# INSTRUCTION MANUAL

FOR

Onan®

# ELECTRIC GENERATING PLANTS

## ALTERNATING CURRENT MODELS

## BATTERY CHARGING MODELS

## DIRECT SERVICE MODELS

## CK

## SERIES

ONAN
2515 UNIVERSITY AVE. S.E. • MINNEAPOLIS, MINNESOTA 55414
A DIVISION OF STUDEBAKER CORPORATION
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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. Electrocution 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.

# ONAN ELECTRIC GENERATING PLANTS

## CK *Series*

ALTERNATING CURRENT MODELS

☆

BATTERY CHARGING MODELS

☆

DIRECT SERVICE MODELS

☆

**ONAN**

DIVISION OF
STUDEBAKER CORPORATION
2515 University Avenue S.E.,
Minneapolis 14, Minnesota

## HANDY REFERENCE TO CONTENTS

## LIST OF ILLUSTRATIONS

# GENERAL INFORMATION

THIS INSTRUCTION BOOK CONTAINS INFORMATION FOR THE PROPER INSTALLATION, OPERATION AND MAINTENANCE OF YOUR EQUIPMENT. WE SUGGEST THAT THIS BOOK BE KEPT HANDY SO THAT IT CAN BE REFERRED TO WHEN NECESSARY.

THIS EQUIPMENT IS THE RESULT OF PROVEN ENGINEERING DESIGN, HIGHEST QUALITY MATERIALS, AND EXPERT WORKMANSHIP. THOROUGH INSPECTION AND TESTING ASSURES YOU THAT THIS EQUIPMENT WILL PERFORM AS EXPECTED.

IF YOU WISH TO CONTACT YOUR DEALER OR THE FACTORY REGARDING THIS EQUIPMENT, BE SURE TO SUPPLY THE COMPLETE MODEL AND SPEC. NO., AND THE FULL SERIAL NUMBER OF THE EQUIPMENT AS SHOWN ON THE NAMEPLATE. THIS INFORMATION IS NECESSARY TO IDENTIFY THE EQUIPMENT AMONG THE MANY BASIC AND SPECIAL OPTIONAL TYPES MANUFACTURED.

# PLANT RUNNING HOURS COMPARED TO AUTOMOBILE RUNNING MILES

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

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

However, do not conclude that the wear on the generating plant engine and the wear on the automobile engine would be the same. The generating plant engine is built much more ruggedly, (having larger main bearings, bigger oil capacity and has a heavier crankshaft proportionately per horsepower) than most automobile engines. Given the proper care and periodic servicing the generating plant engine will continue to give many more hours of efficient service than an automobile engine will after having been run the equivalent number of running miles.

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

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

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

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

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

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

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

## ORIENTATION

This instruction manual applies specifically to the ONAN electric generating plants designated as the "CK" Series. Each plant includes an internal combustion engine, an electrical generator, and necessary accessories. Some models include hooded carrying frames, fuel tanks, self-rewinding manual starters, or tubular steel dollies.

Generating sets are given actual running tests at the factory under various electrical loads as assurance that the unit is free of defects and will produce its rated output. All plants have been radio suppressed.

Give the plant a careful visual inspection after uncrating; it may have been damaged in transit between the factory and the destination. All parts that are obviously broken or damaged must be repaired or replaced.

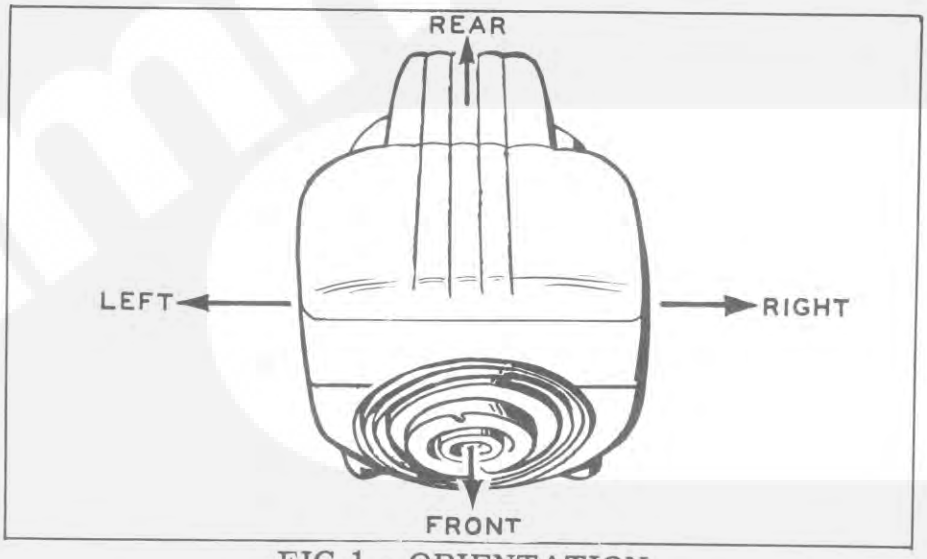



FIG.1 - ORIENTATION

The engine end of the plant is to be considered the FRONT end. Right and left sides are determined by standing at the front end and facing the generating set.

## PLANT DATA

ALTERNATING CURRENT PLANTS. - Plants of the alternating current type produce their full rated capacity in alternating current ( ac ) plus 150 watts of direct current ( dc ). The dc is used as excitation current and to charge the starting batteries. This type of plant must be operated whenever alternating current is used. A small auxiliary load may be taken from the starting battery for short periods of time while the plant is idle. NOTE: Most electrical appliances can be used on either 50 or 60 cycle frequency but it is advisable to check appliances before purchasing to assure that they are adaptable to the current frequency and voltage.

DUAL PURPOSE PLANTS. - Plants of this type produce alternating current and direct current. Alternating current may be used up to the rated capacity of the generator (3000 Watts) or up to 750 watts of direct current may be used to charge the 32 volt battery and the balance of 2250 watts used in alternating current. Electrical appliances that operate off the generator must have the same phase and voltage as the generator. Appliances that operate off the battery must all be 32 volt dc appliances.

The alternating current is supplied directly to the load from the generator and the plant must be operated whenever alternating current is used. Direct current is supplied directly to the load from the battery. Direct current may be used while the plant is running or as limited by the charge in the battery while the plant is not running.

DIRECT SERVICE PLANTS. - Plants of this type produce direct current only which is supplied directly to the load from the generator. This type of plant must be used when ever direct current electricity is used. Receptacles permit direct plug in of the load. Electrical appliances that operate off the generator must use universal motors or be for DC of the proper voltage.

BATTERY CHARGING PLANTS. - Plants of this type are operated to generate electricity which is supplied directly to a storage battery. Electricity may be used while the plant is running or, as limited by the charge in the battery, while the plant is not running. DO NOT OPERATE THIS TYPE OF PLANT WITHOUT HAVING THE BATTERY CONNECTED. Electrical appliances that operate off the battery must all be 32-volt, dc appliances.

The MODEL, SPECIFICATION, and SERIAL numbers of the generating set are stamped on a nameplate attached to the side of the generator. Illustrated below are two examples of how the information may appear on the plant nameplate. DO NOT USE the illustrated numbers when writing for information. DO USE the numbers as they are found on the generating set nameplate.

| | MODEL NO. | SPECIFICATION | SERIAL NO. |
|---|---|---|---|
| Example 1 - | 5CK-216E/99Z | | 14B98765432 |

| | MODEL & SPEC. NO. | SERIAL NO. |
|---|---|---|
| Example 2 - | 5CK-216E/99Z | 14B98765432 |

The numbers and letters with which the factory or service stations are concerned are the numbers and letters stamped in the white blocks.

Part catalogs are based upon the type of current delivered by the set (ac or dc) and the Specification Letter. Note that a letter appears after the Model and Specification numbers but before the Serial number. In the examples above, the specification letter is "Z". This is the

SPEC letter or specification letter, and it is an important clue to special features of the generating set. Be sure that the letter appears in its proper place when quoting the number to the factory or service station for information.

## ENGINE DATA

| | |
|---|---|
| Type | Four cycle, L Head, horizontally opposed, two cylinder |
| Piston Stroke | 2-3/4" |
| Cylinder Bore | 3" |
| Cooling | Air |
| Displacement | 38.8 cu. in |
| Compression Ratio | 5.9 to 1 |
| Fuel | Gas or Gasoline |
| Ignition | Magneto or Battery |
| Tilt Angle | 15° maximum |
| Engine Speed Control | Centrifugal weight type governor externally adjustable. |
| Oil Pressure Control | Adjustable, spring loaded, by-pass |
| Main and Connecting Rod Brgs. | Pressure Lubricated |
| Camshaft Bearings | Splash Lubricated |
| Oil Pump | Gear Type |
| Air Cleaner | Oil Bath |

The crankcase is an aluminum casting. . The crankcase and cylinders are of one piece construction with cast iron cylinder liners and oil lines cast into the crankcase.e. The high grade steel crankshaft is counterweighted and dynamically counterbalanced. Pistons and connecting rods are made of aluminum alloy. There are two compression rings and one oil control ring; piston pins are of the free floating type. The oil base is removable. There are stellite exhaust valves and seats plus positive type rotators in the exhaust system. Valve seat inserts and main bearings are replaceable. Oil pressure is regulated by a spring loaded by-pass, and pressure can be externally controlled.

## GENERATOR

AC PLANTS. - The generators of all models covered in this manual are of the four pole, air cooled, revolving armature type. The ac or dc windings of the armature are wound on the same laminations, the ac windings connecting to the collector rings, the dc windings to the commutator. The field coils are saturated shunt wound. The Remote Start and Dual Purpose plants have a series winding in addition for cranking. The armature is directly connected to the engine crankshaft and turns at engine speed. It is supported at the inner end by the rear main crank-

shaft bearing and at the outboard end by a ball bearing. The frame is a rolled steel ring, machined on the inside, in which the poleshoes and coils are mounted.

DC PLANTS. - The generator of all dc models covered in this manual are of the self-ventilated, four pole, direct current type with commutating poles. The field coils of the Battery Charging plants are shunt wound and have a series field in addition for cranking purposes. The field coils of the Direct Service plants are compound wound. The brush rig position is adjustable, witness marks designating neutral brush position. The armature shaft is directly connected to the crankshaft by a taper with a key. A ball bearing supports the outboard end of the armature shaft. The armature assembly and frame assembly are easily removable. Pole shoes and field coils are mounted rigidly in the generator frame.

## CONTROLS

MANUAL START PLANTS. - AC & DC. - Controls for manual plants consist of a manually operated choke and a stop button.

REMOTE START PLANTS. - AC & DC. - Remote starting plants have a control box mounted on the generator frame which contains switches, relays, charge rate ammeter, start and stop buttons or switch, and other electrical equipment necessary for stopping and starting the plant electrically at the plant and at any remote start-stop stations as may be installed.

## SPECIAL ACCESSORIES

The following special accessories are not standard equipment but are available at extra cost from your dealer. When ordering any of the following special accessories, always be sure to give the Model and Serial numbers of the plant on the order.

GASEOUS FUEL CONVERSION KITS. - These kits contain parts and instructions which permit the use of Butane, Propane or natural gas as well as gasoline.

AUTOMATIC CONTROLS (AC Remote Start Plants Only). - A separate control is available for either 50 or 60 cycle ac units that will automatically start and stop the plant as the load requires.

LINE TRANSFER CONTROLS (AC Remote Start Plants Only). - Line transfer controls are available for use with either 50 or 60 cycle units in standby service. When regular high line power fails, the line transfer control

automatically starts the standby plant and takes over the load. The plant stops automatically when regular service is restored.

UNDERGROUND FUEL TANKS AND LINES. - 55 gallon and 110 gallon fuel tanks and 1/4 inch and 5/16 inch copper fuel lines in either 25 or 50 foot length are available for installing the fuel tank underground.

REMOTE START-STOP SWITCHES. - Additional remote start-stop switches are available from your dealer.

3-CONDUCTOR CABLE. - This cable is designed for remote start-stop station installation and is available in any length desired.

DOLLIES. - Lightweight tubular steel dollies equipped with pneumatic tires are available for most manual start plants.

FUEL RESERVOIR (DAY) TANK. - In standby service, an automatic line transfer control is used and the generating plant may stand unused for many days. In this period of shut-down, sufficient gasoline may evaporate from the carburetor to lower its fuel level considerably. Prolonged cranking may then be necessary in order to pump enough gasoline into the carburetor for the engine to start. The cranking limiter in the line transfer control may interrupt the engine cranking circuit before the gasoline reaches the carburetor and the engine will not start. On installations where automatic unattended starting after extended shut down is necessary, an auxiliary, gravity feed fuel tank should be installed. Fuel from this tank flows by gravity to the carburetor, thus replacing any fuel lost through evaporation and promotes quick starting after an idle period.

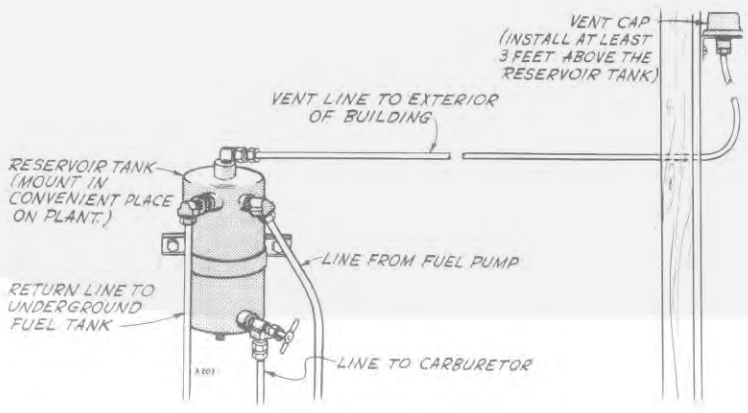



FIG. 2A-TYPICAL DAY TANK INSTALLATION

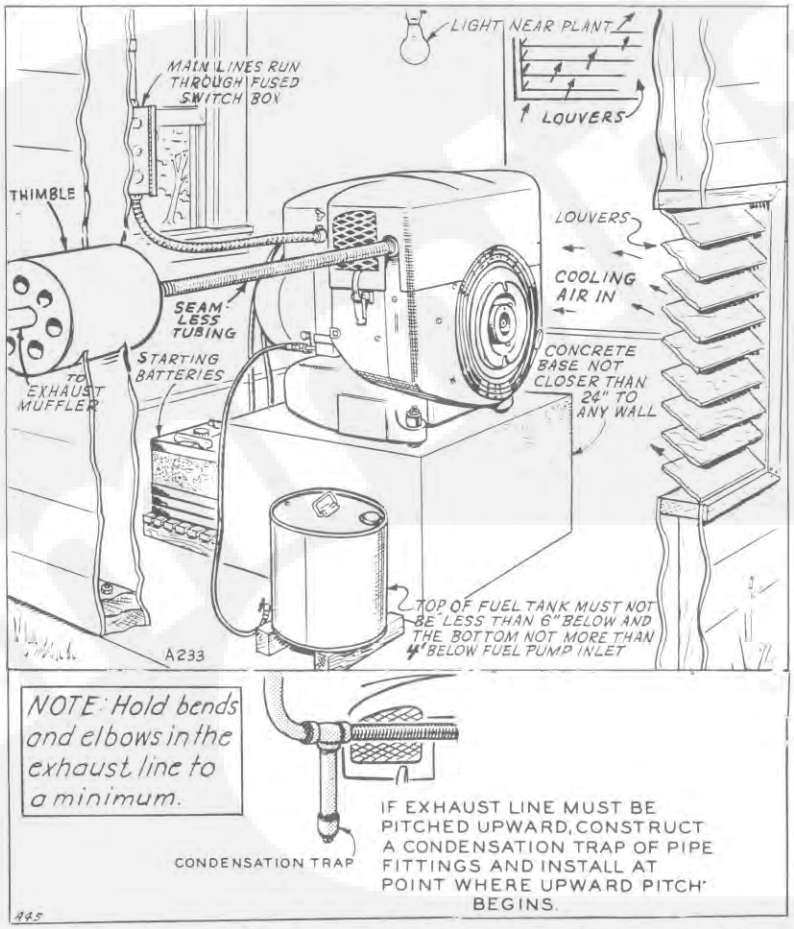



FIG. 2B- TYPICAL INDOOR INSTALATION

Proper installation of the generating set is as important to the efficient operation of the plant as is the use of proper lubricants and fuel. Extreme temperatures, vibration, dirty and wet conditions are injurious to the plant and shorten the life and efficiency of the plant. If prevailing operating conditions do not allow the recommended methods of installation, select the group of instructions most applicable to the immediate needs and proceed as far as possible with them.

## Stationary Or Indoor Operation

The location selected for the plant should be as near to the center of the electrical load as practicable. For example: When servicing several buildings with electricity, it is much better and costs less to run lines from a central point to each building than to run lines from building to building. See Fig 3. Not only will voltage drop from plant to load be less but smaller wires can be used without much voltage loss between the plant and the point of service.

The enclosure selected for the installation should be clean, dry, well ventilated, and heated if temperatures are expected to drop below freezing.

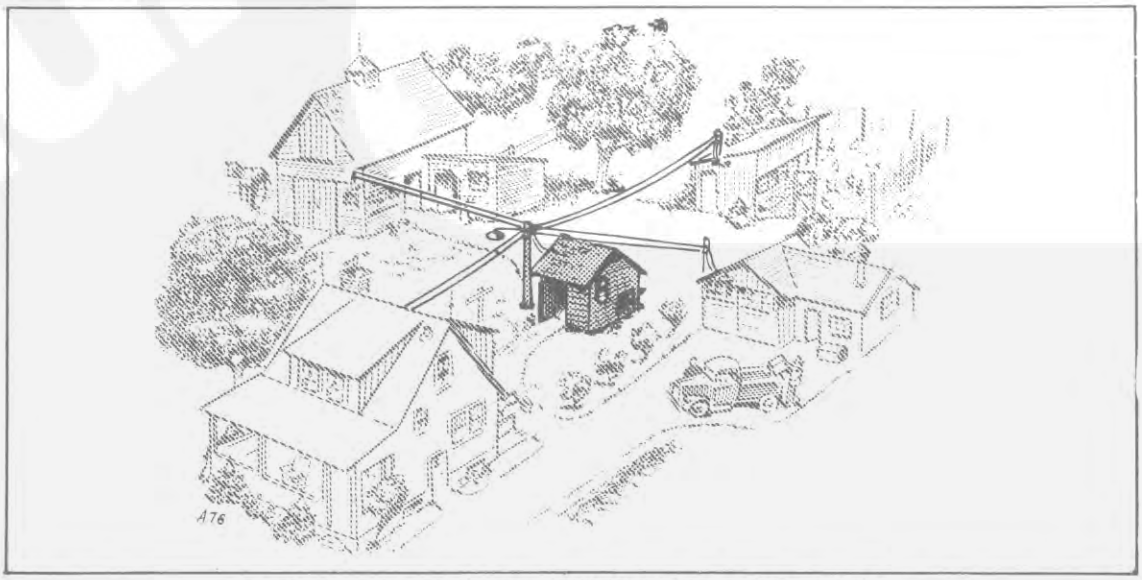



FIG. 3- TYPICAL OUTDOOR LOCATION

EXHAUST LINES. - All exhaust gases must be piped outdoors. Use pipe as large as the exhaust outlet at the plant but increase the pipe size by one size for each 10 feet used. A short length of flexible tubing must be installed between the plant and any rigidly mounted exhaust pipe or connection. Keep the exhaust pipe at least 9" from combustible materials, and protect walls and partitions through which exhaust pipes pass with a thimble having a diameter 12" greater than the exhaust pipe and extending 9" beyond the inside and outside of the walls and partitions; see Figure 2B.

Avoid sharp bends or long runs of pipe. If the exhaust line must be pitched upwards, place condensation traps at the lowest points in the line. Drain traps periodically to prevent accumulation of water from reaching the muffler. The traps must be closed securely after draining to prevent exhaust gases from entering the enclosure.

CAUTION!

Exhaust gases will cause severe sickness or death to operators inhaling gases for even short periods of time. Provide sufficient ventilation to dispel gases that may have escaped from the plant.

VENTILATION. - Provide ample ventilation. There should be at least two openings, preferably at opposite ends of the enclosure, to provide ample ventilation. The openings should be adjustable so that the volume of air can be controlled for cold weather operation. The area of the air inlet should be at least 3-1/2 square feet. The area of the air outlet should be at least as large as that of the air inlet.

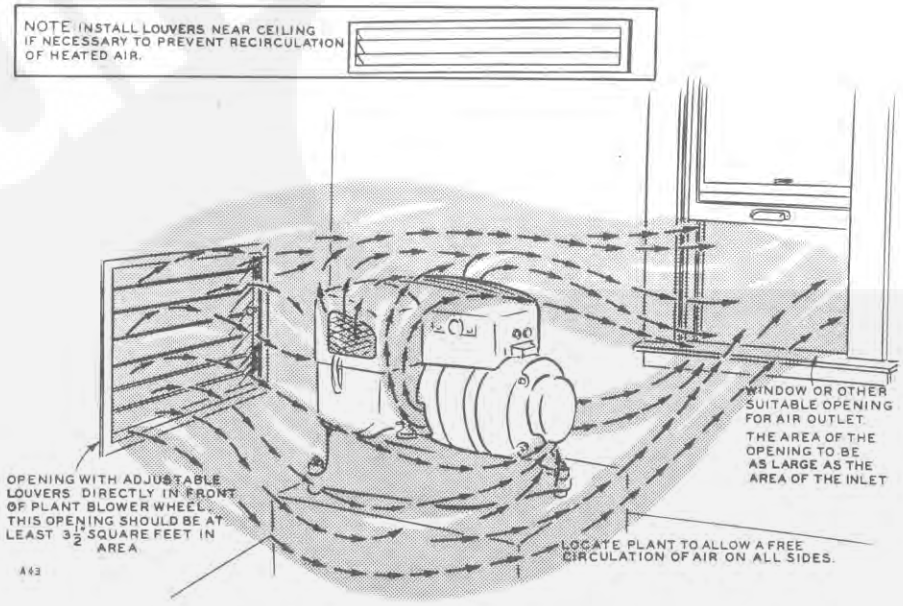



FIG. 4 - VENTILATION

The installation of additional openings may be necessary under some conditions to prevent recirculation of heated air. If this becomes necessary, air outlets in the roof or in the wall near the ceiling will help. The size of the air inlet can be increased or an additional air inlet installed nearby.

If the unit is to be operated where flying lint, chaff or dust is likely to be carried to the intake air stream, air inlet, and air outlet, openings should be made with reference to the prevailing wind. In such installations, the air inlet should be screened and the screen kept clean to prevent restriction of air flow.

MOUNTING BASE. - The plant should be mounted on a permanent base of timber or concrete. The base should be at least two inches larger on all sides than the plant base and about 12 inches high. Leave at least 24 inches between the base and the nearest wall. See Fig.5 for dimensions.

If concrete is used for the base, set three mounting bolts into the concrete. Make cleats and place them across the form to hold the bolts in position until the cement hardens. Adjust the bolts on the cleats so that not more than 4" extends above the concrete. Place a large washer and a nut on each bolt before pouring the concrete. A mixture of 1 part cement, 2 parts sand and 4 parts gravel or crushed stone will make a good base. Be sure the mounting surface of the base is smooth and level. Allow the cement to harden for 3 days before mounting the plant on the base.

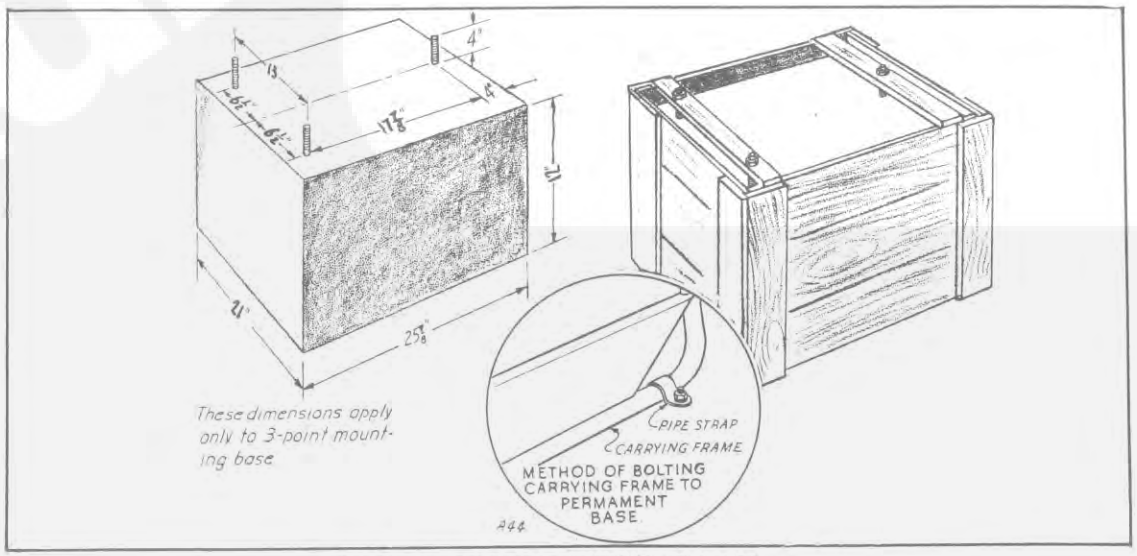



FIG. 5- MOUNTING BASE

If the generating set has four mounting points, follow the directions for the three point mounting base but change the bolt spacing to accommodate the four holes in the oil base.

If timbers are used as a mounting base, they should be large enough to adequately support the plant. The timbers should also be securely fastened to the foundation on which they are to rest.

MOUNTING THE PLANT ON THE BASE. - Give special attention to the proper assembly of the shock mounting cushions when installing the plant on the mounting base.

Check the assembly as shown in Fig. 6. A spacer is used and the single nut can be tightened securely. The spacer prevents compressing the top cushion.

Units not having a carrying frame are shipped with the shock mounting cushions only partly assembled. The lower cushions are cemented in the base. The upper cushions and hardware are to be assembled as shown in Fig. 6 after the unit is removed from the crate and installed on the mounting base. Be sure the spacer is in place as shown. This prevents the cushions from being compressed when the nut is tightened.

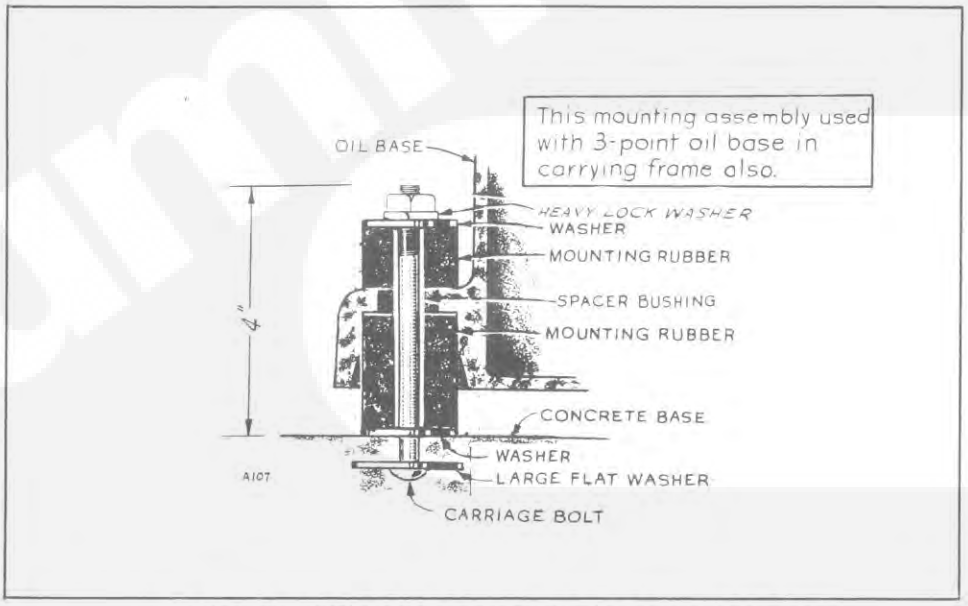



FIG. 6- SHOCK MOUNTING ASSEMBLY

BATTERY, AC REMOTE CONTROL PLANT. - A 12-volt battery is required. If two 6-volt batteries are used, the batteries must be connected in series by connecting a short cable between the positive post of one battery and the negative post of the other battery.

Connect one of the long battery cables between the positive (+) battery post on the battery to the POSITIVE terminal in the plant control box. Connect the other long cable from the negative (—) post on the battery to the NEGATIVE terminal in the plant control box. The short jumper cable is not used with a single 12 volt battery. Be sure connections are tight at all points.

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 "freshening" charge before putting them in use. Use a hydrometer to determine the charge condition.

When making cable connections at the battery, it may be necessary to spread the cable lug open slightly before it will fit properly on the terminal post. Do not use a hammer to drive the cable lugs onto the battery terminal posts, the battery may be damaged. The cable lugs should have full contact on the battery terminal posts to insure good contact at this point. Be sure the contact surfaces of the cable lugs and battery terminal posts are clean before making connections. Coat the lugs and battery terminal posts with a thin coating of vaseline to help prevent corrosion from forming.

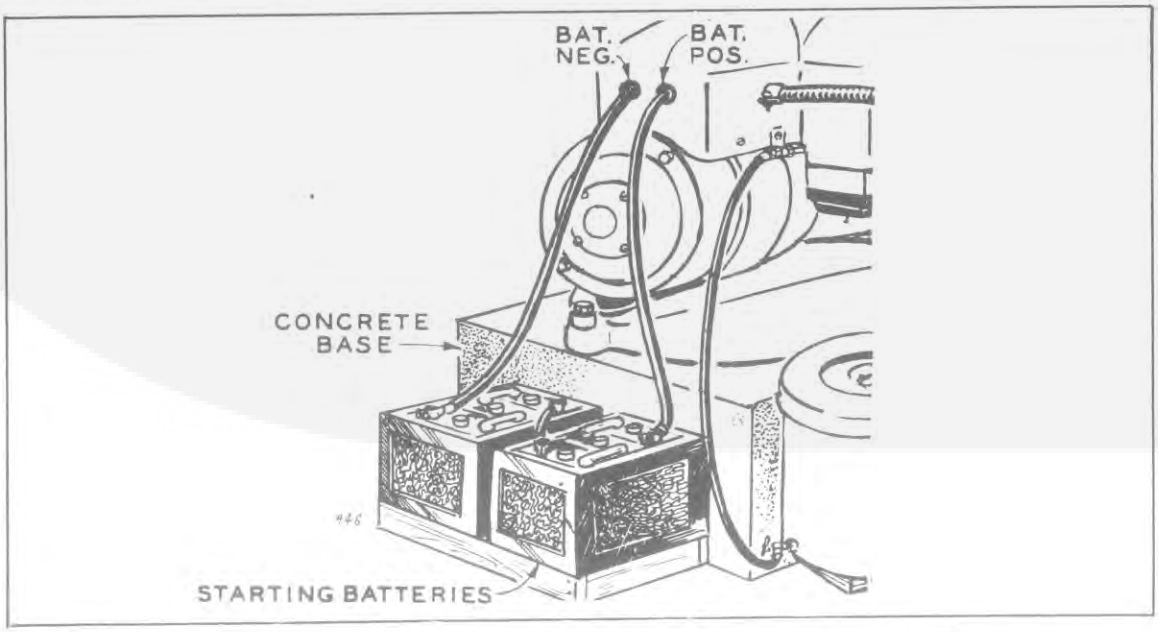



FIG. 7 - STARTING BATTERY CONNECTIONS

BATTERY - DC 32 VOLT. - The 32-volt battery should be prepared for use according to the instructions supplied by the battery manufacturer. Several different makes of automotive or glass jar type are available on the market. Your dealer can recommend the type best suited for your particular installation.

Cables for connecting the battery to the plant are not supplied with these units. Ask your dealer to recommend the size and length of cable best suited for your needs. Both cables should be of the same length, and the length should be held to a minimum.

A single throw, double pole fused switch should be installed between the plant and the battery. See Fig. 10. Your dealer should be able to supply a suitable switch. If not, they are available at most electrical supply houses. Be sure to use 100 ampere fuses in the switch. Keep the switch closed except when servicing the plant. It can then be opened to prevent accidental starting of the plant.

Connect a short length of cable from the battery positive (+) post to the hot side of the switch. Connect another length of cable from the hot side of the switch to the POSITIVE terminal on the plant control saddle. See Fig. 10.

Connect another short length of cable from the battery negative (—) post to the ground side of the switch. Connect a second length of cable from the ground side of the switch to the NEGATIVE terminal on the plant control saddle.

CONNECTING THE LOAD WIRES, AC REMOTE PLANTS. - The ac load terminals are located inside the control box and are marked. The same markings appear on the wiring diagram. These terminals are of the solderless type and connections are made by simply inserting the end of the load wire into the connector and tightening the screw. Thoroughly strip 1/2 of an inch of insulation from the end of each wire before inserting it into a terminal. Load wires enter the control box through a grommeted hole. Be sure connections are clean and tight.

Leave the load line switch open until the plant has been started and checked. No damage to the generator or controls will result from running the plant with no load connected.

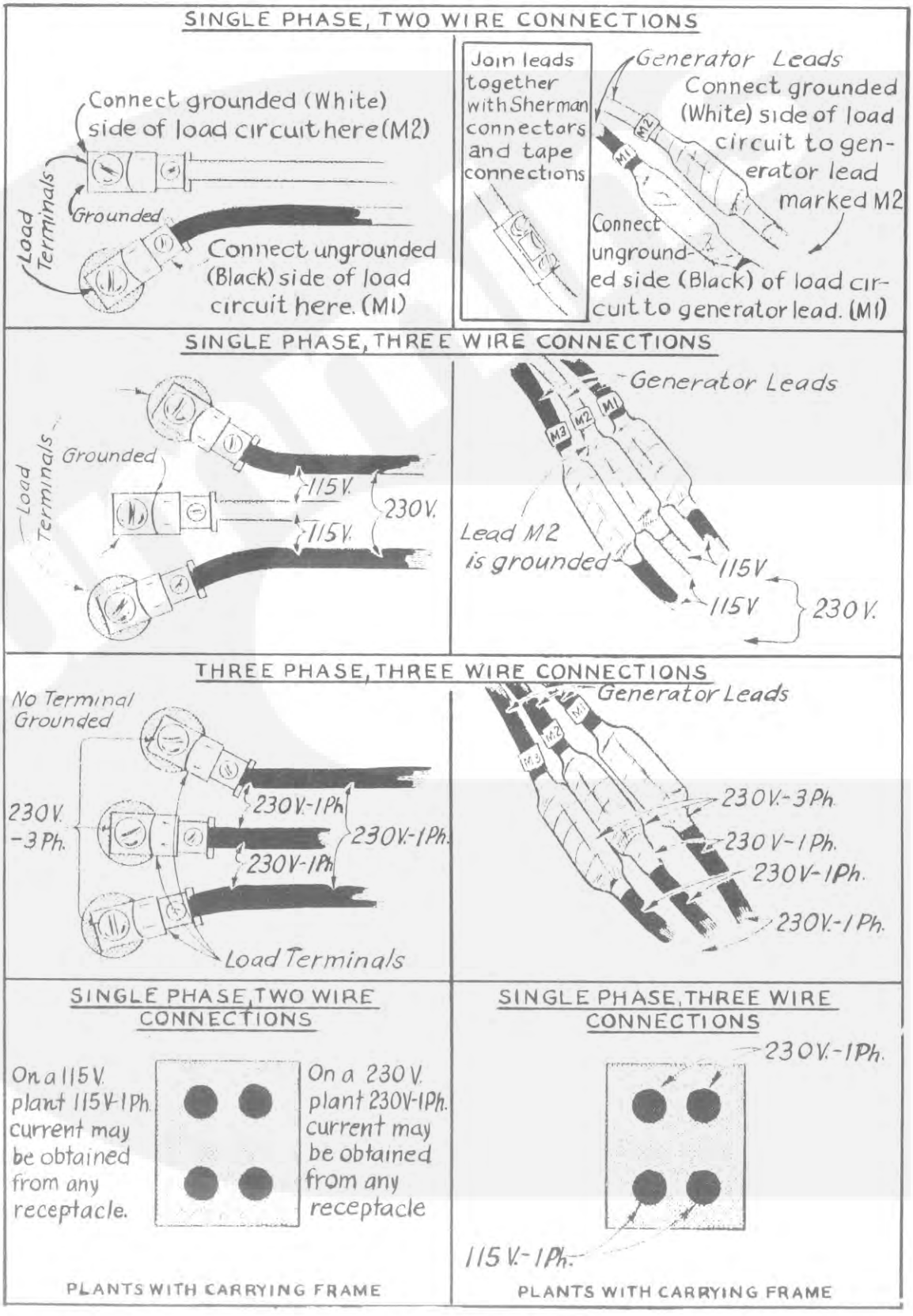



FIG. 8 - AC LOAD CONNECTIONS

### 1 Phase, 2 Wire - AC Remote

On single phase, two wire plants, connect the load wires to the plant by connecting the ground (white) load wire to the control box terminal marked "M2". Connect the "hot" ungrounded (black) load wire to the control box terminal marked "M1".

### 1 Phase, 3 Wire - AC Remote

On single phase, three wire plants, connect the load wires to the plant by connecting the ground (white) load wire to the control box terminal marked "M2". Connect one of the "hot" ungrounded (black) load wires to the control box terminal marked "M1", and connect the remaining "hot" ungrounded (black) load wire to the control box terminal marked "M3".

Two 115 volt circuits are available. One circuit across "M1" and "M2" and another circuit across "M2" and "M3". The load on each 115 volt circuit should not be more than 1/2 the capacity of the plant.

One 230 volt circuit is available. This circuit is across "M1" and "M3". "M2" is not used with a 230 volt circuit. If only 230 volt current is used, the full rated capacity of the plant may be used.

Both 115 volt current and 230 volt current may be used at the same time. However, the total of either 115 volt load plus 1/2 the 230 volt load should not exceed 1/2 the capacity of the plant. For example: a total of 2500 watts is available on each 115 volt circuit of a 5000 watt single phase 3 wire plant. If 2000 watts of current is used on either 115 volt circuit, only 1000 watts of 230 volt current can be used at the same time. To determine the current available on each 115 volt circuit when the 230 volt load is known, subtract the 230 volt load from the plant rated capacity and divide the remainder by two.

### 3 Phase, 3 Wire - AC Remote

For three phase current, connect one load wire to each of the three generator terminals "M1", "M2", and "M3". If a test run indicates wrong rotation of 3 phase motors in the load circuit, reverse the connections at any two generator terminals.

Single phase current can be obtained between any two terminals. Three such single phase circuits are thus available: "M1 and M2", "M1 and M3", "M3 and M2". Not more than one third the capacity of the generator is available on each single phase circuit.

If both single and three phase current is used at the same time, use care not to over-load any one of the single phase circuits. Subtract the amount of the three phase load from the rated capacity of the generator.

Divide the remainder by three, to determine the amount of single phase load which may be connected to each of the single phase circuits.

4 Wire Plant - AC Remote

The four wire plant is designed to produce single phase current of one voltage, and three phase current of different voltage. As indicated on the plant nameplate, the single phase current is the lower voltage, and the three phase current is the higher voltage.

For single phase current, connect the "hot" load wire to any one of the terminals "M1", "M2", or "M3". Connect the ground (white) load wire to the terminal marked "M0". Up to one third the rated capacity of the generator is available on each single phase circuit, if no 3 phase load is connected.

For three phase current, connect the "hot" load wires to the terminals marked "M1", "M2", and "M3", one wire to each terminal. Connect the ground load wire, if used, to the plant terminal marked "M0".

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

CONNECTING THE LOAD WIRES, AC MANUAL PLANTS. - Manual type plants have generator output leads which extend into an outlet box. Connections to the output leads may vary between different installations. The user should install a circuit breaker or a fused switch in the main load line to provide for automatic disconnecting of the load.

If the application is essentially stationary, the user may desire to connect the load leads within the outlet box on the plant, using bolts or connectors and taping each lead. If the main load lines are to be run in rigid conduit, install a short length of flexible conduit between the outlet box and the rigid conduit. Flexible conduit may be used entirely if so desired. If conduit is not used, install a Romex connector, or a similar load conductor securing device, to hold the load wires where they enter the outlet box.

Manual type plants have marking ("M1", etc.) on the generator leads which correspond to the same markings on the control box output terminals of the remote type plants. The instructions for connecting the load wires are not repeated here. Please refer to the instructions CONNECTING THE LOAD WIRES, AC REMOTE PLANTS and select the paragraphs which apply to the model in question.

**TABLE OF WIRE SIZES FOR 115 VOLTS**

| Amperes | Watts at 115 volts | No. 14 | No. 12 | No. 10 | No. 8 | No. 6 | No. 4 | No. 2 | No. 0 | No. 00 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 115 | 450 | 700 | 1,100 | 1,800 | 2,800 | 4,500 | 7,000 | | |
| 2 | 230 | 225 | 350 | 550 | 900 | 1,400 | 2,200 | 3,500 | | |
| 3 | 345 | 150 | 240 | 350 | 600 | 900 | 1,500 | 2,300 | 3 /50 | |
| 4 | 460 | 110 | 175 | 275 | 450 | 700 | 1,100 | 1,750 | 2,750 | 3,500 |
| 5 | 575 | 90 | 140 | 220 | 360 | 560 | 880 | 1,400 | 2,250 | 2,800 |
| 10 | 1,150 | 45 | 70 | 110 | 180 | 280 | 450 | 700 | 1,100 | 1,400 |
| 15 | 1,725 | 30 | 45 | 70 | 120 | 180 | 300 | 475 | 750 | 950 |
| 20 | 2,300 | *22* | 35 | 55 | 90 | 140 | 225 | 350 | 550 | 700 |
| 25 | 2,875 | *18* | *28* | 45 | 70 | 110 | 180 | 280 | 450 | 560 |
| 30 | 3,450 | *15* | *25* | 35 | 60 | 90 | 150 | 235 | 340 | 470 |
| 35 | 4,025 | | *20* | *30* | 50 | 80 | 125 | 200 | 320 | 400 |
| 40 | 4,600 | | *17* | *27* | 45 | 70 | 110 | 175 | 280 | 350 |
| 45 | 5,175 | | | *25* | *40* | 60 | 100 | 155 | 250 | 310 |
| 50 | 5,750 | | | *22* | *35* | 55 | 90 | 140 | 225 | 280 |
| 60 | 6,900 | | | | *30* | 45 | 75 | 120 | 185 | 240 |
| 70 | 8,050 | | | | *25* | *40* | 65 | 100 | 160 | 200 |
| 80 | 9,200 | | | | | *35* | 55 | 85 | 140 | 180 |
| 90 | 10,350 | | | | | *30* | *50* | 75 | 125 | 160 |
| 100 | 11,500 | | | | | *28* | *45* | *70* | 115 | 140 |

**TABLE OF WIRE SIZES FOR 230 VOLTS (OR 3-WIRE 115/230 VOLTS)**

| Amperes | Watts at 230 volts | No. 14 | No. 12 | No. 10 | No. 8 | No. 6 | No. 4 | No. 2 | No. 0 | No. 00 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 230 | 900 | 1,400 | 2,200 | 3,600 | 5,600 | 9,000 | | | |
| 2 | 460 | 450 | 700 | 1,100 | 1,800 | 2,800 | 4,500 | 7,000 | | |
| 3 | 690 | 300 | 480 | 700 | 1,200 | 1,800 | 3,000 | 4,600 | 7,500 | |
| 4 | 920 | 220 | 350 | 550 | 900 | 1,400 | 2,200 | 3,500 | 5,500 | 7,000 |
| 5 | 1,150 | 180 | 280 | 440 | 720 | 1,020 | 1,750 | 2,800 | 4,500 | 5,600 |
| 10 | 2,300 | 90 | 140 | 220 | 360 | 560 | 900 | 1,400 | 2,200 | 2,800 |
| 15 | 3,450 | 60 | 90 | 140 | 240 | 360 | 600 | 950 | 1,500 | 1,900 |
| 20 | 4,600 | *45* | 70 | 110 | 180 | 280 | 450 | 700 | 1,100 | 1,400 |
| 25 | 5,750 | *35* | *55* | 90 | 140 | 220 | 360 | 560 | 900 | 1,100 |
| 30 | 6,900 | *30* | *50* | 70 | 120 | 180 | 300 | 470 | 680 | 940 |
| 35 | 8,050 | | *40* | *60* | 110 | 160 | 250 | 400 | 640 | 800 |
| 40 | 9,200 | | *35* | *55* | 90 | 140 | 220 | 350 | 560 | 700 |
| 45 | 10,350 | | | *50* | *80* | 120 | 200 | 310 | 500 | 620 |
| 50 | 11,500 | | | *45* | *70* | 110 | 180 | 280 | 450 | 560 |
| 60 | 13,800 | | | | *60* | 90 | 150 | 240 | 370 | 480 |
| 70 | 16,100 | | | | *50* | *80* | 130 | 200 | 320 | 400 |
| 80 | 18,400 | | | | | *70* | 110 | 170 | 280 | 360 |
| 90 | 20,700 | | | | | *60* | *100* | 150 | 250 | 320 |
| 100 | 23,000 | | | | | *55* | *90* | *140* | 230 | 280 |

Figures in both columns represent ONE-WAY distances, not the length of wire back and forth. Distances shown in italics indicate that for the amperage on the same line in left column, only weatherproof wire may be used. Use Type R or T (or weatherproof wire) in all other cases. Each figure indicates maximum distance in feet that each size wire will carry the amperage in the left column with 2% voltage drop. If you wish a 4% drop, double the distance shown. If a 5% drop is needed, multiploy all distances by 2½.

FIG. 9 - WIRE SIZE TABLE

CONNECTING THE LOAD WIRES, AC PORTABLE PLANTS. - The portable type plant is designed for applications which require plant operation at various locations. These plants have outlet receptacles of the grounding type which serve for easy connection and disconnection of the load. Matching electrical plugs or caps must be provided on the load wires.

CONNECTING THE 32-VOLT DC LOAD - DUAL PURPOSE PLANTS ONLY. - Although these plants are basically ac plants, they produce up to 750 watts of 32 volt, direct current for charging 32-volt batteries. Connect the 32-volt dc load as directed for the 32 volt battery charging plant.

Connecting The Load - DC Plants

A. 32-VOLT BATTERY CHARGING PLANTS. - Make load connections as shown in Fig. 10. The main line should be protected by a main switch fused with 100 ampere fuses. Be sure the wire used between the battery switch and the main switch is large enough to safely carry the output of the battery plus the rated capacity of the generator. Smaller wire may be used for branch circuits. The size depends upon the amount and kind of load. Electrical appliances to be operated from this unit must be for operation on 32-volt dc systems.

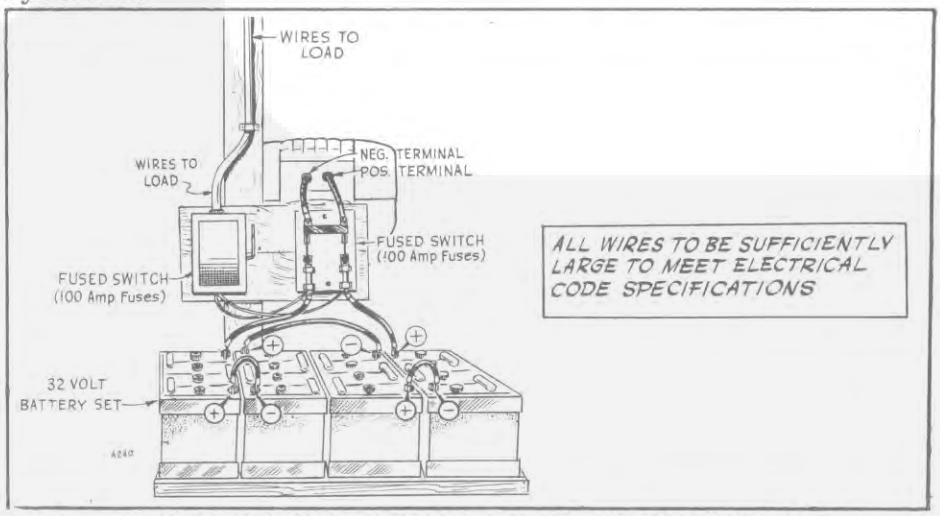



FIG. 10 - BATTERY CHARGING LOAD CONNECTIONS

B. DIRECT SERVICE PLANTS WITH CARRYING FRAME. - These plants have outlet receptacles mounted in a box located on the generator frame. Lights, tools, power equipment, etc., of the proper dc or universal type can be directly connected at these receptacles. All receptacles may be used at the same time but the amperage output through any one receptacle must not exceed 20 amperes and the total demand in watts through all receptacles used must not exceed the output of the generator.

On a 115 Volt plant, 115 volt current may be obtained from any receptacle. On a 230 Volt plant, 230 volt current may be obtained from any receptacle.

The output of the 115-volt Direct Service plants is about 43 amperes at 5,000 watts. The output of the 230-volt Direct Service plants is about 22 amperes at 5,000 watts. The two Twistite receptacles require a special plug. Turn the plug after inserting to lock it in place. Any standard plug can be used in the Twistlock receptacles.

C. DIRECT SERVICE PLANTS WITHOUT CARRYING FRAME. - The output leads of the generator are located in a box mounted on the generator frame. Remove the cover to expose the leads. Install a fused main switch or circuit breaker at a point near the plant. Connect a lead from the generator lead marked "A1" in the outlet box to the "hot" side of the main switch. Connect a second lead from the generator lead marked "A2" in the outlet box to the grounded side of the main switch. The outlet box has several "knockout" holes in it. Use the one most convenient for the installation. Use a connector where wires exit from the box. Run wires in conduit where practicable. Wires from the plant to the main switch must be large enough to carry the entire output of the plant. Smaller wires can be used for branch circuits. The size depends on the amount and kind of load on each circuit.

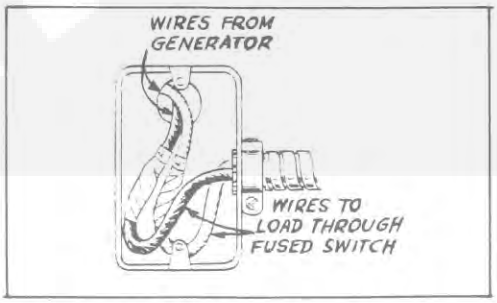



FIG. 11 - LOAD CONNECTIONS-DC MANUAL PLANTS

Selecting Right Wire Size

The National Electrical Code permits nothing smaller than No. 14 for ordinary wiring. It is better to consider No. 12 the smallest this being required in some places by local ordinance. If you need wire heavier than the minimum permitted, it is a fairly complicated matter to figure the right size, but a simple matter to look it up in the tables.

REMOTE CONTROL CONNECTIONS. - Alternating current plants of the remote control type and battery charging plants of the remote control type have provisions within the plant control box to connect remote control start-stop switches. These switches enable you to start and stop the plant from any building within 1,000 feet of the plant when properly installed. Use No. 18 wire up to 250 feet, No. 16 wire up to 400 feet and No. 14 wire up to 630 feet.

Refer to the remote control wiring diagrams in the rear of this manual. Note that there is a terminal block in the control box marked "REMOTE

CONTROL" B+, 1, 2, and 3. Terminal 1 is a common ground, terminal 2 is in the stop circuit and terminal 3 is in the start circuit. The terminal marked B+ is to be used only with an automatic control installation. The remote control switch terminals are marked ON, OFF, and one remains blank, or 1, 2 and 3. Make connections as shown in Fig.12.

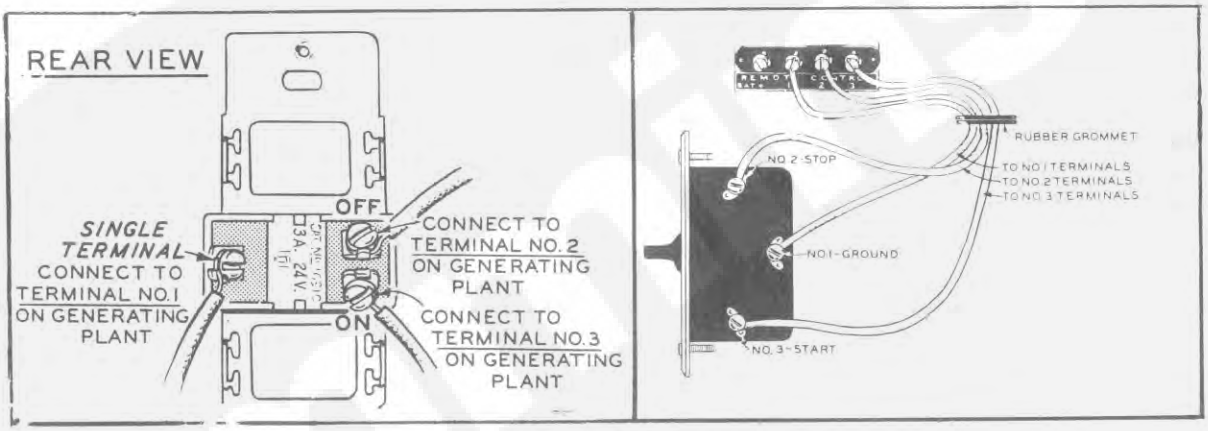



FIG. 12 - REMOTE CONTROL SWITCH

GROUNDING THE PLANT. - The National Electrical Code is a publication containing recommended procedures for grounding generating plants and branch circuits. The code is especially set up for the protection of the operator of the plant and the users of the branch circuits; electrical shocks are dangerous and sometines fatal. Employ competent electricans to install wiring and ground connections or follow the Code and local regulations close to assure adequate protection against hazardous operating conditions.

FUEL TANK AND FUEL LINE INSTALLATION. - The fuel tank of plants having a carrying frame is mounted in the frame, and all fuel lines were connected before the plant was shipped.

A separate fuel tank is shipped with plants not equipped with a carrying frame. Install the shut-off valve and screen supplied with the tank at the tank outlet. Set the tank on timbers or a low rack. This will prevent moisture from forming under the tank which may cause the tank to rust. The top of the tank should not be less than 6" below and the bottom of the tank not more than 4' below the fuel pump inlet. Install the flexible line between the tank and the fuel pump at the plant.
If a rigid tubing is used, run it close enough to the plant to permit connecting the flexible line. This flexible line connects at the fuel pump on some models. On other models it connects to a fitting mounted on the side of the generator.

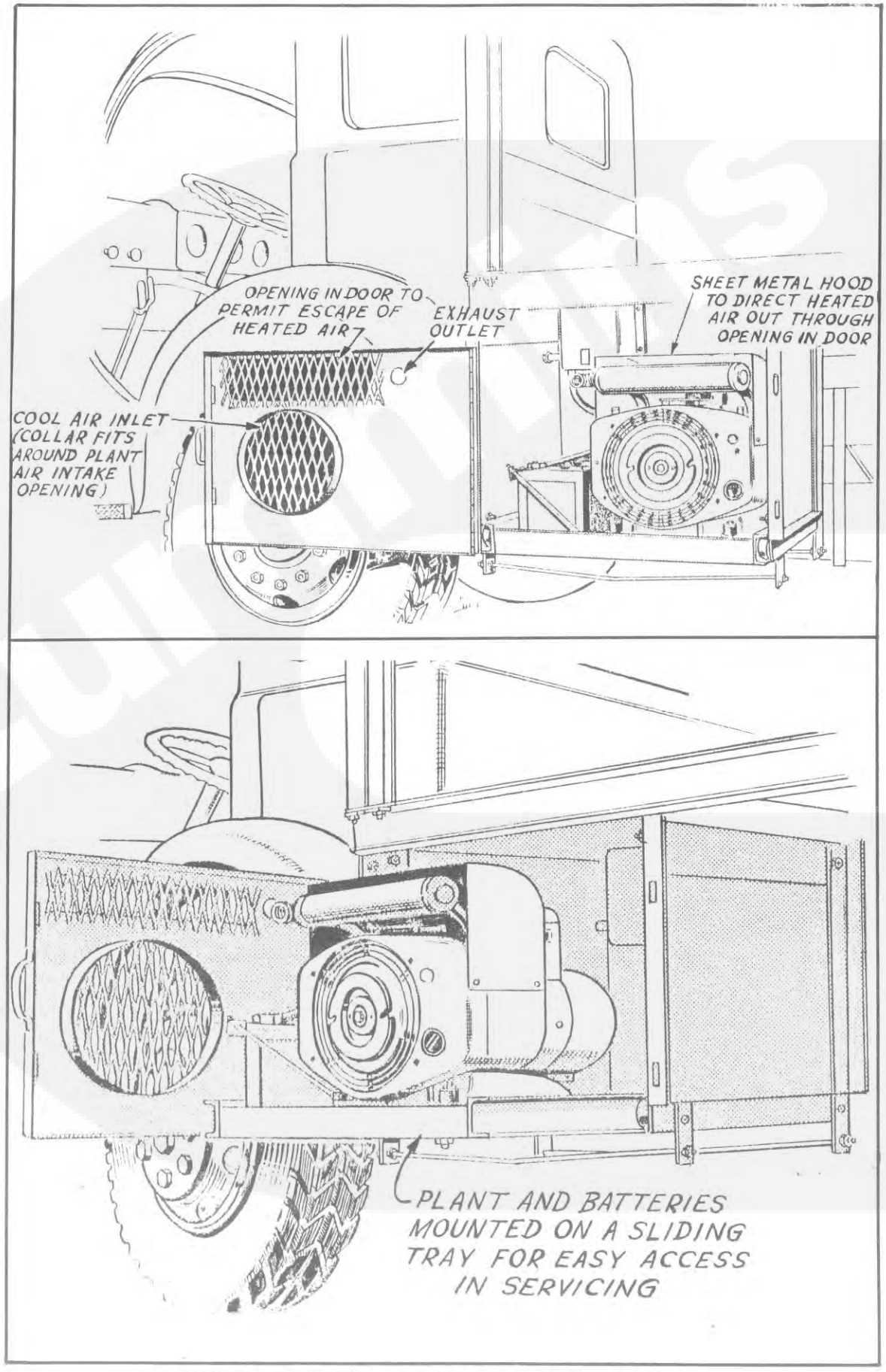



FIG 13 - TYPICAL MOBILE INSTALLATION

## MOBILE INSTALLATION

The generating set must be securely bolted to the floor or other rigid member if it is to be mounted in a vehicle. Do not neglect the piping of the poisonous exhaust gases to the outdoors. Keep the exhaust piping several inches away from inflammable materials and support the piping securely so that it will remain permanently in place.

CAUTION: Do not run the vehicle into a closed building and operate the generating set. Be sure that the exhaust lines are carefully extended to the outside of the building.

If the vehicle is a closed one, proper ventilation must be provided. Several small openings will suffice but there must be at least 3-1/2 square feet of inlet area and a similar amount for an outlet. Prevent recirculation of heated air wherever possible.

Support all permanent wiring within the vehicle so that vibration will not wear away the insulation or break the wires.

Do not store other items loosely near the generating set in such manner as to risk damaging the plant while the vehicle is in transit.

Sets mounted in vehicles must also be grounded. Review the applicable sections in the National Electrical Code and local regulations to determine the steps to be taken for grounding the set.

Do not attempt to start or operate the generating set until it has been properly serviced for operation as recommended in this section. If extreme ambient temperatures or abnormal operating conditions exist refer to the separate section on Abnormal Operating Conditions.

LUBRICATION. - Use detergent oils classified by the American Institute as Service "MS or MS/DG". The use of SERvice "DG" and Service "DS" oil is satisfactory, but the higher cost of such oil does not justify its use in this type of service.

Multiviscosity oils such as 5W-20 or 10-30 are not recommended as the oil consumption increases greatly, in some cases consumption may be more than doubled. At low temperatures where cold starting may be difficult and high oil consumption is not a factor, the use of multiviscosity oil may be justified.

The drain plug should be removed from the oil base and the coupling and nipple supplied with the plant installed in its place. Then insert the drain plug into the coupling and tighten enough to prevent oil leakage.

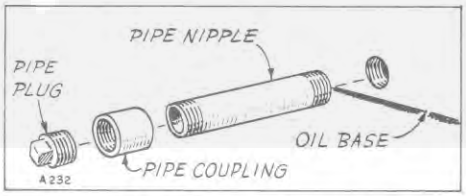


FIG.14- OIL DRAIN ASSEMBLY

Use the correct SAE number oil in the crankcase according to the lowest ambient temperature to which the generating set will be subjected during inactive periods. See Fig.15. Use only enough oil in the engine to bring the level up to the "F" mark on the oil level indicator. Overfilling causes foaming in the crankcase and interferes with efficient lubrication. Refill the crankcase with the proper SAE grade of oil if the level reaches the "L" mark on the gauge.

The oil capacity of an oil base is found in raised numbers cast into the base. In any instances where there isn't an outward indication of the exact oil capacity, be guided by the oil level indicator.

| LOWEST TEMPERATURE AT THE PLANT | SAE NUMBER |
|---|---|
| Above 90°F. (32°C.) For Heavy Duty Operation | No. 50 |
| Between 30°F. & 90°F. (-1°C. and 32°C.) | No. 30 |
| Between 0°F. & 30°F. (-18°C. and -1°C.) | No. 10W |
| Below 0°F. (-18°C.) | No. 5W |

FIG.15-OIL GRADE TABLE

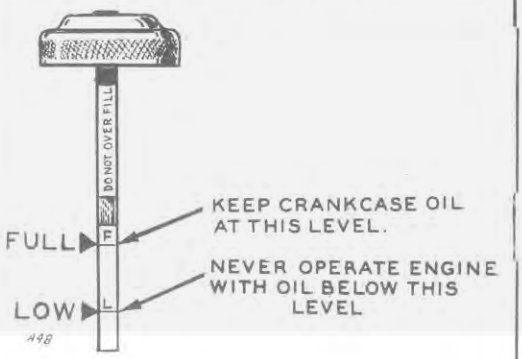


FIG.16- OIL LEVEL INDICATOR

A partial vacuum exists in the crankcase when the plant is in operation. Close the oil fill cap securely to prevent oil leakage at the seals. If the partial vacuum is destroyed by an open oil fill or a frozen breather valve, oil will be forced out of the crankcase under pressure.

AIR CLEANER OIL LEVEL. -

Turn out the thumb screw on the underside of the air cleaner cup as far as it will go, and remove the cup. Fill the cup to the level shown in Fig 17 . Use the same SAE grade of oil as is used in the crankcase except as noted under Abnormal Operating Conditions. Replace the cup securely.

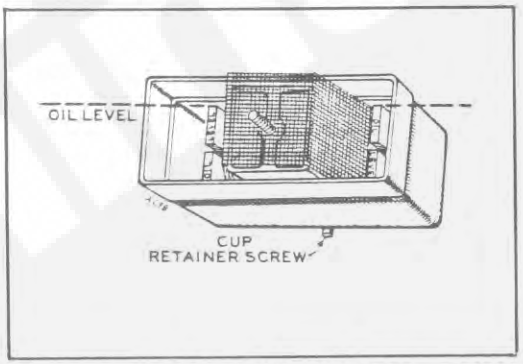


FIG.17- AIR CLEANER OIL LEVEL

FUEL (GASOLINE & GASEOUS). - All plants except those mounted in a carrying frame have a separate 5 gallon fuel tank. Plants equipped with a carrying frame have a 4 gallon fuel tank mounted in the frame. Fill the fuel tank nearly full with clean, fresh regular grade, automotive gasoline. Do not use premium grade gasoline. Engine life will be greatest when fuel containing the smallest amount of lead is used. NEVER FILL THE FUEL TANK WITH THE ENGINE RUNNING AND DO NOT FILL THE TANK ENTIRELY FULL. The gasoline may expand, overflow, and become a fire hazard.

Follow national and local codes on installing fuel pipes and fuel containers according to the type of fuel being used. A secondary regulator is supplied with each gas unit or kit. If the line pressure exceeds 4 to 6 ounces per square inch on the Ensign Regulator, a primary regulator must be installed to reduce the pressure before it enters the secondary regulator.

Open the appropriate fuel shutoff to assure a flow of fuel, gasoline or gaseous fuel to the carburetor.

SPARK PLUGS. - Rust inhibitor oil was sprayed into each cylinder after the plants were tested. Failure of a new engine to start may be the result of the oil depositing around the spark plug points. Remove the plugs and wash them in gasoline. Dry them thoroughly, and install them. Be sure that the gaskets are in place and that the plugs are securely tightened. The plug setting should be 0.025" for gasoline operation and 0.015-0.018" for gaseous fuel operation.

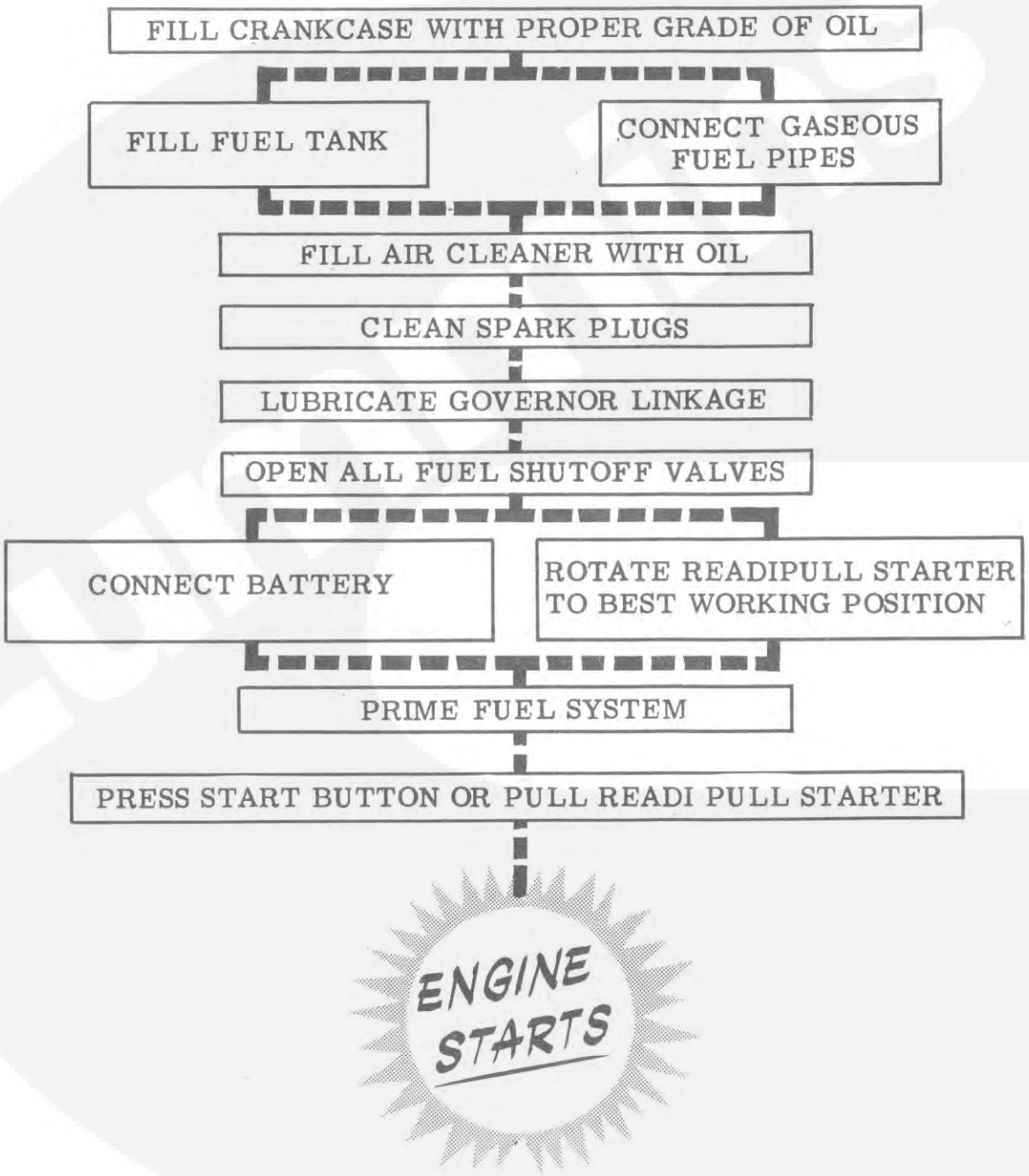



FIG.18- STEPS TO FOLLOW IN STARTING THE PLANT

Before starting the generating set, make a final inspection to see that the plant has been installed as recommended and that it has been serviced with fuel and oil. If the plant has been prepared for Abnormal Operating Conditions, see that all of the necessary precautions have been taken.

Starting Remote Control, Dual Purpose, Or Battery Chargers

If the plant is being run for the first time or is being put into service after a long period of time, the fuel system will have to be primed. Open the appropriate fuel valve.

Choking is automatic on these plants and it may take quite a few revolutions of the engine to fill up the fuel system. Once the system is filled, the engine should start a few seconds after the START button is pressed.

Never push the START button any longer than ten seconds at a time without equivalent stops in between attempts. Check the ignition and fuel systems thoroughly if the plant doesn't start after a few attempts.

A thermostat has been incorporated in the series field windings of the generator of ac remote start plants. The contacts of this thermostat are connected into the starting circuit of the plant and act as a cranking limiter during the cranking period to protect the generator. Should the engine fail to turn over when pressing the start button due to a seized engine, too heavy oil for prevailing temperatures etc., the series field windings of the generator would soon become overheated. When this occurs the contacts of the thermostat open, the start circuit is broken, and cranking stops. The reason for failure to crank should be determined and the trouble corrected before attempting to start the plant again.

The thermostat contacts automatically close when the temperature of the series field windings returns to normal, usually from 3-1/2 to 12 minutes, depending upon how hot the windings become.

If the engine fails to crank when pressing the start button, connect a jumper wire from the start button terminal to the coil terminal of the start solenoid switch. Then press the start button. If cranking starts or attempts to start, the thermostat contacts are open.

If the charged condition of the battery is so low that it does not have power enough to crank the plant, it may be started manually as follows:

Wind the starting rope in a clockwise direction around the rope sheave and give a strong steady pull the full length of the rope. Choking is automatic and the plant should start at the first attempt. Repeat if necessary. If the plant does not start readily, check the fuel and ignition systems and repeat the starting procedure after correcting any trouble found.

### Starting The Manual Start Plants

Before starting a new plant or a plant that has run out of fuel, quite a few revolutions of the crankshaft will be necessary to fill the fuel system with gasoline. Open the fuel line shut-off valve. Pull the choke control knob out 3/4 of the way. Some Manual Start plants are equipped with a Readi-Pull starter assembly, the starting rope automatically recoiling to the start position. On other models it is necessary to wind the starting rope in a clockwise direction around the rope sheave. Give a strong steady pull the full length of the rope. Repeat until the engine starts. As the engine begins to warm up, slowly push the choke control knob in until it is all the way in with the engine running smoothly. After the initial starting of the engine it will usually start at the first attempt. If it does not, push the choke control knob part way in before cranking the engine again. If the engine does not start readily after the initial start has been made, check the fuel and ignition systems and correct any trouble found. Oil was placed in the cylinders before the plant was shipped and it may be necessary to remove the spark plugs and clean them in gasoline before the plant will start the first time.

### IMPORTANT

On the initial start of a unit, or when starting the unit after a long storage period, check the oil pressure gauge reading immediately. Long inactive periods may cause the oil pump to lose its prime. Wait only a few seconds after the plant starts to see if the pressure gauge shows at least 20 pounds pressure. Shut the engine down if pressure fails to build up.

Check the oil level in the crankcase to be sure that there is enough of the right grade of oil. Crank the engine over slowly by hand about 10 times. Start the plant again and check the oil pressure. Repeat the procedure until pressure registers on the gauge.

The correct oil pressure at normal operating temperature is 25 to 40 pounds. Adjust the pressure as instructed in OIL PRESSURE RELIEF VALVE ADJUSTMENT in the MAINTENANCE AND REPAIR SECTION if the oil pressure does not come within the recommended limits.

## Adjusting The Charge Rate On Remote Control, Dual Purpose, and Battery Charging Plants

REMOTE START PLANTS. - The charging rate to the starting battery is controlled by a two step voltage regulator and adjustments are not required.

DUAL PURPOSE PLANTS. - The charging rate to the battery is controlled by a HIGH-LOW charge switch located near the ammeter on the plant control box. When this switch is at the HIGH position, the charging rate is about 20 amperes. When the switch is at the LOW position, the charging rate is about 3 amperes.

The total ac load on the Dual Purpose plants should not exceed 2250 watts when the charge switch is at the HIGH position. When the charge switch is at the LOW position, the full ac capacity of 3,000 watts may be used.

If the battery is in a discharged condition, throw the charge switch to the HIGH position and leave it there until the battery nears a fully charged condition. Return it to the LOW position. Keep a close check on the battery with a hydrometer. Add distilled water as necessary to keep the level of the electrolyte above the separators. A safe level is 3/8 of an inch above the separators. When the battery manufacturer's instructions differ as to the proper level, use his recommendations.

Cycling the battery at regular intervals is recommended. Instructions for proper cycling are usually included with the batteries. Contact the dealer from whom you purchased the batteries if instructions aren't available.

These plants produce alternating current (ac) as well as direct current (dc) and must operate at about 1800 rpm for the 60 cycle plants to produce the right frequency of current. NEVER INCREASE ENGINE SPEED TO INCREASE THE CHARGING RATE. Engine speed should be adjusted only to correct the rpm of the plant to obtain the right frequency.

BATTERY CHARGING PLANTS. - The charge rate is controlled by engine speed. To increase the charge rate and engine speed, turn the governor speed adjusting nut in. To decrease the charge rate and engine speed, turn the nut out.

Set the charge rate at the point where the ammeter shows the rate of charge recommended by the battery manufacturer. Allow the plant to run for a period of about one hour. Reset the charge rate to the point where the ammeter again shows the recommended charging rate. The charge rate at any given setting will gradually get lower as the battery nears a fully charged condition and its internal resistance increases.

This gives a desirable tapering off effect to the charge. Check the ammeter once in a while during the end of the charge period. Reset the charge rate to keep the needle of the ammeter on the charge side if necessary.

### Adjusting Engine Speed - All AC Plants

Maintain engine speed at maximum no-load speed of 1890 rpm for 60 cycle plants, and 1590 rpm for 50 cycle plants. See Figure 24 and Governor Adjustment Section.

### Operation of Gaseous Fuel Plants

1. To convert to gaseous fuel, shut off the gasoline supply at the fuel filter and run the engine dry. Lock the float by turning in the locking screw located above the gasoline idle adjusting screw. Lock the choke plate in the wide open position. Remove the spark plugs and set at 0.018" gap. Prime by momentarily pushing the priming button on the gas regulator.

2. Run the plant as directed in this section until it reaches operating temperature. Adjust the main gaseous adjustment screw to give smoothest operation at full load. Adjust the idle gaseous adjustment screw until the engine runs smoothly at no-load. If the engine tends to surge, turn the main adjustment screw out a half additional turn.

3. If the engine speed is unusually high, it will be necessary to adjust the tension on the governor spring to get the correct speed. See ADJUSTING ENGINE SPEED in this section. If the governor is operating properly, the engine speed should be slightly above recommended speed when there is no load on the plant and slightly below this speed when there is a full load on the plant.

4. Adjustments to the governor and carburetor should always be made when the plant is operating at normal operating temperature.

To return to gasoline operation, shut off the fuel supply. Open the gasoline shut off valve at the fuel pump. Reset the spark plugs to .025". Turn the carburetor float lock out as far as it will go. Release the choke lock. Operate the plant as described for gasoline burning engines.

### Stopping The Plant - All Plants

Disconnect the load by throwing the circuit breaker or main line ac switch to the OFF position, if practicable. Then press the STOP button firmly until the plant has completely stopped running. The STOP button of the Manual Start plants is located on the blower housing. The STOP switch of the Remote Control, Dual Purpose, and Battery Charging plants is located on the plant control box.

Abnormal operating conditions are those elements and ambient temperatures to which a generating set may be exposed and which tend to shorten the lifetime of the component parts of the set. Subzero temperatures, equatorial exposure, and extremely dusty atmosphere are typical examples. The following steps must be taken to prevent unnecessary breakdown of equipment.

## LOW TEMPERATURES

LUBRICATION. .- If the plant is to be operated at temperatures of 0°F (-18°C) or below, the condition should have been anticipated and a winter grade of SAE oil should have been placed in the engine.

Do not attempt to start the plant if the proper grade (See Fig. 15 ) of SAE crankcase oil has not been used, and the plant has been idle in an unheated location. Provide some means of heating the generating set or the room until the oil in the crankcase will flow freely when the drain is opened; at this point run the set for 15 minutes to thoroughly warm up the plant. Drain the crankcase completely and refill with the proper grade of oil according to Fig. 15 . Never add kerosene to the crankcase because the protective film of oil around the moving parts will break down and cause bearing failures.

AIR CLEANER. - The oil in the air cleaner should be the same grade as that used in the crankcase. If frost persists in forming in the cleaner, drain the oil from the cup and run the plant with the air cleaner dry. Refill the cup when temperature conditions again permit the use of oil in the normal manner.

BATTERIES. - Keep the battery well charged at temperatues below 32°F (0°C) to avoid any possibility of its freezing. Ample power for cranking the plant electrically will be thus assured. Colder temperatures lower the output of a battery and freeze the liquid if the battery is discharged. At a specific gravity of 1. 100 the electrolyte will freeze at 19°F; at a specific gravity of 1. 250 the battery will withstand freezing down to -65°F. The effect of low temperature on a battery can be more readily appreciated if it is known that the cranking power of a battery at 0°F is reduced to only 2/5 of its normal power, and the cranking load is increased 2-1/2 times due to stiff oil.

Disconnect the battery and store it in a warm place if the plant is to remain idle for any length of time in a cold location. If the idle period extends beyond 30 days, give the battery a freshening charge each 30 days.

FUEL. - Keep the fuel tank nearly full to prevent condensation within the tank. Use only fresh automotive type regular grade of gasoline. Premium grades of gasoline are not recommended for use in these plants.

If the fuel tank is mounted on the generating set, do not fill the tank too full; the fuel will warm up, expand, overflow the tank, and create a fire hazard.

Wipe all snow, dirt, and ice from dispensing equipment and from the area around the fuel tank filler cap before refueling. Replace the cap securely after refueling.

A vapor lock may occur if the ambient temperature in the plant enclosure rises to 70°F and winter grade fuel is being used in the tank. The blower wheel cools the fuel pump sufficiently to prevent a vapor lock while the plant is running. Within 10 to 20 minutes after the plant is stopped the fuel pump reaches its highest temperature and is most likely to develop a vaporlock. Open existing ventilators wider or provide additional ventilation.

HEATING. - Provide a means of heating the enclosure if the plant is to be operated under extremely cold conditions for long periods during the year. Do not neglect the introduction of fresh air into the enclosure since cooling depends on air circulation.

ELECTRIC CHOKE. - It may be necessary to readjust the electric choke for easier starting at lower ambient temperatures. Refer to the ACCESSORY SERVICE Section for specific procedure in adjusting the electric choke.

## HIGH TEMPERATURES

Extremely warm operating conditions require:

1. Ample ventilation.
2. Oil level in the crankcase must be at the high mark on the gauge at all times.
3. The plant must be kept free of dust, dirt, grease, and oil.
4. Proper grade of oil must be used in accordance with the ambient temperature and the chart on Page 23.
5. Change crankcase oil each 100 operating hours.
6. If the battery will be used in equatorial areas or in locations such as hot boiler rooms, reduce the specific gravity of the battery in the following manner:
   a. Charge the battery fully. After the battery is a little more than 80% charged a fairly large amount of gassing occurs in the cells; keep open flames, cigarettes, or sparks away while the batteries are on charge.

b. Leave the battery on charge and syphon off all the electrolyte above the plates. Use a hydrometer to remove the acid solution, do not pour the solution off by tipping the battery. Dispose of the solution by mixing it with large quantities of water and pouring it down a drain. Rinse the containers thoroughly to remove all traces of the acid.

c. Use distilled water to replace the solution removed.

d. Charge the battery for 1 hour at a 4 to 6 ampere rate.

e. Test each cell with a reliable hydrometer. Repeat steps b, c, d, e until the highest reading is 1.225. Most batteries require repetition of the steps at least two times before the reading is brought down to the proper level.

7. Keep the ignition system properly balanced by holding the spark plug and breaker gaps to the recommended tolerances. See that the ignition timing is correct.

NOTE: When the battery is moved from hot locations to cooler areas, increase the specific gravity by fully charging, siphoning off solution, adding battery acid, and then recharging until the hydrometer reads 1.250.

## DUSTY OR DIRTY CONDITIONS

Plants may sometimes be located in areas where dust, dirt, or sand is blown around in large quantities. Clean the outside of the plant and its accessories as often as required to keep the plant clean. Service the air cleaner as often as required to keep the oil clean. Keep the generator commutator, slip rings, and brushes clean. See that the brushes ride freely in the brush rig guides. Keep supplies of fuel and oil in airtight containers.

## HIGH ALTITUDE

FUEL MIXTURE - If the unit is to be operated at an altitude of 2, 500 feet or more above sea level, adjust the carburetor main jet for a slightly leaner mixture to obtain maximum available power. The carburetor was factory adjusted for best performance at approximately 860 feet altitude. Because the air becomes less dense as the altitude increases, less fuel is required to maintain the proper air-to-fuel ratio. Consequently, any engine will develop less power at higher altitudes. The usual altitude de-rating amount is approximately 4 per cent for each 1, 000 feet above sea level.

## GENERATING PLANT SERVICE CHART

The service chart may be used as a guide in performing periodic service operations. The service periods shown are based on average operating conditions and normal use For unfavorable or severe operation, more frequent service is recommended.

| SERVICE & PARTS REQUIRED | HOURS OF OPERATION | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 | 1500 | 2000 | 2500 | 3000 | 3500 | 4000 | 4500 | 5000 |
| Oil Change | x | x | x | x | x | x | x | x | x | x | | | | | | | | COMPLETE RECONDITIONING |
| Clean and Adjust Spark Plugs | x | x | x | x | x | x | x | x | x | x | | | | | | | | |
| * Service Air Cleaner | x | x | x | x | x | x | x | x | x | x | | | | | | | | |
| Check Ignition Points | | x | | x | | x | | x | | x | | | | | | | | |
| Clean Carbon | | | | | x | | | | | x | x | x | x | x | x | x | x | |
| Clean Carburetor | | | | | | | | | | x | | x | | x | | x | | |
| Check Tappets | | | | | x | | | | | x | x | x | x | x | x | x | x | |
| Grind Valves | | | | | | | | | | x | | x | | x | | x | | |
| Remove and Clean Oil Base | | | | | | | | | | x | | x | | x | | x | | |
| Clean Crankcase Breather | x | x | x | x | x | x | x | x | x | x | | | | | | | | |
| Inspect Commutator | | x | | x | | x | | x | | x | | | | | | | | |
| Inspect Brushes | | x | | x | | x | | x | | x | | | | | | | | |
| † Lubricate Generator Bearings | | | | | | | | | | x | | x | | x | | x | x | |
| Clean Generator | | | | | | | | | | x | | x | | x | | x | | |
| Replace Spark Plugs | AS REQUIRED | | | | | | | | | | | | | | | | | |
| Replace Valves | AS REQUIRED | | | | | | | | | | | | | | | | | |
| Replace Points | AS REQUIRED | | | | | | | | | | | | | | | | | |
| Replace Generator Brushes | AS REQUIRED | | | | | | | | | | | | | | | | | |
| Replace Piston Rings | AS REQUIRED | | | | | | | | | | | | | | | | | |

† Does not apply to shielded type bearing.

* For dusty conditions, service the air cleaner more frequently.

If parts are removed for inspection and gaskets are disturbed, those gaskets should be replaced with new ones. Keep spare cylinder head, valve cover, and similar gaskets on hand.

If generator brushes are replaced, make certain the commutator and slip rings are in good condition.

Each service check should include close inspection for loose screws, poor electrical connections, etc.

A set schedule of inspection or service will help to keep the generating set in good running order at all times and keep running expenses at a minimum. For extreme conditions of load, temperature, dust and dirt, or frequent starts and stops, service the plant more often than is indicated in the following paragraphs. Keep a log of servicing operations performed to assure servicing at proper intervals.

## Daily Service

If the plant is operated more than 8 hours daily, perform the following services each 8 hours of operation.

FUEL. - Check the fuel supply often enough to assure a continuous supply. Use fresh, clean, regular grade, automotive gasoline. Keep the fuel tank cap securely fastened in place to prevent dirt or moisture from entering the tank.

CRANKCASE OIL LEVEL. - Check the oil level in the crankcase frequently during the break-in period; the rings may not be fully seated, and the plant may use extra oil until they seat properly. Keep the level at the full mark on the gauge, but do not overfill; excessive quantities of oil in the crankcase will cause the connecting rods to foam the oil and interfere with efficient lubrication. Never run the plant with the oil level below the low mark on the gauge.

The oil fill cap gasket must always be in good condition and the cap must always be securely tightened in place. Air leakage into the crankcase at this point will cause oil leakage around the seals and excessive oil consumption.

GENERAL. - Keep the plant as clean as possible by wiping it off with a rag each time it is serviced. Do not leave oily rags laying around because they are a fire hazard. Keep them in a metal container.

AIR CLEANER. - Check the oil level daily. If necessary refil the cup to the indicated level with oil of the same SAE number as used in the engine crankcase, except as noted under ABNORMAL OPERATING CONDITIONS.

## Weekly Service

Perform the following service operations at the end of each 50 operating hours.

CRANKCASE. - Change the oil at this time if it was necessary to use a highly leaded fuel, diluted oil used for cold weather operation, or if dusty conditions prevail. Continue to change oil each 50 operating hours when using premium grades of fuel. Replace the oil fill cap securely to avoid leaks.

AIR CLEANER. - Remove the element and cup from the air cleaner (See Fig.17) and thoroughly clean them in gasoline or other suitable solvent. Allow the element to dry out by using compressed air before replacing it. Refill the cup to the level shown in the cup with oil of the same grade used in the engine crankcase except as noted under Abnormal Operating Conditions.

SPARK PLUGS. - The generating set will use less fuel and start easier if the plugs are removed and cleaned at least once a week. If highly leaded fuels are used it may be necessary to clean the plugs more often. Use Champion #H-8 COMM plugs or a comparable brand with the same characteristics.

BATTERY. - Check the level of the fluid in the battery. If necessary, add clean distilled water to bring the level to 3/8 inch above the separators. If the battery manufacturer specifies a different level, follow his recommendations. Do not overfill the battery. Be sure to cycle the batteries of the Dual Purpose and Battery Charging plants according to the battery manufacturers instructions.

GOVERNOR LINKAGE. - Use powdered graphite to lubricate the ball joint on the governor linkage. If graphite is not available, use a non-gumming oil. Inspect the joint to see that it is not binding or too loose.

DOLLY WHEELS. - The bearings of some of the dolly wheels are lubricated through the Zerk fittings on the hubs. Use an approved wheel bearing lubricant. One or two shots from a high pressure gun will usually be sufficient.

## Semi-Monthly Service

Perform the following service operations at the end of 100 operating hours.

CRANKCASE. - Change the oil each 100 hours of running time under normal operating conditions

## Monthly Service

Perform the following service operations at the end of each 200 operating hours.

FUEL SEDIMENT BOWL. - Close the fuel shutoff valve. Remove and clean the fuel bowl and screen. Replace the bowl gasket if the old one isn't in good condition. Install the bowl and screen, and open the fuel shutoff valve. Repair any noticeable leaks in the fuel system. On plants with separate fuel tanks, remove the shutoff valve and screen, and clean them thoroughly.

EXHAUST SYSTEM. - Inspect the entire exhaust system while the engine is running. Correct any leaks found in any part of the system.

ENGINE COMPRESSION. - Loss of compression is usually indicated when the plant is low on power and the generator does not produce its rated output. The best way to tell if the compression is poor is to use a compression gauge. If you do no have a compression gauge, checkthe compression of each cylinder by turning the engine flywheel slowly by hand. If the compression is good quite a little effort will be needed to rock the flywheel past the compression stroke. Loss of compression may be due to leaking spark plugs, spark plugs gaskets, valves, cylinder head gaskets, or piston rings. Repair or replace as needed. Turn to the paragraph on COMPRESSION READINGS in the Maintenance and Repair section for further instructions.

CARBON. - Remove the cylinder heads and scrape the heads, pistons, and valves clean of any carbon formation. Use a putty knife or similar tool. Remove carbon every 250 operating hours unless it is found from experience that the plant needs it more often. Inspect the cylinder head gaskets before installing them. Replace the gaskets if they are not in good condition.

BREAKER POINTS. - Remove the breaker box cover and inspect the breaker points. If they appear to be too badly burned or pitted, discard them and install a new set. Dress the old points with a fine stone providing they still appear servicable.

Adjust the breaker point gap to 0.020 inch at full separation after dressing the points or changing them. Place a drop of light lubricating oil on the breaker cam pivot after installing new points.

The ignition condenser is faulty and should be replaced if the following conditions persist.

1. Excessive arcing at the breaker points.

2. Breaker points continually burn over.
3. Yellow colored spark at the points.

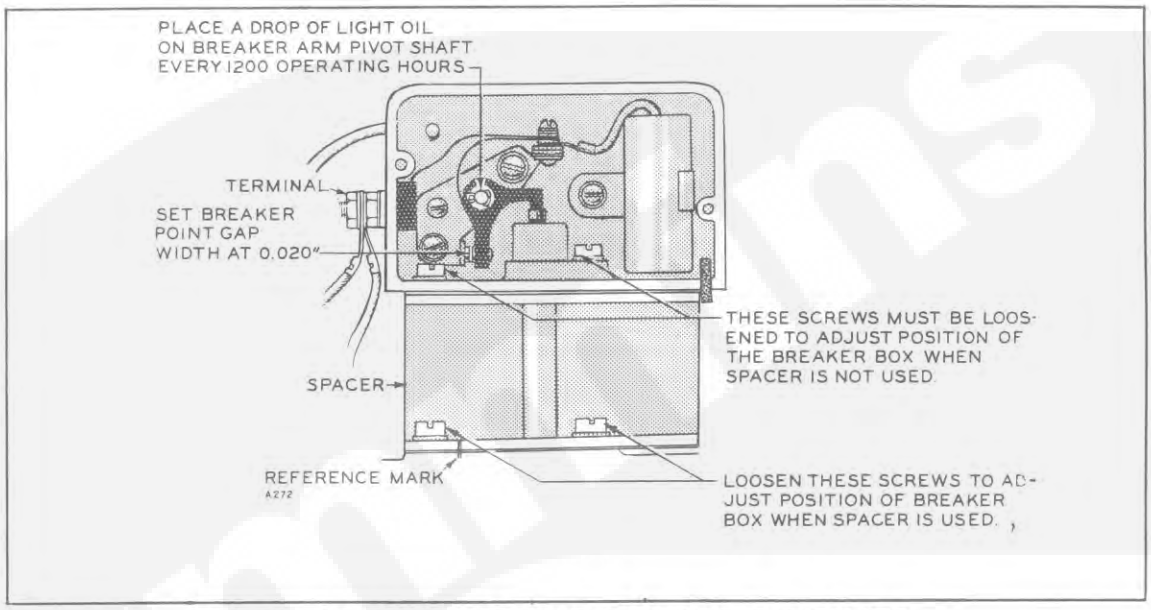



FIG.19- SERVICING THE BREAKER POINTS

GENERAL CHECKUP. - Check over the plant for leaks, loose bolts or screws, or loose electrical connections. Tighten or replace parts as required.

VALVE GRINDING. - Valve grinding is a service that should be done if your plant is to continue running efficiently. There isn't any set period for grinding the valves. However, it is recommended that you make the following tests at the end of each 250 hours of running time or whenever your plant begins to lose power or to use more fuel or oil than it normally does.

Check the compression of each cylinder with a reliable compression gauge while the engine is still warm and as soon after stopping the engine as you can. The compression of each cylinder in a new engine at sea level is about 90 lbs. at hand cranking (105 lbs elec. cranking) speed. Compression readings of the cylinders should be within 10 lbs. of each other and high enough to assure no loss of power. A low compression reading may point to a poor valve condition, worn or sticking piston rings, worn pistons ring grooves, or worn cylinder walls. An excessively high compression reading may point to a heavy carbon formation within the cylinders.

After the first readings have been taken, remove the spark plugs and pour only enough SAE number 50 oil into each cylinder to seal the rings. Take the compression readings again. If the readings remain about the same, the valves probably need servicing. However, if the readings have increased quite a bit, the valves are probably in good condition.

Loss of compression may be due to worn or sticking piston rings, worn piston ring grooves, or worn cylinder walls. Follow instructions given in the Maintenance and Repair section when making repairs.

If a compression gauge is not available, turn to the heading ENGINE COMPRESSION in this section for instructions on testing compression without a compression gauge.

GENERATOR. - Examine the collector rings (ac units), commutator, and brushes. The brush surfaces of the collector rings and commutator must be smooth and cylindrical to assure good brush contact. Brushes worn to 5/8 inch in length should be replaced. Rapid brush wear may be caused by excessive arcing due to the brushes not being in the neutral position. Instructions for servicing are given under the heading GENERATOR in the Maintenance and Repair section.

## Semi-Yearly Service

Perform the following service operations at the end of each 1200 hours of plant operation.

BREAKER ARM PIVOT SHAFT. - Note Fig. 19. Place a drop of light lubricating oil on the breaker arm pivot shaft to prevent arm from sticking.

NEUTRAL BRUSH POSITION. - Brushes will arc excessively and brush wear will be rapid if the brush rig is moved from its original "neutral" position.

Markings were made at the factory to indicate the "neutral brush position". These markings are shown in Fig. 20. Two different methods of mounting the brush rig on these plants are used and both are shown in the illustration. Select the one that applies to your plant and proceed as follows.

If the brush rig is mounted as shown in Fig. 20A. the location of the "neutral brush position" mark is indicated by a chisel mark on the brush rig ring near mounting boss. This mark should be in the position shown in the illustration. If it is not, loosen the brush rig ring mounting screws and shift the whole brush rig assembly as needed to align the mark. Tighten the mounting screws securely.

If the brush rig is mounted as shown in Fig. 20B , the "neutral brush" position markings are located on the bearing hub and the end bell. These marks should be in alignment. If they are not aligned, loosen the four screws in the hub and shift the hub and brush rig as needed to align the marks. Tighten the mounting screws securely.

## CAUTION

If a new armature or brush rig is installed, the "neutral brush position" must be relocated and remarked. Neutral brush position is that point at which no arcing of the brushes occurs. If a voltmeter is available, the brush rig should be set at the point where highest voltage is generated. If a voltmeter is not available, set the brush rig at the point where the brushes show the least arcing.

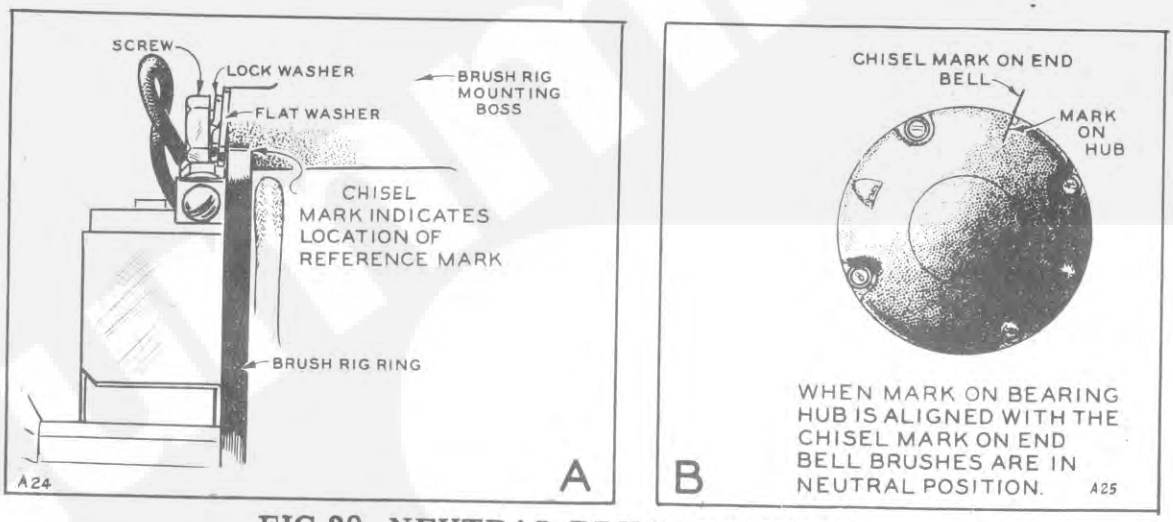



FIG.20- NEUTRAL BRUSH POSITION

GENERATOR BEARING. - The bearing is factory lubricated with lithium base grease and does not need further lubrication for 2 years or 5000 operating hours. If dirt has entered the bearing, it must be thoroughly cleaned in a good solvent, allowed to dry, and relubricated. Fill only 1/4 section of the bearing if lithium base grease is used for relubrication. Pack the whole bearing if lithium base grease is not available. Repack each 6 months or 1200 operating hours.

Later models have a sealed bearing which requires no lubrication.

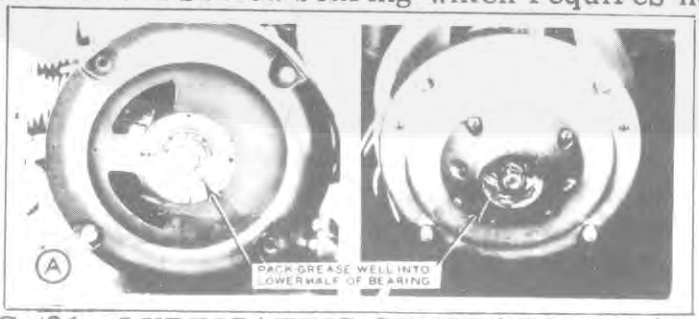



FIG. 21- LUBRICATING GENERATOR BEARING

This section includes instructions for making adjustments to engine accessories and other vital engine parts. Read this section carefully and use it in conjunction with the Service Diagnosis Section to locate and solve engine problems.

CARBURETOR ADJUSTMENTS. - The carburetor has adjustable main and idling jets It is simple in construction and normally needs little attention other than a good cleaning once in a while. If the engine runs unevenly at half or full load due to faulty carburetion, the main adjustment needs correcting. See Fig.22. Adjust while the plant is running at normal operating temperature and carrying almost a full load. Turn the main adjusting needle out about two full turns. Slowly turn it in until the engine begins to lose power and speed. Turn it out very slowly until the engine runs at maximum power and speed. Onan carburetor wrench # 420A169 can be purchased from your Onan dealer for easier adjustment of carburetor.

The engine should be running at normal operating temperatures and carrying no load when adjusting the idle jet needle. See Fig.22. Turn the needle in until the engine looses considerable speed. Turn the needle out until the engine runs smoothly. The correct setting is about 3/4 to 1 turn open.

If the carburetor is entirely out of adjustment, open both needles about 1-1/2 turns to permit starting. Make final adjustments as described in the above paragraph after the engine reaches normal operating temperature.

When the engine is not running, the throttle should be held wide open by the governor. In this position the throttle arm should rest against the boss on the underside of the carburetor.

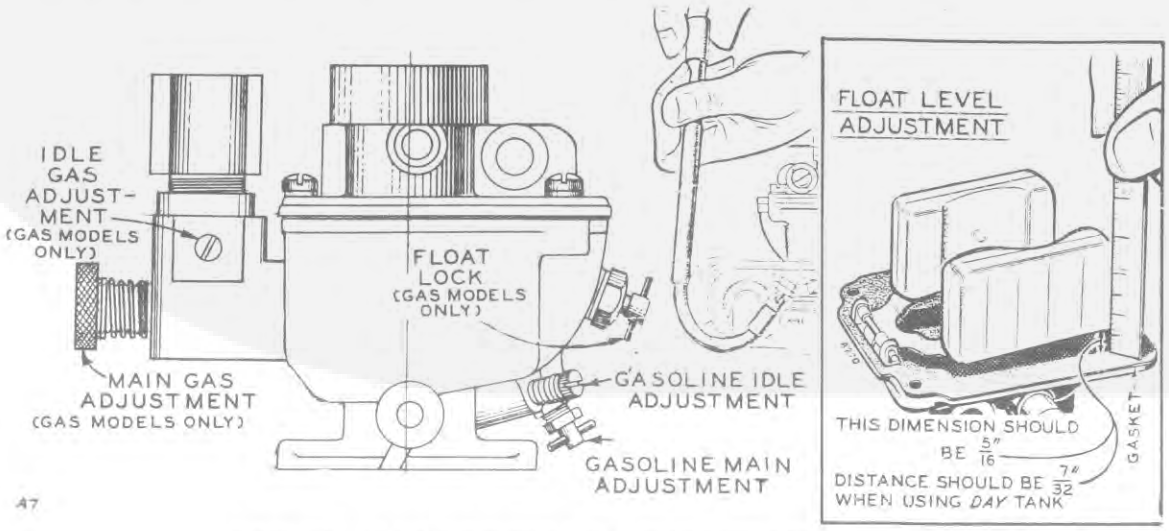



FIG.22- CARBURETOR ADJUSTMENTS

If the engine develops a hunting condition (continuous increase and decrease of engine speed), try correcting by opening the main adjusting needle a little more. Do not open more than 1/2 turn beyond the maximum point of power. If this does not correct the condition, follow the instructions given for regulating the sensitivity of the governor under GOVERNOR ADJUSTMENT.

Loss of power or uneven operation may be due to carbon deposits on the venturi of the carburetor. If inspection shows that this condition exists, remove and clean the carburetor. Clean the jets and jet passages with compressed air or with a strand of fine soft copper wire. Never use a needle or steel wire. Adjust the carburetor after the engine reaches normal operating temperature.

GOVERNOR ADJUSTMENT. - Proper governor adjustment is one of the most important factors in maintaining proper engine speed under various load conditions. The governor of ac plants is set at the factory for a maximum no-load engine speed of 1920 rpm for the 60 cycle plants and 1710 rpm for the 50 cycle plants. No load engine speed for 115 volt and 230 volt dc plants is set at 2700 rpm. This setting should be maintained at all times. No-load engine speed of battery charging plants is set at 2000 rpm for full output but the rpm will vary with the charge rate setting. Before making any adjustments on the governor, carefully study the following paragraphs. Check each point in the order given.

1. Governor Arm and Linkage - Throttle Shaft and Lever

   Check the governor arm and linkage and the throttle shaft and lever for the binding condition and for excessive slack or wear at connection points. A binding condition at any point will cause the governor to act slowly and regulation will be poor. Excessive looseness will cause a hunting condition and regulation will be erratic. Work the arm back and forth several times by hand while the plant is idle. If either of the described conditions exist, find out at which point the trouble lies and adjust or replace parts as needed.

   a. Governor Arm and Linkage

      The linkage and the position of the governor arm must synchronize the travel of the governor and the throttle plate so that the governor is at its wide open position when the throttle plate is at its wide open postion. The governor should also be at its closed position when the throttle plate is at its closed position.

      The position of the governor arm on its shaft is fixed. Turn the governor arm toward the carburetor until the governor shaft yoke is against the governor cup. See Fig. 24. Then with the tension of the governor speed adjusting spring holding the arm at the wide

open position, adjust the governor arm linkage to hold the throttle lever at the wide open position. Be sure there isn't any looseness or binding at any point.

b. Throttle Shaft and Lever

The position of the throttle lever on the shaft is fixed. However, the throttle lever stop should be in the position shown in Fig.23 when the engine is not running. The stop should rest against the boss on the under side of the carburetor bowl. To correct this position, simply increase or decrease the length of the connecting linkage between the governor arm and the throttle lever as needed. Make the adjustment with the governor spring and linkage connected.

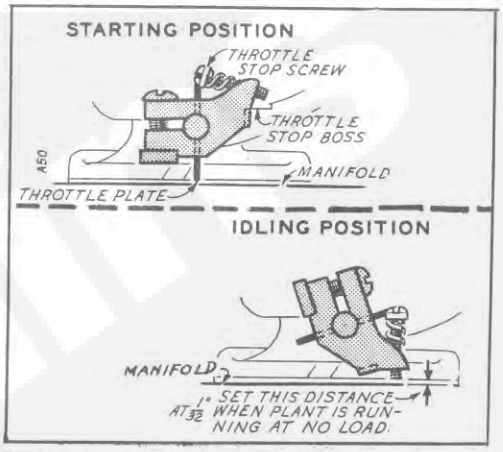



FIG.23- THROTTLE STOP LEVER POSITION

The throttle lever stop screw should be adjusted to allow about 1/32 of an inch clearance between the screw and the manifold when the plant is running and carrying no load. See Fig.23.

If the plant is being run with the throttle held in the wide open position, either the governor is not properly adjusted or the capacity of the plant is being exceeded and proper current frequency and voltage cannot be maintained.

2. Governor Spring

Because governor springs become fatigued and lose their original tension from long usage, it may be necessary to replace the governor spring to get proper regulation. It is hard to determine whether or not a spring is fatigued. Usually if all other adjustments have been properly made and regulation is still erratic, replacing the governor spring and resetting the sensitivity and speed adjusting screws will correct the trouble.

3. Sensitivity Adjustment

The position of the sensitivity adjusting screw, See Fig.24, controls the travel and leverage of the governor spring and determines the speed drop between no load and full load. The maximum difference should be about 90 rpm. Check with a tachometer. To increase the rpm between no load and full load turn the sensitivity screw in. To decrease the rpm between no load and full load, turn the sensi-

tivity screw out. See Fig.24. Engine speed should always be checked after making a sensitivity adjustment. See paragraph 4.

a. Hunting Condition

A hunting condition (engine alternately increasing and decreasing speed) may result from the rpm between no load and full load being too low. Should this condition exist, turn the sensitivity screw in until the condition is corrected. A more likely cause will be a lean fuel mixture. Check the carburetor to see that it is in good operating condition and properly adjusted.

4. Speed Adjustment

The speed at which the engine runs is determined by the tension applied to the governor spring. Increasing spring tension increases engine speed and generator voltage. Decreasing spring tension decreases engine speed and generator voltage. Nominal engine speed and voltage should be as follows.

Speed tests and voltage tests should be made when the plant is warm and running for at least one hour before the test is made.

a. AC Plants

Maximum no load engine speed should not be more than 1920 rpm for 60 cycle plants nor more than 1710 rpm for 50 cycle plants.

Maximum no load voltage should not be more than 126 volts for 115 volt circuits nor more than 252 volts for 230 volt circuits.

Minimum engine speed at full rated generator capacity should not be less than 1710 rpm for 60 cycle plants nor less than 1410 rpm for 50 cycle plants.

Minimum voltage at full rated generator capacity should not be less than 109 volts for 115 volt circuits nor less than 218 volts for 230 volt circuits.

Maximum speed drop from no load to full load should not be more than 90 rpm.

NEVER INCREASE ENGINE SPEED TO INCREASE THE CHARGING RATE TO THE BATTERY OF REMOTE CONTROL AND DUAL PURPOSE PLANTS. These are basically alternating current plants and must be operated at the right speed to get proper frequency.

b. DC Plants.

| | MAXIMUM VOLTAGE | MINIMUM VOLTAGE | MAXIMUM ENG. RPM | MINIMUM FULL LOAD VOLTAGE | FINISHING CHARGE |
|---|---|---|---|---|---|
| 115 Volt | 120 | 115 | 2400-2700 | | |
| 230 Volt | 240 | 230 | 2400-2700 | | |
| 32 Volt | | | 2000 | 36 | 32 Amps at 41 Volts |

If an adjustment is needed, turn the speed adjusting screw nut in to increase engine speed and generator voltage, or turn it out to decrease them. See Fig. 24. Be sure that the knife edges of the nut fit into the slots in the governor spring bracket.

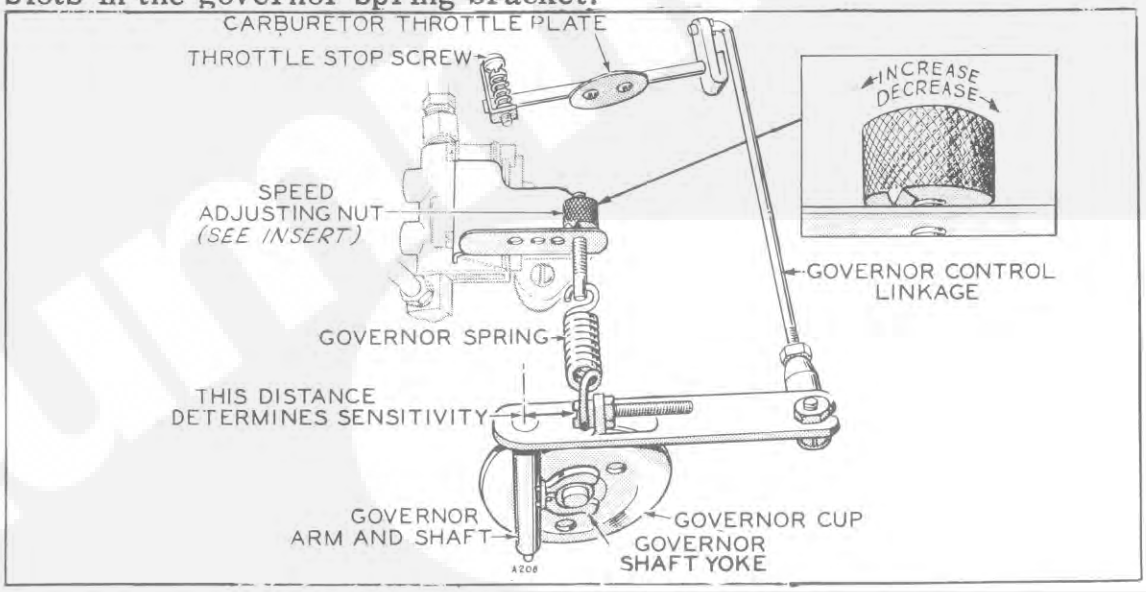



FIG.24- GOVERNOR SYSTEM

5. Steps to follow in adjusting the governor.

A. Check the position of the governor arm and the throttle lever stop. Make adjustments as described in paragraph 1 if needed.

B. Check the connecting linkage. Make adjustments as described in paragraph 1 if needed.

C. After the governor arm, throttle lever stop, and linkage have been carefully adjusted, start the plant and check the rpm at no-load. Correct as described in paragraph 4 if needed.

D. When all other adjustments have been completed, check the rpm between no-load and full load. Make adjustments as described in paragraph 3 if needed.

OIL PRESSURE RELIEF VALVE ADJUSTMENT. - The oil pressure of the plant can be easily adjusted by means of the slotted stud and locknut located just below the governor linkage. See Fig. 25. Oil pressure reading when the plant is thoroughly warmed up is from 25 to 40 pounds. To increase oil pressure, loosen the locknut and turn the stud in. To decrease oil pressure, loosen the locknut and turn the stud out. Be sure to tighten the locknut securely after making an adjustment.

Low oil pressure may point to worn or poorly adjusted main or connecting rod bearings, a weak or broken by-pass spring, a defective gauge or a poor adjustment. Check the oil pressure gauge before making any other test, it may be defective.

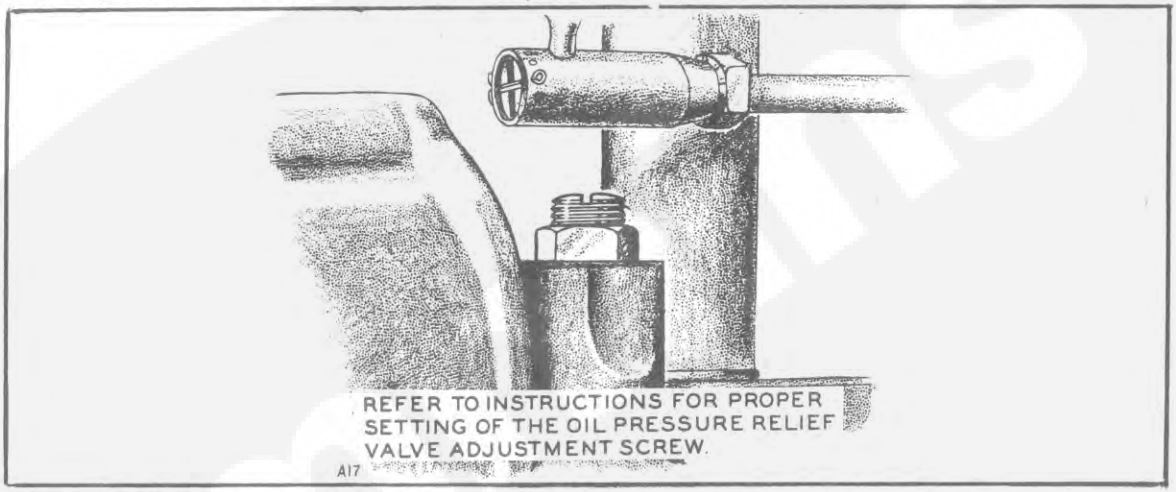



FIG.25- OIL PRESSURE RELIEF VALVE ADJUSTMENT

CRANKCASE BREATHER VALVE. -

If the engine begins to leak oil the valve in the breather tube may be sticking. Lift the rubber cap from the breather tube. Then lift out the valve and inspect it. Frequently the breather valve will lift off and remain inside the rubber cap. Pry it out. If the disc within the valve is not free, place the valve assembly in a shallow pan of kerosene or other suitable solvent and let it soak for a few minutes. Work the disc back and forth to allow the solvent to reach all points. Then replace the assembly. Start the engine and hold the valve assembly in place while the engine is running. If the action of the disc is not free and easy, install a new valve assembly. Reassemble as shown.

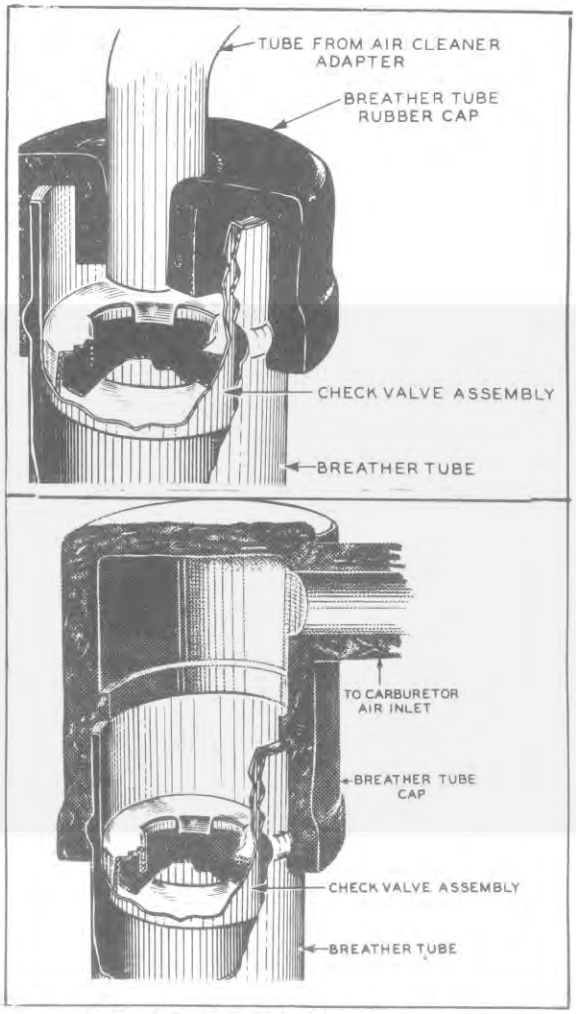



FIG. 26-BREATHER VALVE

FUEL PUMP. - A fuel pump of the diaphragm type is used to transfer fuel from the fuel tank to the carburetor. If fuel does not reach the carburetor, make the following checks before removing the fuel pump. Check the fuel tank to see that there is enough fuel in it and the shut-off valve is open. Disconnect the fuel line at the carburetor and turn the engine over slowly by hand. Fuel should spurt out of the line at the carburetor. Disconnect the line at the fuel pump inlet and see that this line is not plugged. If there is enough fuel in the tank, the shutoff valve open, and the line between the tank and pump is clear but gas does not spurt out of the line at the carburetor, repair or replace the pump. Fuel pump failure is usually due to a leaking diaphragm, a valve or valve gasket; a weak or broken spring; or wear in the driving linkage.

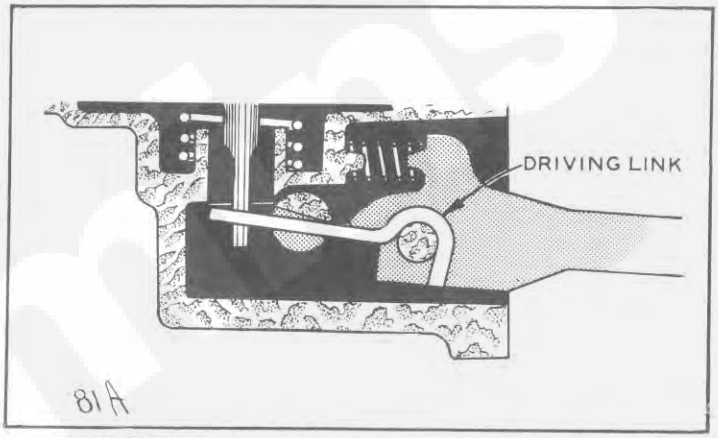


FIG. 27 DRIVE LINK INSTALLATION

SPEED BOOSTER. - The vacuum speed booster is a device used on certain ac plants of the CK series to maintain or increase the engine speed by opening the throttle when engine vacuum is decreased. The effect is maintained or increased speed at higher loads (3KW to 3.5KW) and the result is near constant output voltage. Refer to Figure 28.

The booster is mounted on the intake manifold and is operated by engine vacuum. See the illustration. While the engine is running at no load, the engine vacuum is great enough to cause the booster internal diaphragm (G) to overcome the booster internal spring (d) regardless of the position of the adjusting bracket (E). Then the booster spring (C) has no tension and the booster is not affecting engine regulation. As sufficient load is applied the engine vacuum is decreased. Then the booster diaphragm no longer overcomes the booster internal spring and tension is put on the booster external spring which causes the throttle to open wider.

The booster will increase the speed at which the plant carries a given load but the booster will not increase the maximum power of the plant. However, more of the available engine power can be utilized because the voltage is maintained by the closer speed control at high loads.

The effect of the booster is limited by the condition of the engine. The booster will not compensate for a faulty operating engine due to restricted air cleaner, dirty carburetor, leaky valves or rings or other conditions which cause reduced vacuum. The booster is effective only at loads less than the load requiring a wide open throttle.

The booster should require little maintenance other than using a fine wire to clean the small hole in the vacuum tube which pilots in the manifold. Don't enlarge the hole! Tension on the external booster spring at no load indicates either incorrect adjustment, restricted vacuum tube, or leaky diaphragm. The booster diaphragm assembly is easily replaceable.

BOOSTER ADJUSTMENT. - To adjust a vacuum speed booster or measure the effect gained by the booster, it is necessary to check the voltage with a voltmeter. Maximum no-load voltage should be not more than 126 volts for 115 volt circuits nor more than 252 volts for 230 volt circuits. Minimum voltage at full rated generator capacity (3.5KW) should not be less than 110 volts for 115 volt circuits nor less than 220 volts for 230 volt circuits. A preferable regulation between no-load and full rated load (3.5KW) is within a spread of 4 volts for 115 volt circuits or 8 volts for 230 volt circuits when the booster is in operation.

1. If the governor adjustment has been disturbed, it must be readjusted as shown under the Governor Adjustment section.

Use a 3,000 watt load instead of a full rated load of 3,500 watts when making governor adjustments.

2. Connect the external booster spring between the bracket (A) and the booster lever (H). Adjust the bracket (A) on the governor link (B) just to the position where the spring (C) has no tension while the engine is running at no-load.

3. To increase the effect of the booster, adjust the tension of the internal spring (D) by pulling out the booster spring bracket (E) and reinserting the cotter pin (F).

Without the booster in operation, a maximum speed drop of 90 rpm from no-load to 3KW load is normal. With the booster in operation, a maximum speed increase of 90 rpm from no-load to full load (3.5KW) may occur and is not objectionable.

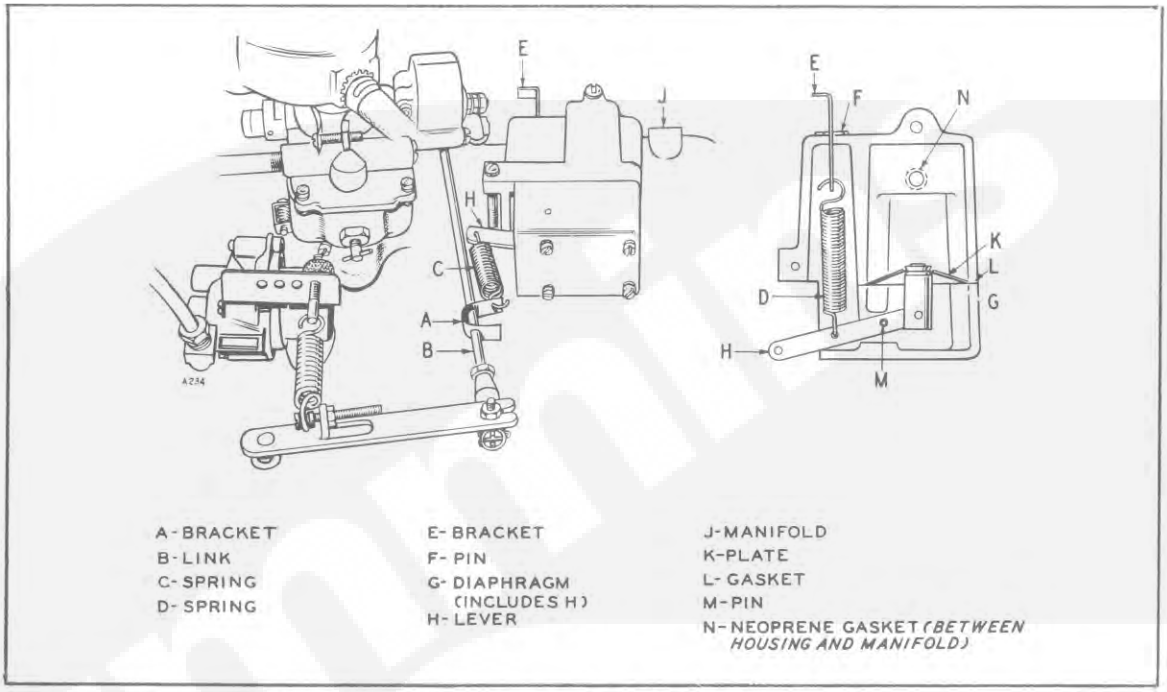



FIG. 28 - VACUUM SPEED BOOSTER

ELECTRIC CHOKE ADJUSTMENT. - The Remote Control and Dual Purpose plants are equipped with an electric choke which consists mainly of a nichrome heating element and a bi-metal thermostat. This bi-metal thermostat is attached to the choke shaft and works the choke plate. If the choke is operating properly don't change the adjustment in any way. Once the choke is properly adjusted it shouldn't need changing.

As soon as the START button is pressed in, current begins to flow from the battery to the heating element. The battery supplies the current during the starting period. After the plant is started, current is supplied from the series field winding of the generator until the plant is stopped.

The bi-metal thermostat opens and closes with temperature changes. The heat from the heating element tends to open the choke plate until it is fully open. The heat from the element then tends to keep it in the open position as long as the plant is running. After the plant is stopped the bi-metal thermostat cools off and gradually closes the choke plate. The choke plate will not close entirely when the plant is stopped unless the temperature at the thermostat drops to 58°F. or below. At 58°F. the choke plate should be fully closed. At 72°F. the choke plate should be about half way open. At 82°F. the choke plate should be fully open. See Fig.29.

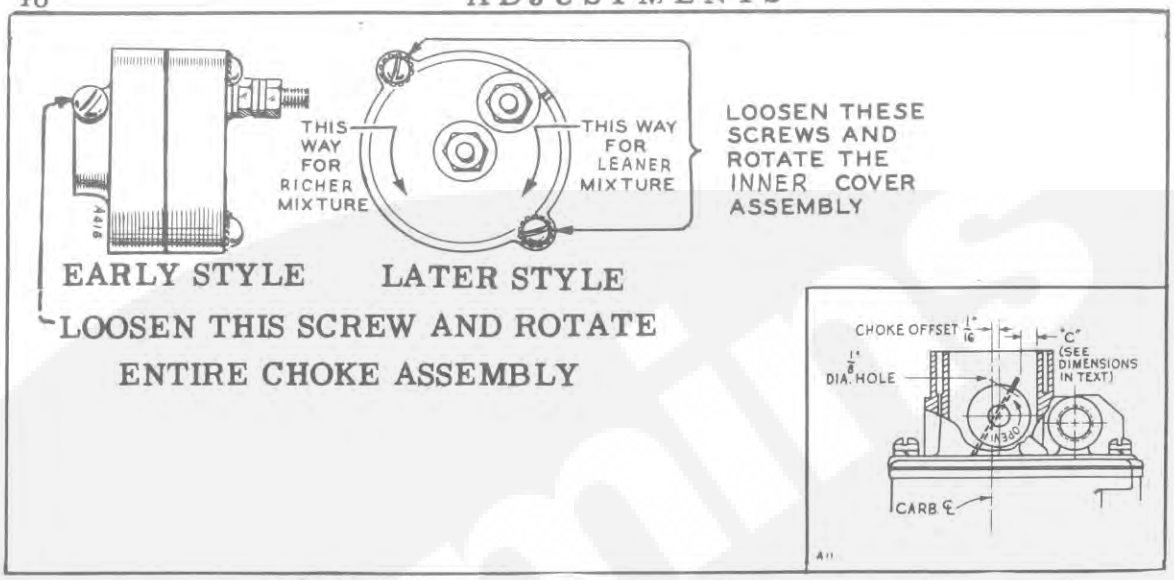



FIG. 29- ELECTRIC CHOKE ADJUSTMENT

If the plant is hard to start or runs poorly when temperatures at the plant drop to 32°F. or below, it may help to change the choke setting. Check engine starting time before making any changes. The engine should be cold when making the test. Proceed as follows:

1. Press the START button. If the engine fires and begins to run in not less than 6 seconds and not more than 15 seconds, the choke is properly adjusted.

2. If the engine fires in less than 6 seconds, the choke is set too rich. This will cause the plant to run rough after a minute or two of operation.

3. If the engine does not fire within 15 seconds, the choke setting is too lean. This will cause hard starting and the engine will sputter and spit until it warms up or it may quit entirely after a few seconds of running.

Make choke adjustments as shown in Fig. 29.

For best results the choke should be set according to the figures given in the following table.

| TEMP. °F. | OPENING "C" (See Fig. 29) |
|---|---|
| 58 | Closed |
| 66 | 1/4 Open |
| 72 | 1/2 Open |
| 76 | 3/4 Open |
| 82 | Wide Open |

For a choke setting at temperatures below 32°F., a "cut and try" method must be used. Turn the choke assembly clockwise until the choke plate just starts to move away from its fully closed position and there isn't any tension on the thermostat. Secure the choke to the shaft and try starting the engine. Check starting time as described in a preceding paragraph. Change the choke adjustment as necessary to get proper operation.

Once the choke is properly set, no further adjustment is required.

Refer to the Service Diagnosis section for assistance in locating and correcting troubles that may occur. If a major overhaul becomes necessary, employ only a competent mechanic who is thoroughly familiar with four cycle gasoline engines and revolving armature generators.

## ENGINE

Certain new engines when leaving the factory have an oversize cylinder bore. This oversize is indicated by the addition of a letter to the plant serial number. For example: Serial No. 48B382425E, the letter E indicating .005" oversize. The oversize also is stamped on a flat metal surface near the left hand valve box. The piston oversize is stamped on top of the piston. If oversize valve seat inserts have been used, the actual oversize will be stamped on the cylinder block bevel just above the insert.

Pistons and rings are available in various oversizes for rebore jobs. See the parts list. Piston pins and valve seat inserts are also available in the oversize shown in the parts list. Before ordering any oversize repair parts that may be needed, check the serial number of the plant and the positions of the oversize stampings.

CYLINDER BLOCK INSPECTION. - The need for major repairs to the plant can usually be determined after draining the oil, by removing the oil base and feeling the fits of the working parts. Use a trouble lamp and carefully look over the inside of the crankcase. If your experience with engines is limited, any competent mechanic should be able to help decide on the need for repairs. Drain the oil whenever servicing bearings, timing gears, rods, rings, or pistons. Thoroughly clean the oil pump screen and oil base before replacing the base.

COMPRESSION READINGS. - Loss of power or failure of the plant to produce its rated output may point to a loss of compression. See VALVE GRINDING under Periodic Service for testing compression. Loss of compression may be due to leaking spark plugs, spark plug gaskets, valves, cylinder head gaskets, carbon deposits on valve seats, worn cylinders or piston rings. A compression leak past the piston rings may be heard at the oil filler opening. Compressed gases leaking past an exhaust valve can be heard at the exhaust outlet of the plant. If compressed gases are leaking past an intake valve, a hissing noise may be heard through the carburetor. If any valve is leaking, all valves should be serviced. Unusually high compression readings indicate heavy carbon deposits on the cylinder heads and pistons. Remove the cylinder heads and scrape the carbon from the pistons, cylinder heads, and valves.

CYLINDERS. - When making major repairs to the plant, it is well to have the cylinders measured for wear. This requires the use of a micrometer. Your dealer should be able to help you. The cylinder bore of a new engine is 2.9985" to 2.9995". If the new engine was bored to oversize originally, the bore will be 0.005 inch over. If the cylinder bore measures more than 0.002 inch out of true, the cylinders should be refinished to use the next available oversize pistons. Pistons are available in .005", .010", .020", .030" & .040" oversize. Piston rings are available in .005", .010", .020", .030" & .040" oversize.

If the cylinder walls do not need refinishing, remove the ridge from the top of the cylinder sleeve before replacing the pistons and rings. Read the following paragraph on PISTON AND PISTON RING SERVICE.

PISTON AND PISTON RING SERVICE. - Each piston has two compression rings and one oil control ring. Inspect the rings carefully for fit in grooves, for tension, and for seating on cylinder walls. Install new rings where there is any doubt about the condition of the old rings.

Inspect each piston. If the pistons are badly scored, very loose in the cylinders, have badly worn ring grooves, or otherwise are not in good condition, install new pistons. Install new pistons if the old ones are loose on the piston pins and 0.005 inch oversize piston pins will not correct it. Handle pistons carefully to avoid nicking the walls. Any raised surface of this type must be dressed down carefully with a fine file.

CAUTION

When installing split skirt type pistons, the split must be installed so that it does not take the thrust on the power stroke of the engine. On the left hand (No. 1) cylinder the split in the piston skirt should be toward the manifold when in operating position. On the right hand (No. 2) cylinder the split in the piston skirt should be toward the oil base when in operating position.

When installing piston rings, fit each ring singly to its cylinder from the top. See Fig.30. The correct ring gap while in the cylinder is between .010 and .023 inch. Rings usually need some filing at the ends to obtain the right gap. Don't use rings that need a lot of filing because they will not seat properly on the cylinder walls. Rings of the tapered type will be marked "TOP" or identified in some other manner. This identifying mark must be installed facing the top of the piston. Space each ring gap 1/3 of the way around the piston from each other. Be sure that there isn't any ring gap directly in line with the piston pin.

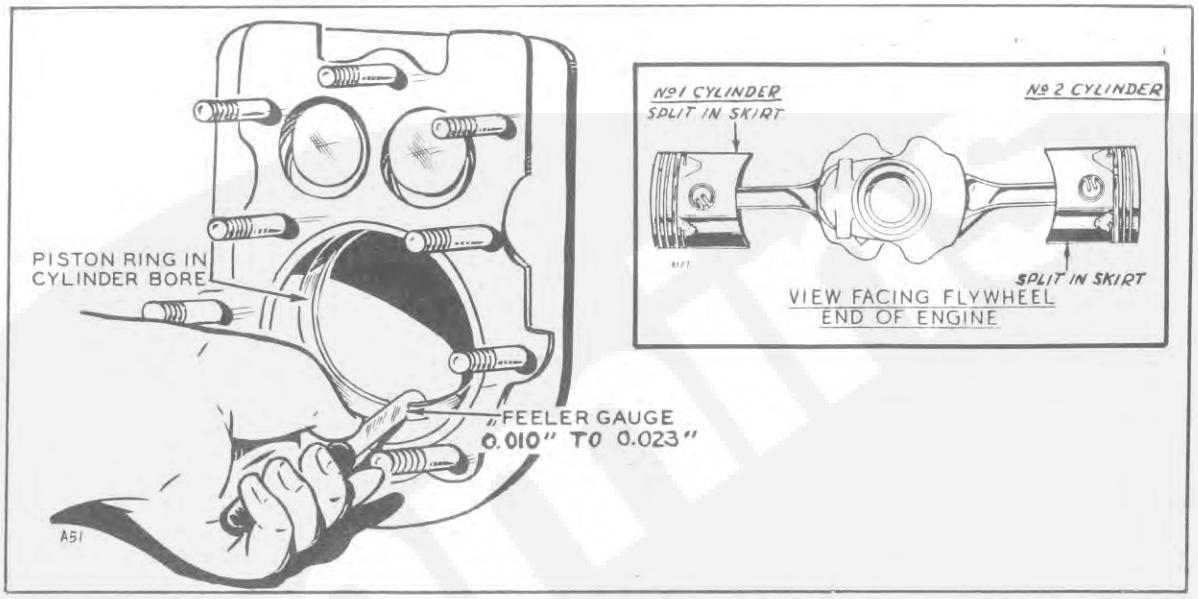



FIG.30- PISTON & RING SERVICING

CONNECTING RODS. - The connecting rods should be serviced at the same time the pistons or piston rings are serviced. Rods must be removed with the piston. This requires draining the crankcase oil and removing the oil base, cylinder air housings and the cylinder heads. Rods are available in 0.020" undersize.

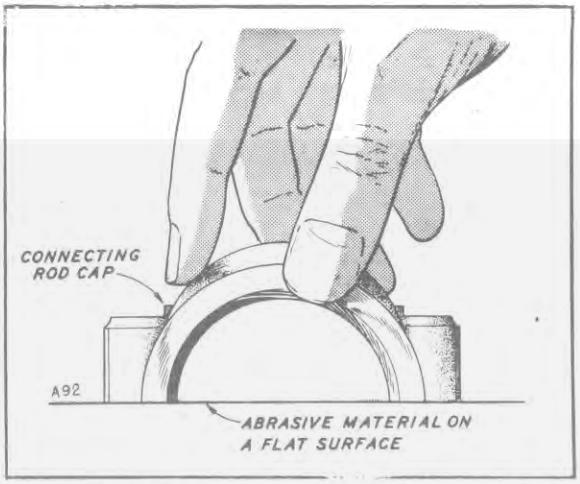



FIG 31-REDUCING CONNECTING ROD BEARING CLEARANCE

The connecting rod bearing surface is aluminum alloy and proper clearance between the rod bearing surface and the crankshaft bearing surface is obtained by dressing the connecting rod cap. The correct clearance is between 0.002 and 0.003 inch. Use a sheet of 320 grit or smaller abrasive on a smooth flat surface. Place the ends of the connecting rod cap on the abrasive material and carefully dress the ends down as needed. Be sure the cap is held perfectly straight. Remove all abrasive from the cap before installing it. Install the connecting rods and caps with the numbers facing toward the oil base. The rod and cap numbered "1" goes on the crankshaft journal nearest the timing gears. Coat the crankshaft journal bearing surfaces with oil before installing the rods. Turn the engine over by hand to see that the rods are free. If necessary, rap the connecting rod cap screws sharply with a soft hammer to set the rod square on the journal.

VALVE SERVICE. - When removing the cylinder heads, rap sharply with a soft hammer to loosen. Do not use a pry. Clean all carbon from the cylinders, cylinder heads, valves, valve seats, valve stems, valve faces, and valve guides. Check the valves carefully. Any valves that are badly burned must be replaced. Correct valve SEAT angle is 45°. Correct valve FACE angle is 44°. This 1° interference angle results in a sharp seating surface between the valve and the top of the valve seat. The interference angle method of grinding valves minimizes face deposits and lengthens valve life. The valve should not be hand lapped, if at all avoidable, since the sharp contact may be destroyed. The finished seat must be between 3/64 and 5/64 of an inch wide. Before lightly grinding each valve to its seat, read the paragraph on VALVE ADJUSTMENT. Be sure to remove all grinding compound from engine parts. Locate each valve in its proper place when reassembling. The larger valves are the intake valves.

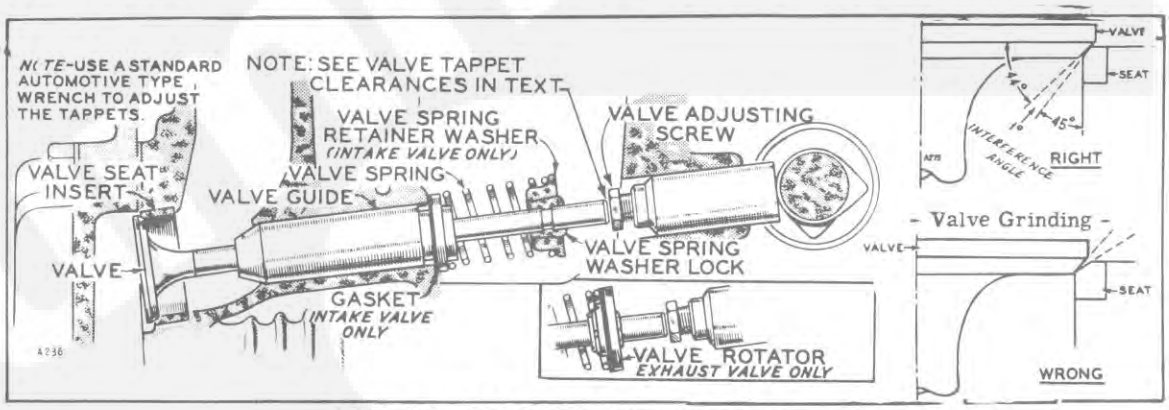



FIG. 32- VALVE ASSEMBLY

VALVE ADJUSTMENT. - These plants are equipped with adjustable tappets. To make a valve adjustment, remove the valve covers. Crank the engine over slowly by hand until the left hand intake valve, when facing the flywheel, opens and closes. Continue about 1/4 turn until the "TC" mark on the flywheel and the mark on the gear cover are in line. This should place the left hand piston at the top of its compression stroke, the position it must be in to get proper valve adjustment for the left hand cylinder. Clearances given are for room temperature (72° F., 22°C.). Use 0.006 and 0.008 inch feeler gauges for the exhaust valves and 0.004 and 0.006 inch feeler gauges for the intake valves. In each case the thinner gauge should pass freely between the valve stem and valve tappet but the thicker gauge should not.

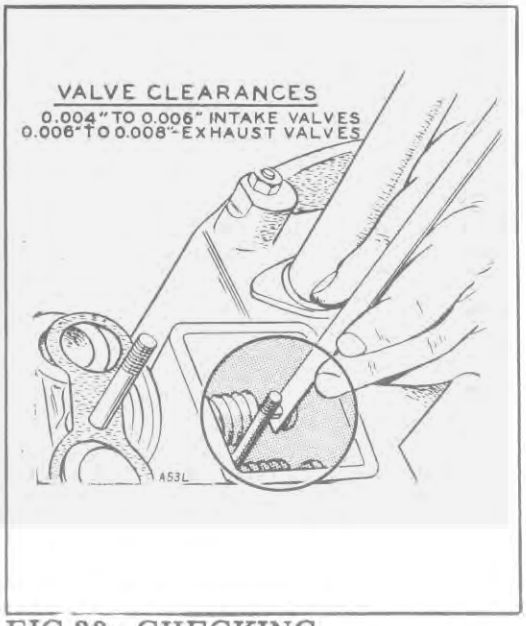



FIG. 33- CHECKING VALVE CLEARANCE

To correct the valve clearance, simply turn the adjusting screw as needed to obtain the right clearance. The screw is self-locking and will stay where set.

For plants having non-adjustable tappets, either the valve stem, valve face, or valve seat must be ground. Use a valve grinding machine. Grind the valve face or seat to reduce valve clearance. Grind the valve stem to increase valve clearance. If valve clearance can no longer be held within given limits, replace the valve.

To adjust the valve on the right hand cylinder, crank the engine over one complete revolution and again line up the "TC" mark on the flywheel and the mark on the gear cover. Then follow the adjustment given for the valves of the left hand cylinder.

FLYWHEEL. - Before the flywheel can be removed, all parts necessary to expose the flywheel must be removed. Turn the flywheel mounting screw out two full turns, insert a screwdriver between the flywheel and the gear cover to take up crankshaft end play, and strike a sharp endwise blow on the head of the cap screw with a heavy soft hammer. If the plant is equipped with a Readi-Pull starter, the starter mechanism should be removed from the flywheel and the flywheel mounting screw replaced and used in removing the flywheel. Remove the flywheel carefully to avoid damaging the magneto stator assembly. Do not drop the flywheel. A suitable puller can easily be made from a peice of bar steel and the flywheel removed with the aid of the puller. Remove the flywheel key if further work is to be done on the engine. The gear cover oil seal will be damaged if an attempt is made to remove the gear cover with the key still on the shaft.

When replacing the flywheel be sure the key is in place on the crankshaft. Then install the flywheel. If a Readi-Pull starter is used, place it in position on the flywheel. Replace other parts removed, reversing the order in which they were removed.

GEAR COVER. -All parts necessary to remove the flywheel must be removed, including the flywheel, before the gear cover can be removed. Then disconnect the linkage and the spring from the governor arm, take out the gear cover mounting screws and remove the gear cover. Tap the gear cover gently to loosen it.

When installing the gear cover, select the instructions which apply to the model in question. Don't lose the governor-shaft-end-thrust ball.

On models of later design, position the governor cup so that the chamfered hole is at the 3 o'clock position, and will admit the stop pin located in the gear cover.

On engines of the earlier design, the governor cup stop pin is located on the governor cup and must fit into the slot in the governor shaft yoke,

as illustrated. Turn the governor cup to the position where its stop pin agrees with the 9 o'clock position on the face of a clock. Then turn the governor arm and shaft clockwise as far as it will go and hold it in this position until the gear cover is flush against the cylinder block. Turn the governor arm and shaft counterclockwise as far as it will go and hold or tie it in this position until the governor linkage is connected so that the governor stop pin will remain engaged with the yoke.

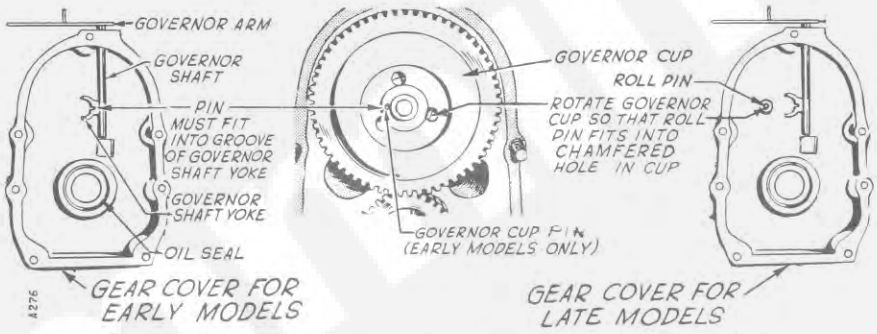



FIG. 34 - REPLACING THE GEAR COVER

GOVERNOR CUP. - With the gear cover removed, the governor cup can be taken off by removing the snap ring from the camshaft center pin and sliding the cup off. Before attempting to slide the cup off, tip the engine backwards by placing blocks under the front of the oil base. The governor flyballs will then be held in place in the cam gear groove and can be removed without difficulty.

When installing the governor cup, tip the plant upward from the engine end, place the flyballs in place, and install the governor cup on the center pin. Install the snap ring on the camshaft center pin. The distance from the snap ring to the governor cup sleeve, when the cup is flush against the flyballs, must be exactly 7/32 of an inch if the governor is to operate as it should. See Fig. 35. If it is more than 7/32 of an inch, the camshaft must be removed and the center pin carefully pressed in by means of an arbor press to allow 7/32 of an inch clearance. See Fig. 35.

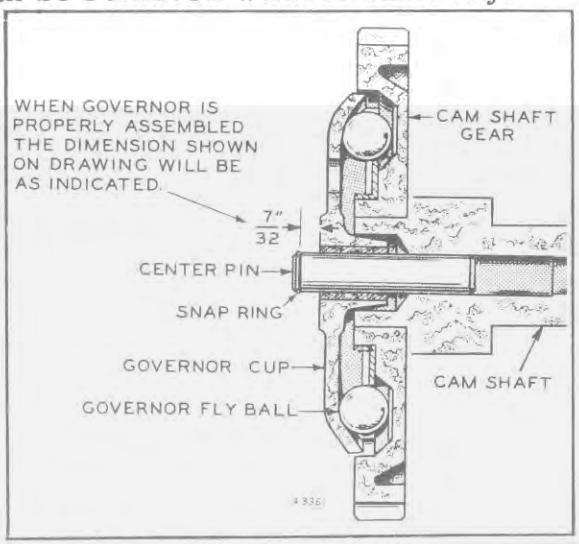



FIG. 35- GOVERNOR CUP ASSEMBLY

Leave the cup and snap ring on the pin to measure by. If it is less than 7/32 of an inch, remove the cup and carefully dress down the face that contacts the snap ring. Take off as much material as is required for the necessary clearance. Be careful not to bend the center pin since it is not replaceable in the field.

CRANKSHAFT GEAR. - The crankshaft gear is easily removed after taking off the snap ring and crankshaft gear washer. A suitable gear puller can be used. The gear is drilled and tapped, and the gear can be removed by using two number 10-32 steel screws with hex. heads and turning them in until they butt up against the shoulder on the crankshaft and push the gear off. Turn each screw in a little at a time. If a puller is used and the gear is to be used again, apply the puller carefully to avoid damaging the teeth.

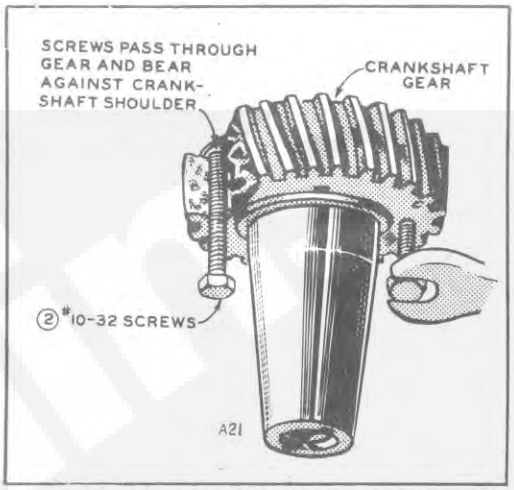


FIG.36-CRANKSHAFT GEAR REMOVAL

When installing the crankshaft gear, use a hollow pipe that will fit over the crankshaft but will not hit the teeth of the gear. Press the gear on to the shoulder on the shaft. Be sure the Woodruff key is in place.

Should it become necessary at any time to replace the crankshaft gear, the camshaft gear must also be replaced. The gears are matched and are sold only in sets.

CAMSHAFT AND GEAR ASSY. - The camshaft and gear should be removed from the plant as an assembly. Before this can be done, the gear cover, lock ring and special washer on the crankshaft, the ignition breaker box and plunger, the fuel pump, and the valve stem locks must be removed. Pull the valve tappets into the box. Then slide the camshaft and gear out as an assembly.

If the gear is to be removed from the shaft, remove the snap ring from the center pin, the governor cup, and the flyballs. Place the camshaft and gear in an arbor press and remove the gear. Be very careful not to damage the center pin since it is not replaceable in the field.

If the camshaft gear is to be replaced, the crankshaft gear must also be replaced as they are a matched set. When pressing the camshaft gear into place on the shaft, be sure the key is in place and the gear is straight on the shaft.

TIMING GEARS. - The crankshaft gear and the camshaft gear form the timing train. These gears are matched and are sold only in sets. Should either gear need replacing, both gears must be replaced. When installing new timing gears or replacing the old timing gears, the timing marks must be aligned as shown.

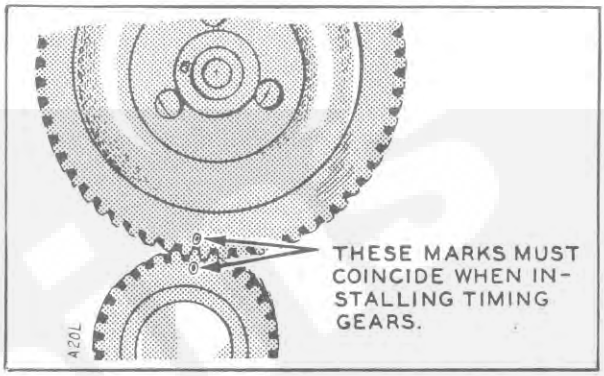



FIG.37- TIMING GEAR ASSEMBLY

CRANKSHAFT. - The plant must be completely disassembled to remove the crankshaft. Whenever making major repairs on the engine, always inspect the drilled passages of the crankshaft. If necessary, clean them to assure proper lubrication of the connecting rods. Also the bearing journals should be inspected. If they are scored and cannot be smoothed out by dressing down, the bearing journals should be refinished to use 0.002" or 0.020" undersize bearings, or a new crankshaft should be installed. When replacing the crankshaft, use gaskets as needed behind the bearing plate to assure end play of 0.006 to 0.012 inch. See Fig. 38.

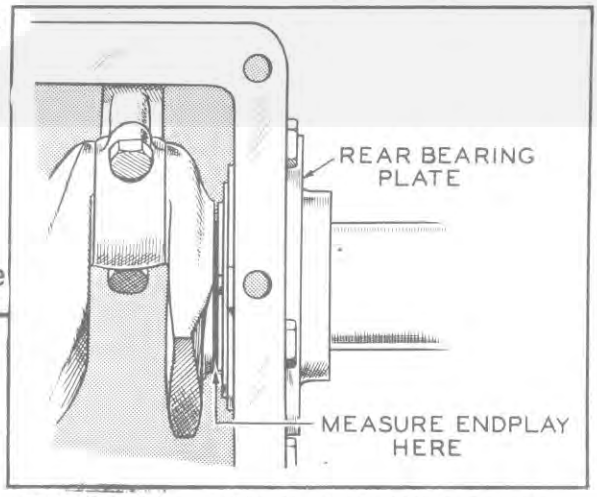



FIG.38-CRANKSHAFT ENDPLAY

BEARINGS. - Removal of the camshaft and crankshaft bearings requires complete disassembly of the engine. Use a press or a suitable drive plug to remove the bearings. Drive or press the crankshaft bearings from the outside toward the inside of the cylinder block. Drive or press the camshaft bearings from the outside toward the inside of the cylinder block. Be very careful not to damage the bearing boss when removing a bearing.

The crankshaft bearings must be installed from the inside of the cylinder block with the oil holes in the bearings aligned with the oil holes in the bearing boss. Use a press or suitable drive plug to install the bearings. Press or drive both bearings in until the flange is flush with the inner end of the bearing boss. Use oil on the outer bearing surface to reduce friction. Coat the inner surface of each bearing with oil before installing the crankshaft.

Replacement crankshaft bearings are accurately machined precision type bearings that do not require line reaming after installation. They are available in 0.002" and 0.020" undersizes.

The oil groove of the front camshaft bearing must be centered at the top. The oil hole in the rear camshaft bearing must be aligned with the hole in the bearing boss. Install both bearings from the outside. Press or drive the front bearing in flush with the bearing boss and the rear bearing in flush with the welch plug groove. Replace the rear bearing welch plug.

NOTE: The camshaft bearings must be line bored or line reamed after being installed in the cylinder block. The camshaft bearings should be line bored to allow a clearance of .0015 to .003 inch clearance. Any reliable machine shop should be able to perform this service. If equipment for line boring or reaming is not available locally, see the dealer from whom you purchased your engine or return it to the factory for repairs.

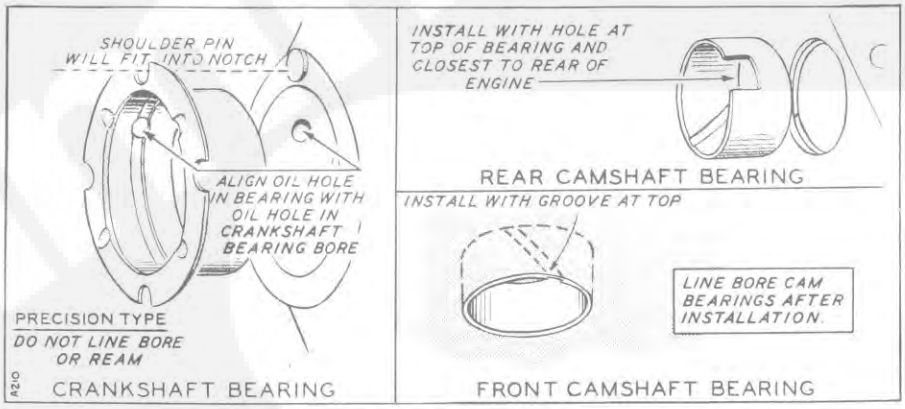



FIG.39- BEARING INSTALLATION

OIL SEALS. - The gear cover must be removed to replace its oil seal. Drive the old seal out from the inside of the gear cover.

The bearing plate must be removed to replace its oil seal. Drive the old seal out from the inside.

When installing the gear cover oil seal, tap the seal inward until it is 31/32 of an inch from the mounting face of the cover.

When installing the bearing plate oil seal, tap the seal into the bearing plate bore to bottom against the plate bore shoulder. After the seal is in place, apply a thin coating of shellac or Permatex around the outer surface of the seal at the point where it comes in contact with the bearing plate boss. Place a piece of shim stock around the end of the crankshaft when replacing the bearing plate to avoid damaging the seal. Remove the shim stock as soon as the plate is in place.

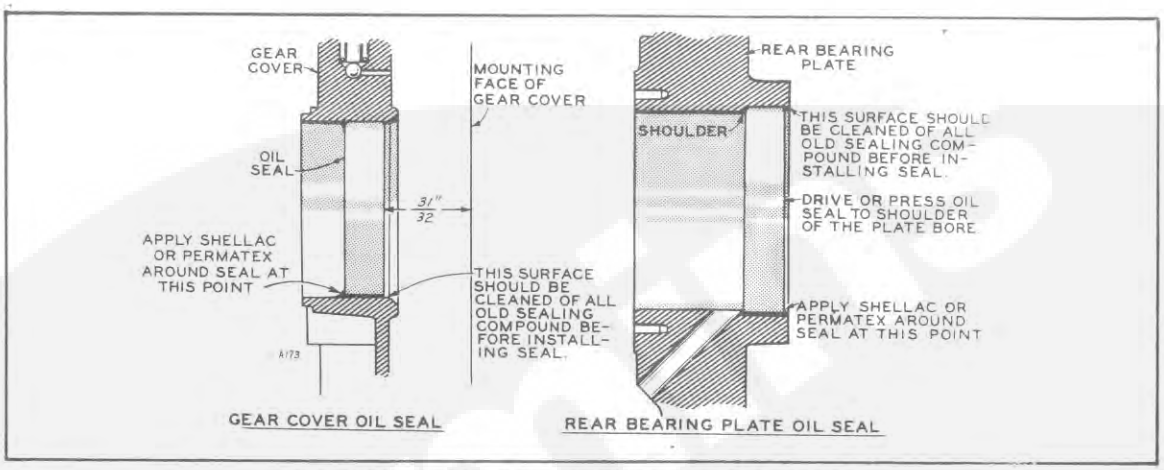



FIG.40- OIL SEAL INSTALLATION

OIL PUMP. - The engine must be completely disassembled to remove the oil pump. Only on the earlier built engines, it is necessary to first unscrew the pump assembly from the intake cup before removing the pump from the cylinder block. Check the oil pump throughly for worn parts. Should any part need replacing, replace the entire pump assembly. The oil pump is available only as a complete unit.

FUEL SYSTEM. - Instructions for adjusting and servicing the different parts of the fuel system are given under Periodic and Accessory Service.

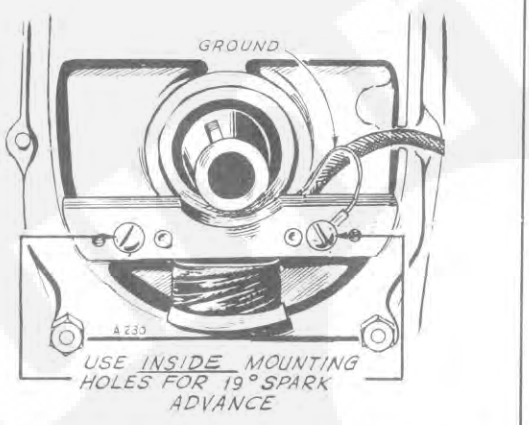
MAGNETO STATOR INSTALLATION. - The magneto stator assembly is mounted on the gear cover and the flywheel must be removed to expose it. Fig. 41 shows the stator assembly correctly installed on the gear cover. Note that there are inside mounting holes for the stator for a 19° spark advance, the outside holes for a 25° spark advance. Connect the small coil lead to the stator mounting screw. Connect the large lead to the breaker box. Be sure it is held in place by the clip as illustrated.

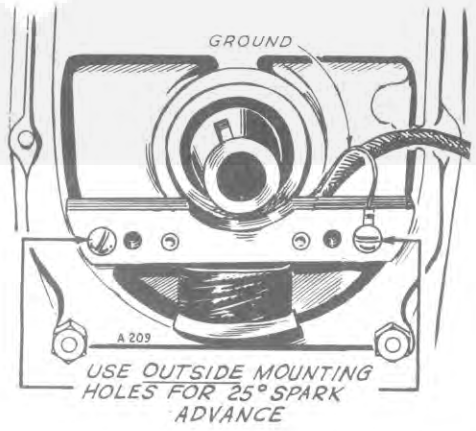
TIMING THE IGNITION. - The spark advance is 19° before top center for all models with engine speeds ranging from 1500 to 2400 rpm. Models with engine speeds of 2500 rpm and up use the 25° spark advance.

1. Remove the cover from the breaker box and check the witness marks on the crankcase and breather box (or spacer). If these marks are not in alignment, loosen the breaker box (or spacer) mounting screws and align these marks. See Fig. 19. This will give a nearly correct setting of the breaker box.

2. Crank the engine over slowly by hand in the direction of crankshaft rotation until the "TC" mark on the flywheel and the mark on the gear cover are exactly in line. See Fig. 43.

3. Adjust the ignition breaker point gap width to .020 inch at full separation.



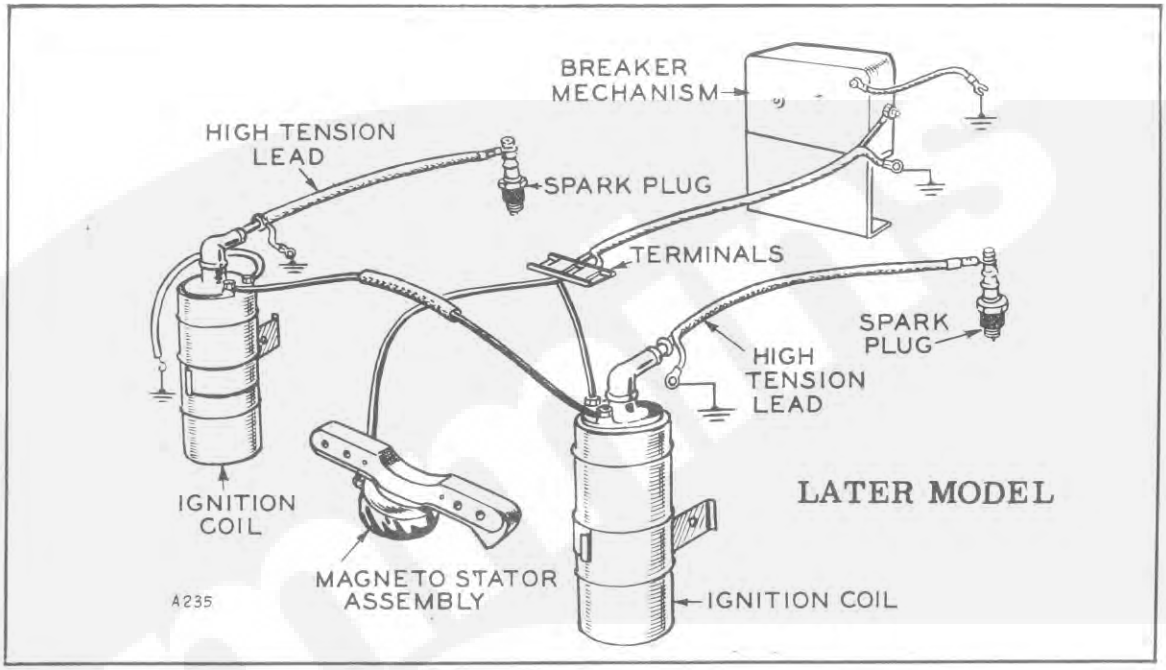

If flywheel rubs or binds on mag stator, loosen mounting screws and tap mag at point of bind with a soft-faced hammer. Retighten screws.

FIG.41- MAGNETO STATOR INSTALLATION

4. Turn the flywheel to the left against crankshaft rotation until the degree mark is about two inches past the mark on the gear cover.

5. Turn the flywheel slowly clockwise and note whether the ignition points in the breaker box just separate when the degree mark on the flywheel aligns with the mark on the gear cover. If the marks align as the points break, timing is correct. If they do not, loosen the breaker box ( or spacer) mounting screws, see Fig. 19, and shift the whole breaker box ( and spacer) assembly towards the air cleaner side of the plant to retard the timing. Shift the whole assembly away from the air cleaner to advance the timing. The witness marks on the cylinder block and breaker box (or spacer) may not be in alignment after this adjustment but this is not important since these marks give only an approximately correct position of the breaker box. Tighten the breaker box or spacer mounting screws securely after making an adjustment.

6. Replace the breaker box cover.



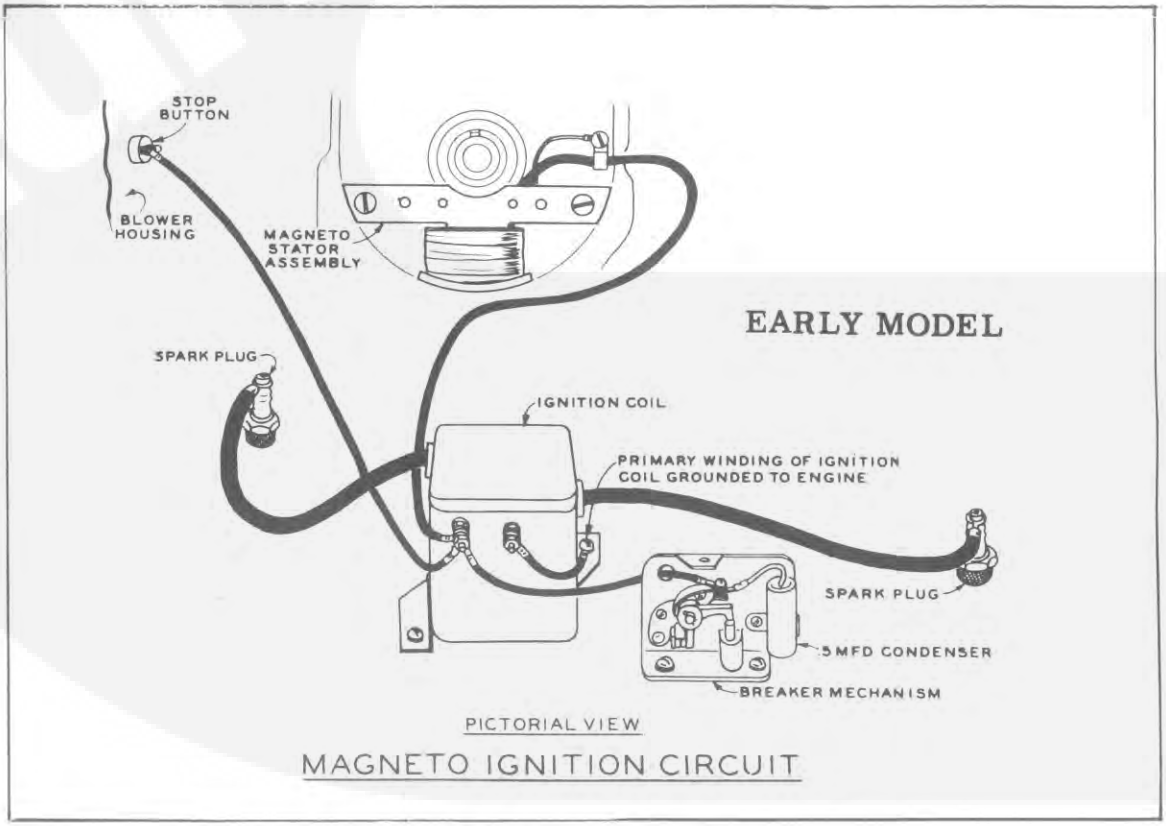




FIG. 42- IGNITION SYSTEM

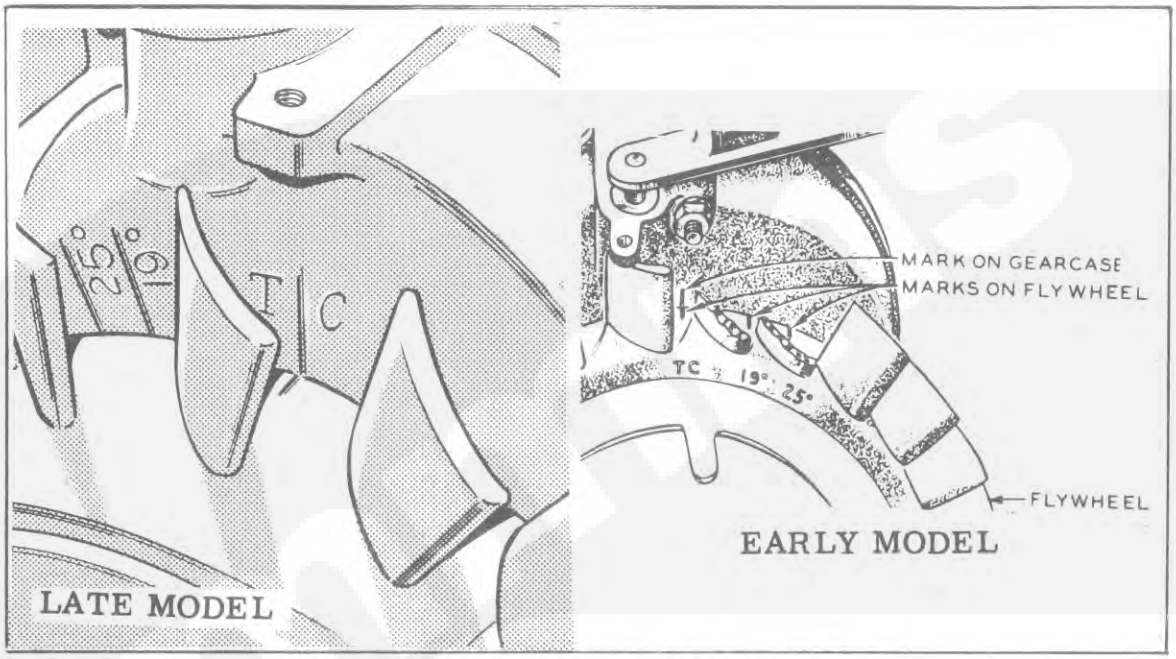



FIG.43- TIMING MARK ALIGNMENT

GASKETS. - Always use new gaskets when replacing any part that requires a gasket. Thoroughly clean the surface that the gasket contacts before installing the gasket. Gaskets are listed singly in the Parts List and are also listed in kit form under SERVICE KITS.

## ASSEMBLY TORQUES

Assembly torques as given here require the use of a torque wrench. These assembly torques will assure proper tightness without danger of stripping the threads. If a torque wrench is not available, you will have to estimate the degree of tightness necessary for the stud or nut being installed and tighten accordingly. Do not strip the threads. Check all studs and nuts frequently. Tighten as needed to prevent their working loose.

CYLINDER HEAD STUDS AND NUTS. - Tighten to 18 to 20 pound feet torque.

OTHER 5/16 INCH CYLINDER BLOCK STUDS AND NUTS. - Tighten to 10 to 12 pound feet torque. Tighten other studs and nuts just enough to assure tightness. Be careful not to strip the threads.

CONNECTING ROD BOLTS. - Tighten to 24 to 26 pound feet torque.

FLYWHEEL CAPSCREW. - Tighten to 40 to 45 pound feet torque.

ARMATURE THROUGH STUD AND NUT. - Tighten to 45 to 50 pound feet torque.

## TABLES OF CLEARANCES

| | MINIMUM | MAXIMUM |
|---|---|---|
| Intake Valve Tappet Clearance at 72°F. | 0.004" | 0.006" |
| Exhaust Valve Tappet Clearance at 72°F. | 0.006" | 0.008" |
| Intake Valve Stem Clearance in Guide | 0.001 " | 0.0025" |
| Exhaust Valve Stem Clearance in Guide | 0.0025" | 0.004" |
| Valve Seat Width | 3/64" | 5/64" |
| Crankshaft Main Bearing Clearance | 0.002" | 0.003" |
| Crankshaft End Play | 0.006" | 0.012" |
| Camshaft Bearing Clearance | 0.0015" | 0.003" |
| Connecting Rod Bearing Clearance | 0.002" | 0.003" |
| Connecting Rod End Play | 0.002" | 0.014" |
| Timing Gear Backlash | 0.002" | 0.005" |
| Oil Pump Gear Backlash | 0.003" | 0.010" |
| Piston Clearance in Cylinder | 0.0005" | 0.0025" |
| Piston Pin Clearance in Piston at 70°F. | Thumb Push Fit | |
| Piston Pin Clearance in Rod at 72°F. | 0.0001" | 0.0006" |
| Piston Ring Gap in Cylinder | 0.010 " | 0.023 |
| Breaker Point Gap at Full Separation | 0.020" | |
| Spark Plug Gap for Gasoline Operation | 0.025" | |
| Spark Plug Gap for Gaseous Operation | 0.018" | |

## GENERATOR

The generator normally needs little care other than proper lubrication of the armature, ball bearing and a periodic check of the brushes, commutator and collector rings. If a major repair job on the generator should become necessary, have the equipment checked by a competent electrician who is thoroughly familiar with the operation of electric generating equipment.

BALL BEARING. -If replacement of the armature ball bearing becomes necessary, pull the bearing from the shaft with a suitable bearing puller. Be careful not to damage the armature shaft because it must remain true to serve as a turning center when refinishing the commutator or collector rings. Install the bearing with the sealed side toward the windings. Drive the bearing on to the shoulder on the shaft. Be sure to pack the open type bearing with grease before running the plant. The sealed bearing requires no lubrication.

GENERATOR DISASSEMBLY. - The procedure is mostly self-evident. Remove the band from the generator end bell and lift all brushes into their holders until the spring will hold them in place.

Remove the two cap nuts from the generator end bell. Insert a thin chisel into the joint between the generator frame and the adapter and tap gently with a hammer to loosen the frame. Then remove the generator frame assembly, being careful not to let it rest or drag on the armature. Hold both the end bell and the frame as they are separate parts.

Turn the armature mounting nut out to the end of the armature stud. Place one hand under the armature, strike a sharp endwise blow on the head of the nut to loosen the armature, and remove the armature and blower as an assembly. If the armature does not come loose, place a heavy brass rod on the armature shaft, between the collector rings and the bearing, and strike a sharp downward blow on the rod with a soft heavy hammer. Rotate the armature 1/2 turn before repeating. Do not strike the commutator, collector rings, or bearing.

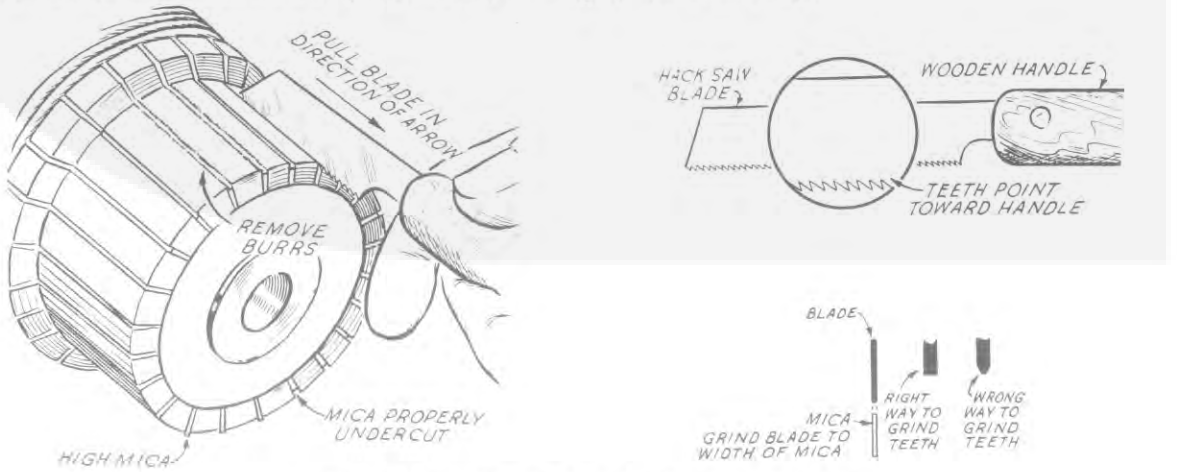



FIG. 44 - COMMUTATOR REPAIR

BRUSHES. - Keep a close check on the generator brushes. Brushes worn to 5/8 of an inch should be replaced. If the brushes seem to wear rapidly, check the collector rings and commutator. If they become rough or pitted or if the mica between the commutator bars comes in contact with the brushes, brush wear will be rapid. An improperly adjusted brush rig will also cause rapid brush wear. Each of these causes of brush wear are treated in separate paragraphs.

BRUSH RIG POSITION. - Check the witness mark on the brush rig and if necessary align it with the boss in the end bell as shown in Fig.20. If the brush rig is adjusted so that there is arcing of the brushes, brush wear will be rapid, voltage and current will not hold steady, and the generator may overheat.

Whenever a new brush rig or armature is installed, the brush rig must be adjusted to the point where the brushes do not arc regardless of where the witness mark falls. This is commonly known as the "neutral" brush position.

COLLECTOR RINGS (AC Units). - If the collector rings become grooved or out of round, or the brush surface becomes pitted or rough so that good brush seating cannot be maintained, remove the armature and refinish the collector rings in a lathe. If the commutator appears to be rough or scored refinish it at the same time.

COMMUTATOR. - The commutator bars wear down with usage so that the mica between them must be undercut. This should be done as soon as the mica on any part of the commutator touches the brushes. A suitable undercutting tool can be made from an old hack saw. Use it as shown in Fig.44. Avoid injury to the surfaces of the copper bars. Leave no burrs along the edges of the bars. The mica must also be undercut whenever the commutator is refinished.

TESTING WINDINGS. - A test lamp set and an armature growler are required for the various tests. Before making any tests, lift all brushes into their holders and disconnect the load circuit wires from the plant. If the armature tests defectively, the practical repair is to replace it. If a field coil tests defectively, replace the entire coil assembly unless the trouble is in one of the external leads. Then it can be repaired as the nature of the trouble requires.

ARMATURE GROUND TEST. - To test the armature for a grounded condition, pull all the brushes up so that none contact the commutator or collector rings. Use a continuity type test lamp set. Place one test prod on the commutator, and the other test prod on a bare, clean part of the armature shaft. The test prods must make good electrical contact. The test lamp should not

glow. If the test lamp does glow, the dc winding or the commutator is grounded. To test the ac winding, place one test prod on one of the collector rings and the other test prod on the armature shaft. If the test lamp glows, the ac winding or a collector ring is grounded. Replace a grounded armature with a new one.

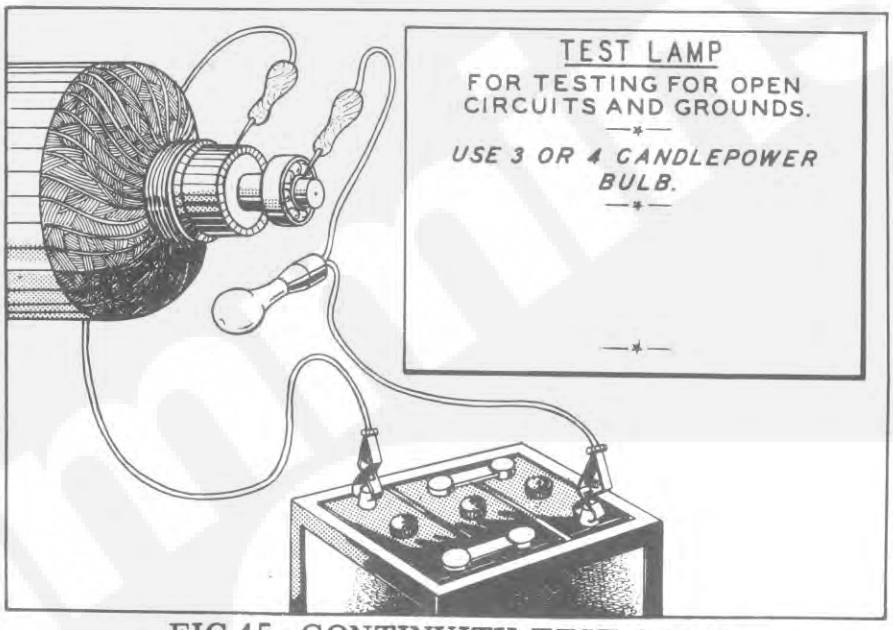



FIG.45- CONTINUITY TEST LAMP

ARMATURE OPEN CIRCUIT TEST. - The armature ac winding may be tested for an open circuit without removal of the armature. Testing the dc winding requires removal and the use of an armature growler.

To test the ac winding, be sure all brushes are pulled up out of contact. Use a test lamp set. Place one test prod on each of the collector rings. If the test lamp does not glow, the ac winding is open circuited.

To test the dc winding, place the armature in a growler. With the growler current on, pass a smooth steel strip across the commutator segments. Repeat all around the commutator. At some point around the commutator, a spark should occur as the strip contacts two adjacent segments. See Fig 46. Rotate the armature slightly and repeat the test. Continue until a spark is obtained between all adjacent segments. If no spark is obtained at some point, an open

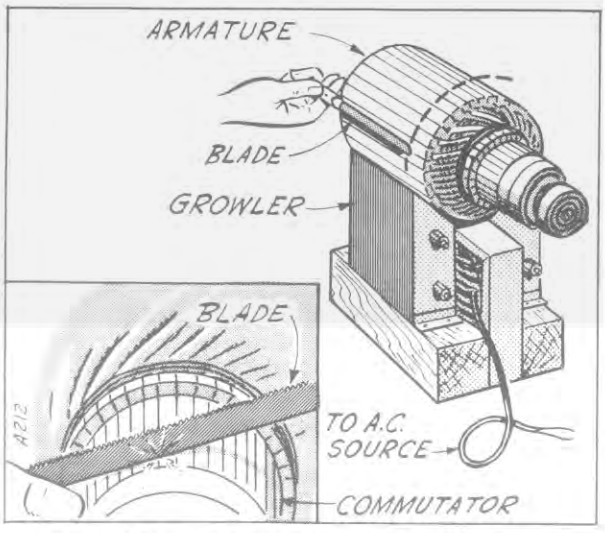



FIG.46- ARMATURE GROWLER

circuit is indicated. NOTE - A short circuit in the winding might prevent sparking. This condition may be indicated by the short circuit test described in the next paragraph. Replace an open circuited armature with a new one.

ARMATURE SHORT CIRCUIT TEST. - To test for a short circuit, place the armature in a growler. With the growler current on, hold a steel strip about 1/2 inch above the armature laminations. Pass the strip back and forth over the laminations. Cover as much of the lamination area as possible. If the strip is magnetically attracted to the armature at any point, a short circuit is indicated. After testing in one position, rotate the armature slightly in the growler and repeat the test. Continue until a complete revolution of the armature in the growler has been made. Replace a short circuited armature with a new one.

TESTING FIELD WINDINGS. - Use a test lamp set (Fig 45 ) for all tests except a short circuit. The field coils of all ac plants are saturated shunt wound, the Remote Start and Dual Purpose plants having a series field winding in addition for cranking and battery charging purposes. The field coils of the Battery Charging plants are of the shunt wound type with interpoles and a series field. There are actually three separate windings to test. The 115 volt and 230 volt dc plants are of the compound wound type with interpoles and all windings are connected. When testing a field coil assembly, disconnect all of its external leads from their terminals. Tag and mark each lead to assure proper connections when reassembling.

TESTING FIELD WINDINGS FOR GROUNDS. - To test a coil assembly for a ground, disconnect its external leads and touch one test prod to the terminal of one of its leads and the other test prod to the generator frame. If the lamp lights, the coil assembly being tested is grounded. The ground may be in a coil, coil connection, or coil lead. Repair or replace as needed.

TESTING FIELD WINDINGS FOR OPEN CIRCUIT. - To test a coil assembly for an open circuit, disconnect its external leads and touch one test prod to the terminal of one coil lead windings and the other test prod to each of the other leads of that coil winding in turn. If the lamp does not light, the circuit being tested is open. If the fault lies in connection between coils or in a coil lead, the trouble can be repaired. If it is inside the coil proper, replace the entire coil assembly.

GENERATOR ASSEMBLY. - When reassembling the generator, see that there aren't any nicks or dirt on the armature tapered surface. These conditions may lead to an armature that is not properly aligned. Tighten the armature stud nut securely.

## CONTROLS

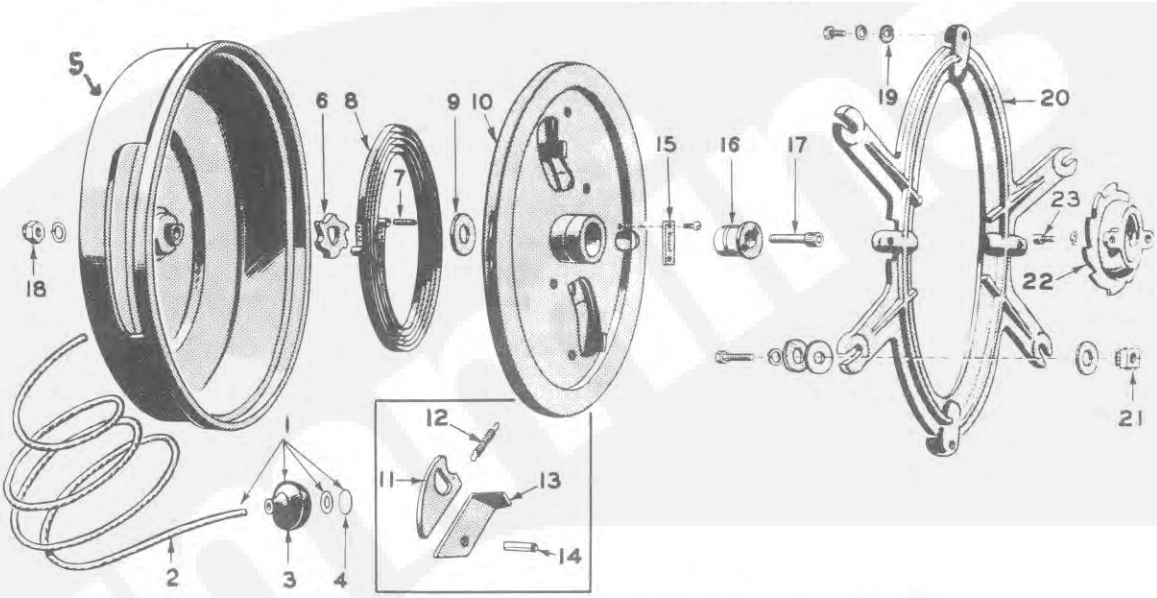
If any of the control equipment fails to function properly, replace the defective part with a new part of the same kind rather than try to repair the old part. No attempt should be made to repair such parts as meters, fuses, switches, relays, or receptacles. Check all electrical connections and contacts whenever servicing control equipment.

Always disconnect the battery whenever servicing controls to avoid accidentally starting the plant. When disassembling controls, tag each lead that has to be removed and mark the connection point of the lead on the tag to assure correct connections when reassembling.

INSTALLING "MODEL D" READI-PULL STARTER. - For use with a Readi-Pull starter, the blower housing on the engine must be as rigid as possible. Examine the blower housing carefully. If the mounting holes are worn or if the blower housing is otherwise damaged, replace it with a new one. Blower housings of No. 18 gauge sheet steel metal, for greater rigidness, are available for replacement on older engines. Proceed as follows to install the complete starter kit.

1. Refer to the installation drawing. If this starter replaces an older model (other than a model D), remove the original ratchet from the center of the blower wheel. If the original ratchet and flywheel attaching screw has a special pilot head, discard the pilot head screw and use one of the two screws provided, selecting the proper length to correspond with the discarded one. Tighten the new screw securely to 45 to 50 lbs. ft. torque.
2. Install the new ratchet-wheel (1) to the blower wheel, using the two special head screws and lockwashers provided. A 3-8 inch 12 point socket or closed end wrench fits these screws. Tighten securely.
3. Four special nuts are supplied for mounting the starter to the blower housing. If the blower housing is not already fitted with similar mounting nuts, remove the blower housing and install the nuts in the square holes (2) in the blower housing. See detail A. Reinstall the blower housing, tightening securely in place.
4. Note that there are two small holes drilled through the starter cover. See detail C. Pull slowly out on the starter rope while sighting through one of these holes. When the starter is turned a partial turn, the open-center roll pins in the starter rope sheave will align with these two holes. While holding in the aligned position, insert a ten penny common nail through each of the holes. Push the nails in up to their heads.
5. Install the starter assembly (3) to the blower housing, making sure that the nail ends enter the pilot holes in the ratchet wheel mounting screws. It will probably be necessary to turn the flywheel a partial revolution to allow the proper alignment. While holding in position, mount the starter, using a hex head screw (4), lock washer (5), and three flat washers (6) at each mounting arm as shown in the detailed drawing A. Tighten the mounting screws securely. Remove the nails.
6. The direction of pull on the starter rope is adjustable to fit the requirements of the individual installation. See detail B. To change the direction of pull, loosen the four clamp screws (8) and turn the starter in its mounting ring to the desired position. Tighten the four clamp screws securely. Try the starter several times, making sure that the pull rope will not rub against one of the clamp screws.
7. Occasionally check the operation of the starter, making sure the starter is properly centered (step 5 above). See that the blower housing mounting screws are tight. If the blower housing tends to shift, its mounting holes may have become worn oversize. If the blower housing tends to weave or distort during the starter operation, installation of a new housing is recommended.

1-ROPE AND GRIP
2-ROPE ONLY
3-GRIP ONLY
4-PLUG
5-STARTER COVER
6-COG WHEEL
7-ROLL PIN
8-RECOIL SPRING
9-THRUST WASHER
10-ROPE SHEAVE
11-PAWL
12-PAWL SPRING
13-RATCHET ARM
14-PIVOT ROLL PIN
15-ROPE CLAMP
16-BEARING
17-SCREW
18-FLEXLOCK NUT
19-WASHER
20-MOUNTING RING
21-SPEED GRIP NUT
22-RATCHET WHEEL
23-SPECIAL CAPSCREW




READI-PULL STARTER (MODEL-D)

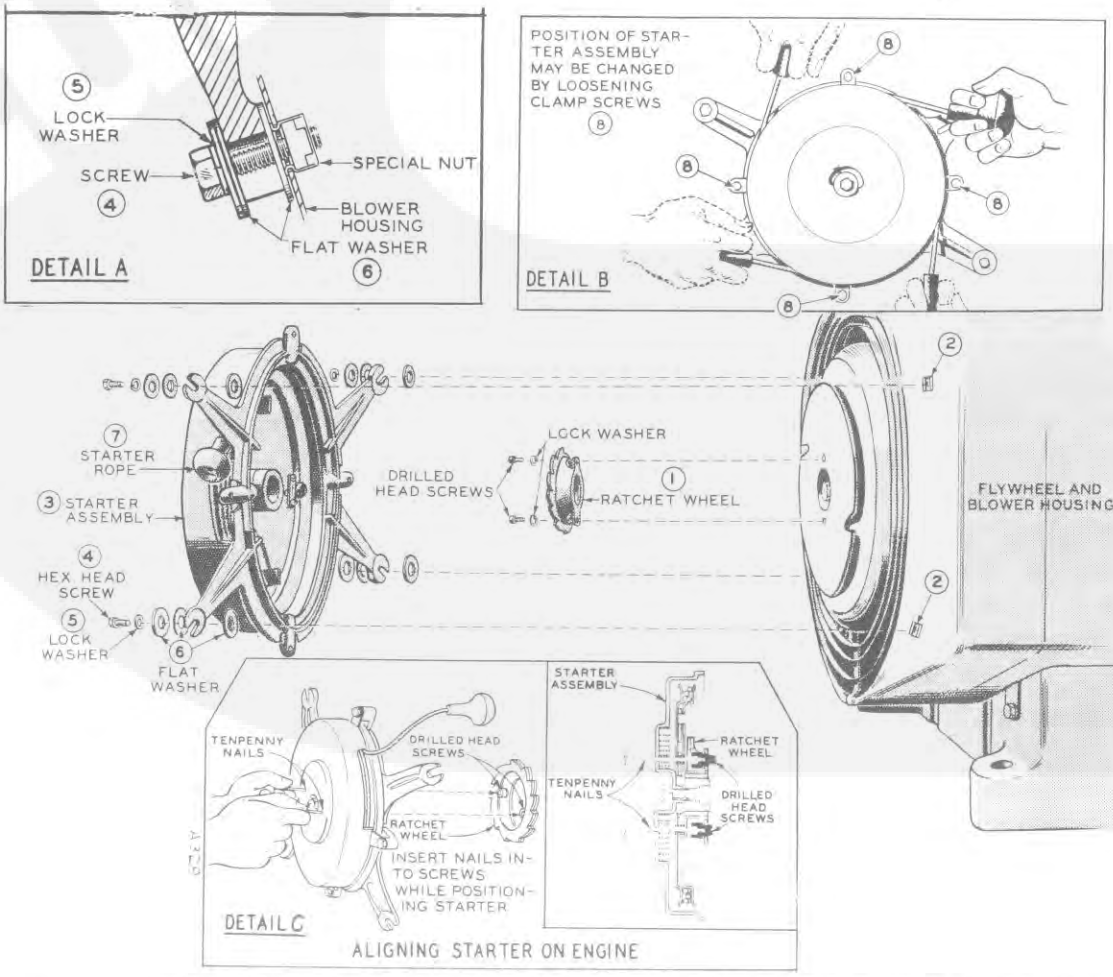



FIG. 47 - INSTALLING "MODEL D"READI-PULL STARTER.

SERVICING THE "MODEL D" READI-PULL STARTER. -Refer to the illustration showing the readi-pull starter (model D) disassembled.

CAUTION: The recoil spring may unwind and cause injury if let fly wildly when starter is disassembled or reassembled.

The sheave hub bearing (16) has a recess which was packed full of grease at the factory. Normally no additional lubrication is required. However, if the starter is disassembled for some other reason, add grease to the bearing and the spring pawls (11) where they contact the ratchet arm (13).

To install a new rope or internal parts remove the starter from its mounting ring by removing the 4 clamping screws (19).

To install a new rope, rotate the sheave (10) with crankshaft rotation direction to fully tighten the spring (8), back up only as necessary to align the hole in the sheave with the slot in the cover (5), clamp the rope to the sheave, then when released the rope will wind on the sheave.

To install a new recoil spring remove the sheave from the cover. Wind the spring, with its rivet heads outward, forming a coil small enough to be inserted in the recess of the starter cover. It may be necessary to tie the spring with a piece of wire to prevent its unwinding during installation unless other help is available. Place the spring in the cover recess in crankshaft rotation direction. Remove the tying wire if used. While holding the spring to prevent its unwinding install the inside end of the spring on the roll pin (7) in the cover. With the pull rope removed, install the sheave assembly in the cover so that the tab on the sheave enters the outside end loop of the recoil spring. Be sure the thrust washer (9) is in place. Then install the pull rope.

Spring breakage is much less common than spring fatigue due to long usage. In either case the spring should be replaced. Cleaning and lubricating the pawls, and ratchet arms in the rope sheave will improve a sluggish acting recoil. To temporarily extend the life of a fatigued spring, try rewinding it "inside out" (rivets heads inward).

To install a ratchet arm (13) in the sheave, the pawl (11) must first be removed. The ratchet arm will fit in only the correct position. The spring pawl must be installed with its flat edge against the ratchet arm.

The anti-back lash cogwheel (6) is an easy press fit on the starter cover.

## READI-PULL STARTER

The recoil starter is an accessory. Several models have been manufactured. Select the illustration which applies to the model in question.

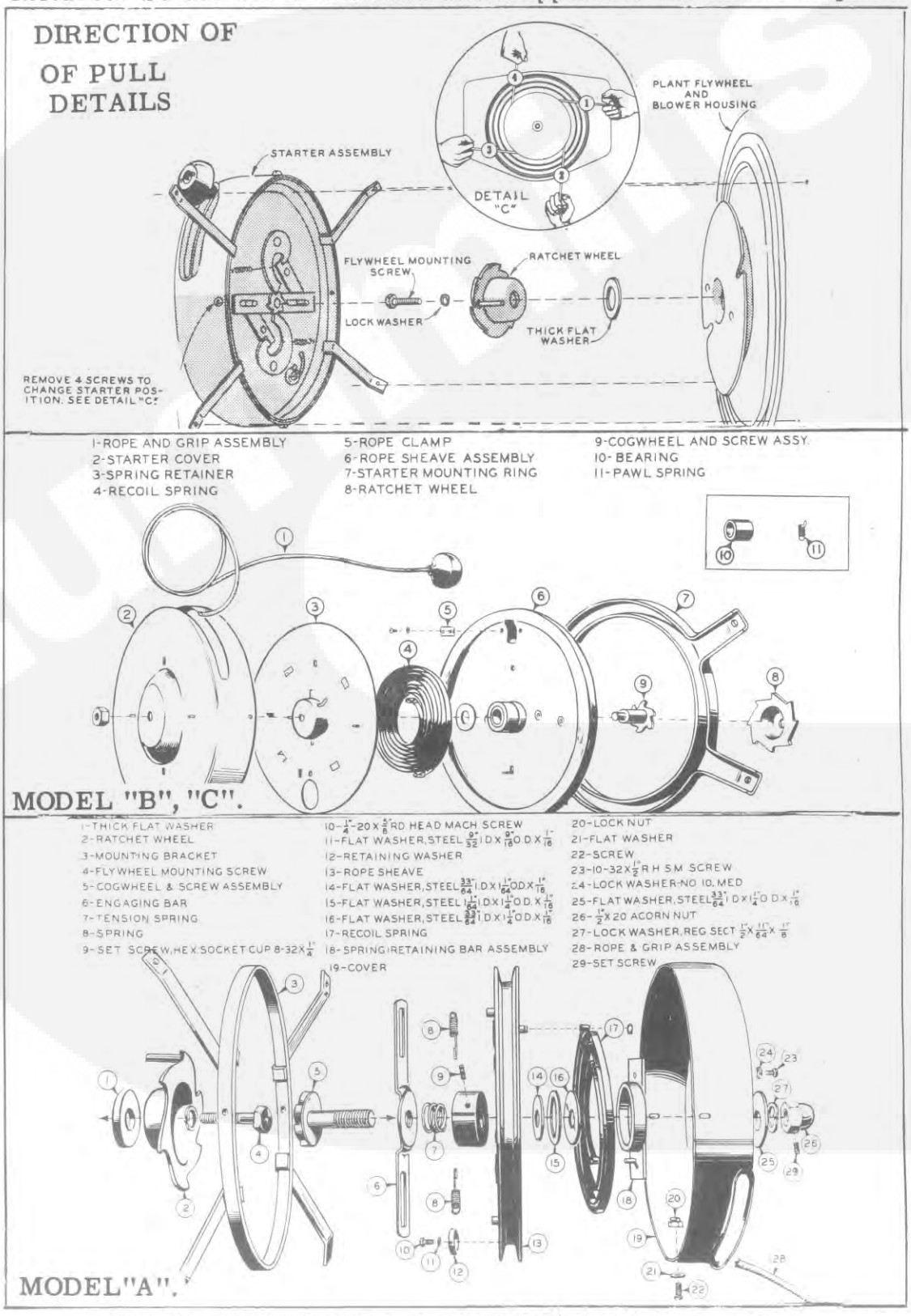



FIG. 48 -READI-PULL STARTER (Model A, B, C)

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **ENGINE CRANKS TOO STIFFLY** | |
| Too heavy oil in crankcase. | Drain. Refill with light oil. See PREPARATION. |
| Engine seized | Disassemble and repair. |
| **ENGINE CRANKS TOO SLOWLY WHEN CRANKED ELECTRICALLY** | |
| Discharged or defective battery. | Recharge or replace. |
| Loose connections. | Tighten loose connections. |
| Corroded battery terminals. | Clean corroded terminals. Replace cable if necessary. |
| Brushes worn excessively or making poor contact. | Replace brushes or clean commutator. |
| Short circuit in generator or load circuit. | Repair or replace parts necessary. Disconnect load. |
| Dirty or corroded points in start solenoid switch. | Replace switch. |
| **ENGINE WILL NOT START WHEN CRANKED** | |
| Faulty ignition. | Clean, adjust, or replace breaker points, spark plugs, condenser, etc., or retime ignition. |
| Lack of fuel or faulty carburetion. | Refill the tank. Check the fuel system. Clean, adjust or replace parts necessary. |
| Clogged fuel filter. | Clean. |
| Cylinders flooded. | Ground spark plug cables. Crank engine with spark plugs removed. |
| Poor fuel. | Drain. Refill with good fuel. |
| Poor compression. | Tighten cylinder heads and spark plugs. If still not corrected, grind the valves. Replace the piston rings if necessary. |
| Wrong ignition timing. | Reset breaker points or retime ignigion. See IGNITION. |

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **ENGINE RUNS BUT VOLTAGE DOES NOT BUILD UP** | |
| Poor brush contact. | See that brushes seat well on commutator and collector rings, are free in holders, are not worn shorter than 5/8 inch, and have good spring tension. |
| Open circuit, short circuit, or ground in generator. | Refer to the GENERATOR section of Maintenance and Repair. |
| Residual magnetism lost. | Magnetize the field. |
| **VOLTAGE UNSTEADY BUT ENGINE NOT MISFIRING** | |
| Speed too low. | Adjust governor to correct speed. |
| Poor commutation or brush contact. | Refinish commutator or undercut mica if necessary. See that brushes seat well on commutator and collector rings, are free in holders, are not worn shorter than 5/8 inch, and have good spring tension. |
| Loose connections. | Tighten connections. |
| Fluctuating load. | Correct any abnormal load condition causing trouble. |
| **GENERATOR OVERHEATING** | |
| Short in load circuit. | Correct short circuit. |
| Generator overloaded. | Reduce the load. |
| Improper brush rig position. | See BRUSHES, Maintenance and Repair. |
| **ENGINE OVERHEATING** | |
| Improper lubrication. | See Low Oil Pressure. |
| Poor ventilation. | Provide ample ventilation at all times. |
| Dirty or oily cooling surfaces. | Keep the engine clean. |
| Retarded ignition timing. | Retime ignition. |
| Generator overloaded. | Reduce load. |

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **VOLTAGE DROPS UNDER HEAVY LOAD** | |
| Engine lacks power. | See remedies under "Engine Misfires at Heavy Load". |
| Poor compression. | Tighten cylinder heads and spark plugs. If still not corrected grind the valves. Replace piston rings if necessary. |
| Faulty carburetion. | Check the fuel system. Clean, adjust or repair as needed. |
| Dirty carburetor air cleaner. | Clean. Refill with proper oil. |
| Choke. | Choke plate must be wide open at operating temperature. |
| Carbon in cylinders or in carburetor venturi. | Remove carbon. |
| Restricted exhaust line. | Clean or increase the size. |
| **ENGINE MISFIRES AT LIGHT LOAD** | |
| Carburetor idle jet clogged or improperly adjusted. | Clean. See ACCESSORY SERVICE. |
| Spark plug gaps too narrow. | Adjust to correct gap. |
| Intake air leak. | Tighten manifold and carburetor mounting screws. Replace gaskets if necessary. |
| Faulty ignition. | Clean, adjust, or replace breaker points, spark plugs, condenser, etc. |
| **ENGINE MISFIRES AT HEAVY LOADS** | |
| Defective spark plug. | Replace. |
| Faulty ignition. | Clean, adjust, or replace breaker points, spark plugs, condenser, etc. or retime ignition. |
| Clogged carburetor. | Clean carburetor. |
| Clogged fuel screen. | Clean. |
| Defective spark plug cable. | Replace. |

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **ENGINE MISFIRES AT ALL LOADS** | |
| Fouled spark plug. | Clean and adjust. |
| Defective or wrong spark plug. | Replace. |
| Leaking valves. | See VALVE SERVICE. |
| Broken valve spring. | Replace. |
| Defective or improperly adjusted breaker points. | Adjust or replace breaker points. |
| **LOW OIL PRESSURE** | |
| Oil too light. | Drain, refill with proper oil. |
| Oil badly diluted. | Drain, refill with proper oil. |
| Oil too low. | Add oil. |
| Oil relief valve not seating. | Remove and clean, or replace. |
| Badly worn bearings. | Replace. |
| Sludge on oil screen. | Remove and clean. |
| Badly worn oil pump. | Replace. |
| Defective oil pressure gauge. | Replace. |
| **HIGH OIL PRESSURE** | |
| Oil too heavy. | Drain, refill with proper oil. |
| Clogged oil passage. | Clean all lines and passages. |
| Oil relief valve stuck. | Remove and clean. |
| Defective oil pressure gauge. | Replace. |
| **ENGINE BACKFIRES AT CARBURETOR** | |
| Lean fuel mixture. | Clean carburetor. Adjust jets. |
| Clogged fuel filter. | Clean. |
| Air leak at intake manifold or carburetor flange. | Tighten mounting screws. Replace gaskets as necessary. |
| Poor fuel. | Refill with good, fresh fuel. See PREPARATION. |
| Spark advanced too far. | Reset breaker points or retime ignition. |
| Intake valve leaking. | Reseat or replace. |

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **EXCESSIVE OIL CONSUMPTION, LIGHT BLUE EXHAUST** | |
| Poor compression. Usually due to worn pistons, rings, or cylinders. | Refinish cylinders. Install oversize pistons and rings. |
| Oil too light or diluted. | Drain. Refill with proper oil. |
| Too large bearing clearance. | Replace bearings necessary. |
| Engine misfires. | Refer to "Engine Misfires At All Speeds" |
| Faulty ignition. | Clean, adjust, or replace breaker points, spark plugs, condenser, etc., or retime the ignition. |
| 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. | See that choke opens properly. Adjust jets properly. Adjust the float level. |
| Choke not fully open. | See that choke opens properly. |
| Dirty air cleaner. | Clean. Refill with proper oil. |
| **LIGHT POUNDING KNOCK** | |
| Loose connecting rod. | Adjust clearance or replace. |
| Low oil supply. | Add oil. Change if necessary. |
| Oil badly diluted. | Drain. Refill with proper oil. |
| Low oil pressure. | See Low Oil Pressure for remedies. |
| **ENGINE STOPS UNEXPECTEDLY** | |
| Empty fuel tank. | Refill. |
| Defective ignition system. | Check the ignition system. Repair or replace as needed. See that the STOP button lead is not grounded. |

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **SHARP METALLIC THUD, ESPECIALLY WHEN COLD ENGINE FIRST STARTED.** | |
| Low oil supply. | Add oil. Change if necessary. |
| Oil badly diluted. | Drain. Refill with proper oil. |
| **PINGING SOUND WHEN ENGINE IS SUDDENLY OR HEAVILY LOADED.** | |
| Carbon in cylinders. | Remove the carbon. |
| Spark advanced too far. | Reset breaker points or retime ignition. |
| Wrong spark plugs. | Install correct spark plugs. Champion H9 Com. |
| Spark plugs burned or carboned. | Clean. Install new plugs if necessary. |
| Valves hot. | Adjust tappet clearance. See VALVE SERVICE. |
| Fuel stale or low octane. | Use good, fresh fuel. See PREPARATION |
| Lean fuel mixture. | Clean fuel system. Adjust carburetor jets properly. |
| **TAPPING SOUND** | |
| Valve clearance too great. | Adjust to proper clearance. See VALVE SERVICE. |
| Broken valve spring. | Install new spring. |
| **HOLLOW CLICKING SOUND WITH COOL ENGINE UNDER LOAD** | |
| Loose piston. | If noise is only slight and disappears when engine warms up, no immediate attention needed. Otherwise replace parts necessary. |
| **VOLTAGE LOW AT FAR END OF LINE BUT NORMAL NEAR PLANT** | |
| Too small line wire used for load and distance. | Install larger or extra wires or reduce load. |
| **MOTORS RUN TOO SLOWLY AND OVERHEAT AT FAR END OF LINE BUT OK NEAR THE PLANT** | |
| Too small line wire used for load and distance. | Install larger or extra wires or reduce load. |

| POSSIBLE CAUSE | REMEDY |
|---|---|
| **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. |
| Brushes not seating properly. | Sand to a good seat or reduce load until worn in. |
| Open circuit in armature. | Install a new armature. |
| Brush rig out of position. | Line up properly. |
| **SPARK PLUG FOULED IN SHORT PERIODS OF TIME ON GASOLINE OPERATION** | |
| Wrong spark plug gap. (Spark plug may be set at 0.018" for gaseous operation, but not changed to 0.025" when switching over to gasoline operation.) | Clean spark plugs and set at 0.025". |
| **MISSING, POPPING, ERRATIC OPERATION ON GASEOUS FUEL OPERATION** | |
| Spark Plug gap too wide. (Spark plug gap set at 0.025" for gasoline operation but not changed to 0.018" when switching over to gaseous fuel operation). | Set spark plug gap at 0.018". |
| **HARD STARTING ON GASEOUS FUEL OPERATION** | |
| Spark Plug gap too wide. (Spark plug gap set at 0.025" for gasoline operation but not changed to 0.018" when switching over to gaseous fuel operation). | Set spark plug gap at 0.018". |

# RUNNING TIME METER

Do not Guess - Know how many hours your plant runs, so that you can change oil and service the plant at proper intervals.

This meter will be an investment rather than an expense. Simple to connect. This meter runs only when the plant is operating.

| PART NO. | USED WITH PLANT |
|---|---|
| 302B212 | 60 Cycle, 115 V. A.C. |
| 302-102 | 50 Cycle, 115 V. A.C. |
| 304-99 | Resistor - adding to either meter above makes it suitable for 230 V. use. |

Meters listed above are 3-1/2 inch diameter, and are for flush mounting on panel; fit into 2-29/32 inch hole. For wall mounting, order separately.

301-500 Instrument Box

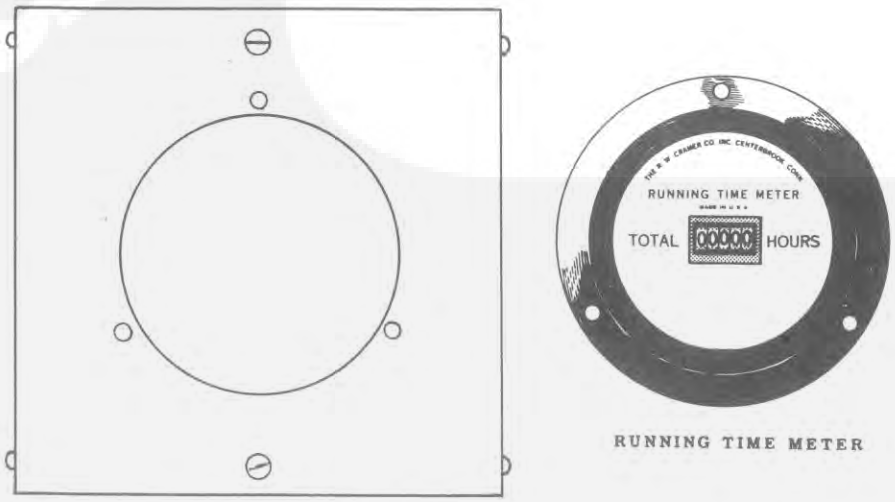
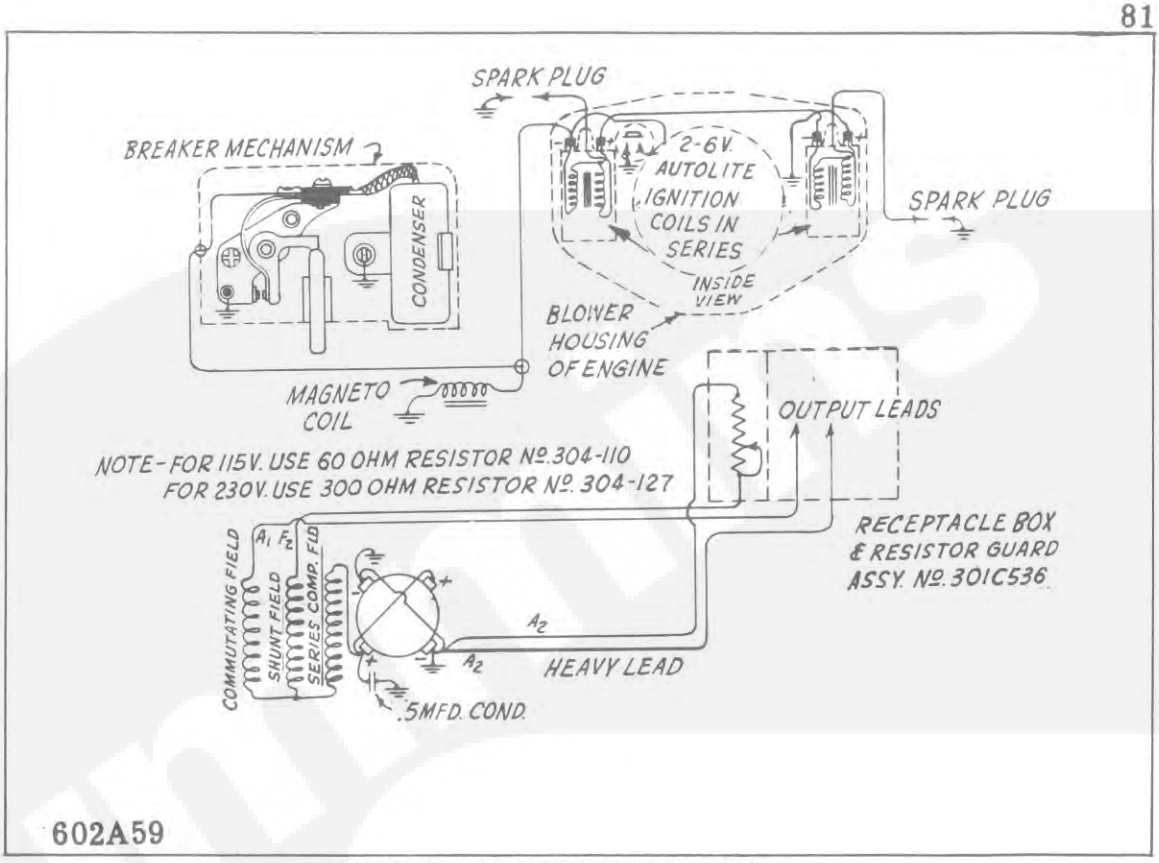
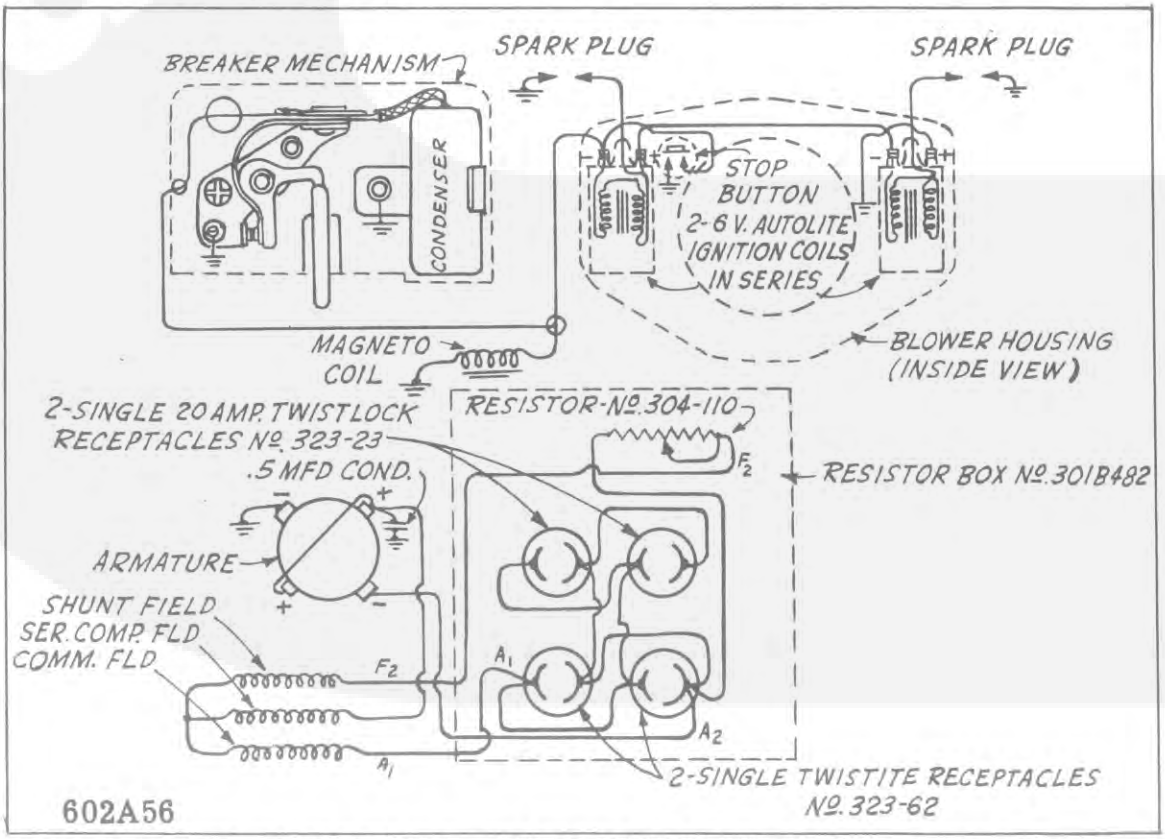


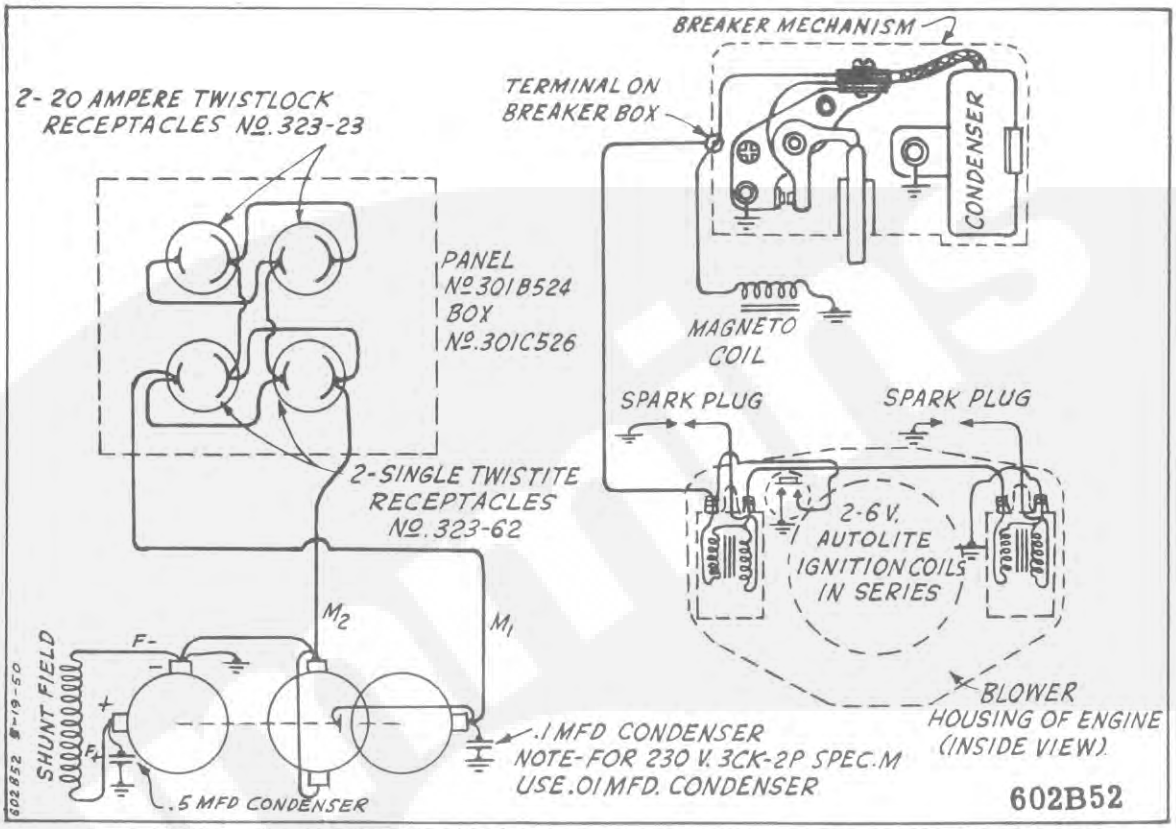

FIG. 49 - RUNNING TIME METER



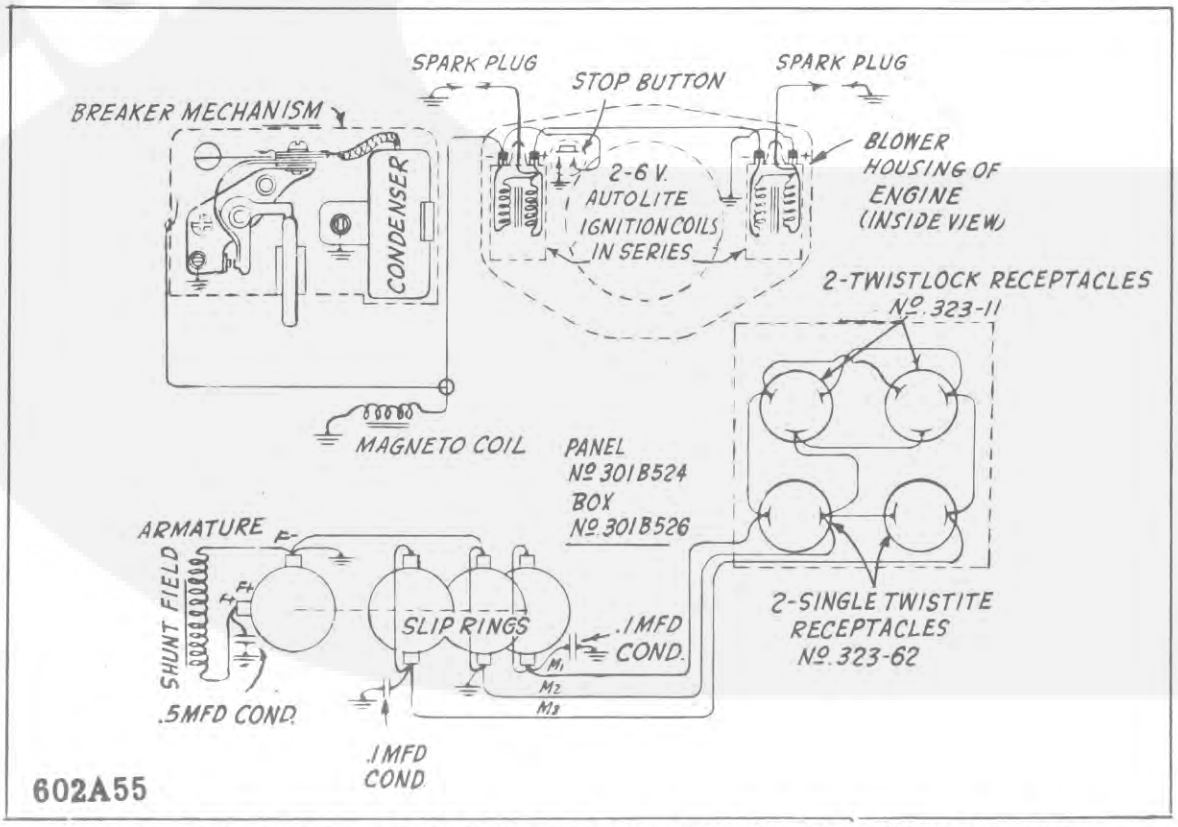

DIRECT SERVICE PLANT -
115 & 230 VOLT DC LESS CARRYING FRAME



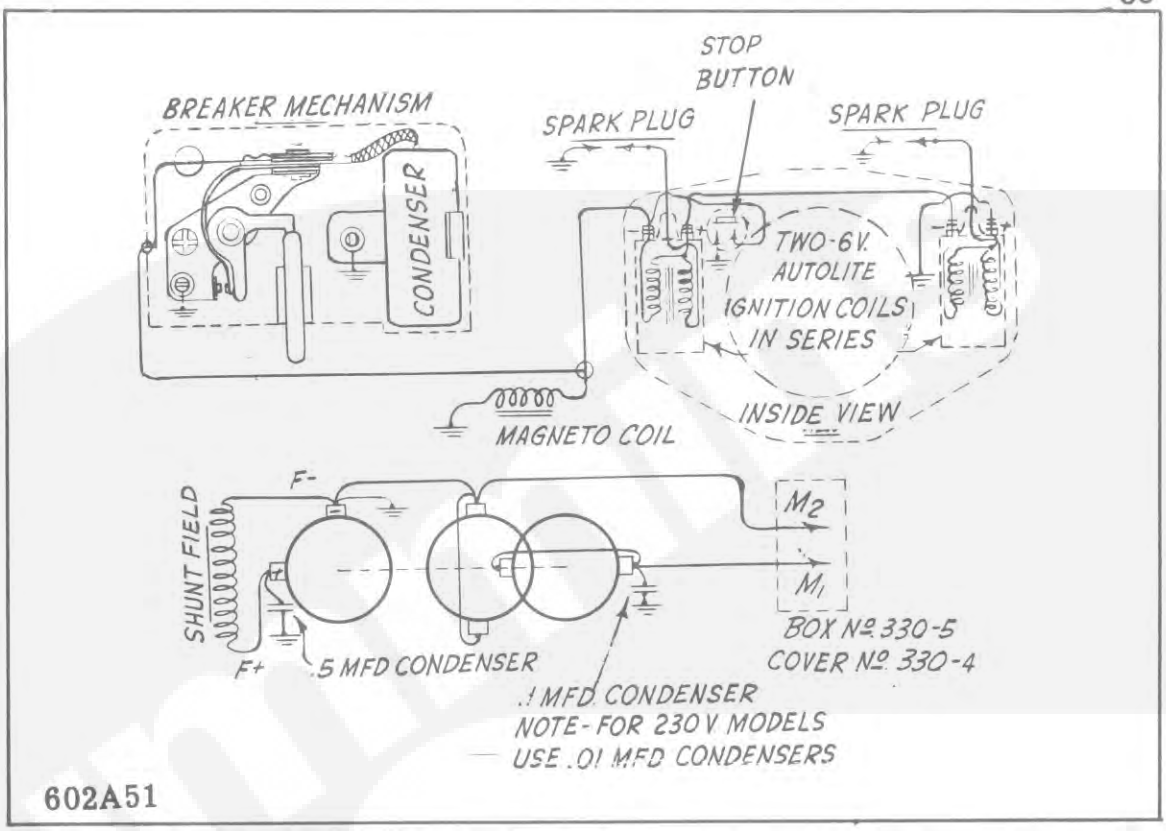

DIRECT SERVICE PLANT - 115 VOLT DC WITH CARRYING FRAME



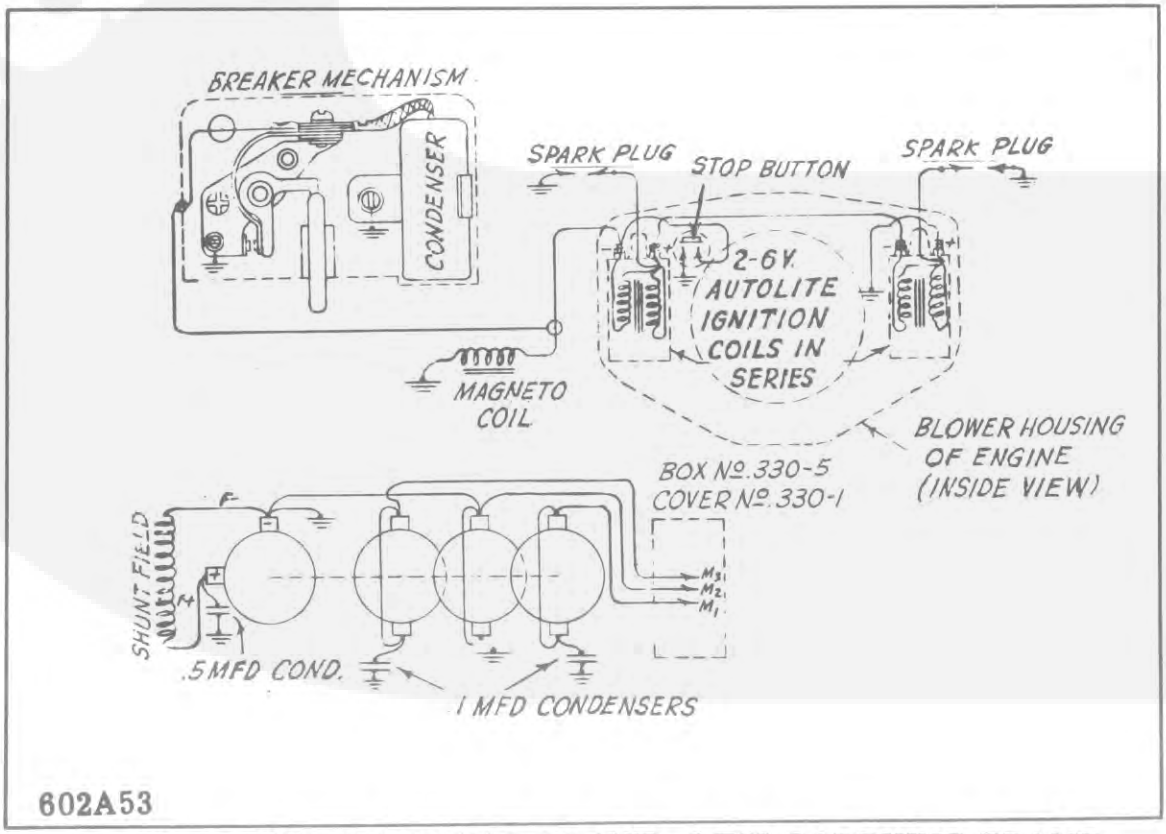

1 PHASE, 2 WIRE MANUAL PLANT WITH CARRYING FRAME



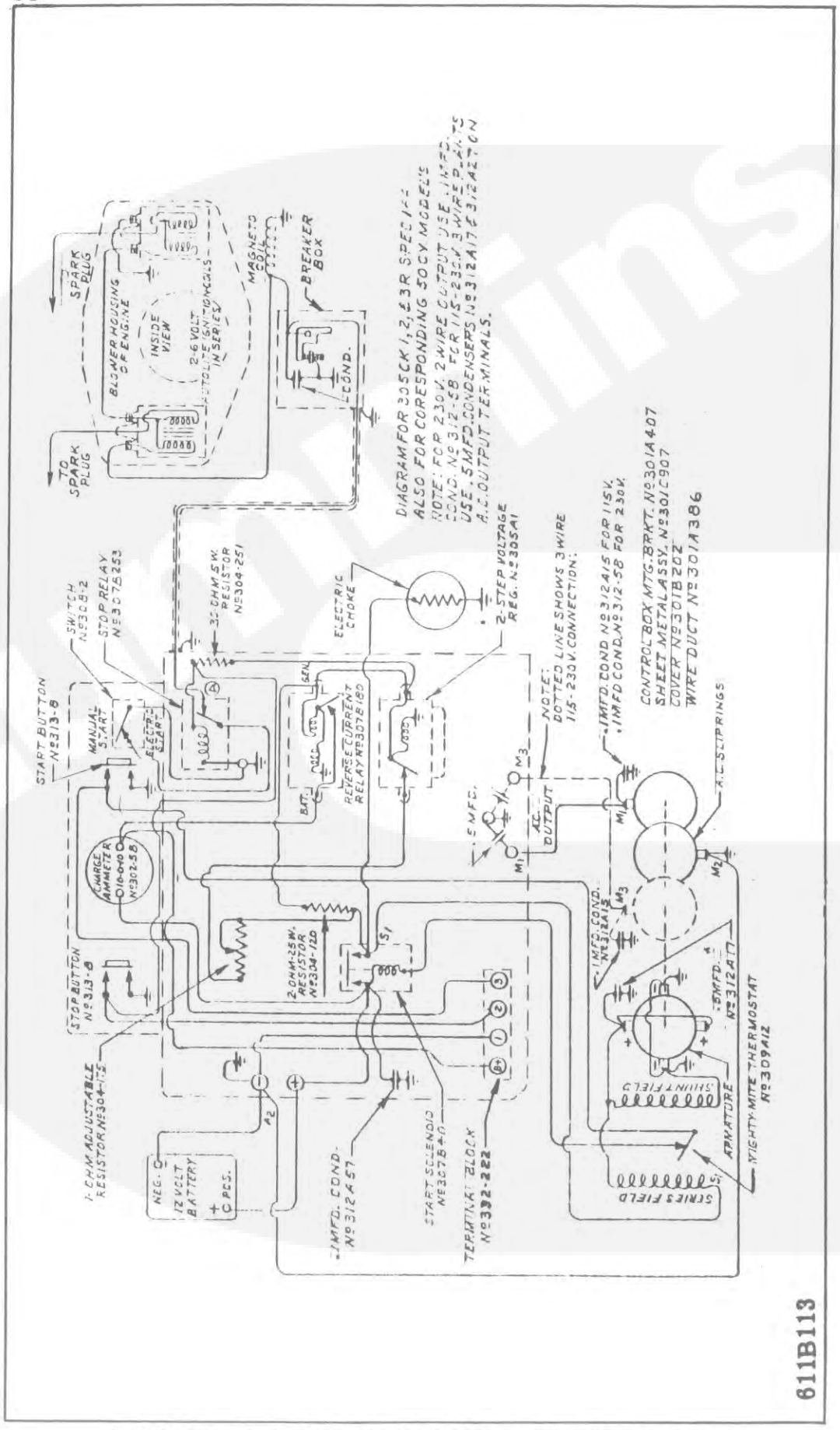

1 PHASE, 3 WIRE MANUAL PLANT WITH CARRYING FRAME



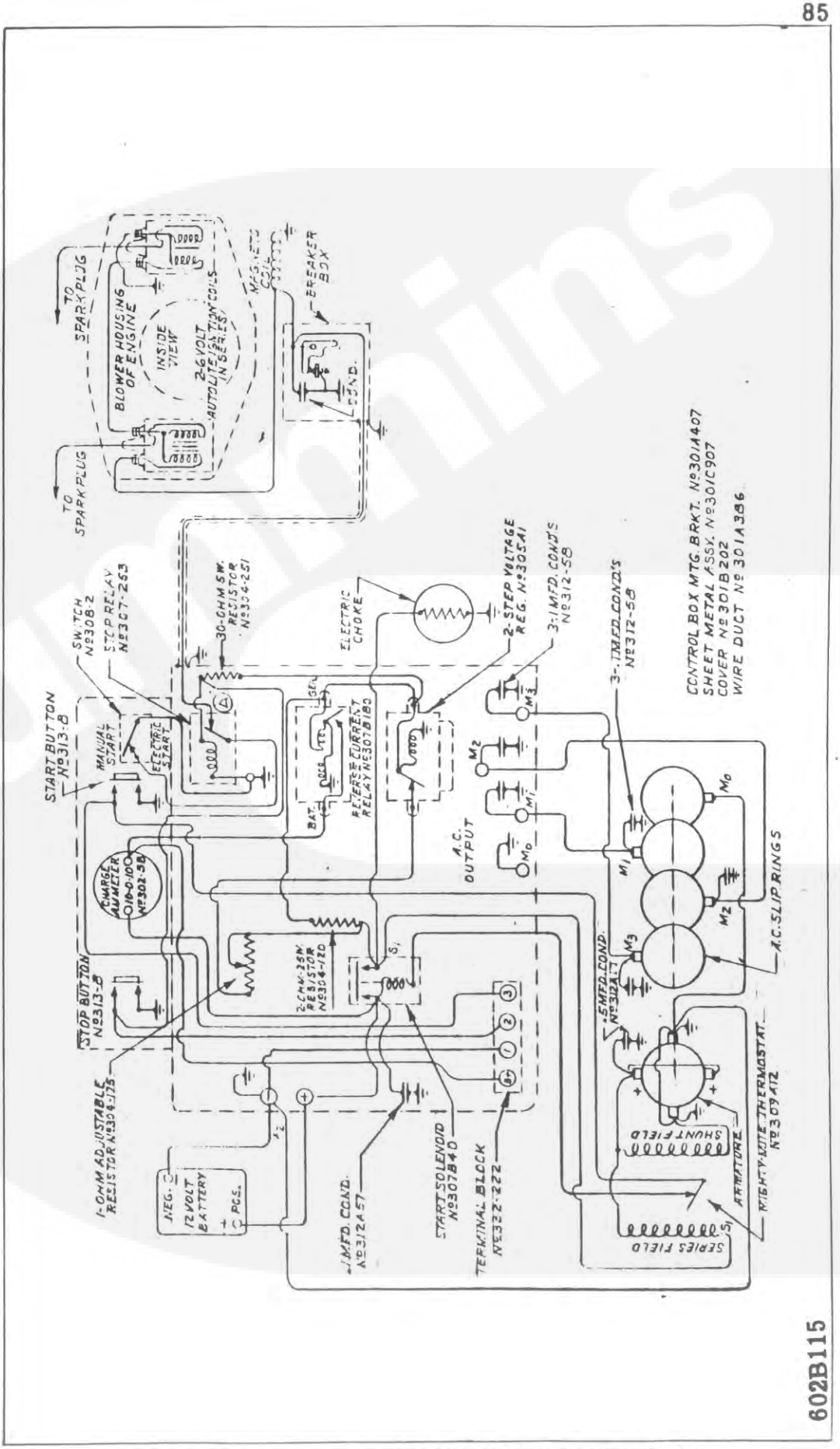

1 PHASE, 2 WIRE MANUAL PLANT, LESS CARRYING FRAME



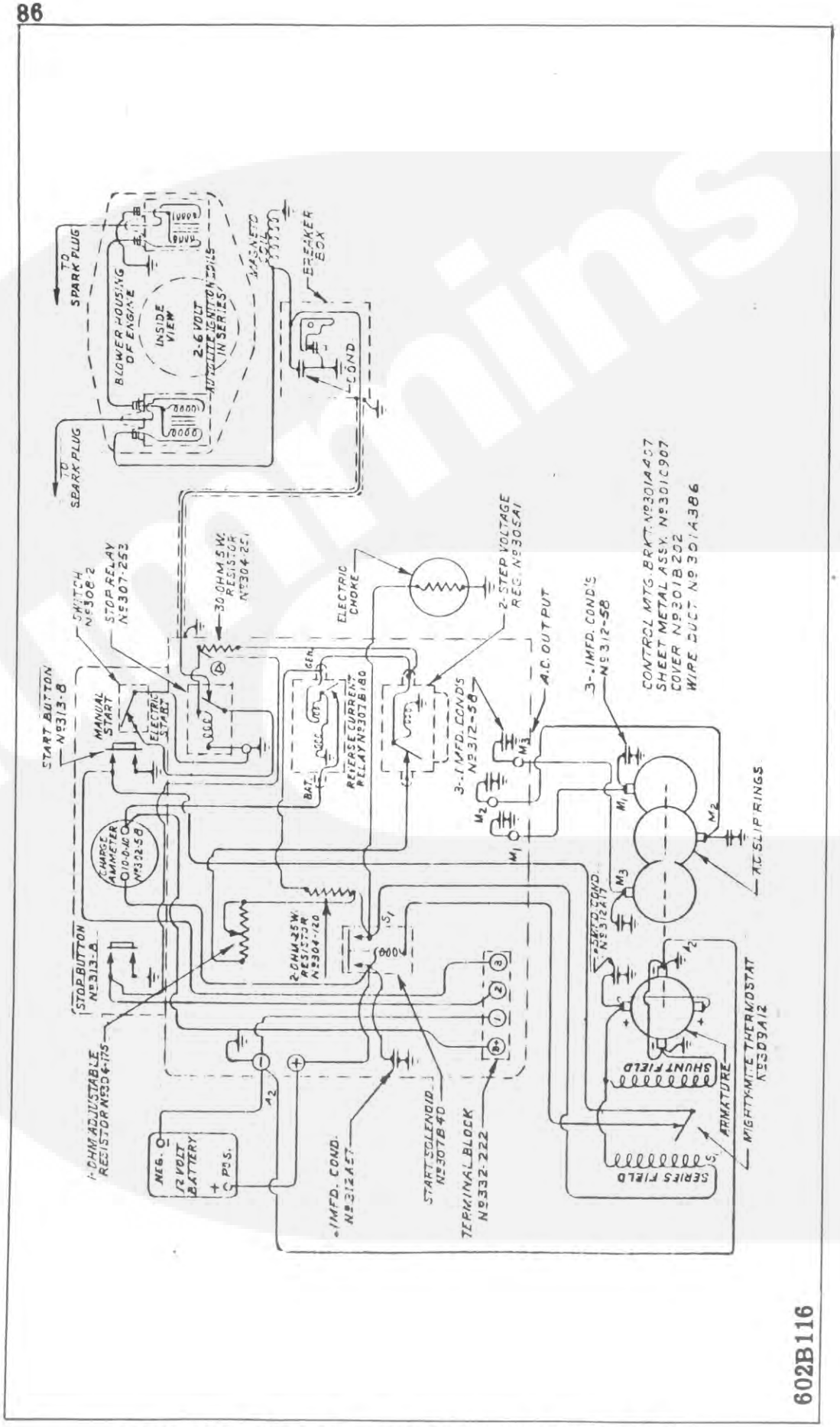

1 PHASE, 3 WIRE MANUAL PLANT, LESS CARRYING FRAME



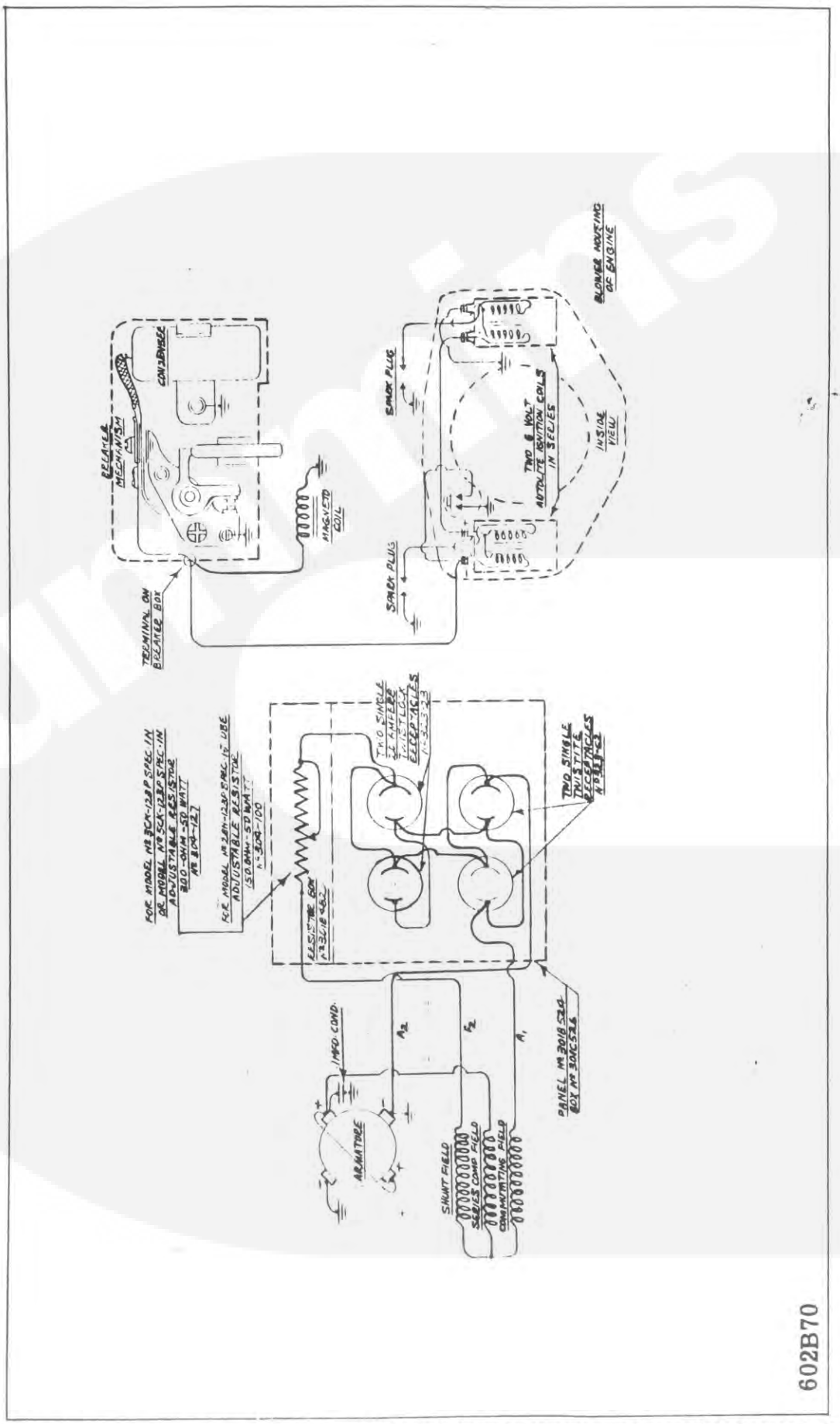

1 PHASE, 2 & 3 WIRE REMOTE START PLANT




3 PHASE, 4 WIRE, REMOTE START PLANT




3 PHASE, 3 WIRE, REMOTE START PLANT




DIRECT SERVICE PLANT- 230 VOLT DC WITH CARRYING FRAME


cummins