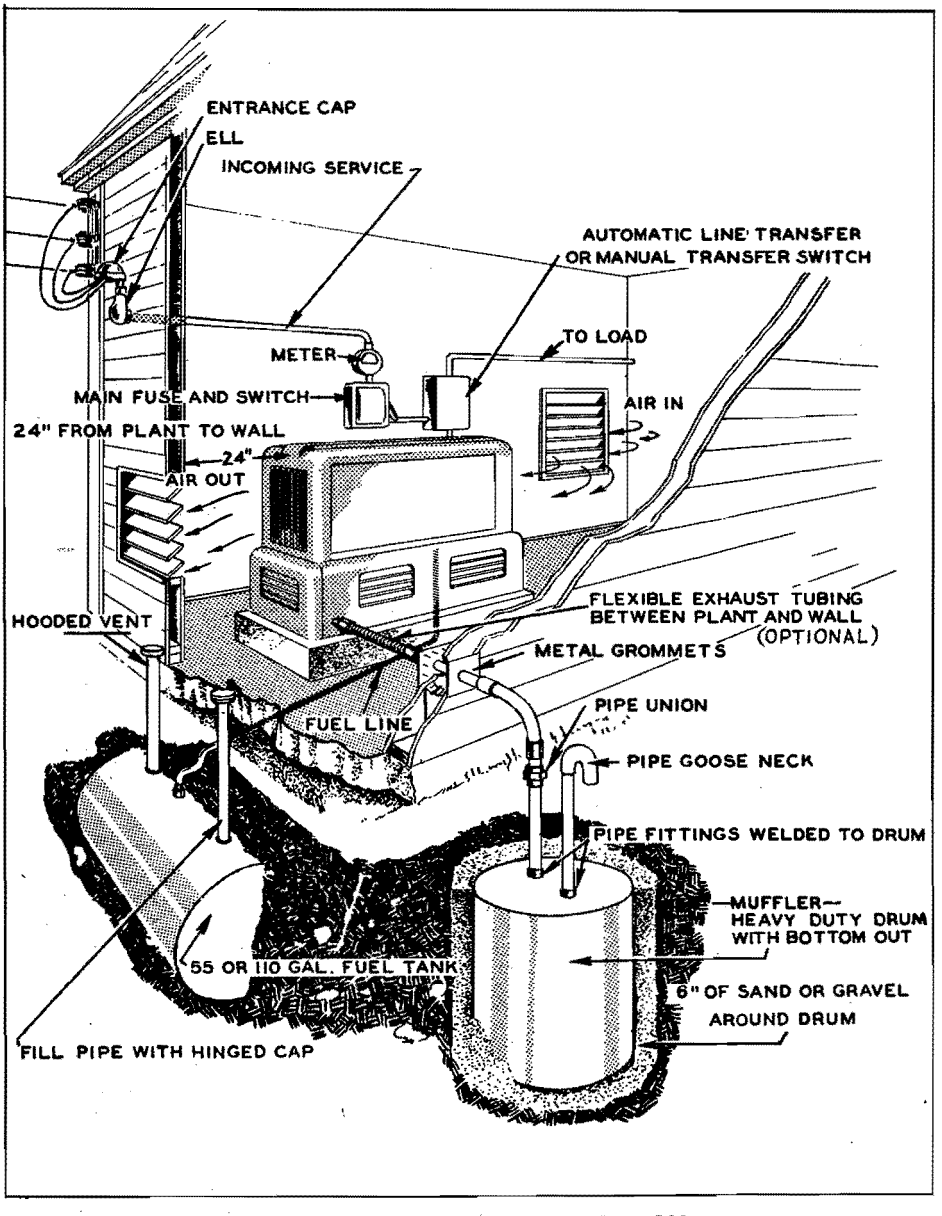
Select a site for the generating plant which will be dry, clean, and well ventilated. Choice of either a damp or dusty location will require more frequent inspection and servicing of the plant. If practicable, install the plant inside a building or covered vehicle for protection from extremes in weather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

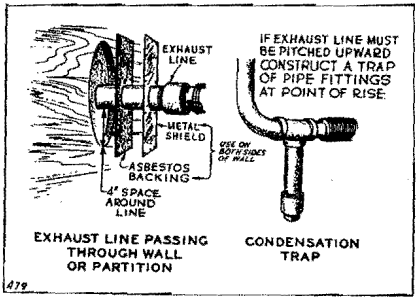
If the plant is mounted in a mobile vehicle, be sure the plant is bolted securely in place so that it can not shift when in transit. The plant must set approximately level when in operation.

VENTILATION. - The engine and generator create a considerable amount of heat, which must be dissipated. The radiator fan is a pusher type, blowing cooling air out through the front of the radiator, just the reverse of an automobile. If the plant is installed inside a small room or compartment, separate air inlet and outlet openings must be provided. The air outlet opening should be located directly in front of, and as close to the radiator as conditions permit. The air inlet should be located opposite the outlet and at a lower point. These openings should be a minimum of 5 square feet in area, larger if louvers or grille work reduce the effective opening area. A duct may be constructed to run from the plant radiator front to the outlet opening, to prevent recirculation of the heated air. In cold climates, provide adjustable openings so that the temperature of the compartment may be regulated, using the heat generated by the plant.

EXHAUST. - If the plant is installed inside a building or other enclosed space, the exhaust gases must be piped outdoors. Use pipe at least as large as the exhaust outlet on the plant. Keep the exhaust line as short as practicable, avoiding unnecessary sharp turns. Housed plants have the muffler mounted in the plant housing front compartment. Unhoused plants are supplied with a separate muffler and flexible exhaust tube, with pipe



TYPICAL STANDBY INSTALLATION



connections. Provide metal shields as shown at the left if the exhaust line must pass through an inflammable wall. Wrap the line with asbestos if there is danger of any one touching it.

If the exhaust line can not be run downward, install a condensation trap at the low point of the line. Drain the condensation from the trap periodically.

EXHAUST LINE

CAUTION

Exhaust gases are deadly poisonous. These gases must be piped outside any enclosure in which the plant may be installed. Be sure all exhaust connections are tight, to avoid exhaust leakage. Excessive breathing in of exhaust gases will cause serious illness or death.

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 the gasoline tank, the lift of the fuel to the fuel pump on the plant must not be more than 8 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.

For the unhoused plant, remove the fuel pump connector from the pump elbow and attach the non-swivel end of the fuel line to the pump inlet elbow. Connect the swivel end of the fuel line to the fuel tank shut-off connection. Do not reverse these fuel line connections. The thread on the non-swivel end of the line is 1/8" standard pipe, and on the other end is the inverted flare type, 1/4" tube size. The non-swivel end will not fit the shut-off valve connection, but will fit the fuel pump connection when the connector fitting is removed from the elbow.

FUEL SUPPLY, GAS. - Some special model plants are equiped to burn natural or LPG gas fuel. The gas pressure regulator is of the atmospheric type. It is designed to operate on a gas line pressure of not over 6 ounces. If the line pressure is more than 6 ounces, it will be necessary to install a primary type gas regulator in the line ahead of the plant regulator.

The plant regulator inlet is threaded for 3/4" standard pipe. Comply with the local gas code provision in making the installation. In some localities, presence of foreign matter in the gas supply may require the installation of a filter in the line.

BATTERIES. - The battery cables are not attached to the batteries. Two 6 volt (or one 12 volt) batteries are required. Use the short (6 inch) jumper cable to connect the positive post of one 6 volt battery to the negative post of the second 6 volt battery. For housed plants, connect the battery cable attached to the start solenoid switch to the remaining positive (+) post of the batteries. Connect the battery cable which is grounded, to the remaining negative (-) post of the batteries. 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.

For unhoused plants, solderless screw terminals are provided inside the rear of the control box. Bring the battery cables through the grommets at the rear of the box. Use care to connect the battery cables to the proper terminals as marked on the control box. The negative battery cable must connect to the grounded terminal post inside the control box.

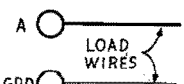
Batteries shipped "DRY" must be prepared for use as directed on the tags attached to the batteries.

Batteries shipped ready for use were fully charged at time of shipment. Such batteries slowly lose their charge when standing idle, and it may be found necessary to give them a "freshening" charge before putting them in use. Use a hydrometer to determine the charge condition.

CONNECTING THE LOAD WIRES

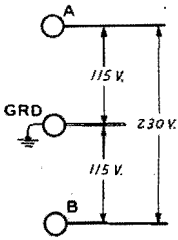
HOUSED PLANTS. - The AC output terminal studs, to which the load wires are to be connected, are located below the control panel, on the chassis. Remove the smaller grille from the right side of the plant (facing the radiator end). Solderless screw type connectors are provided for connecting the load wires to the output terminal studs. 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. The "T" designations of the terminal posts indicate the generator lead connections only. Use the A, B, or C designations for load wire connections to the terminal posts.

115 VOLT OR 230 VOLT, SINGLE PHASE, 2 WIRE PLANT



One terminal post is grounded. The insulated "A" terminal post is "hot". Connect the neutral or ground load wire to the plant terminal post marked "GRD". Connect the "hot" load wire to the plant terminal post marked "A".

115/230 VOLT, SINGLE PHASE, 3 WIRE PLANT

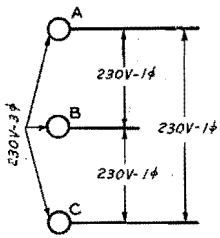


The center terminal is grounded. Terminals "A" and "B" are "hot". For 115 volt current connect the neutral load wire to the plant terminal post marked "GRD". Connect the "hot" load wire to either of the two outside terminals A or B. Two separate 115 volt circuits are thus available with not more than 1/2 the total plant rating available on each circuit. Balance the load as closely as possible between the two circuits.

For 230 volt current, connect the load wires to the plant terminals A and B, leaving the center "GRD" terminal unused.

A load not to exceed 15 amps., 115 volts may be connected to each outlet of the receptacle mounted on the control panel. Any load connected to this receptacle will not register on the meters.

230 VOLT, THREE PHASE, 3 WIRE PLANT

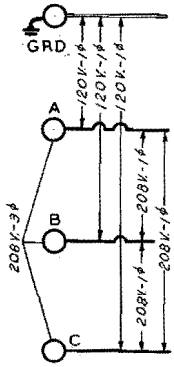


No terminal is grounded. For three phase current, connect a separate load wire to each plant terminal, A., B, and C, one wire to each terminal. Reversing the connections between any two terminals will reverse the direction of rotation of 3 phase motors. Use a phase sequence indicator to assure in-phase connection.

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



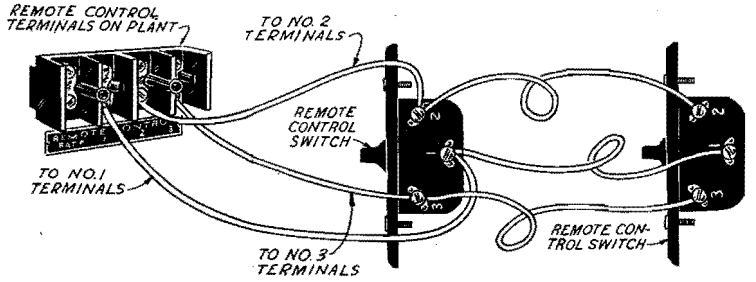
The topmost terminal is grounded. For 120 volt, single phase current, connect the grounded load wire to the grounded (top) plant terminal, and the other load wire to any one of the other three terminals A, B, or C. Three 120 volt, single phase circuits are thus available, with 1/3 the plant rating to each circuit. Balance the load as closely as possible between the circuits.

For 208 volt, three phase current, connect a load wire to each of the three insulated plant terminals A, B, and C, leaving the grounded (topmost) terminal unused. Reversing the connections between any two insulated 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.

REMOTE CONTROL CONNECTIONS

A small, four place terminal block is mounted above and to the left of the a-c output terminals. This is the block marked "DC OUTPUT-REMOTE" on the wiring diagram. One or more remote control switches may be connected to this block for remote starting and stopping. Connect the switch terminals Nos. 1, 2, and 3 to the corresponding terminals on the terminal block. Leave the B+ terminal unused. Remote control switches may be connected at any desired point within 250 feet of the plant. Number 19 wire for this purpose is listed in the parts list. If automatic line transfer equipment is to be connected follow the directions supplied with the equipment.



PROPER CONNECTIONS FOR REMOTE START-STOP SWITCHES

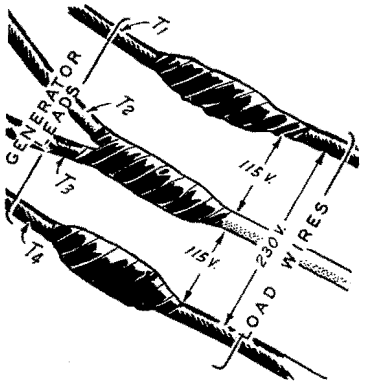
UNHOUSED PLANTS. - The generator output leads are within the small cast iron box at the rear of the generator. The load wires may be brought in through the hole at one end of the box. Load wires must be of the proper size of insulated wire, taking into consideration the distance involved and the amount 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.

NOTE - 3 PHASE PLANTS

If no switchboard (meter box) is to be used, generator leads marked A1 and AF must be connected together. If a switchboard is used, connect all generator leads to the proper points as shown on the wiring diagram for the switchboard.

115/230 VOLT, SINGLE PHASE, 3 WIRE PLANT

Connect generator leads marked T2 and T3 together. This will be the "neutral" load connection lead. For 115 volt 3 wire, connect the neutral (white) load wire to the T2, T3 generator leads. Connect two separate black (hot) load wires, one to each of the T1 and T4 generator leads. Two 115 volt circuits are thus available, one between T1 and T2, T3 and the other between T4 and T2, T3. One half



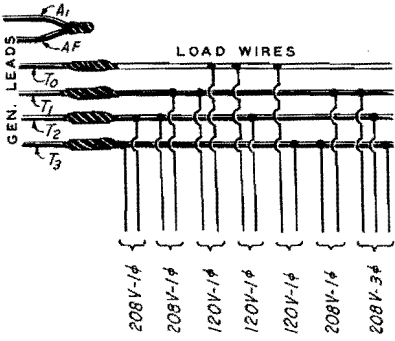
the capacity of the generator is available on each circuit. Do not attempt to take the entire generator capacity of 115 volt current from one circuit only, as the generator will be unbalanced and overloaded. Divide the load between the two circuits as equally as is practicable.

NOTE

If the full generator capacity is desired on a single 115 volt circuit, connect generator leads T1 and T3 together, then leads T2 and T4 together. Connect one load wire to the T1, T3 lead and the other load wire to the T2, T4 lead. For 230 volt service, do not connect a load wire to generator leads T2, T3 which must be connected together. Connect one load wire to the generator lead T1, and the other lead wire to the generator lead T4.

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 generator lead marked T0. Connect a "hot" (black) load wire to either T1, T2, or T3. Three separate 120 volt circuits are thus available: T0 - T1, T0 - T2, and T0 - T3. 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.

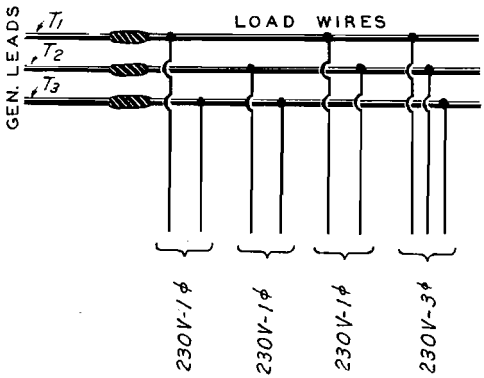


For 208 volt, 1 phase current, the T0 generator lead is not used. Connect separate load wires to any two of the T1, T2, or T3 generator leads. Three separate single phase circuits are available: T1 - T2, T1 - T3, and T2 - T3. As when connected for 120 volts, the load should be divided between the three single phase circuits.

For 3 phase current the T0 generator lead is not used. Connect the three load line wires to the generator leads T1, T2, and T3, one load wire to each generator lead. Reversing the connections between any two leads 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



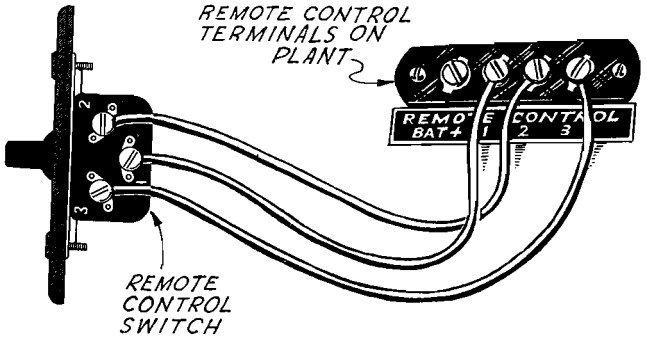
For 3 phase current, connect the three load wires to the generator leads T1, T2, and T3, one wire to each lead. Reversing the connections between any two leads will reverse the direction of rotation of 3 phase motors

For single phase current, connect a separate load wire to each of any two generator leads. Three separate single phase circuits are thus available: T1-T2, T2 - T3, and T1 - T3. 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, 4 place terminal block marked "REMOTE-DC OUTPUT" is located inside the control box. If automatic or line failure controls are to be connected, follow the directions for connections as supplied with the control equipment.



REMOTE CONTROL CONNECTIONS

A remote control switch is supplied with the plant. This switch may be installed at any desired point within 250 feet of the plant, using #18 or #19 wire. The switch will provide for remote control of starting and stopping the generating plant. Additional switches may be installed as desired, using #16 wire up to 500 feet, or #14 wire up to 1000 feet.

To install the remote control switch, connect the switch terminals #1, 2, and 3 to the corresponding terminals marked 1, 2, and 3 on the terminal board in the control box. Be sure to connect switch terminal #1 to control box terminal #1, etc. Any additional switches must be connected in parallel, all #1's together, all #2's together, etc.

DO NOT ATTEMPT TO START THE PLANT UNTIL IT HAS FIRST BEEN PROPERLY INSTALLED AND SERVICED WITH OIL, FUEL AND WATER (OR ANTI-FREEZE) AS INSTRUCTED IN THIS SECTION.

LUBRICATION

CRANKCASE. - Fill the engine oil pan with 4 quarts (U.S. measure) of a high quality oil. Use a heavy duty (detergent) type of oil. If a non-detergent type of oil is used, then a change made to the use of a detergent oil, allow not more than one third the usual operating hours between the next two oil changes. Change the crankcase oil at the regular recommended periods thereafter, as given under PERIODIC SERVICE.

Do not use an oil heavier than SAE #20 in a plant being put into service the first time, or one newly overhauled. After the first oil change period, use oil of the proper SAE number as indicated in the following table. Select the oil according to the LOWEST temperature to which the plant may be exposed when standing idle long enough to cool to the surrounding temperatures.

LOWEST TEMPERATURE	SAE NUMBER
Above 90° F (32° C)	40
32° F to 90° F (0°C to 32° C)	30
10° F to 32° F (-12° C to 0° C)	20
-10° F to 10° F (-23° C to - 12° C)	10W
below - 10° F (-23° C)	* 10W diluted with 10% kerosene

* Do not put diluted oil into the engine until ready to start the plant. Mix the oil and kerosene thoroughly just before pouring it into the engine.

Keep the crankcase oil level at or near the "FULL" mark on the bayonet (stick) type oil level gauge, but never above it. If the crankcase is over-filled, the connecting rods may strike the oil and cause improper lubrication and excessive use of oil.

CAUTION
NEVER OPERATE THE PLANT WITH THE OIL LEVEL AT OR BELOW THE "DANGER" MARK ON THE OIL LEVEL GAUGE.

AIR CLEANER. - Loosen the air cleaner clamp and remove the bottom cup of the air cleaner. Fill the cup with oil to the level marks on the side of the cup. Use oil of the same SAE number as that used in the crankcase, except as instructed under ABNORMAL OPERATING CONDITIONS.

RADIATOR. - The capacity of the cooling system is approximately 14 quarts (U.S. measure). Be sure that the radiator and the cylinder block drain cocks are closed. Use clean, alkali-free water such as clean rain water. Use a good rust and scale inhibitor. In freezing weather, use a standard automotive type of antifreeze in the proportion recommended by the manufacturer of the antifreeze. Fill the radiator only to within 1 or 2 inches below the bottom of the filler neck. Overfilling will cause loss of antifreeze through the overflow pipe, due to expansion of the liquid as the plant warms up. Check the cooling system carefully to be sure there are no leaks.

FUEL, GASOLINE. - Use clean, fresh, "regular" automotive type gasoline of 68 to 74 octane rating. Do not use a premium type of gasoline with a high lead content. The use of a highly leaded gasoline will require more frequent spark plug and valve servicing, and more frequent carbon removal. Unleaded gasoline of 68 to 74 octane rating is available in some communities. However, do not use "white" gasoline intended for use in stoves, lamps etc., as its octane rating is much too low. The use of low octane gas will cause severe knocking and probable damage to the engine.

If the fuel tank is close to the generating plant, do not fill the tank completely full of cold gasoline. As the plant warms up, expansion of the gasoline may cause it to over-flow, resulting in a definite fire hazard. See that all fuel connections are tight.

FUEL, GAS . - If the plant is equipped to burn gas fuel, see that the fuel line connections have been properly made. Be sure the gas line pressure is correct for the regulator installation.

BATTERY PREPARATION

For a usual plant installation, follow the instructions for Batteries 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 BATTERIES ON CHARGE BECAUSE THE GAS RELEASED DURING 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. Don't 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 batteries 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.

PRELIMINARY. - Before attempting to start the plant, recheck the installation and preparation details. Turn on the fuel supply and check to see that there are no leaks. See that no electrical load is connected to the plant.

CAUTION

If the preparation has been made for extremely cold weather, the initial filling of the crankcase with diluted oil should have been left to be done immediately before starting the plant. Be sure the crankcase is filled to the "FULL" mark on the oil level gauge.

STARTING THE PLANT ELECTRICALLY. - See that the ignition toggle switch is set at the ELECT. START position. Operate the START switch, holding it in contact firmly. When starting a plant for the first time (or a plant which has run out of fuel) it will require several seconds of cranking for the fuel pump to become full and to pump enough fuel to the carburetor for starting. The carburetor is automatically choked, except on some special manual models. The plant should start after a few seconds of cranking once the carburetor has become filled with gasoline. As the plant starts, continue to hold the START switch in contact until the engine has picked up running speed. Releasing the START switch too soon will cause the plant to stop. If the plant fails to start after a few attempts, do not continue cranking so long as to discharge the batteries. Check the fuel and ignition systems for the source of the trouble.

If gas fuel is to be used, be sure that the arm of the automatic choke, mounted atop the exhaust manifold, is locked in the horizontal position, making the choke inoperative. When using gas fuel, no carburetor choking is necessary. Be sure that the gasoline supply is turned off, and that there is no gasoline in the carburetor. With the gas fuel supply turned on, press the gas regulator priming button for an instant. The priming button is at the center of the outlet side of the regulator. Do not overprime. Operate the START switch and start the plant as described for gasoline fuel. After the carburetor has been properly adjusted to the gas fuel being used, it should not be necessary to use the priming button. See ADJUSTMENTS.

STARTING THE PLANT MANUALLY. - If the starting batteries have not sufficient power to crank the engine, the plant may be started by manual cranking. However, the batteries must have sufficient power to provide ignition current (except on special magneto ignition models). If gasoline fuel is used, the engine must be cranked enough to fill the fuel pump and carburetor. When ready to start the plant, throw the ignition toggle switch to the HAND START position. Crank the engine with the hand crank, using only a quick upward pull. Do not spin the crank, or push downward on it. If the plant does not start readily, it may be necessary to have someone hold the automatic choke arm up in full choking position or to block the choke arm up for one or two preliminary crankings. Manual operation of the choke will be necessary on manual models having the manual choke control.

If gas fuel is used, the gas used should have a BTU rating above 900 BTU per cubic foot. The surrounding temperature should be above 30 deg. F. (-1° C.) Use of the priming button on the regulator may be necessary when hand cranking. Avoid overpriming. After the plant is started, BE SURE TO RETURN THE IGNITION SWITCH TO THE "ELECT. START" POSITION.

CAUTION

KEEP THE IGNITION SWITCH AT THE "ELECT. START" POSITION AT ALL TIMES EXCEPT WHILE ACTUALLY CRANKING THE PLANT MANUALLY. THROW THE SWITCH TO THE "HAND START" POSITION WHILE CRANKING THE PLANT BY HAND, BUT RETURN THE SWITCH TO THE "ELECT. START" POSITION AS SOON AS THE PLANT IS STARTED, OR IF THE PLANT IS LEFT NOT RUNNING. IF THE SWITCH IS LEFT AT THE "HAND START" POSITION WHEN THE PLANT IS NOT RUNNING, THE BATTERY MAY BECOME DISCHARGED AND THE IGNITION COIL DAMAGED. IF THE PLANT IS FITTED WITH HIGH WATER TEMPERATURE OR LOW OIL PRESSURE SWITCHES, THESE SWITCHES WILL BE OUT OF THE CIRCUIT AND NO PROTECTION PROVIDED WHEN THE IGNITION SWITCH IS AT THE "HAND START" POSITION.

CHECKING THE OPERATION. - After the plant starts, allow the plant to thoroughly warm up. Check the level of the liquid in the radiator, as the thermostat may have allowed an air pocket to form and prevent complete filling. Fill as necessary. The engine oil pressure should be 25 to 35 lbs. The battery charge rate should be between 2 and 10 amperes depending upon the charge condition of the batteries.

CONNECTING ELECTRICAL LOAD. - If the plant is equipped with a circuit breaker, throw the circuit breaker handle to the "ON" position. This action connects the plant output to the load lines. Turn on different electrical loads and check the operation of the plant. As electrical load is increased, the plant governor advances the carburetor throttle, keeping the engine running at the same speed. The governor should act smoothly, with almost instant response to any change in the electrical load. A difference in the sound of the engine exhaust noise will be noticeable with changes of electrical load.

When operating conditions permit, it is best to allow the engine to thoroughly warm up before connecting a heavy electrical load. The plant may be safely operated at any time with no electrical load connected.

CAUTION

NEVER ATTEMPT TO MAKE ANY CHANGES IN THE OUTPUT CONNECTIONS WHILE THE PLANT IS OPERATING. THE OUTPUT OF THE GENERATOR IS SUFFICIENT TO PRODUCE SEVERE ELECTRICAL SHOCK.

METERS. - On plants equipped with panel equipment, any load connected to the generator output will register on the ammeter. Three phase plants have a selector switch which is used for checking the individual phases of the circuit. Single phase plants equipped with a duplex receptacle on the panel will not register any load connected to the receptacle. The receptacle is provided for an auxiliary light (115 volts) or similar load up to 15 amps. per outlet.

Voltage as shown on the voltmeter will vary with the load, in inverse proportion. For a 115 volt plant, at no load condition the voltmeter should read approximately 126 volts. With a full load on the plant, the voltmeter should read approximately 110 volts. For plants of higher rated voltage, the readings will be correspondingly higher.

Continuous overloading of the generator will cause the temperature of the generator to rise to a dangerously high point and may lead to early failure of the windings. A circuit breaker, standard equipment on housed models, will trip to the "OFF" position if the plant is severly overloaded. Remove the cause of the electrical overload before returning the handle to the "ON" postion.

On the three phase plant, if part of the load is single phase, be sure the total load on any one "leg" does not exceed one third the total capacity of the generator. On the 115/230 volt single phase plant, be sure to confine the load on each 115 volt circuit to not more than one half the plant capacity.

HIGH WATER TEMP. SWITCH. - The high water temperature switch is standard equipment on the housed type of plant. This switch is optional equipment on other models. If the engine water temperature rises to a dangerous point, the cut-off switch operates to automatically close the stop circuit, having the same effect as pressing the stop button on the plant. The engine must cool off approximately 10^{o} 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 close the stop circuit, 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 temporarily with the switch at the HAND START position. This is purely an emergency measure and should be resorted to only if necessary. The starting batteries will not receive any charging current, and 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. - To stop the plant, press the STOP switch momentarily. The stop circuit will not work if the ignition switch is at the HAND START position. In an emergency, if the stop circuit fails to work, stop the plant by turning off the fuel supply.

LOW TEMPERATURES

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

CRANKCASE LUBRICATION. - If the plant will be exposed to low temperature when not running, so that it becomes thoroughly chilled, and the crankcase oil congealed, follow the crankcase oil recommendations as given under PREPARATION, LUBRICATION.

If temperature conditions require the use of diluted oil proceed as follows. Run the engine until thoroughly warmed up, then stop and drain the crankcase oil. Thoroughly mix 5-1/2 quarts (U.S. Measure) of SAE #10 or #10W oil with one pint of kerosene. Use 4 quarts of this mixture to fill the crankcase to the "FULL" mark on the bayonet gauge. Start the plant and run for at least ten minutes to thoroughly circulate the mixture throughout the engine. Use the remainder of the mixture to add oil when necessary. When using diluted oil, change the oil every 25 operating hours, and check the level at least every 8 hours. Use oil which is not diluted as soon as temperature conditions permit.

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 atmospheric conditions permit the use of oil in the normal manner.

COOLING SYSTEM. - The coolant must be protected if there is any possibility of its freezing. Use any good antifreeze, in the proportion recommended by the manufacturer for the lowest temperature to which the plant will be exposed. The capacity of the cooling system is approximately 14 quarts, U.S. Measure.

If using an antifreeze which has a low boiling point, set the high water temperature cut-off switch at a temperature setting which will properly protect the plant if excessive evaporation occurs.

If the plant will be standing idle in freezing temperatures without adding antifreeze, be sure to open the cylinder block drain cock to thoroughly drain all water from the block, after draining the radiator.

FUEL, GASOLINE. - The use of fresh, clean, winter grade (not highly-leaded premium) gasoline is an aid to easy starting in cold weather. If the plant has a fuel tank mounted in the housing, keep the tank nearly full to prevent moisture condensation inside the tank, which could cause considerable trouble from ice formation in the fuel system. Do not fill the tank entirely full of cold gasoline, for expansion as the plant warms up may cause the gasoline to overflow.

FUEL, GAS. - Some types of Liquid Petroleum Gas will not vaporize readily at low temperatures. Heat exchanger equipment can be installed at the factory.

BATTERIES. - Check the charge condition of the batteries to be sure that they are kept in a high state of charge. A discharged battery may freeze at approximately 20° F. (-7° C.) and be permanently damaged. A fully charged battery will not freeze at -90° F. (-67° C.). Run the plant for at least 20 minutes after adding water, to assure mixing the water with the electrolyte.

HIGH TEMPERATURES

If the plant is to be operated in unusually high temperatures, observe the following precautions.

1. Provide sufficient air circulation for proper cooling.
2. Keep the cooling system clean and free of rust and scale. Keep the radiator well filled.
3. See that the high water temperature cut-off switch is properly set.
4. Keep the fan belt tension adjusted properly.
5. Keep the ignition properly timed.
6. Keep the crankcase oil level at, but not above, the "FULL" mark on the oil level gauge. Use SAE #30 oil for temperatures up to 90° F. (32° C.) and SAE #40 for higher temperatures.
7. Keep the battery electrolyte level up to normal.

DUST AND DIRT

Keep the plant as clean as practicable. Clean the air cleaner as often as conditions require. Keep the radiator fins clean and free of foreign matter. Keep the generator, its commutator and slip rings, and brushes clean. See that all brushes are free in their holders. Keep supplies of fuel and oil in air tight containers. Change the oil filter element as frequently as conditions require.

GENERAL. - Follow a definite schedule of inspection and servicing. This will 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 conditons, or abnormal operating conditions, service more often.

DAILY SERVICE

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

FUEL. - If the plant is operated on gasoline fuel, check the fuel supply often enough to assure a continuous 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 1" of the bottom of the filler neck. In freezing weather, if a non-permanent type antifreeze is used, check the protective strength of the coolant.

CRANKCASE OIL LEVEL. - Check the oil level as indicated on the bayonet oil level gauge. Do not allow the engine to run with the oil level at or below the "DANGER" mark on the gauge. Add sufficient oil of the proper SAE number to bring the oil level to the "FULL" mark, but do not overfill the crankcase.

AIR CLEANER. - Check the oil level in the air cleaner cup and add enough oil to bring it to the indicated level. Under very dusty conditions, clean and refill.

WEEKLY SERVICE

If the plant is operated more than 50 hours a week, perform the WEEKLY SERVICE operations each 50 hours. The WEEKLY SERVICE should include the applicable DAILY SERVICE operations.

CRANKCASE OIL. - Add crankcase oil, or change the oil after 50 operating hours. If the plant has been operating with diluted oil, change the oil after 25 hours operation.

AIR CLEANER. - Clean the 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 CONDITONS.

BATTERIES. - Check the level of the electrolyte. Keep the electrolyte level at the proper 3/8" level above the plates by adding only clean water approved for use in batteries. Do not overfill. In freezing weather add water just before running the plant. See that battery connections are clean and tight.

FAN BELT. - Check the fan belt tension. Adjust to permit about 3/4" play when pressure is applied midway between the fan and crankshaft pulleys. See the illustration in the Adjustment section. Install a new belt if the old one is badly worn.

GENERAL LUBRICATION. - Put a drop of light oil on each of the governor arm to carburetor link ball joints, and a few drops in the

distributor oil cup. Do not oil the carburetor throttle or choke shaft bearings if dusty conditions prevail.

SPARK PLUGS. - Clean the spark plugs and check the electrodes gap. Keep the gap adjusted to .025". More frequent spark plug service may be required if leaded fuels are used.

DISTRIBUTOR. - Check the distributor contact points. If they are only slightly burned or pitted, resurface them with a fine stone. Install new points if the old ones are badly burned. After either resurfacing or replacing points adjust the gap to .020". Excessive arcing at the points 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, service every 200 hours. THE MONTHLY SERVICE operations should include the applicable DAILY and WEEKLY SERVICE operations.

GASOLINE FUEL SUPPY. - Shut off the fuel supply. On plants which have a fuel filter, remove and clean the filter bowl and screen, Be sure the bowl gasket is in good condition when reassembling the filter. Remove the pipe plug at the bottom of the carburetor and drain the carburetor bowl of any sediment which may have accumulated. Drain the fuel pump of any sediment. Turn on the fuel supply and check carefully for leaks, correcting any found.

DISTRIBUTOR. - After removing the cap, place one drop of light oil on the pivot pin of the breaker arm. Place three or four drops of oil on the flyweight mechanism, making sure it reaches the points of friction. Place a light coating of grease on each lobe of the cam which operates the breaker arm. Fill the small oil cup on the side of the distributor with light oil.

OIL FILTER. - If the engine oil is becoming discolored, install a new oil filter element. Clean the filter shell of all sediment before installing the new element. The new filter element will absorb approximately one quart of oil when the plant is started up. Check the oil level after a short running period and add a sufficient amount of oil to bring the oil level up to the "FULL" mark on the level indicator.

NOTE

When using detergent oil, a gradual darkening of the oil color is natural. Install a new element whenever sediment accumulates excessively on the filter element.

CRANKCASE BREATHER VALVE. - Remove the breather valve from between the valve cover plate and the intake manifold. Soak the valve assembly thoroughly in a good solvent (alcohol or acetone). Dry the valve and reinstall it to the engine.

OIL FILL BREATHER CAP. - Wash the breather cap in gasoline or other suitable solvent. Be sure the cap fits the oil fill tube properly when replacing it.

EXHAUST SYSTEM. - Inspect all exhaust connections carefully, particularly if the plant is installed inside a building or other enclosure. Make any repairs necessary to correct any leak found.

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.

Engine compression should not be below 80 lbs. pressure at sea level. New engine compression is approximately 100 lbs. at cranking speed.

GENERATOR. - Carefully examine the condition of the generator commutator, slip rings, and brushes. In service, the commutator and the slip rings acquire a glossy brown color, which is a normal condition. Do not attempt to maintain a bright, newly machined finish. Clean the commutator and slip rings with a clean, dry, lint free cloth. Hold the cloth against the commutator or slip ring while the generator is turning. If the commutator becomes heavily coated, sand lightly with #00 sand paper. Never use emery or carborundum cloth or paper.

Check the condition of the generator brushes. Replace with new ones 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. See that brushes are free in their holders. Clean out brush carbon dust from the brush rig and end bell.

GENERAL INSPECTION. - Thoroughly inspect the entire plant for signs of oil or water leaks, loose electrical connections, and loose bolts or nuts. Make any necessary repairs. A short time spent in discovering and correcting a possible source of trouble may avoid a later shut-down at an inconvenient time.

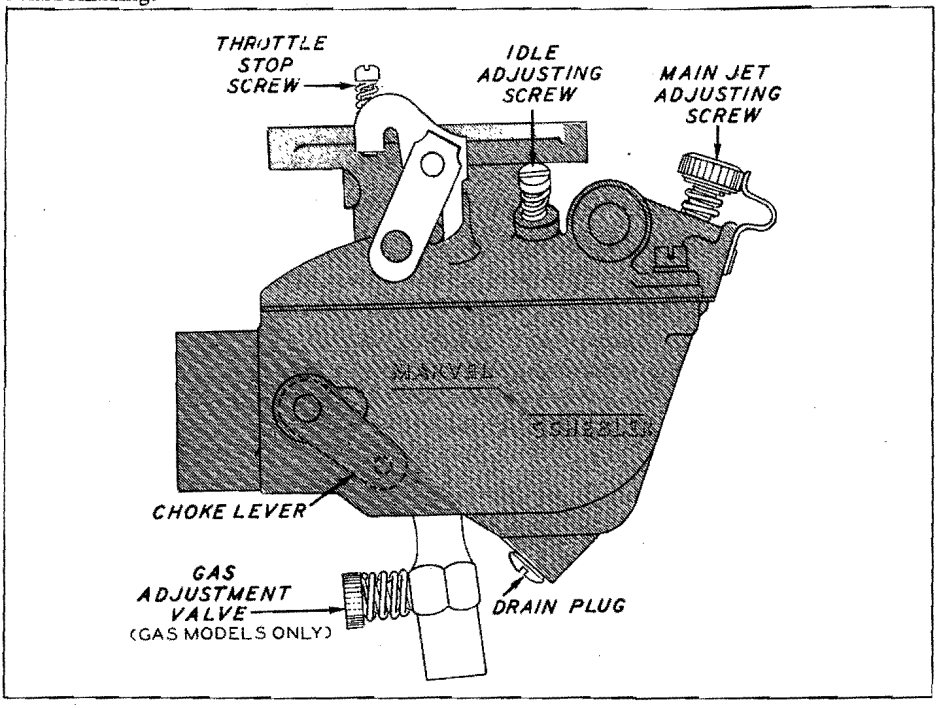
SEMI-YEARLY SERVICE

Every six months or 1200 operating hours, whichever occurs first, service the generator bearing and the fan idler bearing as follows.

GENERATOR BEARING. - Thoroughly clean all dirt from around the bearing cover and gasket. Remove the old lubricant with a clean finger, and work about one tablespoon of new ball bearing lubricant well into the bearing and again remove the lubricant. Refill the bearing housing about 1/2 full of bearing lubricant, packing it well into the lower half of the bearing. Be sure that no dirt gets into the bearing. Install the bearing cover, using a new gasket if necessary.

FAN IDLER BEARING. - Remove the fan idler pulley and arm by disconnecting the arm at the pivot. Remove all dirt from the assembly. Remove the snap ring and pipe plug. Press the bearing from the pulley. Clean the pulley and bearing in solvent. Replace the plug. Be sure the bearing is completely dry, and pack the bearing well with clean ball bearing grease. Reassemble, taking care not to get any foreign matter into the bearing. Adjust the fan belt tension as directed under ADJUSTMENTS.

CARBURETOR. - 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 all gaskets are in place when reassembling.



CARBURETOR ADJUSTMENT

Changes in the type of fuel used, or in operating conditions may necessitate a readjustment of the carburetor. For gasoline operation, adjust as follows. See the carburetor illustration. With the plant operating at full load, and at operating temperature, turn the main jet adjusting screw in (clockwise) until the voltage, as shown by the AC VOLTMETER, drops noticably. Then turn the screw out (counter-clockwise) until the voltage rises to normal, and the engine runs smoothly. Check the operation under various load conditions. If it is necessary to open the adjustment more than 1/2 turn beyond the point where normal voltage is attained, in order to obtain smooth operation, a readjustment of the governor may be necessary.

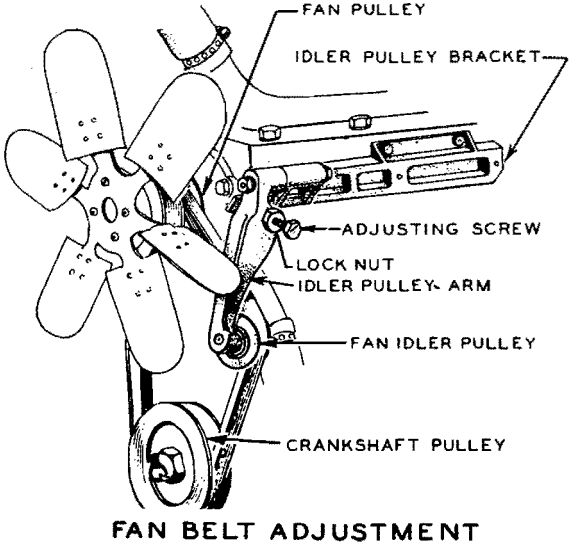
After the plant has been adjusted for load operation, disconnect the load and adjust the idle adjustment screw in the same manner. This adjustment is usually not as critical as the main jet adjustment.

For natural gas, or Propane or Butane vapor operation, the only adjustment is the gas regulating valve at the bottom of the carburetor. Follow the principles as outlined above for gasoline operation.

AUTOMATIC CHOKE. - The choke control should not require seasonal readjustments, 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 shaft hole. Check to see that when the lever is lifted up to the limit of its travel, the carburetor choke valve is wide open. For gas or vapor operation, the choke should be locked in the wide open position.

HIGH WATER TEMPERATURE SWITCH. - The high water temperature switch operates to stop the engine if the coolant temperature rises to a dangerous point, thus preventing overheating, which could cause serious damage to the engine parts. The engine may be started again when the coolant temperature drops approximately 10^{o}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^{o}F. for each 1000 feet above sea level. The dial was set at 205^{o}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 normal operating temperature. Do not set the switch to operate at too high a temperature, or the engine will not be protected against overheating.

FAN BELT ADJUSTMENT. - The fan belt adjustment is made with an adjusting screw on the idler pulley arm. Loosen the lock nut on the adjusting screw. Turn the adjusting screw in (clockwise) to tighten the fan belt, and out (counterclockwise) to loosen. Be sure to tighten the lock nut after the adjustment is made. There should be approximately 3/4" play when pressure is applied at a point midway between the fan and crankshaft pulleys. Too tight a belt will have a short life, and will cause excessive strain and wear on the water pump bearing. A belt too loose will slip, wear out rapidly, and cause inefficient cooling.



FAN BELT ADJUSTMENT

GOVERNOR. - The governor controls the speed of the engine, and therefore the voltage and frequency of the current. Should resetting of the governor become necessary, proceed as follows, referring to the illustration GOVERNOR ADJUSTMENT.

1. With the engine stopped, and tension on the governor spring, adjust the governor linkage length so that the carburetor throttle stop lever clears the stop pin by not less than 1/64" as shown.

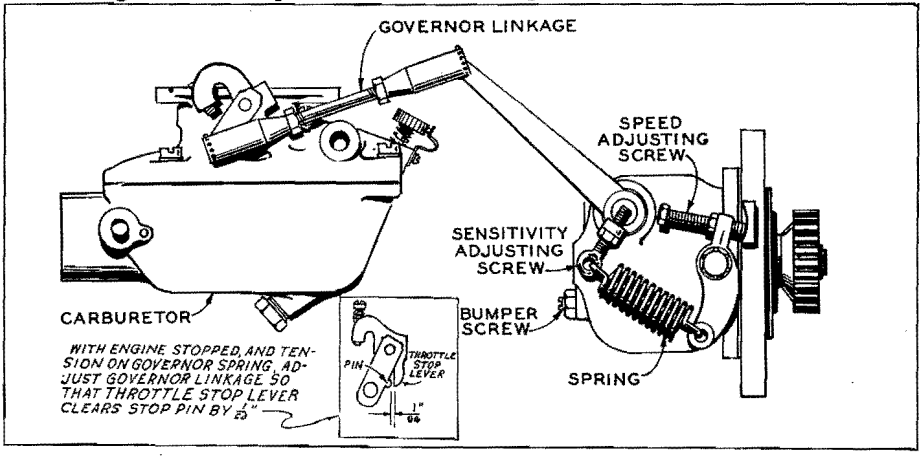
2. Start the plant and allow it to reach operating temperature.

3. With no electrical load connected, adjust the speed screw to the point where the panel voltmeter shows approximately 126 volts for a 115 volt A.C. plant. Apply a full load to the plant and again check the voltage, which should be approximately 110 volts for a 115 volt A.C. plant. Voltages will be proportionately higher for plants of other voltages. Engine speed for a 60 cycle plant, as checked with a tachometer, should be within the limits of 1890 r.p.m. at no load, to 1710 r.p.m. at full load, with the actual spread between no load and full load conditions not more than 100 r.p.m.

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

5. If hunting occurs at NO LOAD, screw the small bumper 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.

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



GOVERNOR ADJUSTMENT

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 should be made by a competent mechanic who is thoroughly familiary with modern internal combustion engines and revolving field generators.

ENGINE

IGNITION TIMING. - If a change is made to a lower octane fuel, a "pinging" condition may result which will require retarding the ignition timing. Loosen the distributor clamp bolt slightly, and turn the distributor body in a counterclockwise direction just enough to eliminate the "ping". Turning the distributor in a clockwise direction will advance the timing. Be sure to retighten the clamp bolt after the correct adjustment is made. If the distributor is removed from the engine, it will be necessary to retime the spark to the cylinder upon reinstalling the distributor. Be sure the contact point gap is set at .020" before retiming the ignition.

RETIMING, PRIOR TO SERIAL #417757. - Insert a bent piece of stiff wire through the spark plug hole far enough into the cylinder to feel the near edge of the piston as it rises. Crank the engine slowly until the piston is exactly at top dead center on a compression stroke. Install the distributor so that the low tension terminal points approximately toward the water pump, and the distributor rotor points to a position corresponding to the No. 1 tower of the distributor cap. Press the rotor in a clockwise direction, to eliminate any backlash, and turn the distributor body counterclockwise to the point where the contact points just start to separate. Tighten the clamp bolt, and install the distributor cap. The correct firing order is 1-2-4-3, counterclockwise. Recheck the timing under running conditions.

RETIMING, BEGINNING WITH SERIAL #417757.- Remove the #1 spark plug and crank the engine until the #1 piston is coming up on its compression stroke. Remove the cover from the timing hole in the flywheel housing. Slowly crank the engine until the 4 degree mark on the flywheel is directly in line with the pointer in the hole.

If the distributor has been removed from the engine, hold it so that the oil cup is toward the engine rear. Install the distributor to the engine, being sure the distributor gear meshes with the drive gear inside the gear cover on the engine. The distributor rotor should point directly over the breaker points.

Turn the distributor body to the point where the breaker points just separate. It may be necessary, to lift the distributor up, out of gear engagement, and position it again in order to get the breaker to separate properly. Tighten the distributor clamp bolt securely. Install the distributor rotor and cap. With the #1 spark plug wire connected, lay the spark plug on top of the engine so that its shell is grounded. Turn on the ignition current. Crank the engine slowly, stopping at the point where the spark occurs at the #1 plug. Observe the flywheel pointer, which should line up with the 4 degree mark on the flywheel. It may be necessary to loosen the clamp bolt and turn the distributor body slightly to advance or retard the timing as necessary until the spark does occur at the 4 degree mark.

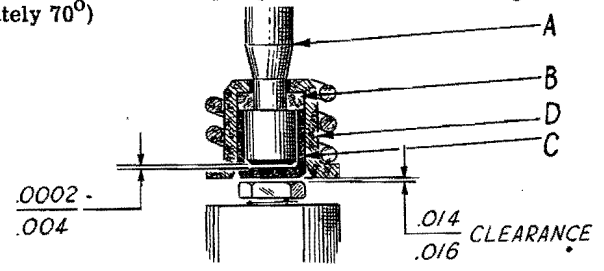
VALVE CLEARANCE. - The proper cold clearance for setting exhaust valves is .014 to .016", and for intake valves is .010 to .012". The tappets on later engines are adjustable for setting valve clearance. Adjustment can be made without tappet holding tools by removing valve springs so that tappets can be lifted. Recheck clearance again after assembling springs. Adjustable tappets are interchangeable with nonadjustable tappets used previously.

On engines with nonadjustable tappets, adjust the valve clearance by grinding the valve face to decrease the clearance or grinding the bottom of the valve stem to increase the clearance. If a valve face is ground to correct tappet clearance, lap the valve seat as necessary to correct valve leakage.

In order to specify a uniform method of checking valve clearances the following chart is suggested:

Valves Open	Valves to be Checked
#1 Exhaust & 3 Intake	#2 Intake & 4 Exhaust
#1 Intake & 2 Exhaust	#3 Exhaust & 4 Intake
#2 Intake & 4 Exhaust	#1 Exhaust & 3 Intake
#3 Exhaust & 4 Intake	#1 Intake & 2 Exhaust

Correct adjustment of valve clearance may be obtained only if the valves indicated in the above chart are in full open position and with the engine at room temperature (approximately 70^{O})



A new type exhaust valve assembly is illustrated above. The assembly consists of a valve "A", two keys "B", a cap "C", and a special retainer "D", the standard spring being used with this assembly.

REMOVING VALVES, TWO PIECE GUIDES. - The valve assemblies may be removed for servicing in the following manner. Insert a small pry bar through the port at the side of the cylinder block and pry downward on the top of the guide, being sure that the valve is closed. Remove the valve guide retainer from the guide, and remove the pry bar. The valve, guide, and spring assembly can than be removed upward. If the assembly is difficult to remove, crank the engine until the valve is open and insert a piece of wood under the head to hold it open. Then crank the engine until the tappet is down and insert the flat end of a wrench or a similar metal block between tappet and valve end. Crank the engine and the valve will be pushed higher. By thus alternately increasing the blocking beneath the valve head and between valve and tappet, and cranking the engine to push the assembly up by easy stages, no damage will result to the valve. Do not try to raise a stuck assembly by prying under the valve head. Remove springs and guides from valves. Keep the two piece guides in pairs, each with its proper valve.

REMOVING VALVES, ONE PIECE GUIDES. - On engines using the one piece guides, the lower end of the valve stem is straight and the valve guide need not be removed for usual valve servicing. With a conventional valve spring compressor, lift the valve spring and retainer washer. Remove the two valve keys and the valves can then be removed upward. If old valves are to be kept in service, be sure to keep them in order so that each may be ground and reinstalled to its former position.

The one piece guides may be removed upward after first removing the retainer at the bottom of the guide.

Remove carbon and corrosion from valves and guides. Clearance of stem in guide should be between .0015" and .0035". If the inside of guide has worn larger than .314", discard it.

After grinding each valve to its seat, check the tappet clearance. The clearance must be between .014" and .016" for the exhaust valves, and between .010" and .012" for the intake valves.

PISTON RING REPLACEMENT. - Pistons and connecting rods are removed from the top of the cylinder. Two compression and one oil control ring are used on each piston. Check the cylinders for out of round or taper, installing new sleeves if worn more than .005". Any ridge at the top of the cylinder bore should be removed. Fit each ring to its individual cylinder, being sure that the gap between the ends of the ring, when in the cylinder, is between .012" and .017". Fit the proper ring in each ring groove on the piston, with the ring gaps equally spaced around the piston, and with no gap directly in line with the piston pin. Be sure the ring grooves are clean, and oil return holes are open before installing the rings on the piston.

NOTE

The piston rings used on the steel pistons are not interchangeable with those used on the aluminum pistons. Be sure to obtain piston rings to fit the type of piston used.

PISTONS AND PINS. - If a piston is worn or scored, install a new piston. Pistons which are to be reused must be reinstalled on their connecting rods so that they will face in the original direction. Fit piston pins to the piston with a maximum clearance of .0005", and to the connecting rod with a clearance of .0001". The piston pins are locked in place by retaining snap rings in the piston bosses at either end of the pin. When reassembling, make sure that both snap rings are tightly in place.

NOTE

Aluminum pistons may be substituted for steel pistons when a complete set is installed. The newer aluminum piston is cam ground and has less cylinder clearance at operating temperature. When old pistons are being reused, be sure all four are of the same material.

LUBRICATING SYSTEM. - A gear type oil pump delivers oil under pressure to the crankshaft main, camshaft, and connecting rod bearings. Spray holes in the upper halves of connecting rod bearing spray oil on the cylinder walls. Other internal parts are lubricated by oil spray from the bearings. A spring loaded oil relief valve at the front of the engine regulates the oil pressure. Whenever the engine is disassembled for servicing, make sure that all oil passages are unobstructed. Thoroughly clean the oil pan and the oil pump strainer screen.

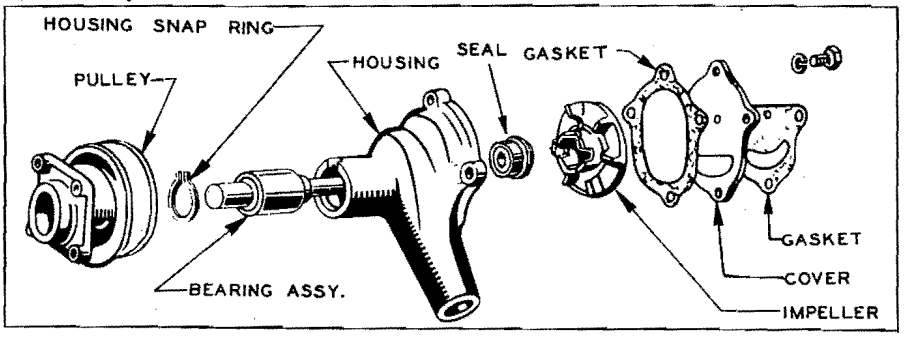
CONNECTING RODS. - The connecting rod lower end bearing shells are steel backed, alloy lined, and are readily replaceable. Connecting rods are numbered on the camshaft side of the bearing end, and each connecting rod and piston assembly must be reinstalled in its original position. If one bearing shell becomes worn, both shells for that rod should be discarded, and new ones installed. The bearing shells are designed to give a clearance of .0004" to .0025" without any scraping or other fitting.

Never attempt fitting a connecting rod by filing of either the cap or upper half of the rod. Be sure that no foreign material gets under the shell, and that each fits snugly when reassembling. Note that notches machined in the connecting rod halves receive matching ears stamped into the bearing shell. When installing pistons and connecting rod assemblies, be sure that they are properly aligned, and that connecting rod to crankshaft end play of .004" to .008" is maintained.

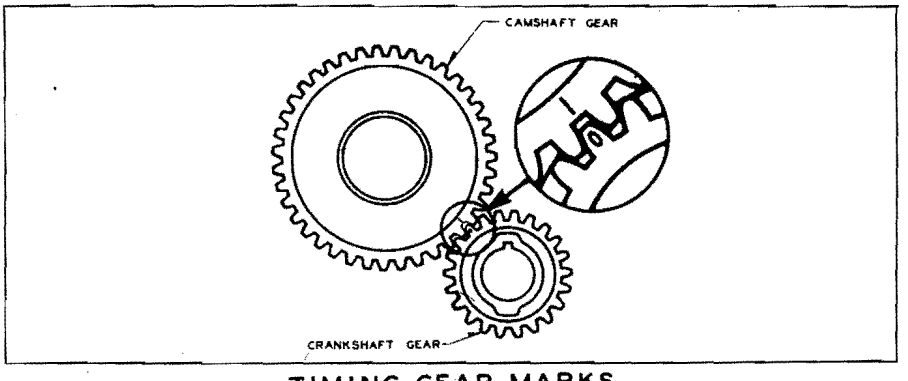
MAIN BEARINGS. - The crankshaft main bearings are of the same type as the connecting rod bearings. Front and rear bearing shells are interchangeable. The center bearing shells are flanged to take the crankshaft end play. The same general precautions given for fitting connecting rod bearings should be followed when fitting main bearings. The clearance, when installed should be .001" to .0025". A packing is fitted into grooves in the crankcase and the oil pan, to prevent the escape of oil at each end of the crankshaft. The packing is replaceable and the pan packing should be renewed each time the oil pan is removed.

TIMING GEARS. - Should it become necessary to replace a worn camshaft timing gear, be sure that the timing marks stamped on the gears are properly aligned as shown in the illustration. The proper backlash is .003" to .004". Oversize camshaft timing gears are available in .006" and .010" oversizes. Some engines are equipped with an aluminum camshaft gear, others with a fibre gear. Either material may be used when replacing with a new gear. Note that one bolt hole is offset so that the gear may be installed in only one position on the camshaft. The cast iron crankshaft gear is pressed onto the crankshaft and may be removed with a gear puller.

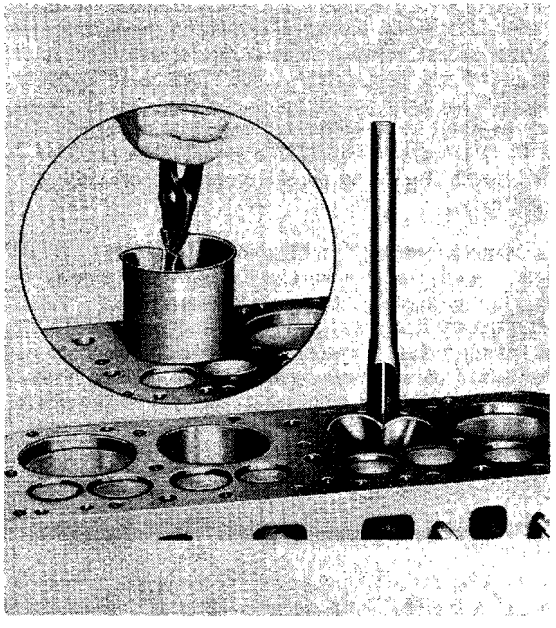
WATER PUMP. - The water pump is prelubricated, and is not adjustable. If the water pump leaks, usually as a result of having the fan belt adjusted too tightly, install a new pump assembly, or replace worn parts. To disassemble the water pump, first remove it from the engine, and remove the fan from the pulley. See the illustration. Remove the rear cover and gasket. Press the pulley off the shaft in an arbor press, using a fixture which will hold the pulley at the belt groove. Remove the housing snap ring, and press the shaft from the impeller. Remove the seal from the impeller. Install a new seal and replace with new any other worn parts. Reassemble, reversing the procedure of disassembly.



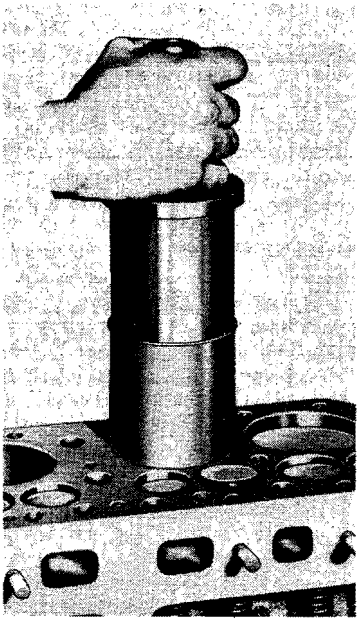
WATER PUMP



TIMING GEAR MARKS



REMOVING CYLINDER SLEEVE



INSTALLING CYLINDER SLEEVE

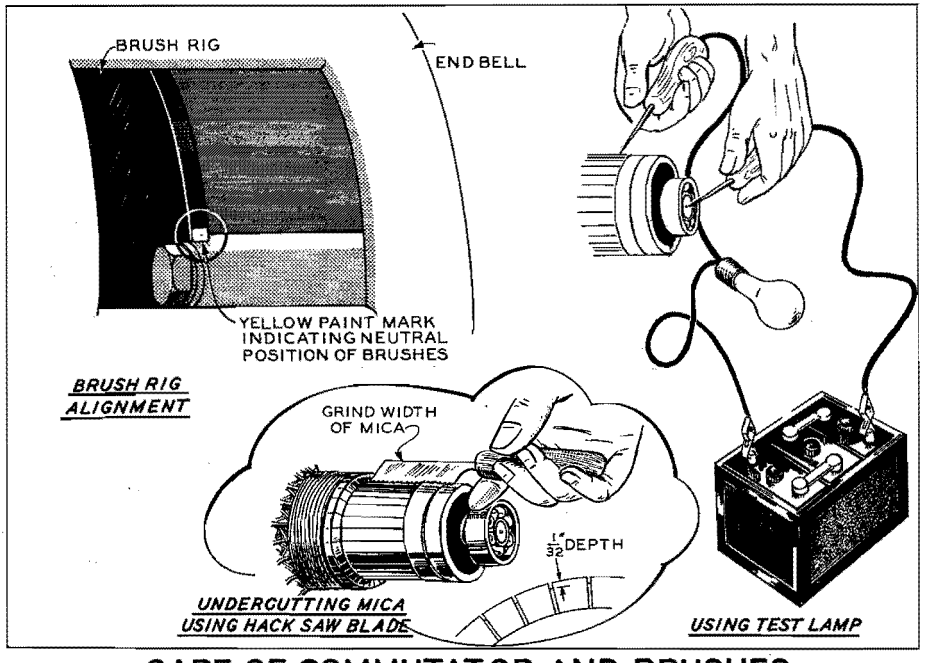
CYLINDER SLEEVES. - The cylinder sleeves are the replaceable dry type. If examination shows taper or out of round wear of more than .005", the sleeves should be replaced. Use a sleeve crushing tool to bend the sleeve inward. Drive the tool to the bottom of the cylinder. Pull the sleeve upward to remove it. Drive the new sleeve into place with a sleeve replacer plug tool, using care not to buckle or warp the new sleeve. Use a piston or a proper plug gauge to test the new sleeve. If the piston (or plug gauge) sticks at any point, the sleeve was buckled during the installation. Remove the buckled sleeve and install a new one, again checking as before.

CRANKSHAFT. - Drilled oil passages run from the crankshaft main bearing journals to the connecting rod journals. See that these passages are clean and open. Examine the crankshaft gear, installing a new one if teeth are chipped. If a bearing journal is grooved, out of round more than .0015", or tapered more than .001", regrind the shaft to use undersize bearings. Bearings are available in .001", .002", .005", .010" and .020" undersizes. Very light scores or scraches may be honed, then polished with fine abrasive cloth, #320 grit or finer.

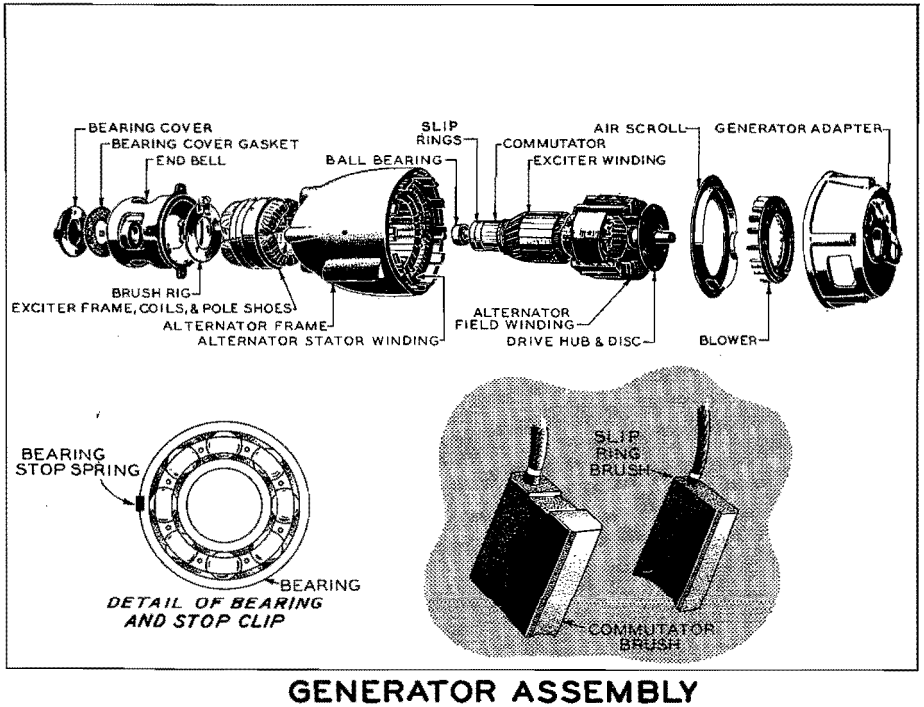
CAMSHAFT. - To remove the camshaft, first remove the valve assemblies. Remove or block up tappets up so that they will clear the cam lobes and bearing journals. Install a new camshaft if cams are scored or badly worn, bearing scored, or if any journal is worn to less than 1.795" in diameter.

TABLE OF CLEARANCES

	MINIMUM	MAXIMUM
Valve Tappet Clearance (Intake)	.010"	.012"
Valve Tappet Clearance (Exhaust)	.014"	.016"
Valve Clearance In Guides	.0015"	.0035"
Crankshaft Main Bearing	.001"	.0025"
Connecting Rod Bearings	.0004"	.0025"
Piston in Cylinder	.003"	
Piston Pin in Piston	.0005"	
Piston Pin in Connecting Rod	.0001"	
Piston Ring Gap	.012"	.017"
Distributor Breaker Points Gap	.020"	
Spark Plug Gap	.025"	
Firing Order	1-2-4-3	
Distributor Rotation	Counterclockwise	



CARE OF COMMUTATOR AND BRUSHES



GENERATOR ASSEMBLY

GENERATOR

GENERAL. - The generator normally requires little maintenance other than the regular periodic servicing of brushes, commutator, slip rings, and ball bearing. Generator failure, if it occurs, can usually be traced to overloading, or to lack of recommended periodic servicing.

COMMUTATOR AND SLIP RINGS. - The commutator consists of a series of parallel bars separated by thin sheets of mica. Eventually the surface of the commutator wears down level with the mica. Continued operation would then cause rapid wear of brushes, sparking, and pitting of the commutator bars.

When the surface of the commutator wears down to the mica, the mica must be cut down to approximately 1/32" below the commutator surface. A tool for this purpose can be made from a hack saw blade. Grind the teeth of the saw to the width of the space between the commutator bars. Use care in cutting the mica out, so as not to scratch the surface of any bar. Be sure to remove any rough edges along cuts, and thoroughly clean out the grooves after cutting.

If the commutator should become grooved, rough, out of round or badly pitted, good brush contact can not be maintained. If this happens, the entire rotor assembly must be removed and the commutator turned down smooth in a lathe, after which the mica must be undercut as previously described. It will be necessary to first remove the main generator frame before the rotor assembly can be removed. Tag all leads which are disconnected, so that correct connections can be made on reassembly. Remove the rotor ball bearing to prevent foreign material getting into it.

Slip rings are to be serviced in the same manner as the commutator, except that there is no mica to undercut.

BRUSHES. - Install new brushes when the old ones become worn so that the top of the brush is below a point midway between the top and bottom of its holder. Always use the recommended brushes when installing new ones. A substitute brush may be the same size and look the same, but may have entirely different electrical qualities not suitable for the application. See that brushes seat properly on the commutator or slip rings and that they do not stick in their holders.

Brush spring tension for commutator brushes is 30 ounces, and for slip ring brushes is 16 to 18 ounces. Measure spring tension at the free end of the spring, with the contact end of the spring level with the top of the holder. Unequal brush wear is usually an indication of uneven brush spring tension.

BRUSH RIG. - The brush rig does not require loosening or removal when installing new brushes. If the brush rig has been loosened or removed for any reason, it must be returned to its original "neutral" position. The proper neutral position was determined at the factory and is marked by a painted indentation on the edge of the brush rig mounting ring, which must align with the painted edge of one brush rig support column in the end bell. Improper positioning of the brush rig will lead to excessive brush sparking, heating of the windings, and general low generator performance.

GENERATOR WINDINGS. - Use a continuity type test lamp set to test for grounded or open circuits in the generator. Disconnect leads as necessary, tagging each one to insure correct replacement. Lift each brush up, letting the brush spring press against the side of the brush and holding the brush away from the commutator or slip ring.

To test the alternator field winding, place one test set prod on each slip ring. If the test lamp fails to light, the field winding is open circuited and will not function. Place one test prod on a slip ring and the other prod on the rotor shaft. If the lamp does light on this test, the field winding is grounded. A grounded or open field requires extensive repair or replacement of the rotor assembly.

To test the alternator stator windings, disconnect the output leads. For generators having a lead marked "T0", place one test lamp prod on the "T0" lead and the other test prod on each of the other leads, in rotation. If the test lamp fails to light when the test circuit is completed for any one lead, that winding is open circuited. For single phase generators, leads T1 and T2 represent one winding; leads T3 and T4 represent the second winding. To test for an open circuit, place a test prod on each lead for either winding. If the lamp fails to light, that winding is open circuited. For three phase, three wire plants, test between leads T1 and T2 then between T1 and T3. If the lamp fails to light on either test, the winding is open.

To test for a grounded circuit, place one test prod on the generator frame. Place the other test prod on each generator lead in turn. If the lamp lights for any lead, that winding is grounded.

Internal short circuits can be determined by the use of a sensitive ohmmeter, comparing resistance readings for individual windings.

CONTROLS

CONTROL EQUIPMENT . - If any of the control box or panel equipment does not function properly, install a corresponding new part, rather than to attempt repairs on the old part.

Disconnect the starting batteries when ever servicing any control equipment. Keep all connections tight and clean.

If the plant will start but does not continue to run, start the plant manually. If it continues to run with the ignition switch at the HAND START position, trouble is indicated in the control equipment. Look for loose connections, check the relays. Check the high water temperature and low oil pressure switches, if used.

> DO NOT LEAVE THE IGNITION SWITCH AT THE HAND START POSITION LONGER THAN NECESSARY TO MAKE TESTS.

The start disconnect relay serves to open the start circuit when the plant is started by automatic or line failure equipment. Failure of the start disconnect relay to operate will cause the start circuit to remain closed after the plant starts, allowing an excessively high voltage to reach the batteries.

The reverse current relay disconnects the batteries from the generator when the plant stops, preventing the batteries from discharging through the generator. If the reverse current relay fails, the charge rate ammeter will show a discharge of approximately 7 amps, when the plant is stopped.

The voltage regulator relay normally allows a battery charge rate of approximately 6 to 10 amps. when the batteries are less than 3/4 fully charged. When the batteries are above a 3/4 fully charged condition, the charge rate should drop to approximately 2 amps. The point at which the higher charge rate cuts in can be changed by changing the spring tension of the relay. To advance the cut in point, increase the spring tension slightly. To retard the cut in point, lessen the spring tension slightly.

POSSIBLE CAUSE	REMEDY
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, coil, etc., or retime ignition.
Lack of fuel or faulty carburetion.	Refill the tank. Check the fuel system. Clean, adjust, or replace parts necessary.
Clogged fuel screen.	Clean.
Cylinders flooded.	Crank few times with spark plugs removed.
Poor fuel.	Drain, refill with good fuel.
Poor compression.	Tighten cylinder head and spark plugs. If still not corrected, grind the valves. Replace piston rings, if necessary.
Wrong timing.	Retime ignition.
ENGINE RUNS BUT CURRENT DOES NOT BUILD UP	
Poor brush contact.	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 collector rings, are free in holders, are not worn too short, and have good spring tension.
Loose connections.	Tighten connections.
Fluctuating load.	Correct any abnormal load condition causing trouble.
GENERATOR OVERHEATING	
Overloaded.	Reduce Load.
Brush rig out of position.	Line up reference marks.

POSSIBLE CAUSE	REMEDY
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 in cylinders.	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, coils, 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.
ENGINE MISFIRES AT HEAVY LOAD	
Spark plugs defective.	Replace.
Faulty ignition.	Clean, adjust, or replace breaker points, plugs, condenser, coil, etc., or retime ignition.
Clogged carburetor.	Clean jets.
Clogged fuel screen.	Clean.
Defective spark plug cables.	Replace.

POSSIBLE CAUSE	REMEDY
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 pump screen.	Remove and clean.
Badly worn oil pump.	Replace.
Defective oil pressure gauge.	Replace.
HIGH OIL PRESSURE	
Oil too heavy.	Drain, refill with proper oil.
Clogged oil passage.	Clean all lines and passages.
Oil relief valve stuck.	Remove and clean.
Defective oil pressure gauge.	Replace .
ENGINE 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

Poor compression, usually due to leaking valves.	Tighten cylinder head and plugs. If still not corrected, grind or replace valves.
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.
Oil pressure too high.	Refer to symptoms of high oil pressure for remedies.
Engine misfires.	Refer to symptoms of engine misfires.
Faulty ignition.	Clean, adjust, or replace breaker points, plugs, condenser, coil, etc., or retime ignition.
Unit operated at light or no load for long periods.	No remedy needed.
Too much oil.	Drain excess oil.

BLACK, SMOKY EXHAUST, EXCESSIVE FUEL CONSUMPTION, FOULING OF SPARK PLUGS WITH BLACK SOOT, POSSIBLE LACK OF POWER UNDER HEAVY LOAD

Fuel mixture too rich.	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.
Oil badly diluted.	Change oil.

ENGINE STOPS UNEXPECTEDLY

Fuel tank empty.	Refill.
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 sympton 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 Champion H-9 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 carburetor.

SPECIAL INSTRUCTIONS FOR GENERATING PLANTS EQUIPPED WITH AN OUTPUT VOLTAGE REGULATOR

FUNCTION. - The voltage regulator is an automatic device for controlling the output voltage of the generator. It is basically a variable resistance inserted in the exciter field circuit of the generator. The generator output voltage actuates an electromagnet in the regulator. The magnet in turn varies the resistance value used. If the generator output voltage tends to drop, the regulator resistance is lowered, allowing the generator exciter field strength to increase, which in turn keeps the output voltage at its original value. If the generator voltage tends to rise, the regulator resistance is raised, reducing the exciter field strength, which in turn keeps the output voltage at its original value. The regulator provides automatically the same effect as is obtained by hand operation of a rheostat on a manually controlled generator.

REGULATOR CONTROLS. - There are three controls on the generating plant which affect the regulator operation, as follows:

1. The "REGULATOR ON - RHEOSTAT ON" toggle switch located on the plant control panel. When the switch is at the "REGULATOR ON" position, the voltage regulator is in operation. When the switch is at the "RHEOSTAT ON" position, the voltage regulator is NOT in operation and voltage MUST BE CONTROLLED BY HAND OPERATION OF THE RHEOSTAT. This switch is provided for emergency operation only, in case of accidental failure of the regulator.

2. The rheostat knob located on the plant control panel. This panel rheostat knob is to be used for manual control of the generator output voltage ONLY when the toggle switch is at the "RHEOSTAT ON" position. This rheostat knob must be turned CLOCKWISE to the limit of its travel when the toggle switch is at the "REGULATOR ON" position. - SEE NOTE. *

3. The voltage adjusting knob for the voltage regulator. This knob is used for raising or lowering the output voltage when the regulator is in operation. The adjusting knob is on the voltage regulator box. Turn the knob clockwise to increase voltage, or counterclockwise to lower the voltage.

VOLTAGE REGULATED OPERATION. - To operate the plant with the voltage regulator in operation, throw the toggle switch to the "REGULATOR ON" position. See that the panel rheostat (not the regulator rheostat) is turned clockwise to the limit of its travel. The voltage regulator can not operate properly if the rheostat is turned counterclockwise. - SEE NOTE. *

---

* NOTE: A double pole double throw (DPDT) toggle switch was used beginning with units produced late in 1952. On these units when the toggle switch is at "REGULATOR ON" position the rheostat is shorted out, making it unnecessary to turn the rheostat knob clockwise.

The regulator is designed to control the voltage within ± 3% of the desired voltage. The output voltage may be raised or lowered within reasonable limits by turning the voltage adjusting knob.

Turn the knob clockwise to raise the voltage. Turn the knob counterclockwise to lower the voltage. It should not be necessary to use the adjusting knob under normal conditions. The regulator will keep the voltage at the same value regardless of changes in temperature, load, or power factor. However, the voltage regulator can not be expected to compensate for poor governor operation, low engine speed, or loss of engine power under load conditions.

If the regulator is ever disconnected, be sure to keep the panel switch at the "RHEOSTAT ON" position.

RHEOSTAT OPERATION. - When the panel toggle switch is at the "RHEOSTAT ON" position, the output voltage must be manually controlled by adjusting the panel rheostat knob. CAUTION: Before starting the plant, turn the knob counterclockwise to lower the voltage. This is necessary to compensate for naturally higher voltage produced by a cold generator, and not under load. The voltage will drop somewhat as it warms up.

The setting of the rheostat must be changed with changes in the electrical load. At a light load, the rheostat must be toward a counterclockwise position. As electrical load is increased, the generator voltage will drop, and it is necessary to turn the rheostat clockwise to bring the voltage up to the proper value.

Do not fail to adjust the voltage with the panel rheostat when ever a substantial change is made in the electrical load on the generator. If a substantial electrical load is reduced, turn the rheostat counterclockwise to lower the voltage. If this is not done, the voltage may be so high as to damage a light load. If a light electrical load is increased substantially, turn the rheostat clockwise to raise the voltage to the proper value. If this is not done, the voltage may be so low as to cause motors to overheat, etc.

The rheostat is provided solely for emergency operation in case of failure of the voltage regulator. Care must be used in the use of the rheostat, and repairs or replacement of the regulator should be made as promptly as possible.

INSTRUCTION MANUAL

FOR

ONAN ELECTRIC GENERATING PLANTS

10EL SERIES

ALTERNATING CURRENT MODELS

SPECIFICATIONS
G-H-J-K

. W. ONAN & SONS INC. MINNEAPOLIS 14. MINN.
4-8 ******