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INSTRUCTION MANUAL

FOR
ONAN HK & HN SERIES
ELECTRIC GENERATING PLANTS

50 & 60 CYCLE
SPECIFICATIONS
A THROUGH J

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

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Important Safety Precautions

Read and observe these safety precautions when using or working on electric generators, engines and related equipment. Also read and follow the literature provided with the equipment.

Proper operation and maintenance are critical to performance and safety. Electricity, fuel, exhaust, moving parts and batteries present hazards that can cause severe personal injury or death.

FUEL, ENGINE OIL, AND FUMES ARE FLAMMABLE AND TOXIC

Fire, explosion, and personal injury can result from improper practices.

- Used engine oil, and benzene and lead, found in some gasoline, have been identified by government agencies as causing cancer or reproductive toxicity. When checking, draining or adding fuel or oil, do not ingest, breathe the fumes, or contact gasoline or used oil.
- Do not fill tanks with engine running. Do not smoke around the area. Wipe up oil or fuel spills. Do not leave rags in engine compartment or on equipment. Keep this and surrounding area clean.
- Inspect fuel system before each operation and periodically while running.
- Equip fuel supply with a positive fuel shutoff.
- Do not store or transport equipment with fuel in tank.
- Keep an ABC-rated fire extinguisher available near equipment and adjacent areas for use on all types of fires except alcohol.
- Unless provided with equipment or noted otherwise in installation manual, fuel lines must be copper or steel, secured, free of leaks and separated or shielded from electrical wiring.
- Use approved, non-conductive flexible fuel hose for fuel connections. Do not use copper tubing as a flexible connection. It will work-harden and break.

EXHAUST GAS IS DEADLY

- Engine exhaust contains carbon monoxide (CO), an odorless, invisible, poisonous gas. Learn the symptoms of CO poisoning.
- Never sleep in a vessel, vehicle, or room with a genset or engine running unless the area is equipped with an operating CO detector with an audible alarm.
- Each time the engine or genset is started, or at least every day, thoroughly inspect the exhaust system. Shut down the unit and repair leaks immediately.

- Warning: Engine exhaust is known to the State of California to cause cancer, birth defects and other reproductive harm.

Make sure exhaust is properly ventilated.

- Vessel bilge must have an operating power exhaust.
- Vehicle exhaust system must extend beyond vehicle perimeter and not near windows, doors or vents.
- Do not use engine or genset cooling air to heat an area.
- Do not operate engine/genset in enclosed area without ample fresh air ventilation.
- Expel exhaust away from enclosed, sheltered, or occupied areas.
- Make sure exhaust system components are securely fastened and not warped.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not remove any guards or covers with the equipment running.
- Keep hands, clothing, hair, and jewelry away from moving parts.
- Before performing any maintenance, disconnect battery (negative [–] cable first) to prevent accidental starting.
- Make sure fasteners and joints are secure. Tighten supports and clamps, keep guards in position over fans, drive belts, etc.
- If adjustments must be made while equipment is running, use extreme caution around hot manifolds and moving parts, etc. Wear safety glasses and protective clothing.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- Always disconnect battery negative (–) lead first and reconnect it last. Make sure you connect battery correctly. A direct short across battery terminals can cause an explosion. Do not smoke while servicing batteries. Hydrogen gas given off during charging is explosive.
- Do not disconnect or connect battery cables if fuel vapors are present. Ventilate the area thoroughly.

DO NOT OPERATE IN FLAMMABLE AND EXPLOSIVE ENVIRONMENTS

Flammable vapor can be ignited by equipment operation or cause a diesel engine to overspeed and become difficult to stop, resulting in possible fire, explosion, severe personal injury and death. **Do not operate diesel equipment where a flammable vapor environment can be created by fuel spill, leak, etc., unless equipped with an automatic safety device to block the air intake and stop the engine.**

HOT COOLANT CAN CAUSE SEVERE PERSONAL INJURY

- Hot coolant is under pressure. Do not loosen the coolant pressure cap while the engine is hot. Let the engine cool before opening the pressure cap.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not service control panel or engine with unit running. High voltages are present. Work that must be done while unit is running should be done only by qualified service personnel.
- Do not connect the generator set to the public utility or to any other electrical power system. Electrocutation can occur at a remote site where line or equipment repairs are being made. An approved transfer switch must be used if more than one power source is connected.
- Disconnect starting battery (negative [-] cable first) before removing protective shields or touching electrical equipment. Use insulative mats placed on dry wood platforms. Do not wear jewelry, damp clothing or allow skin surface to be damp when handling electrical equipment.
- Use insulated tools. Do not tamper with interlocks.
- Follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag open switches to avoid accidental closure.
- With transfer switches, keep cabinet closed and locked. Only authorized personnel should have cabinet or operational keys. Due to serious shock hazard from high voltages within cabinet, all service and adjustments must be performed by an electrician or authorized service representative.

If the cabinet must be opened for any reason:

1. Move genset operation switch or Stop/Auto/Handcrank switch (whichever applies) to Stop.
2. Disconnect genset batteries (negative [-] lead first).
3. Remove AC power to automatic transfer switch. If instructions require otherwise, use extreme caution due to shock hazard.

MEDIUM VOLTAGE GENERATOR SETS (601V TO 15kV)

- Medium voltage acts differently than low voltage. Special equipment and training are required to work on or around medium voltage equipment. Operation and maintenance must be done only by persons trained and qualified to work on such devices. Improper use or procedures will result in severe personal injury or death.
- Do not work on energized equipment. Unauthorized personnel must not be permitted near energized equipment. Induced voltage remains even after equipment is disconnected from the power source. Plan maintenance with authorized personnel so equipment can be de-energized and safely grounded.

GENERAL SAFETY PRECAUTIONS

- Do not work on equipment when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.
- Never step on equipment (as when entering or leaving the engine compartment). It can stress and break unit components, possibly resulting in dangerous operating conditions from leaking fuel, leaking exhaust fumes, etc.
- Keep equipment and area clean. Oil, grease, dirt, or stowed gear can cause fire or damage equipment by restricting airflow.
- Equipment owners and operators are solely responsible for operating equipment safely. Contact your authorized Onan/Cummins dealer or distributor for more information.

KEEP THIS DOCUMENT NEAR EQUIPMENT FOR EASY REFERENCE.

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.
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.

SPEC. K INSERT
FORM #905-10
FOR
ONAN HK & HN SERIES

WATER PUMP: To dismantle the water pump used on Specification K models of the HK & HN Series, proceed as follows:

1. Remove the four screws that mount the water pump assembly to the engine.
2. Remove the screws that hold the end plate on the back of the water pump assembly.
3. Use a suitable puller to remove the pulley from the impeller shaft.
4. Press the impeller shaft out of the body casting from the rear of the water pump. This frees the impeller.
5. Tap the impeller shaft seal out by inserting a plug through the front of the casting. Tap out the seal gently to prevent any damage to the seal.

Reverse the disassembly steps in order to assemble the pump. Note that the impeller hub is assembled to the impeller shaft facing the water pump seal.

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D. W. ONAN & SONS INC.
Minneapolis, Minnesota

GENERAL INFORMATION

The regulator is designed to control the voltage within $\pm 3\%$ 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 counter-clockwise 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 counter-clockwise 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 counter-clockwise 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 counter-clockwise 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.

Form 981 A

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.

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This instruction manual is supplied to assist the operator in the proper installation and operation of the generating plant. Disregarding these instructions may lead to unnecessary trouble and expense.

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 alternating current generator. The engine is a 6 cylinder gasoline burning type. The generator is a four pole, revolving field type, directly connected to the engine. Accessories and controls suitable for a normal installation and according to the particular model are supplied. Housed models have a sheet metal housing for the plant and include an engine control and electrical meter panel. Unhoused models are of the open construction with a box containing the necessary control parts mounted over the generator.

This instruction manual is supplied with all generating plants of the 15HK and 25HN series. Instructions apply specifically to the standard models. Some details may not apply to special models. Some special installation or operating conditions may require the operator of this plant to modify these instructions. However, by following as closely as possible the recommendations as given in this book, the operator should have no difficulty in making a good installation and in properly operating the generating plant.

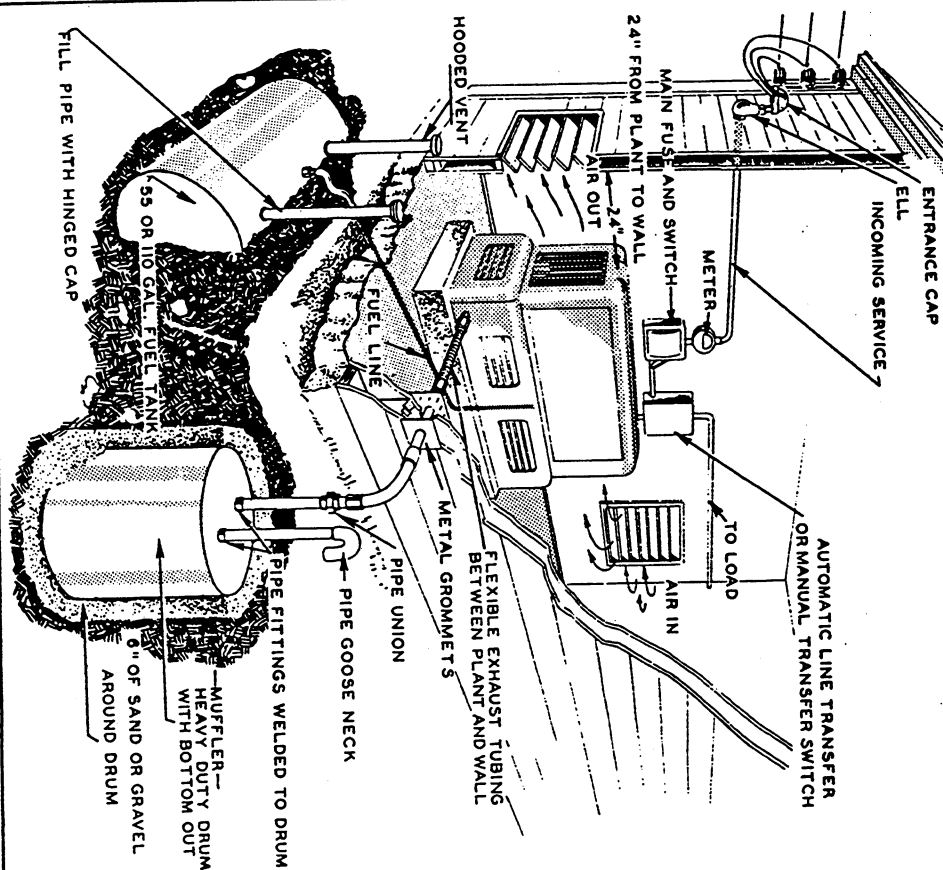
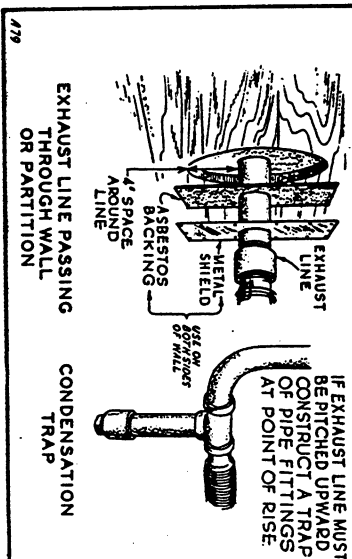
If it ever becomes necessary to contact the factory or an Authorized Service Station in regard to this generating plant, be sure to refer to the nameplate information as shown. This information must be known in order to properly identify the plant and to enable proper advice to be given.

ALWAYS REFER TO THIS PLANT BY NAMEPLATE INFORMATION

TAKE THE INFORMATION STAMPED ON THE PLANT NAME-
PLATE (NOT ENGINE NAMEPLATE).

MODEL NO. SPEC. NO. SERIAL NO.

IMPORTANT - MINIMUM RATING NUMBER AND DATA NO. WITH ORDERS PART OR PARTS ABOUT THE PLANT.			
MODEL NO.		SERIAL NO.	
ELCTRIC PLANT			
TYPE			
A.C. VOLTS		E.V.A. WATTS	
P.F. AMPS		CHAS. CHAS.	
D.C. VOLTS		AMPS WATTS	
GEN. NO.		GEN. DATA NO.	
R.P.M.		USE 60 HZ. VOLT BATTERY	
G. W. ORAN & SONS, INC.			
MINNEAPOLIS, MINNESOTA, U.S.A.			



TYPICAL INSTALLATION

ENGINE

The engine for the 25,000 watt 60 cycle, and the 20,000 watt 50 cycle generating plants is a Continental Model F326, specification 401. The bore is 3-5/16", the stroke 4-3/8", compression ratio 6 to 1, and the maximum horsepower rating at 1800 r. p. m. is 54.2. The engine for the 15,000 watt 60 cycle, and the 14,000 watt 50 cycle generating plants is a Continental Model F186, specification 248. The bore is 3", the stroke 4-3/8", compression ratio 6.4 to 1, and the maximum horsepower rating at 1800 r. p. m. is 45.4.

The cooling system capacity is approximately 18 quarts, U. S. standard measure. Full length water jackets surround the cylinders and valve seats. A belt driven, ball bearing water pump maintains circulation of the engine coolant. The temperature of the coolant is controlled by a thermostat. A pusher type fan forces cooling air out through the front of the radiator. The crankcase oil capacity is 5 quarts (U. S. measure) plus approximately 1 quart used in the operation of the oil filter. A gear type oil pump supplies pressure lubrication to main, connecting rod, and camshaft bearings. Main and connecting rod bearings are precision type replaceable liners. Exhaust valves are the "ROTO" type, and have replaceable seats. Valve tappets are adjustable. 12 volt starting and ignition current is furnished by two 6 volt batteries connected in series. Charging current for the batteries is supplied by a separate automotive type 12 volt generator. Ignition distributor rotation is counterclockwise. Firing order is 1-5-3-6-2-4. 60 cycle plants run at approximately 1800 r. p. m. 50 cycle plants run at approximately 1500 r. p. m. The engine speed is controlled by a flyweight type, gear driven governor. Standard models burn gasoline fuel. Special models are equipped to burn gas fuel (natural gas or liquid petroleum gas, depending upon the model).

GENERATOR

The air cooled generator has two main components, the alternator, and the exciter. The alternator is a 4 pole, revolving field type alternating current generator. The exciter generates direct current for exciting the alternator field. The alternator field and the exciter armature are assembled into a single rotor which is directly connected to the engine flywheel. The rotor is supported at the engine end by the engine rear main bearing and at the exciter end by a large ball bearing. The larger frame contains the stationary armature windings of the alternator, and the smaller frame contains the stationary exciter field.

Due to the inherent design of the generator, voltage regulation between no load and full load is very close. Some special models are equipped with a separate voltage regulator for extremely close regulation. The frequency of the current is determined by the engine speed, and is regulated by the engine governor. The speed is approximately 1800 r. p. m. for the 60 cycle plant, and 1500 r. p. m. for the 50 cycle plant.

CONTROLS

The electrical control equipment varies with the plant model. Housed plants are equipped with an instrument panel mounting meters, gauges, relays, and switches for greatest convenience in observing the performance and properly operating the plant. Unhoused plants are equipped with a control box mounting equipment necessary for operation of the plant. Optional equipment such as automatic line failure, or remote control switches, may be connected.

LOCATION. - If possible, install the plant inside a building or covered vehicle for protection from extremes in weather conditions. The site should be dry, clean, and well ventilated. Either a damp or dusty location will require more frequent inspection and servicing of the plant. For permanent installations, the plant may be mounted on a raised concrete base. Allow at least 24" space on all sides for ease in servicing.

If the plant is mounted aboard a truck or trailer, see that it is fastened securely when in transit, and that it sets in a level position when in operation.

VENTILATION. - The plant generates a considerable amount of heat which must be dissipated by proper ventilation. Engine heat is removed by a pusher type fan which blows cooling air out through the front of the radiator. For room or compartment installations, provide an opening at least as large as the radiator area for exit of the heated air. This opening should be directly in front of the radiator, and as close to the radiator as is practicable. It may be necessary to construct a duct from the front of the radiator to the outdoors. In cold weather, some method of controlling the air flow should be provided, so that the temperature of the room can be kept at a normal point. Generator cooling air is discharged from an air duct near the right rear of the engine. Provide an outlet for this heated air. See that the air heated by the plant will not be recirculated to the plant. Provide for the free entry of fresh air.

EXHAUST. - Exhaust gases are deadly poisonous and must be piped outside if the plant is installed indoors. Excessive inhalation of exhaust gases may cause serious illness or death. The muffler outlet has 2-1/2" standard pipe threads. Do not use pipe smaller than 2-1/2 inch size, and avoid sharp turns as much as possible when running an exhaust line. If the line passes through an inflammable wall, shield the wall by passing the line through properly insulated metal collars. If the exhaust line is lengthy or rises from the plant muffler, provide a means of draining condensation occasionally.

FUEL TANK. - Observe provisions of local fire underwriters codes in the installation of any separate fuel supply tank. If an underground tank is installed, the lift of fuel from the bottom of the tank to the fuel pump inlet on the plant should not exceed 8 ft., which is the practical limit of its efficient lift.

NATURAL GAS OR VAPOR FUEL. - Some special model plants are equipped to burn LPG or natural gas fuel, and some are fitted with heat exchanger equipment. Any applicable gas codes must be complied with when connecting the plant to a source of gas fuel. In some localities, presence of foreign matter in the gas supply may require installation of a fuel filter in the fuel supply line.

NOTE

On natural gas installations the atmospheric regulator on the plant is designed to operate on a line pressure not to exceed 5 pounds. If the line pressure exceeds 5 pounds pressure, it will be necessary to install a primary regulator in the line to reduce the pressure before it enters the atmospheric regulator.

BATTERIES. - Two 6 volt batteries are required. Use the short (6 inch) cable to connect the positive post of one battery to the negative post of the second battery. For housed plants, connect the battery cable which is attached to the start solenoid switch to the remaining positive (+) post of the two batteries. Connect the cable which is grounded to the engine to the remaining negative (-) post of the batteries.

For unboxed plants, screw terminals for the battery cables are provided inside the control box. Run the battery cables in through the rubber grommets at the rear of the box. Use care to connect the battery cables to the proper terminals as marked on the control box.

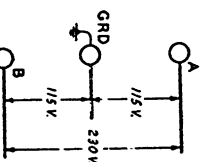
Be sure battery connections are tight. Coat the battery clamps and posts lightly with grease or vaseline to minimize corrosion. Batteries shipped "dry" must be prepared for use as directed on the tag attached to each battery. Batteries shipped ready for use were fully charged when shipped. Such batteries slowly lose their charge when standing idle and it may be necessary to give them a "refreshing" 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 behind the control panel, on the chassis. Remove the right side grille for access to the terminals. Wiring and connections must conform to electrical codes in force in the community. Follow the directions for connecting to the plant terminals, according to the type of plant.

115/230 VOLT, 1 PHASE, 3 WIRE PLANT

The center terminal is grounded. For 115 volt current, connect the grounded load wire to the center terminal, and the other load wire to either of the two outside terminals, A or B. Two 115 volt circuits are thus obtainable, with not more than 1/2 the plant rating available on each circuit. Balance the load as closely as possible between the two circuits.

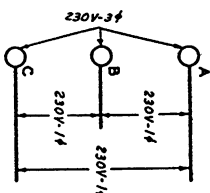


For 230 volt current, connect the load wires to the upper and lower terminals, A and B, leaving the center terminal unused.

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, 3 PHASE, 3 WIRE PLANT

No terminal is grounded. For three phase current, connect a separate load wire to each plant terminal, A, B, or 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.



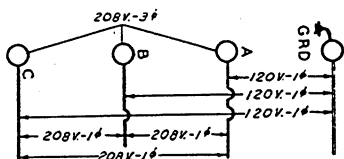
To obtain 230 volt, single phase current, connect separate load wires to each of any two plant terminals, one wire to each terminal. Three 230 volt, single phase circuits are thus available, with 1/3 the plant rating to each circuit. Balance the load as closely as possible between the circuits.

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 10,000 watt load is used. This leaves 15,000 watts available for single phase, if the plant

capacity is 25,000 watts. One third of this 15,000 watts is 5,000 watts, which is the amount that may be taken from each of the 3 single phase circuits. Do not attempt to take all 15,000 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.

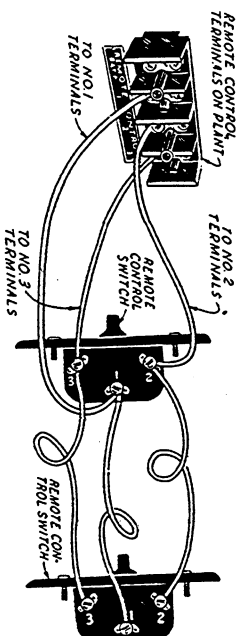


For 208 volt, three phase current, connect a load wire to each of the three insulated plant terminals, A, B, and C, leaving the grounded (topmost) terminal unused. Reversing the connections between any two insulated terminals will reverse the direction of rotation of 3 phase motors. Use a phase sequence 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.

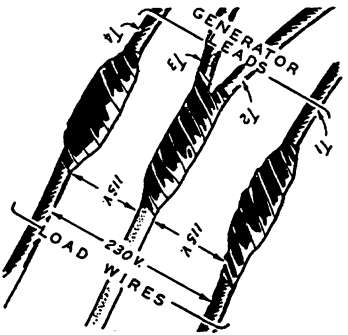
REMOTE CONTROL CONNECTIONS

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.



REMOTE CONTROL CONNECTIONS

UNHOUSED PLANTS. - The generator lead wires 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. The connections must meet specifications of electrical codes which apply in the locality. Install an approved switch or other device for disconnecting the plant from the load. Connect load wires to generator leads as directed below, according to the type of plant.



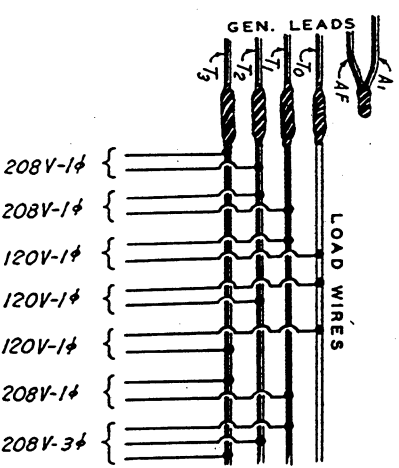
115/230 VOLT, 1 PHASE, 3 WIRE PLANT. - Connect generator leads marked T2 and T3 together. This will be the "neutral" load connection lead. For 115 volt 3 wire service, connect the neutral (white) load wire to the T2, T3 leads. Connect two separate black (hot) load wires, one to each of the T1 and T4 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 from one 115 volt circuit, as the generator will be unbalanced and overloaded. Divide the load as equally as possible between the two circuits.

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 load wire to the generator lead T4.

NOTE - 3 PHASE PLANTS

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

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.



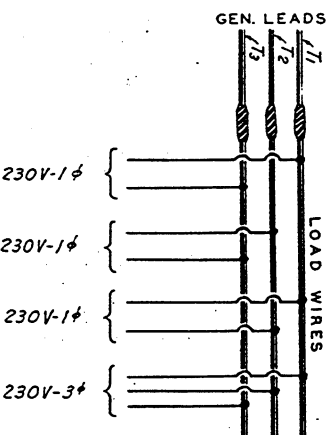
For 208 volt, 1 phase current, the T0 generator lead is not used. Connect separate load wires to any two of the T1, T2 or T3 generator leads. Three separate single phase circuits are available T1 - T2, T1 - T3 and T2 - T3. As when connected for 120 volts, the load should be divided between the three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

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. Do not attempt to take the entire single phase load off one circuit, unless the load is a small one. See the example for the housed type of plant.

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.

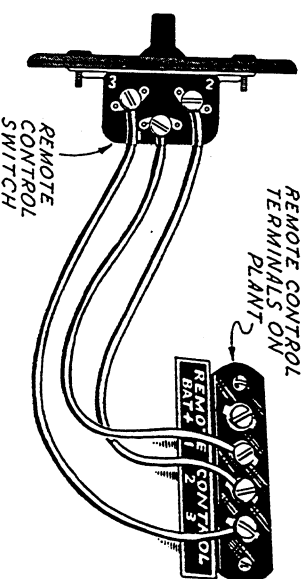


For single phase current, connect a separate load wire to each of any two generator leads. Three separate single phase circuits are thus available T1-T2, T2-T3, and T1-T3. Not more than one third of the generator capacity is available on each single phase circuit.

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

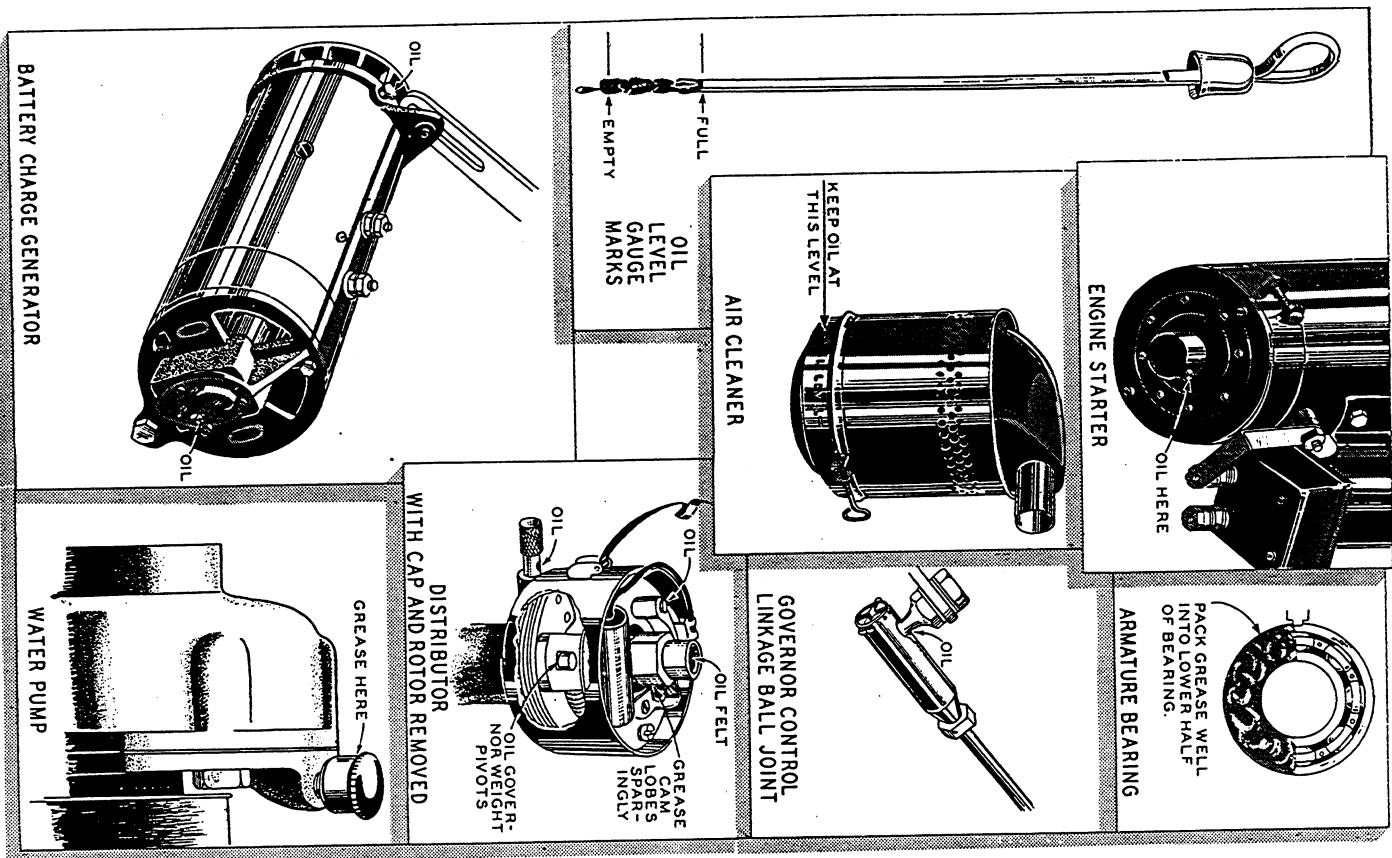
A small 4 place terminal block marked "REMOTE-DC OUTPUT" is located inside the control box. If automatic or line failure controls are to be connected follow the directions for connections as supplied with the control equipment.



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.



LUBRICATION

PREPARATION

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

LUBRICATION. - Fill the crankcase with 5 quarts (U. S. Measure) of a good quality heavy duty (detergent) type oil. Approximately 1 quart of oil remained in the oil filter when the crankcase was drained at the factory. Do not use an oil heavier than SAE number 20 in a plant being put into service the first time. After the first oil change, use an oil of the proper SAE number, according to the lowest temperature to which the plant will be exposed, as indicated in the following table. The temperatures indicated are for conditions where the plant will be standing idle long enough to cool off to the surrounding temperature.

LOWEST TEMPERATURE	SAE NUMBER OF OIL
100° F. (37° C)	40
32° F. (0° C)	30
0° F. (-18° C)	20
Below 0° F. (-18° C)	5W

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

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

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

Pour a few drops of oil into the oil cup on the side of the distributor.

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

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

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

If the plant is equipped with a fuel tank mounted inside the plant housing, the tank capacity is 20 gallons, U. S. measure. Do not fill the tank completely full of cold gasoline. Expansion of the gasoline as the plant warms up, may cause the gasoline to overflow, creating a fire hazard. The fuel gauge on the control panel registers the amount of fuel in the mounted tank only when the plant is running, or if the ignition switch is thrown to the **HAND START** position. Do not fill the tank when the plant is running.

Use fresh, clean "regular" grade gasoline of 88 to 74 octane rating. Do not use any highly leaded premium gasoline. If highly leaded gasoline is used, more frequent carbon and lead removal, valve grinding and spark plug servicing will be necessary. However, do not use a low octane fuel, such as "stove gas".

FUEL, GAS. - If the plant is equipped to burn gas fuel, observe provisions of local gas codes in connecting to a source of gas fuel. The pressure regulator mounted on the plant is a secondary or atmospheric type, capable of handling line pressure up to 5 pounds. If the pressure exceeds 5 pounds, install a primary type regulator in the line to reduce the pressure to 5 pounds or less.

RADIATOR. - The capacity of the cooling system is 18 quarts, U. S. measure. Be sure both drain cocks are closed. Use clean, alkali free (soft) water. Clean rain water may be used. The use of a rust and scale preventative in the cooling system is recommended.

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

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

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

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

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

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

NOTE

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

If the generating plant is equipped for the use of gas fuel, the automatic choke control mounted atop the exhaust manifold is fitted with a lock device. See that the operating arm of the automatic choke is locked in the down position, so that the choke can not operate. **NO CHOKING IS NECESSARY WHEN OPERATING ON GAS FUEL, AND THE CARBURETOR CHOKE VALVE SHOULD BE WIDE OPEN.** A choke sleeve fitted to the air intake of the carburetor, and operated by the flow of air to the carburetor, provides all the choking action necessary for gas operation.

Turn on the gas fuel supply and press the **START** switch. To start a plant the first time, it may be necessary to press the priming button, at the center of the regulator, for an instant. Do not overprime. Release the **START** switch when the plant reaches running speed. The plant was test run on 1000 BTU gas, and if a different BTU content gas is used, it may be necessary to readjust the carburetor gas adjustment valve to insure smooth and economical operation. See the section headed **ADJUSTMENTS**.

STARTING THE PLANT MANUALLY. - If the starting batteries lack sufficient power to crank the engine, or the engine can not be cranked electrically for some other reason, the plant can be started manually if the batteries have sufficient power to provide ignition current.

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

STANDBY SERVICE. - When the generating plant is used for standby service, upon failure of a regular source of electrical power, it is essential to start the plant regularly. If practicable, start the plant once each day and allow to run for approximately 15 minutes. The generating plant should never be allowed to stand for more than a week without such a "dry" run.

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

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

CAUTION

KEEP THE IGNITION SWITCH AT THE ELECT. START POSITION AT ALL TIMES EXCEPT WHEN ACTUALLY STARTING THE PLANT MANUALLY. THROW THE SWITCH TO THE HAND START POSITION WHILE CRANKING THE PLANT MANUALLY, BUT RETURN IT TO THE ELECT. START POSITION AS SOON AS THE PLANT STARTS. WHILE THIS SWITCH IS AT THE HAND START POSITION THE HIGH WATER TEMPERATURE CUT-OFF SWITCH (AND LOW OIL PRESSURE SWITCH, IF THE PLANT IS SO EQUIPPED) IS CUT OUT OF THE CIRCUIT AND THE PLANT IS NOT PROTECTED AGAINST OVERHEATING. 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.

CHECKING THE OPERATION, HOUSED PLANTS. - After the plant starts, allow the engine to reach operating temperature. Check the level of the coolant in the radiator, as the thermostat may have allowed an air pocket to form, thus preventing complete filling. Add coolant to bring the level to the proper point, if necessary. The oil pressure should be between 20 and 40 pounds, the coolant temperature approximately 150° to 180°F. (65° to 82° C.), and the battery charge rate between 2 and 12 amperes, depending upon the charge condition of the batteries.

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

Connect a load to the plant by throwing the circuit breaker handle to the ON position. If the plant tends to surge, it is an indication the engine needs additional warm-up before connecting a heavy load. The electrical meters indicate the output voltage and the amount of load connected to the output terminals. At no load, the voltage should be slightly above the nameplate rating, and with a full load the voltage should be slightly below the nameplate rating. A voltmeter-ammeter selector switch is provided for checking the individual phases of the circuit on the three phase plants. Plants equipped with an output receptacle on the control panel will not register any load which may be connected to the receptacle. This receptacle is provided for a trouble light or similar light load, up to 15 amps. for each outlet.

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

The circuit breaker will open automatically and disconnect the load if the plant is severely overloaded. Correct the cause of overloading before again throwing the circuit breaker handle to the ON position. To disconnect the load, throw the circuit breaker handle to the OFF position.

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

HIGH WATER 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 100° 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. - If practicable, disconnect the electrical load. Press the STOP button firmly. The ignition switch must be at the ELECT. START position, as pressing the STOP button will have no effect if the switch is at the HAND START position.

LOW TEMPERATURES

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

CRANKCASE OIL. - If the plant must be started after standing unused in temperatures between 32° F. (0° C.) and 0° F. (-18° C.) use a good quality oil of SAE number 20W in the crankcase. For temperatures below 0° F. (-18° C.) use SAE number 5W oil. The oil should be the detergent, or heavy duty type.

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

CAUTION

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

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

COOLING SYSTEM. - The coolant must be protected if there is any possibility of its freezing. Use any good anti-freeze solution, in the proportion recommended by the anti-freeze manufacturer for the lowest temperature to which the plant will be exposed. The capacity of the cooling system is 18 quarts, U. S. Measure.

If the water temperature gauge shows the engine to be operating too cool, a portion of the radiator surface may be covered to raise the coolant temperature to normal. Avoid overheating. Set the high water temperature cut-off switch to operate at a temperature several degrees below the boiling point of the coolant, taking into consideration the altitude at which the plant is operating and the type of anti-freeze used. Check the antifreeze solution frequently.

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

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

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

HIGH TEMPERATURES

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

NOTE

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

Use SAE number 30 oil for temperatures up to 100° F. (38° C.) and SAE number 40 for higher temperatures. Check the oil level frequently, and change the crankcase oil at least every 50 hours. Keep the electrolyte level in the batteries up to normal.

DUST AND DIRT

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

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

DAILY SERVICE

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

FUEL. - If the plant is operated on gasoline fuel, check the fuel often enough to assure a continuous fuel supply. Do not fill the tank while the plant is running.

RADIATOR. - Check the level of the coolant and, if necessary, add sufficient liquid to bring the level up to within one or two inches of the bottom of the filler neck. In freezing weather, if a nonpermanent type antifreeze is used, check the protective strength of the coolant.

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

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

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

WEEKLY SERVICE

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

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

GENERAL LUBRICATION. - Put a drop of light lubricating oil on each of the governor to carburetor link ball joints, and fill the distributor oil cup. Put several drops of oil in the oil holes at each end of the battery charging generator, and in the oil hole at the forward end of the starting motor.

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

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

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

SPARK PLUGS. - Clean the spark plugs and check the electrodes gap. Keep the gap adjusted to 0.025". More frequent spark plug service may be necessary if leaded gasoline is used.

WATER PUMP. - Use a good grade of water pump grease in the water pump grease cup. Turn the grease cup cap down 1 turn each 50 hours of operation. If grease appears in the coolant, the water pump is being overlubricated. To correct, turn the cap down less than 1 turn.

DISTRIBUTOR. - Check the distributor contact points. If they are only slightly burned or pitted, resurface them on a fine stone. Install new contact points if the old ones are badly burned. Keep the gap adjusted to 0.020". Excessive burning or pitting of the points usually indicates a faulty condenser, which should be replaced with a new one. Lubricate as directed above under GENERAL LUBRICATION.

MONTHLY SERVICE

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

GASOLINE SUPPLY. - If the plant has a mounted tank, close the gasoline shut off valve and remove and clean the sediment bowl and screen. Be sure the bowl gasket is in good condition when reassembling.

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

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

DISTRIBUTOR. - Place one drop of light oil on the distributor breaker arm pivot pin, several drops on the felt pad under the rotor, and three or four drops on the flyweight mechanism, distributed where it will reach friction points. Place a light coating of grease on each cam lobe.

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

OIL FILTER. - If the crankcase oil is becoming discolored, remove and discard the oil filter element. Clean out the oil filter and install a new element. The new filter element will absorb approximately one quart of oil when the plant is started up. After a short running period, stop the plant and check the crankcase oil level. Add oil as necessary to bring the oil up to the proper level.

ENGINE COMPRESSION. - Check the compression of each cylinder, using a compression gauge. A difference of more than 10 pounds pressure between cylinders or uniformly low compression indicates a compression loss which should be corrected. High compression is an indication of excessive carbon or lead deposits in the combustion chambers. New engine compression is approximately 110 lbs.

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 110 lbs. at cranking speed.

GENERATOR. - Check the condition of the commutator, slip rings, and brushes.

In service, the commutator and slip rings acquire a glossy brown color, which is a normal condition. Do not attempt to maintain a bright metallic, newly machined finish. If the commutator or slip rings become heavily coated, clean with a lint free cloth. Slight roughness may be remedied by lightly sanding with #00 sandpaper. Clean out all carbon and sandpaper dust.

When brushes are worn so that the top of the brush is below a point midway between the top and bottom of the brush holder, replace the brushes with new ones. Brushes must ride freely in their holders, and spring tension should be uniform. Commutator brush spring tension is approximately 30 oz. and slip ring brush spring tension is approximately 16 oz. Tension should be measured with the free end of the spring level with the top edge of the brush holder.

Check the brush rig for proper alignment of the reference marks on the brush rig and its support. See Maintenance and Repair, Brush Rig.

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

SEMI-YEARLY SERVICE

Every 6 months or 1200 operating hours, whichever occurs first, service the generator ball bearing.

Remove the plate from the housing rear end. Thoroughly clean all dirt from around the generator bearing cover and remove the cover and gasket. Remove the old lubricant from the bearing with a clean finger. Work about one tablespoon of new ball bearing lubricant into the bearing and again remove the lubricant. Refill the bearing housing about one-half full of bearing lubricant, packing it well into the lower half of the bearing. Be sure that no dirt gets into the bearing. Reinstall the bearing cover, using a new gasket if necessary.

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

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

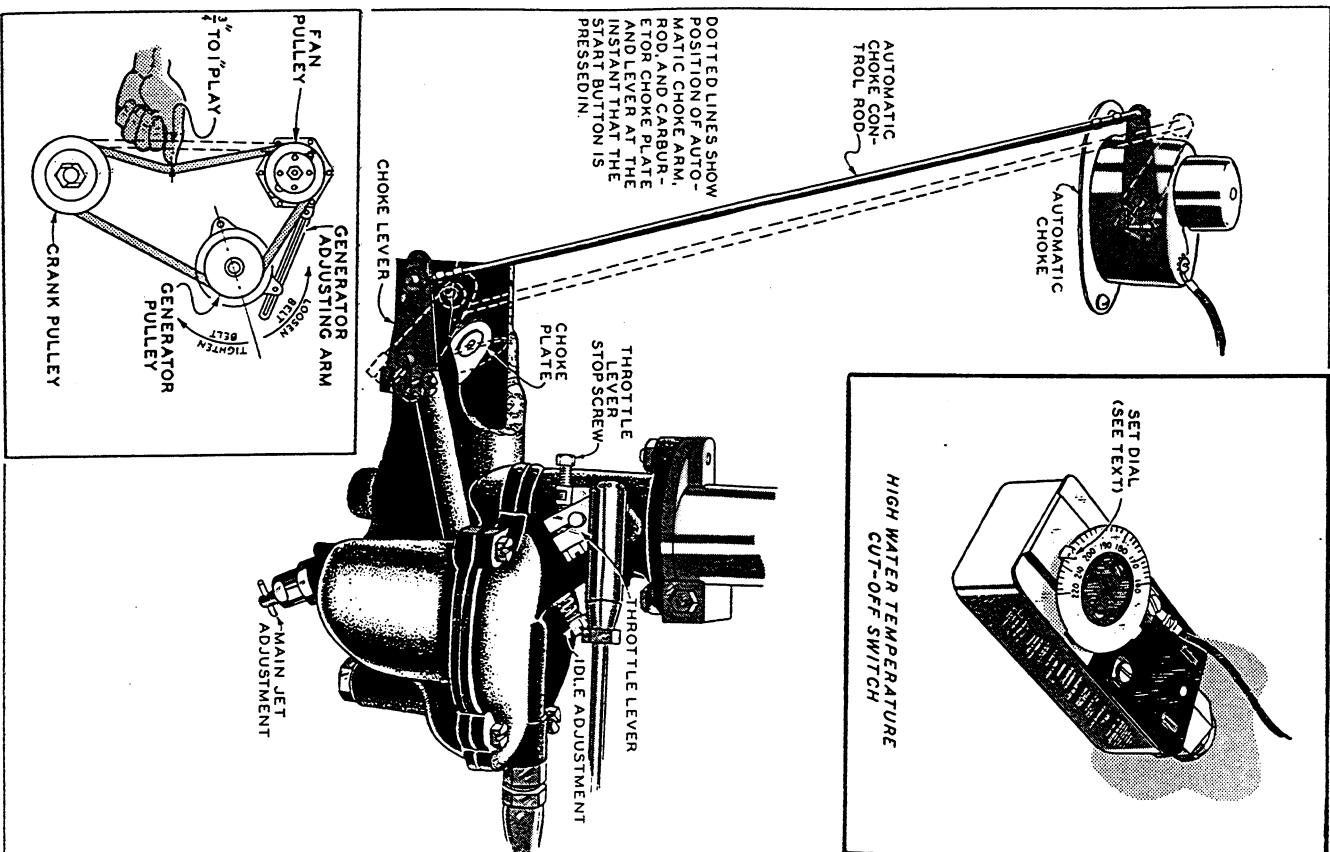
Turn the adjusting needle in (clockwise) until the voltage, as shown on the AC VOLTMETER, drops noticeably. Turn the screw slowly out (counterclockwise) until the voltage rises to normal, and the engine runs smoothly. If it is necessary to open the adjustment more than one half turn beyond the point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

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

CARBURETOR, GAS OR VAPOR. - A change in the BTU rating of the fuel used will probably necessitate readjusting the gas adjustment screw valve at the bottom of the carburetor. With a full load on the plant, turn the adjusting valve in (clockwise) until the voltage as shown on the AC voltmeter drops noticeably. Turn the screw slowly out (counterclockwise) until the voltage rises to normal and the engine runs smoothly. If it is necessary to open the adjustment much beyond the point where normal voltage is attained in order to obtain smooth operation, a readjustment of the governor may be necessary. Check the operation at various loads. There is no idle adjustment necessary for gas or Butane-Propane vapor operation except to see that the throttle lever stop screw is adjusted to 1/32" clearance between the screw end and the throttle stop with the plant operating at no load.

HIGH WATER TEMPERATURE SWITCH. - The high water temperature switch (optional on unhoused plants) operates to stop the engine if the coolant temperature rises too high. This prevents overheating, which could cause serious damage to engine parts. The engine may be started again when the coolant temperature drops approximately 100°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 30°F. for each 1000 feet above sea level. The dial was set at 205° F. at the factory. Do not set the switch to operate at too low a temperature or the engine may be stopped before it reaches operating temperature. The switch will not operate if the ignition switch is at the HAND START position.

FAN AND GENERATOR BELT ADJUSTMENT. - The belt tension is determined by the position of the battery charging generator. To readjust the belt tension, loosen the generator adjusting arm bolt and nut slightly. Move the generator toward the engine to loosen the belt, or away from the engine to tighten the belt. Adjust to permit 3/4" to 1" play in the belt when pressure is applied at a point midway between the fan and crankshaft pulleys. Be sure to retighten the adjusting arm screw and nut when the adjustment is completed. Too tight a belt will wear out rapidly and cause excessive strain on the water pump and battery charging generator bearings. A belt which is too loose will slip, causing rapid belt wear, inefficient cooling, and possible low battery charge rate.



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

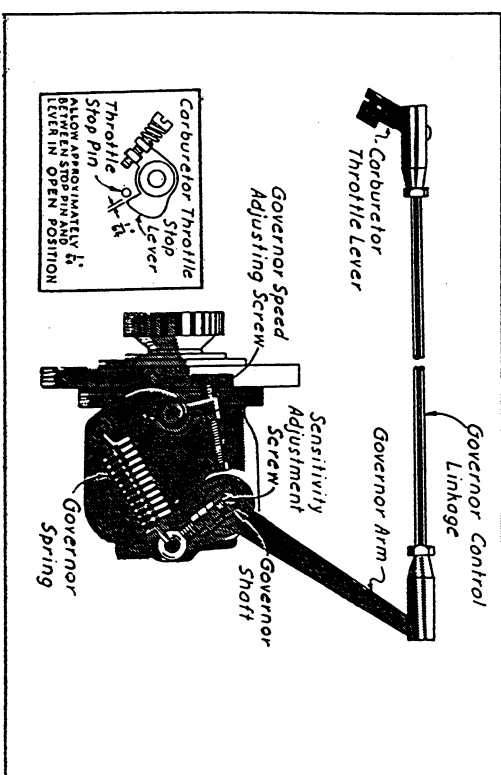
MANIFOLD HEAT ADJUSTMENT. - Under certain atmospheric conditions, such as cold and damp weather, it may be necessary to change the setting of the manifold heat control valve. Moisture in the air may condense and freeze as it passes into the carburetor, causing ice formation in the carburetor venturi. Ice formation would cause low power output. To increase the heat deflected to the intake manifold and carburetor venturi, loosen the heat control valve sector lock nut and turn the sector counterclockwise to the desired position. In very cold weather it may be necessary to turn the valve counterclockwise to the limit of its travel. Under extreme conditions it may be necessary to install an auxiliary air heater around the manifold to deflect more heat to the carburetor air intake. This air heater is available as an accessory kit.

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. See inset.
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. Voltage 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 correcting the speed screw adjustment.

ADJUSTMENTS

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

ENGINE

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

The tappets should be adjusted with the engine hot. Adjust the tappets to clearances of 0.014" for the intake valves and 0.010" for the exhaust valves. Exhaust valves are numbers 1, 4, 6, 7, 9, and 12. Make a final check with the engine running at a slow idle, and at operating temperature. Make certain that the lock nut on each tappet adjusting screw is tightened securely after the adjustment is completed.

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

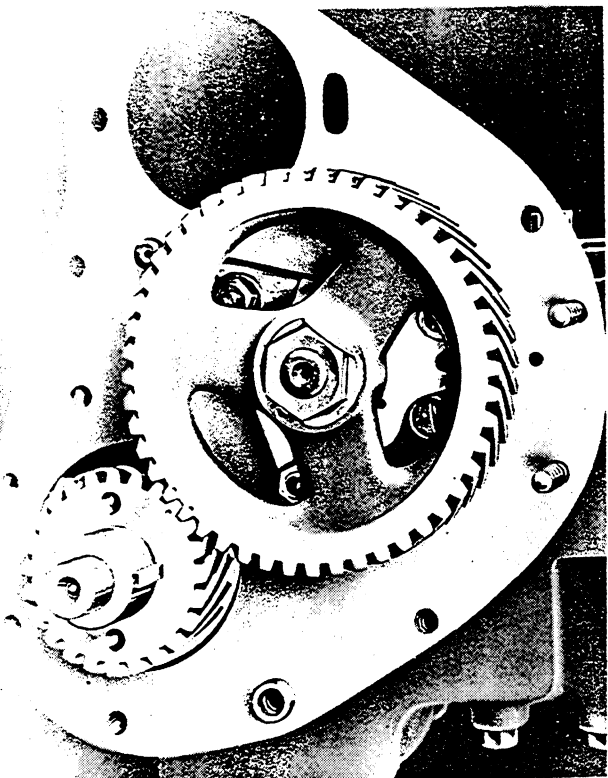
All old valves to be reused should be ground and reassembled to their original seats. Grind only enough to assure a perfect seal. Be careful to remove all traces of grinding compound from valves and seats. Lightly oil valves and guides before reassembly.

The exhaust valves are of the "Roto" type, each valve having a cap under the end of the stem. When reassembling, install the cap on the end of the valve stem before installing the spring retainer locks. Note that the exhaust valve spring retainer locks have a very slight taper. The thinner edge of the lock must face upward. Be sure two locks are properly installed on each valve stem. If the exhaust valves are properly installed, it will be possible to turn them in their guides when the valves are wide open. This is not possible with the intake valves, which are of the conventional type.

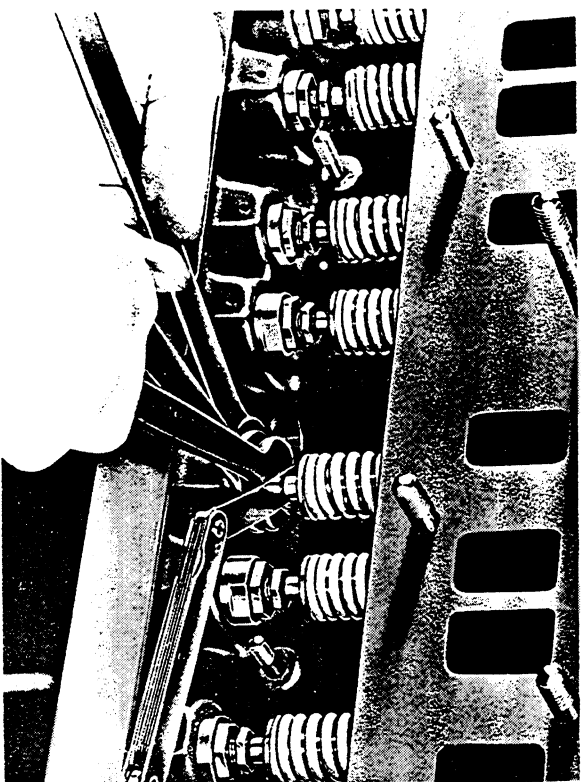
Set all the tappet clearances after the valves have been reassembled. When tightening the cylinder head nuts, start at the center and work outward and towards the ends. Tighten cylinder head nuts to a tension of 80 pounds foot torque. See the paragraph IGNITION TIMING for instructions on proper installation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

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

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



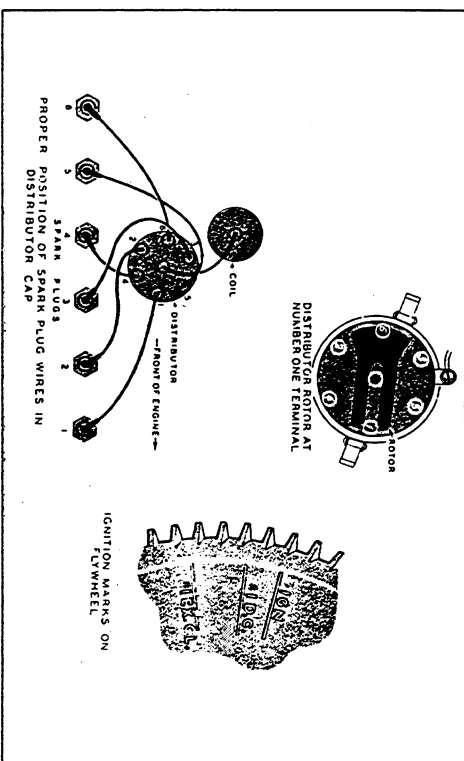
TIMING GEARS



TAPPET ADJUSTMENT

IGNITION TIMING. - If the distributor drive shaft has been removed, install it in the following manner. With the hand crank, turn the engine over until the number 1 piston is coming up on the compression stroke. Continue to slowly crank the engine until the flywheel mark IGN is in the center of the inspection hole just to the rear of the fuel pump. Install the distributor drive shaft with the unpainted side of the coupling toward the manifold side of the engine. Be sure the shaft engages its drive member properly.

Install the distributor and its adapter to the cylinder head. The distributor coupling is off-set to insure proper engagement when the distributor rotor points toward the front of the engine. See that the contact points are adjusted to 0.020" gap at full separation. Loosen the distributor adjusting clamp screw and turn the distributor body counterclockwise to close the contact points. Use a series type timing light, if available. Slowly turn the distributor clockwise until the contacts just separate. At this point the timing is correct for average operating conditions. The timing may be advanced by turning the distributor body slightly in a clockwise direction, or retarded by turning in a counterclockwise direction. Keep the spark advanced as far as possible without causing a "ping".



IGNITION TIMING

PISTON RING REPLACEMENT. - The piston and connecting rod assemblies are removed from the top of the cylinder. Three compression rings and one oil control ring are used on each piston. Check the cylinders for an out of round or tapered condition, reborring for oversize pistons if necessary. Any ridge worn at the top of the bore should be removed, even if not reborring. Fit each ring to its individual cylinder, being sure that the gap between the ends of the ring, when in the cylinder, is within the limits described. The oil ring gap for the F186 engine (15,000 watt plant) is .009" to .014". The oil ring gap for the F226 engine (25,000 watt plant) is .010" to .020". The compression rings for the F186 engine are interchangeable, one groove to the other, and the ring gap should be within .008" to .014". For the F226 engine the top (plain compression) ring and 2nd groove (lapper compression) ring gap is .005" to .015". For the F226 third groove (grooved compression) ring, the gap is .005" to .015". Fit the proper ring in each ring groove on the piston, with the ring gaps spaced an equal distance around the piston. The wide oil control ring fits the bottom piston ring groove. Be sure the ring grooves are clean and free of carbon deposits, and the oil holes are open before installing

the rings on the piston. The rings should have between 0.0015" and 0.002" clearance in their grooves. Replacement rings of the tapered type will be marked "Top", or identified in some other unmistakable manner, and this mark must be installed toward the top of the piston.

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

CONNECTING RODS. - The steel backed connecting rod lower end bearings are readily replaceable. When removing the connecting rods, note the markings on the camshaft side of the rods and caps, so as to reassemble in the original manner. Notches machined in the connecting rod halves receive matching projections stamped into the steel backs of the bearing shells. If a shell becomes worn, discard both shells for that rod and install new ones. The shells are designed to provide a clearance of 0.0015" to 0.002". Never attempt fitting a bearing by scraping or filing of either the cap or upper half of the rod. Be sure that rods and caps as well as bearing shells are perfectly clean and free of oil when inserting the shells. Oil on the back of the shell will prevent proper seating of the shell in the rod or cap. Oil the crankshaft journal after the bearing has been firmly seated in the rod.

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

MAIN BEARINGS. - The crankshaft main bearings are of the same type as the connecting rod bearings. Front, intermediate, and rear bearing shells are not interchangeable, although the two intermediate pair are. Bearing caps are numbered on the camshaft side and are dove-tailed to assure proper reassembly. The same general directions given for fitting the connecting rod bearings should be observed in fitting the main bearings. The clearance, when installed, should be 0.0015 to 0.002". The rear face of the front main bearing takes the end thrust of the crankshaft. The crankshaft end play should be 0.003" and is regulated by a shim pack to the rear of a removable thrust collar behind the crankshaft gear. When servicing the crankshaft or related parts, always make sure that all oil holes in the shaft are open and clean.

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

The camshaft bearings are bushings which are line reamed, after installation in the crankcase, to a clearance of 0.002" to 0.004". The installation of new camshaft bearings is not practicable without the proper line reaming equipment.

WATER PUMP. - The water pump on this engine is a centrifugal, ball bearing, self sealing type. To dismantle the pump proceed as follows:

1. Remove the nut and lockwasher from the front of the water pump shaft and, using a suitable puller, pull the pulley off the shaft.
2. Remove the three nuts mounting the shaft support to the body and remove the support assembly.

3. To remove the impeller, remove the set screw and pull or press the impeller from the shaft. Note that if the set screw is loosened only a few turns it will not be free from the hole in the shaft.

4. To remove the shaft and bearings from the support, remove the set screw from the top of the support and press the assembly out through the front.

5. The seal will be found assembled in the impeller hub. Care must be taken in removing this assembly as the carbon seal is fragile and easily broken. The holes in the brass cup holding the seal should be lined up with the slots in the impeller hub. These are provided to prevent dirt from forming behind the seal ears and preventing efficient sealing. To reassemble, reverse the procedure used in disassembly. When reassembling the pump make sure that the set screw projects far enough to line up the impeller on the shaft. Pack the space between bearings with a good grade of sodium soap type grease such as Mobile grease No. 5.

LUBRICATION SYSTEM. - A gear type oil pump supplies oil under pressure through drilled passageways to the crankshaft main, lower connecting rod bearings, camshaft bearings, timing gears, and valve tappets. Whenever the engine is disassembled for service, make sure that all oil passages are clean and unobstructed. Thoroughly clean the engine oil pan and the oil pump strainer screen. An oil pressure relief valve is adjusted at the factory to give a pressure of 20 to 40 pounds at the governed speed, with the engine oil hot. The oil pressure relief adjustment is reached by removing a large hexagon shaped plug in the side of the crankcase close to the fuel pump. Oil pressure may be increased by adding plunger washers or reduced by removing plunger washers. Too high or too low pressure may be caused by a sticking plunger. Remove the assembly and clean thoroughly. Continued low oil pressure usually indicates excessively worn bearings.

TABLE OF CLEARANCES

	MINIMUM	MAXIMUM
Valve Tappets - Intake	0.014"	
Valve Tappets - Exhaust (Roto)	0.010"	
Valve Seat Angle - Intake	30°	
Valve Seat Angle - Exhaust	45°	
Crankshaft Main Bearings	0.0015"	0.002"
Connecting Rod Bearing	0.0015"	0.002"
Connecting Rod Side Play	0.006"	0.010"
Camshaft Bushings	0.002"	0.004"
Piston to Cylinder - 5 to 10 lb pull with 1/2" wide feeler003
Piston Pin in Rod0003
Piston Pin in Piston		Light Push Fit
Ring Gap, 3 Top Grooves, F186 Engine	0.008"	0.013"
Ring Gap, Bottom Grooves, F186 Engine	0.009"	0.014"
Ring Gap, 3 Top Grooves, F226 Engine	0.005"	0.015
Ring Gap, Bottom Groove, F226 Engine	0.010"	0.020"
Distributor Points Gap		0.020"
Spark Plug Gap		0.025"
Distributor Rotation		Counterclockwise
Firing Order		1-5-3-6-2-4
Cylinder Head Nut - Torque		80 Pounds Foot

GENERATOR

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

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

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

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

BRUSHES. - Install new brushes when the old ones are worn so that the top of the brush is below a point midway between the top and bottom of the brush guide. Do not continue to use brushes that are worn too short, because the spring tension lessens as the brush becomes shorter, and weak spring tension leads to excessive brush sparking and pitting of the commutator or slip rings. It is recommended that only a moderate load be applied to the generator until the new brushes have been "run in", to eliminate excessive sparking. See that brushes ride freely in their guides and that spring tension is uniform. The correct tension is 30 oz. for the commutator brush springs and 16 oz. for the slip ring brush springs, measured with the contact point of the spring level with the top of the guide.

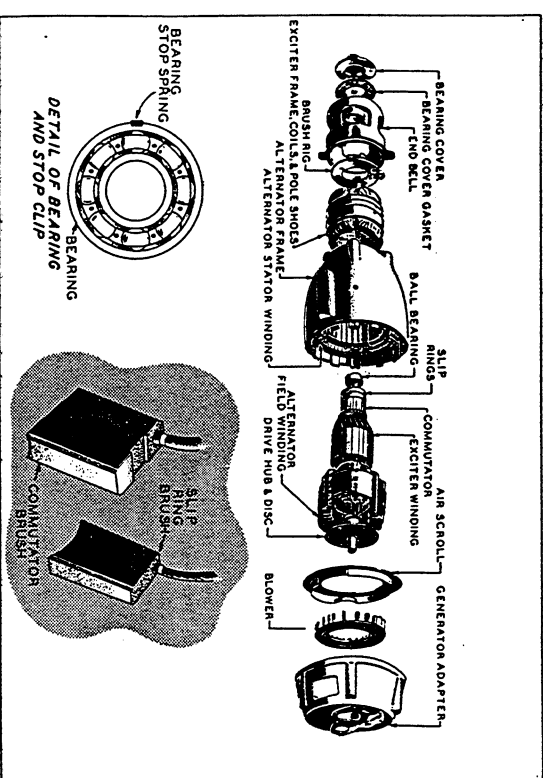
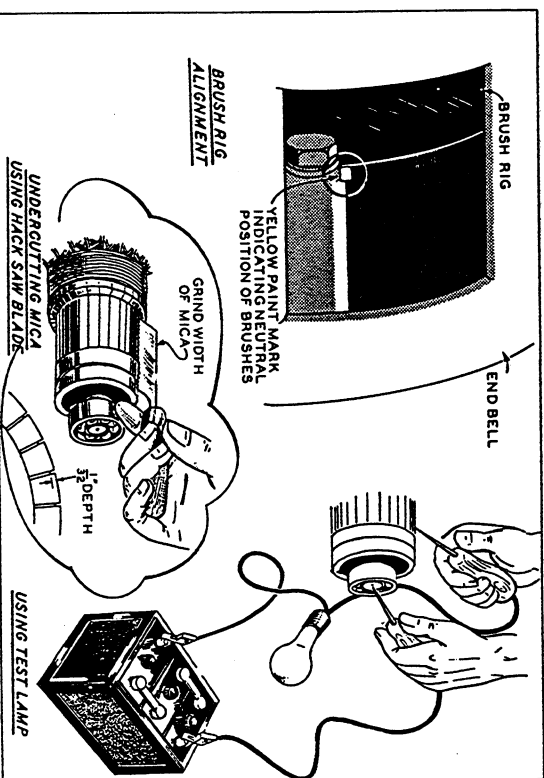
GENERATOR WINDINGS. - Use a continuity type test lamp set to test for grounded or open circuits in the generator windings. Be sure that all brushes are lifted away from contact with the commutator and slip rings, and that generator leads to the control panel are disconnected. When disconnecting leads,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

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

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

THOMAS

CARE OF COMMUTATOR AND BRUSHES



GENERATOR ASSEMBLY

CONTROLS

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

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 one of the relays, the high water temperature switch or a loose connection. Failure of the battery charging generator to deliver current to the stop relay will also prevent the plant from running with the ignition switch at the ELECT. START position.

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

POSSIBLE CAUSE

REMEDY

GENERATOR OVERHEATING

Overloaded.

Reduce load.

Brush rig out of position.

Be sure to line up marks.

VOLTAGE DROPS UNDER HEAVY LOAD

Engine lacks power.

See remedies for engine missing under heavy load.

Poor compression.

Tighten cylinder head and spark plugs. If still not corrected, grind the valves. Replace piston rings, if necessary.

Faulty carburetor.

Check the fuel system. Clean, adjust, or replace parts necessary.

Restricted air cleaner.

Clean and refill.

Excessive choking.

See that choke opens properly.

Carbon or lead in cylinder.

Remove carbon.

Restricted exhaust line.

Clean or increase the size.

ENGINE MISFIRES AT LIGHT LOAD

Carburetor idle adjustment set wrong or clogged.

Adjust, clean if needed.

Spark plug gaps too narrow.

Adjust to correct gap.

Intake air leak.

Tighten or replace gaskets.

Faulty ignition.

Clean, adjust, or replace breaker points, plugs, condenser, coil, etc., or retune 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 retune ignition.

Clogged carburetor.

Clean jets.

Clogged fuel screen.

Clean.

Defective spark plug cables.

Replace.

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<u>POSSIBLE CAUSE</u>	<u>REMEDY</u>
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 sealing.	Remove and clean, or replace.
Badly worn bearings.	Replace.
Sludge on oil screen.	Remove and clean.
Badly worn oil pump.	Replace.
Defective oil pressure gauge.	Replace.
HIGH OIL PRESSURE	
Oil too heavy.	Drain, refill with proper oil.
Clogged oil passage.	Clean all lines and passages.
Oil relief valve stuck.	Remove and clean.
Defective oil pressure gauge.	Replace.
PLANT STARTS BUT DOES NOT CONTINUE TO RUN	
START button released too soon.	Hold in contact longer.
Defective charging generator.	Repair.
Defective panel equipment.	See Controls.
ENGINE BACKFIRES AT CARBURETOR	
Lean fuel mixture.	Clean carburetor.
Clogged fuel screen.	Clean screen.
Intake air leak.	Replace flange gaskets, tighten carburetor
Poor fuel.	Refill with good, fresh fuel.

<u>POSSIBLE CAUSE</u>	<u>REMEDY</u>
ENGINE BACKFIRES AT CARBURETOR (CONT.)	
Spark too late.	Retime ignition.
Spark plug wires crossed.	Install wires correctly.
Intake valves leaking.	Grind or replace.
EXCESSIVE OIL CONSUMPTION, LIGHT BLUE SMOKY EXHAUST	
Worn piston rings.	Install new piston rings.
Oil leaks from engine or connections. This does not cause smoky exhaust.	Replace gaskets or leaking tubing. Tighten screws and connections.
Oil too light or diluted.	Drain, refill with correct oil.
Too large bearing clearance.	Replace bearings.
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.
Low oil pressure.	Refer to symptom of low oil pressure for remedies.
Oil badly diluted.	Change oil.

<u>POSSIBLE CAUSE</u>	<u>REMEDY</u>
ENGINE STOPS UNEXPECTEDLY	
Fuel tank empty.	Refill.
Fuel pump failure.	Repair or replace.
High water temperature.	See symptoms for engine overheating.
Defective ignition.	Check the ignition system. Repair or replace parts necessary.
DULL METALLIC THUD, IF NOT BAD, MAY DISAPPEAR AFTER FEW MINUTES OPERATION. IF BAD, INCREASES WITH LOAD	
Loose crankshaft.	Replace bearings, unless one of the next three remedies permanently corrects the trouble.
SHARP METALLIC THUD, ESPECIALLY WHEN COLD ENGINE FIRST STARTED	
Low oil supply.	Add oil.
Low oil pressure.	Refer to symptom of low pressure for remedies.
Oil badly diluted.	Change oil.
PINGING SOUND WHEN ENGINE IS RAPIDLY ACCELERATED OR HEAVILY LOADED	
Carbon in cylinders.	Remove carbon.
Spark too early.	Retime ignition.
Wrong spark plugs.	Install correct plugs.
Spark plugs burned or carboned.	Install new plugs.
Valves hot.	Adjust tappet clearance.
Fuel stale or low octane.	Use good fresh fuel.
Lean fuel mixture.	Clean or adjust carburetor.
ENGINE CRANKS TOO STIFFLY	
Too heavy oil in crankcase.	Drain, refill with lighter oil.
Engine stuck.	Disassemble and repair.
ENGINE WILL NOT START WHEN CRANKED	
Faulty ignition.	Clean, adjust, or replace breaker points, plugs, condenser, coil, etc. or retime ignition.
Lack of fuel or faulty carburetion.	Refill the tank. Check the fuel system. Clean, adjust, or replace parts necessary.

<u>POSSIBLE CAUSE</u>	<u>REMEDY</u>
ENGINE WILL NOT START WHEN CRANKED (CONT.)	
Clogged fuel screen.	Clean.
Cylinders flooded.	Crank few times with spark plugs removed.
Poor fuel.	Drain, refill with good fuel.
Poor compression.	Tighten cylinder head and spark plugs. If still not corrected, grind the valves. Replace piston rings, if necessary.
Wrong timing.	Retime ignition.
Poor choking.	If plant is cold, adjust choke. If plant is warm, pull up on choke arm momentarily, while cranking.
ENGINE RUNS BUT CURRENT DOES NOT BUILD UP	
Poor brush contact or dirty commutator or slip rings.	See that brushes seat well, are free in holders, are not worn too short, and have good spring tension.
Open circuit, short circuit or ground in generator.	See GENERATOR, replace part necessary.
CURRENT UNSTEADY BUT ENGINE NOT MISFIRING	
Speed too low.	Adjust governor to correct speed.
Poor commutation or brush contact.	See that brushes seat well on commutator and slip rings, are free in holders, are not worn too short, and have good spring tension.
Loose connections.	Tighten connections.
Fluctuating load.	Correct any abnormal load condition causing trouble.
TAPPING SOUND	
Tappet clearance too great.	Adjust or replace tappets.
Broken valve spring.	Install new spring.
HOLLOW CLICKING SOUND WITH COOL ENGINE UNDER LOAD	
Loose pistons.	If noise only slight and disappears when engine warms up, no immediate attention needed. Otherwise replace worn parts.
VOLTAGE LOW AT FAR END OF LINE BUT NORMAL NEAR POWER UNIT	
Too small line wire for load and distance.	Install larger or extra wires or reduce load.

POSSIBLE CAUSEREMEDY**MOTORS RUN TOO SLOWLY AND OVERHEAT AT FAR END
OF LINE BUT OK NEAR POWER UNIT**

Too small line wire for load and distance. Install larger or extra wires, or reduce load.

NOISY BRUSHES

High mica between bars of commutator. Undercut mica.

EXCESSIVE ARCING OF BRUSHES

Rough commutator or rings. Turn down.

Dirty commutator or rings. Clean.

High mica. Undercut mica.

Brush rig out of position. Line up marks on brush rig and support.

ENGINE OVERHEATING

Low water in radiator. Refill radiator.

Overloaded. Remove part of load.

Improper lubrication. See Low Oil Pressure.

Radiator obstructed. Clean radiator.

Ignition timing late. Adjust ignition timing.

Improper ventilation. Provide for better air change.

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