OWNER'S MANUAL

of

Operating Instructions

CW

Series

ELECTRIC GENERATING PLANTS

•

Specifications

A-B

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

920-7 ******

GENERAL INFORMATION

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

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

SERVICE. If trouble occurs and the operator is unable to determine the cause after a thorough study of this book, or if he is unable to determine what repair parts are required, needed information will be furnished upon request. When asking for information, be sure to state the Model, Spec., and Serial numbers of the plant. This information is absolutely necessary and may be obtained from the nameplate on the plant.

MANUFACTURER'S WARRANTY

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

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

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

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

IMPORTANT--RETURN WARRANTY CARD ATTACHED TO PLANT.

ONAN ELECTRIC GENERATING PLANTS

o

CW

Series

o

Alternating Current Models

o

D. W. ONAN & SONS INC.

MINNEAPOLIS 14, MINNESOTA

Handy Reference to Contents

Congratulations!

You have made a fine investment in this ONAN CW series electric generating plant If this is your first ONAN generating plant, be assured that you have the best. If you have had others, you will soon come to appreciate this "CW" unit.

This "CW" electric plant is ruggedly built of the finest materials by master craftsmen. The engine and generator were designed for each other. It will start easily in practically any kind of weather. It will continue to produce its full rated output for an amazingly long time.

The "CW" was designed to be used! You have every right to expect long trouble-free service from your "CW" generating plant and it requires a minimum of care. To insure such service, and to protect your investment, it is only logical that you use a high quality oil in the engine and see to it that the few simple periodic services are performed as recommended in this manual. When minor adjustments are necessary, all adjustable components are readily accessible.

The finest equipment made can provide the service built into it only if it receives the proper service. Likewise the "CW" will reward proper care.

Be sure to return the registration card attached to the unit. Its return affords you all of the factory services to which you are entitled as an owner of an ONAN Electric Generating Plant. It introduces you to us and helps us to be of service to you if it ever becomes necessary for you to write about your plant.

D. W. ONAN & SONS INC.

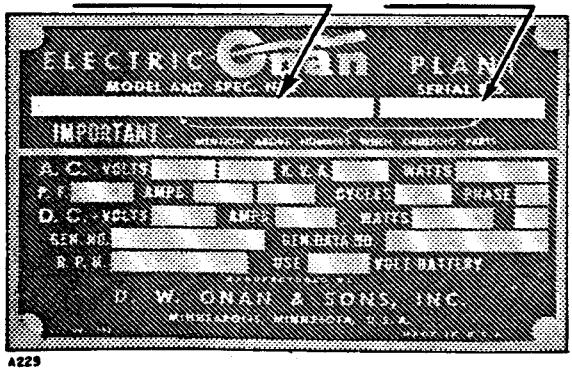
Important !

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

WRITE IN NUMBERS SHOWN ON PLANT NAMEPLATE

MODEL & SPEC. NO.

SERIAL NO.

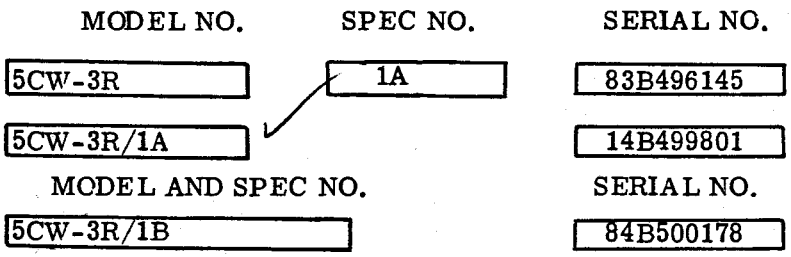


A229

INTRODUCTION

This instruction manual is supplied to assist in the proper installation, operation, and servicing of the CW series of electric generating plants. Unless otherwise stated, these instructions apply to all standard plants of the CW series. Basic differences in the CW plants are indicated by a letter A, B, etc. ending the model or specification number as given on the plant nameplate.

This specification or model designation may appear in one of the three ways shown in the examples below.



Some details of these instructions may not apply to special models having modifications specified by the purchaser. Due to the wide variety of uses for which these plants are suitable, these instructions must be of a general nature. The use of auxiliary or special equipment, special installation requirements, or unusual operating conditions may require the operator of this generating plant to modify these instructions. However, by using the instructions and recommendations given in this manual as a general guide, it will be possible to make a good installation, and to properly operate and maintain the plant.

DESCRIPTION

Each CW generating plant is a complete electric power plant, consisting of an internal combustion engine, and a self excited electric generator directly connected to the engine. Controls and accessories suitable for a normal installation and according to the particular model are supplied. The manual type of plant is designed for manual starting only, and can not be connected to batteries for electric starting. The remote control type of plant is designed for electric starting. When properly connected to a 12 volt battery, the plant may be started electrically at the plant, from one or more remote control switch points, or through automatic controls. The remote control type plant has a built-in charging circuit for keeping the starting battery in a well charged condition.

Each generating plant is given an actual running test at the factory and is carefully checked under various electrical load conditions before shipment, to assure that it is free of any defect and that it meets all performance requirements. Inspect the plant carefully for any damage which may have occurred in shipment. Any part so damaged must be repaired or replaced before putting the plant into operation.

ENGINE

The engine is a horizontally opposed 2 cylinder, air cooled, 4 stroke cycle, L head, internal combustion type. Standard models burn gasoline fuel. Some special models are equipped to burn natural gas or LPG fuel.

DATA

Cylinder Bore - 4" (Cylinders removable)
Piston Stroke - 3-1/2"
Piston Displacement - 88 cu. in.
Compression Ratio - 5.5 to 1
Piston - Aluminum Alloy - 3 ring - chrome plated top ring
Connecting Rods - Forged Steel
Connecting Rod Bearings - Replaceable Precision Type - 2-3/8" diameter.
Main Bearings - Replaceable Precision Sleeve Type - 2-3/4" Dia.
Crankshaft - Forged Steel - Counter-weighted and balanced.
Lubrication - Gear type oil pump - force feed to main and connecting rod bearings. Oil filter, pressure gauge, level indicator.
Oil Capacity - 5 U.S. Quarts
Valves - Stellite faced exhaust valves and seats.
Tappets - Adjustable.
Ignition - Impulse coupled magneto. Alternate firing.
Governor - Internal centrifugal flyball type. External adjustments. Vacuum operated speed booster on models of more than 5,000 watts output rating.
Cooling - Air, Single vent.
Mounting dimensions:
Model # ending with A: 16-1/4" front to rear
16-1/2" side to side
Model # ending with B: 16-1/2 x 16-1/2

GENERATOR

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

CONTROLS

The manual starting models are provided with a manual carburetor choke, and the remote control models are provided with an electric type automatic choke. The remote control model has a start-stop switch, and charge rate ammeter. The remote control models are designed so that auxiliary automatic or line transfer control equipment may be connected.

OPTIONAL EQUIPMENT

"DAY" FUEL RESERVOIR TANK. - The "DAY" tank provides a reservoir of gasoline fuel which feeds by gravity to the carburetor. Gasoline tends to slowly evaporate from the carburetor during shut down periods. If the shut down is of lengthy duration, such as in standby service, the evaporation may be enough to prevent ready starting. The "DAY" tank keeps the carburetor full, thus insuring against starting failure due to a partially filled carburetor.

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

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

DIMENSIONS

A-All 5CW 37"
8CW, 9CW, 10CW single phase 39-1/2"
8CW, 9CW, 10CW three phase 41"
B-All spec. letter A 16-1/4"
All spec. letter B 16-1/2"
C-All spec. letter A or with oil bath air cleaner. 31-1/2"
All with dry type air cleaner 28"

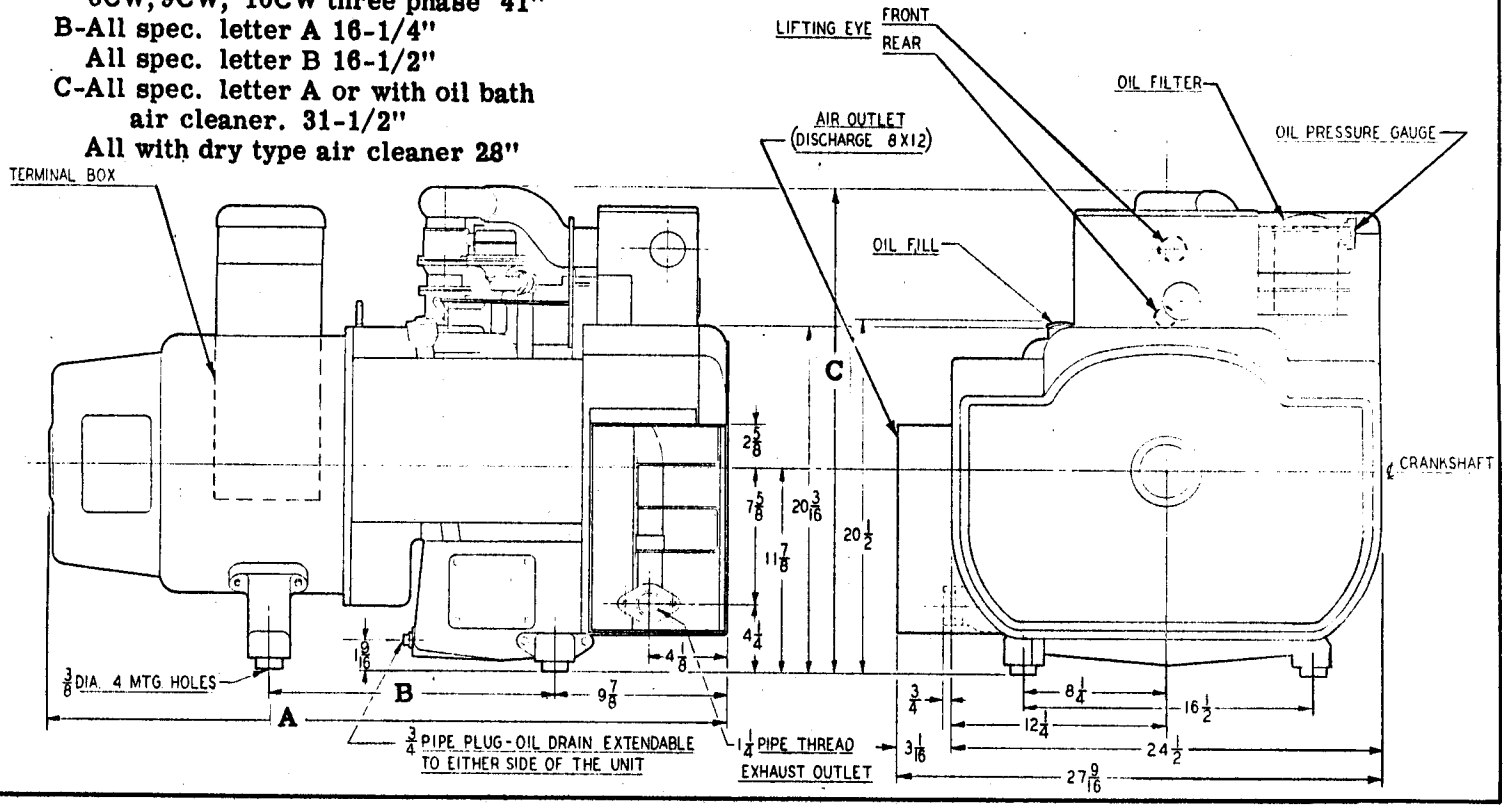


Fig. 3 Dimensions

LOCATION. - If the generating plant is to be installed in a permanent location, choose a site for mounting the plant that will be more or less centrally located in relation to the electrical load. Plan to avoid running wiring which carries a heavy electrical load for a long distance. The greater the distance, the larger the wire must be. Refer to the wiring table, page 12. The selected site should be in a clean, dry, well ventilated location, preferably heated in extremely cold weather. A dusty or damp location will necessitate more frequent servicing.

MOUNTING, PERMANENT INSTALLATION. - The most satisfactory base for mounting the generating plant is one made of concrete. A heavy timber base may prove satisfactory in some installations. The top dimensions of the base should be a minimum of 20" x 20". The base may be of any convenient height, allowing approximately 24" clearance space on all sides for access in servicing the plant. Be sure the top of the mounting base is smooth and level, so as to avoid excessive strain on any one of the four mounting feet. Space the 3/8 inch diameter mounting bolts 16-1/2" x 16-1/2"; except when the plant model number ends in "A" - use 16-1/4" spacing for front-to-rear dimensions Fig. 3. Use care to properly assemble the mounting cushions, washers, and spacer bushings as shown in the mounting detail drawing Fig. 4. The spacer bushing prevents excessive compression of the rubber cushions, which would lessen their shock absorbing qualities.

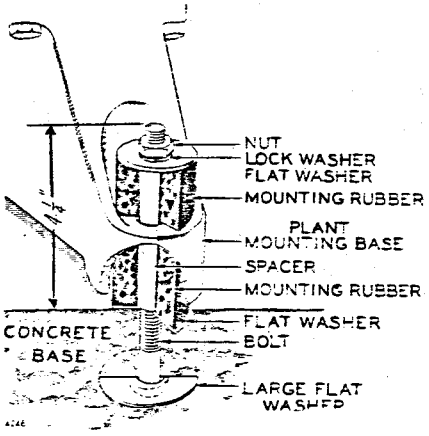


Fig. 4 Mounting Detail

MOUNTING, MOBILE INSTALLATION. - The CW generating plant is adaptable to a variety of mobile applications. If the plant is mounted in a truck or trailer, be sure to mount it securely in place, making provision for servicing the plant as necessary. Proper ventilation for cooling is particularly important in mobile installations, because of the limited space usually available. Refer to VENTILATION AND COOLING in the following paragraph. Extra support for the truck or trailer floor may be necessary, to prevent the mounting bolts from tearing loose. Considerable strain may be present on rough roads or in turning sharp corners. Refer to the PERMANENT INSTALLATION mounting instructions for mounting details. Be sure the plant will be fairly level when in operation.

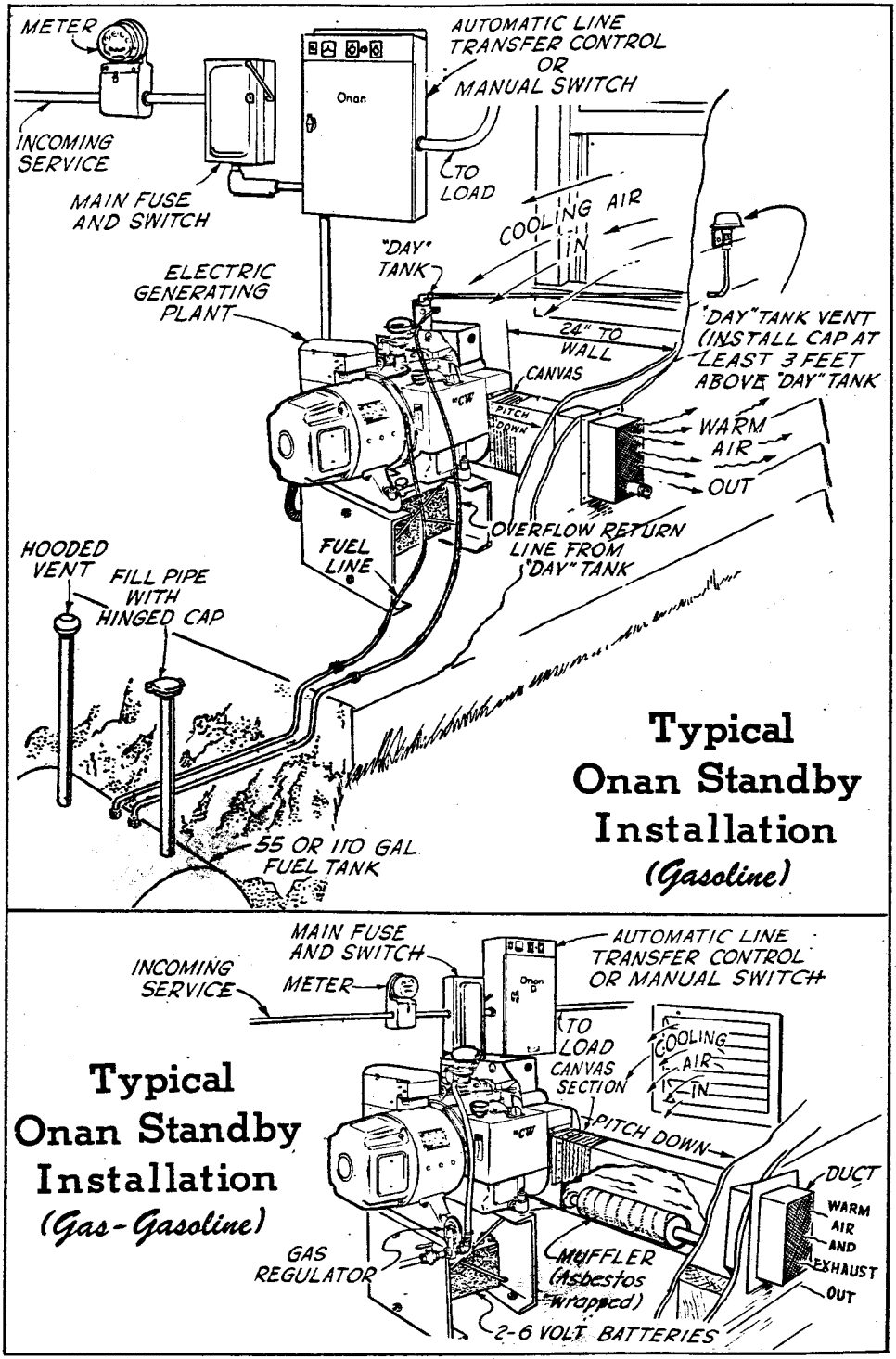


Fig. 5 Typical Installation

VENTILATION AND COOLING. - There must be a constant supply of fresh air for cooling the plant. In a large room, or out doors, cooling will be no problem. However, if the plant is installed inside a small room or compartment , provide separate air inlet and outlet openings. Cooling air travels from the rear of the plant, through the generator and over the engine cooling surfaces, and is blown out through a single outlet at the left front end of the plant. Locate the compartment air inlet opening where most convenient. This air inlet opening should be not less than 4 square feet in area, to provide for proper cooling.

To prevent recirculation of heated air, install a duct between the plant air discharge opening and the room or compartment outlet opening. An 8" x 12" air outlet adapter is supplied with each plant, for use with a duct. Factory tests under high temperature conditions indicate satisfactory cooling using standard commercially available 8" x 12" ducting up to 9 feet in length and with no more than 2 radius type 90 degree elbows. Do not use square type elbows. Increase the duct size for longer lengths or if additional turns are necessary. Use a short convas section to connect the duct to the plant, to absorb vibration.

CAUTION

If the plant will be operated in below freezing temperatures (32°F. or 0°C.) provide a means of blocking off part of the heated air outlet. If an outlet duct is used, a damper valve in the duct will be satisfactory. To prevent over cooling and resulting condensation and sludge formation in such cold weather operation, the heated air outlet flow should be restricted to about 50% of its normal warm weather flow.

EXHAUST. - The engine exhaust gases must be piped outside any room or enclosure, as the exhaust gases are deadly poisonous. The engine exhaust connection is located at the cooling air discharge opening, and is threaded for standard 1-1/4" inch pipe. Use the flexible tubing provided, to connect between the plant exhaust outlet and any rigid pipe extension or the muffler. Never use pipe smaller than 1-1/4 inch size.

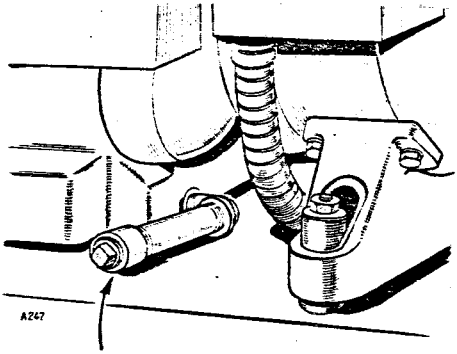
If the exhaust line must be a lengthy one, increase the size of the pipe one size for each additional 10 feet in distance. Thus a 20 foot line would use 1-1/2 inch pipe, a 30 foot line would use 1-3/4 inch pipe, etc.

Insulate or shield the exhaust pipe if there is danger of any one touching it, or if it must be run close to any wall or other material that is not completely fire proof. If the exhaust line must pass through a combustible wall or partition, provide shield collars for the line, with the openings for the line at least 2 inches larger on all sides than the exhaust line.

If turns in the exhaust line are necessary, avoid 90° pipe elbow turns. If the line must be run upward at any point, construct a condensation trap of suitable pipe fittings and install the trap at the low point in the line. The trap must be drained periodically.

Connect the 1-1/4" end of the muffler toward the engine, using the flexible exhaust extension between the plant outlet and any extension pipe.

OIL DRAIN EXTENSION. - The oil drain extension may be changed to the opposite side, if more convenient. Disassemble at the elbow, turn the elbow in 1/2 turn to point in the opposite direction, and reassemble. See Fig. 6.



OIL DRAIN PIPE MAY BE EXTENDED TO EITHER SIDE OF UNIT

Fig. 6 Oil Drain Extension

BATTERY CONNECTION. - For plants designed for electric starting, two 6-volt batteries (or one 12-volt battery) are required to supply starting current. When two 6-volt batteries are used, use the short jumper battery cable to connect the positive (+) post of one battery to the negative (-) post of the second battery, connecting them in series for 12 volts. Connect the remaining battery terminal posts to the proper terminals in the terminal box on the generator, Fig. 7. Do not reverse the connections, taking care to observe correct polarity as shown.

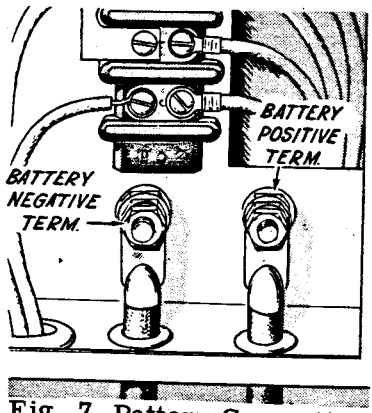


Fig. 7 Battery Connection

NOTE

If the plant will be operated consistently in temperature conditions above 90°F. (32.2°C.) such as in tropical or boiler room installations, reduce the battery specific gravity. Refer to UNUSUAL OPERATING CONDITIONS, HIGH TEMP.

VOLTAGE SELECTION, SINGLE PHASE PLANT. - All plants which have the designation 3M or 3R in their model number-for example 5CW-3M/1A, 10CW-3R/12B - are single phase plants. The single phase plant is designed for use as either a 115/230 volt (3 wire), 115 volt (2 wire), or 230 volt (2 wire) unit.

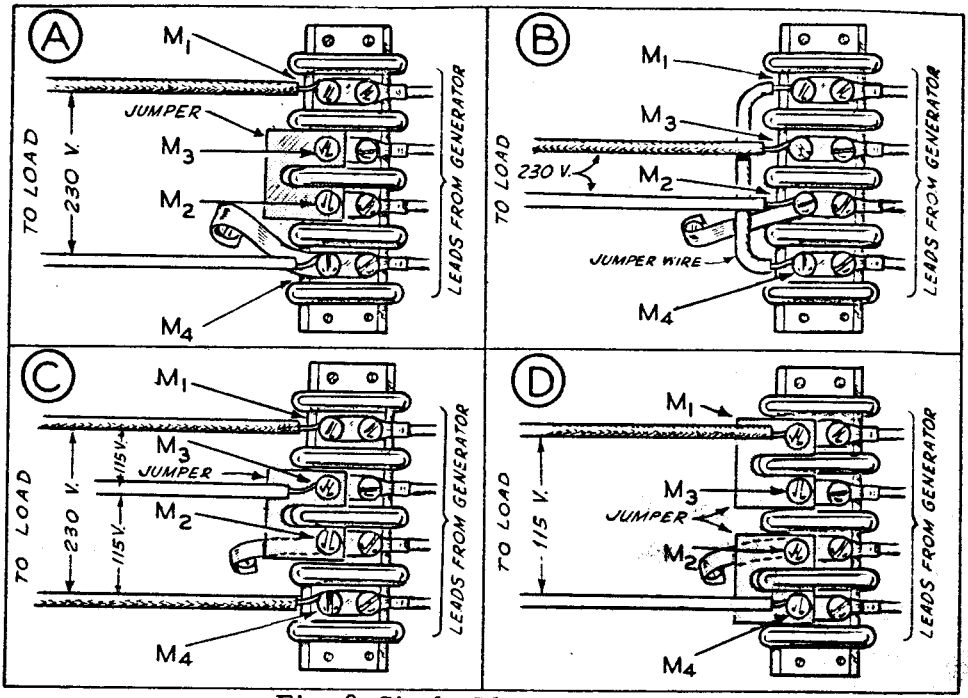


Fig. 8 Single Phase Plant

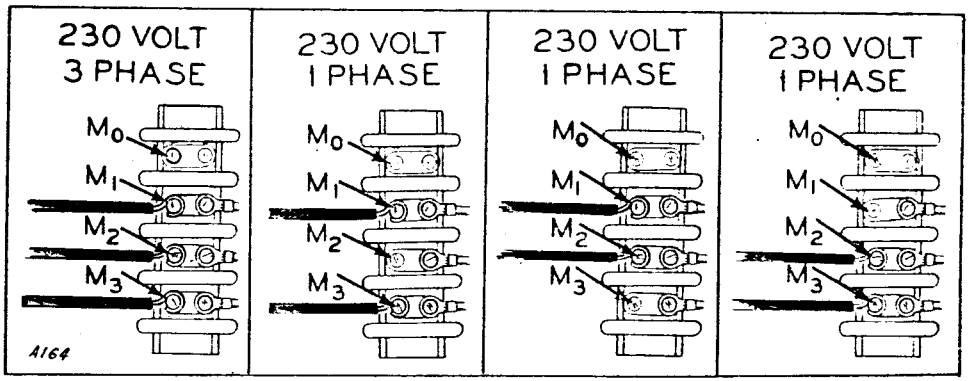


Fig. 9 Three Phase, Three Wire Plant

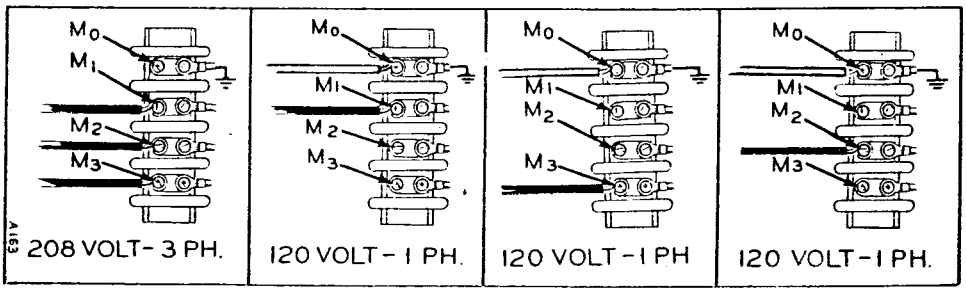


Fig. 10 Three Phase, Four Wire Plant

115/230 VOLT, 3 WIRE SERVICE

Load connections are to be made to terminals inside the terminal box on the side of the generator. These load terminals are marked M1, M3, M2, and M4 from top to bottom. When the plant is shipped, two heavy jumper bars are connected across terminals M3 and M2. This jumper connection provides for two 115 volt circuits (with 1/2 the plant capacity available on each separate circuit), or one 230 volt circuit. Refer to C, Fig. 8 . For 115 volt service, connect the black (hot) wires to the M1 and M4 terminals, and the white (ground) wire to the M2 or M3 terminal. Remember that ONLY ONE HALF the rated capacity of the plant will be available on either of the two separate 115 volt circuits. The two black wires will give 230 volt ungrounded service.

115 VOLT, 2 WIRE SERVICE

If the full rated capacity of the plant at 115 volts ON ONE CIRCUIT ONLY, is desired, remove the two jumper bars from across terminals M3 and M2. Reconnect the jumper bars, one across terminals M1 and M3, and the other jumper across terminals M2 and M4. Connect the black (hot) load wire to the M1 terminal, and the white (ground) wire to the M4 terminal. Refer to D, Fig. 8.

230 VOLT SERVICE

If 230 volt current only is to be used, and NEITHER load wire is white (grounded), leave the jumpers connected across terminals M3 and M2. Connect load wires to terminals M1 and M4. Refer to C, Fig. 8.

NOTE

Consult the local electrical code to determine if a grounded 230 volt load wire is necessary.

If a grounded 230 volt circuit is to be used, refer to the plant nameplate. If the MODEL (or SPEC) designation of the plant ends with the letter "A", follow procedure A below. If the MODEL (or SPEC.) designation of the plant ends with the letter "B" (or C etc.), follow procedure B below.

A. Remove the two jumper bars connecting terminals M3 and M2, temporarily. Disconnect the short grounding wire from the M2 terminal and connect it to the M4 terminal. Reconnect the jumper bars across terminals M3 and M2. Connect the black (hot) load wire to the M1 terminal, and the white (grounded) load wire to the M4 terminal. Refer to A, Fig. 8.

B. Remove (and save for possible future use) the two jumper bars connecting terminals M3 and M2. Using a short length of #10 or larger wire, connect terminals M1 and M4 together. Connect the black (hot) load wire to the M3 terminal, and the white (grounded) load wire to the M2 terminal. Refer to B, Fig. 8.

LOAD WIRE CONNECTIONS. - In making load wire connections to the plant output terminals, comply with requirements of the local electrical code. Install a fused main switch or circuit breaker between the generating plant and the load.

SINGLE PHASE PLANT

Be sure the jumper connections are properly made, as explained under VOLTAGE SELECTION, SINGLE PHASE PLANT. Connect the load wires to the proper terminals as shown, according to the jumper connections made, Fig. 8.

3 PHASE, 3 WIRE PLANT

Connect the load wires to the 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. See Fig. 9.

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

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. Refer to Fig. 10.

For single phase current, connect the "hot" load wire to any one of the terminals M1, M2, or M3. Connect the ground wire to the M0 terminal. 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 M1, M2, and M3, one wire to each terminal. Connect the ground wire, if used, to the M0 terminal.

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.

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	3 750	
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

In both tables above, figures represent ONE-WAY distances, not the length of wire back and forth. Distances shown in *italics* indicate that for the amperage in the same line in column at left, only weatherproof wire may be used. In all other cases either Type R or Type T or weatherproof wire may be used.

Each figure indicates the maximum distance in feet each size wire will carry the amperage in the left column, with 2% voltage drop. If you wish to permit 4% drop, double the distances shown. If you wish to permit 5% drop, multiply all distances by 2½.

REMOTE CONTROL CONNECTIONS. _ A small four place terminal block, for remote control connections, is mounted in the control box of remote control models. To provide for remote control of starting and stopping, connect the remote control switch to this terminal block, Fig. 11.

Two types of remote control switches have been supplied. Connect the single, unmarked terminal of the switch (marked #1 on one type) to the terminal block No. 1 terminal.

Connect switch terminal marked OFF (marked #2 on one type) to the terminal block No. 2 terminal. Connect switch terminal marked ON (marked #3 on one type) to the terminal block No. 3 terminal. If additional switches are installed, they must be connected in a parallel circuit, all No. 1 (or single, unmarked) terminals together, all No. 2 (or OFF) terminals together, and all No. 3 (or ON) terminals together.

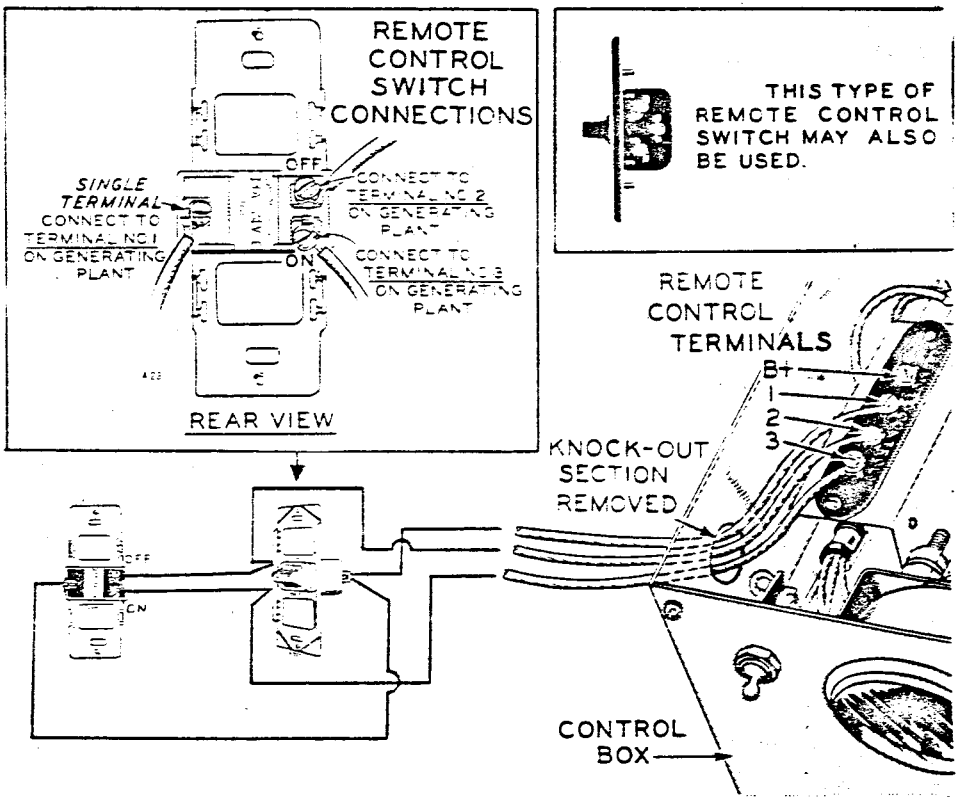


Fig. 11 Remote Control Connections

NOTE

For remote control distances, #18 wire can always be used up to 100 feet in wire length. For distances of more than 100 feet, certain plants will require larger size wire, as shown in Table I.

TABLE I - REMOTE CONTROL DISTANCE AND WIRE SIZE

MODEL (OR SPEC.) ENDING WITH LETTER "A".

MAX DISTANCE	WIRE SIZE
100 Ft.	#18
160 Ft.	#16
250 Ft.	#14
Over 250 Ft. (NOT RECOMMENDED)	

MODEL (OR SPEC.) ENDING WITH LETTER "B".

MAX. DISTANCE	WIRE SIZE
300 Ft.	#18
510 Ft.	#16
775 Ft.	#14

GROUNDING THE PLANT. - Most local electrical codes require that a generating plant be grounded. Methods of grounding may vary according to the local electrical code. A ground which meets most requirements can be made by driving a 1/2 inch pipe into the earth, making sure the pipe penetrates moist earth. Use a suitable clamp on the pipe and run a #4 wire to the plant. Connect the ground wire to any convenient metal part on the plant, such as using a second clamp on the oil drain pipe. Be sure good electrical contact is made.

CAUTION:

Some early plants with SPEC designation ending in the letter "A" were not internally grounded. If inspection shows that there is no ground jumper wire between the M2 terminal and a grounding screw inside the terminal box (Fig. 8), a similar ground connection must be made. Run a short length of No. 10 wire between the battery negative terminal and the M2 terminal, if 115/230 volt service is to be used. If grounded 230 volt service is to be used, connect the ground jumper to the M4 terminal, instead of to the M2 terminal. BE SURE THIS GROUND JUMPER WIRE IS PRESENT IN ALL CASES WHERE USING AUTOMATIC CONTROL EQUIPMENT.

FUEL CONNECTION. - The standard plant is supplied with a separate 5 gallon (U.S. measure) gasoline can. After installing the fuel shut off valve in the fuel tank outlet, connect the flexible line. Connect the non-swivel end first, to the plant fuel inlet connection at the left side of the generator (Fig. 12). Connect the swivel end of the line to the fuel tank shut off valve. Do not reverse these line connections, as the threads on opposite ends of the line are different. Use care to start the theads straight and tighten only enough to prevent leakage.

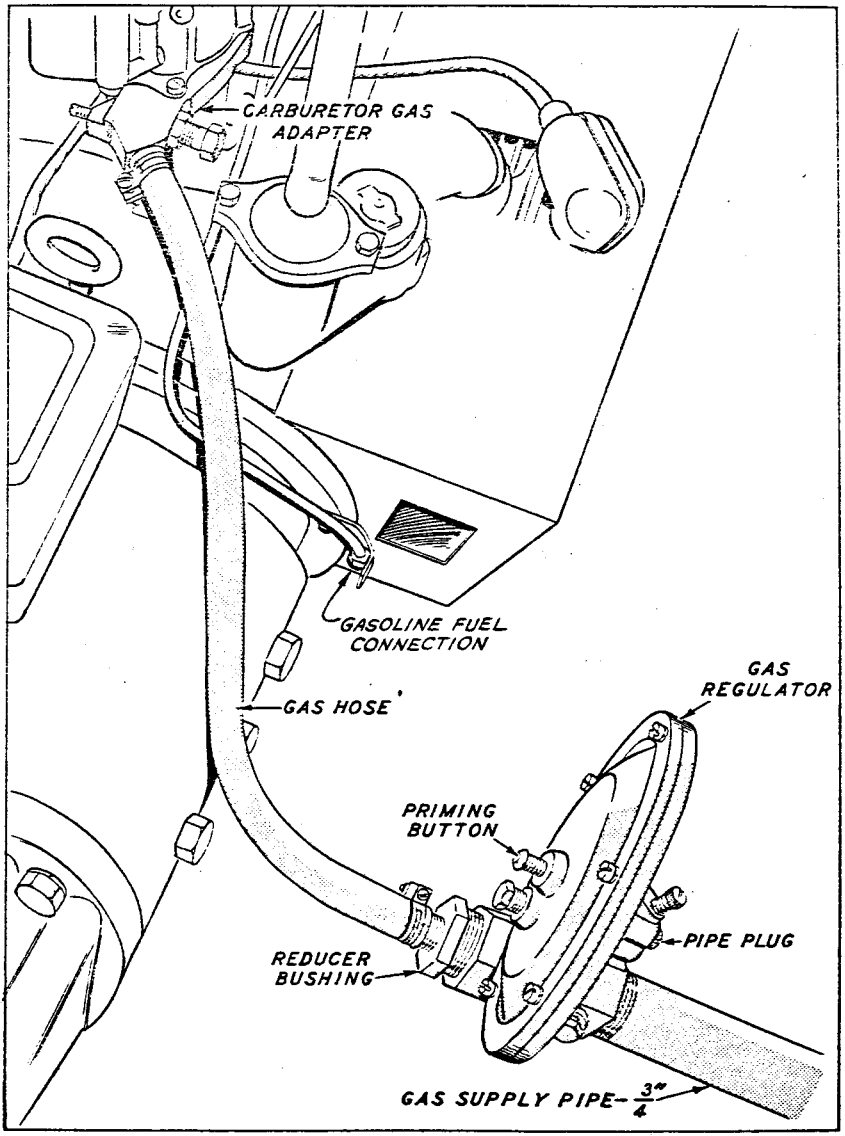


Fig. 12 Fuel Connection

If an underground fuel tank is to be used, follow the instructions supplied with the tank equipment. Comply with any local building or fire regulations.

NOTE

On some applications, if the distance of fuel lift from an underground tank is too great, an auxiliary fuel pump may be necessary. For plants with model (or spec) ending with the letter "A", fuel pump lift is approximately 4 feet. For plants with model (or spec) ending with the letter "B", fuel pump lift is approximately 14 feet.

If the plant is designed for use of natural gas fuel (or LPG), mount the atmospheric type gas regulator in an upright position, separate from the generating plant but as close to the plant as practicable. Do not mount the regulator on the plant. The atmospheric type regulator supplied is designed to operate on a gas supply line pressure of 4 to 6 ounces. If the pressure is excessive, a primary type regulator must be installed to reduce the pressure.

If the gas supply line pressure is not known, consult the fuel supplier. LPG ("bottled") gas tanks are usually fitted with a pressure reducing regulator which may have to be adjusted by the fuel supplier. See that the line pressure as the gas enters the regulator supplied with the plant is between 4 and 6 ounces.

CRANKCASE. - The capacity of the engine oil base is 6 quarts, U.S. Measure. Be sure to fill with 6 quarts of oil before putting the plant into operation. Use a good quality, heavy duty (detergent) type of oil. Select the proper SAE number of oil according to the expected temperature, as indicated in Table II.

TABLE II. CRANKCASE OIL

TEMPERATURE	SAE NUMBER
Above 90°F (32°C.) (Continuous Duty)	50
30°F to 90°F (-1°C to 32°C)	30
0°F to 30°F (-18°C to -1°C)	10
Below 0°F (-18°C) See UNUSUAL OPERATING CONDITIONS)	5W

If a non-detergent type of oil is used, and a change is later made to a heavy duty (detergent) type of oil, allow not more than one third the usual operating hours between the next two oil changes. Thereafter, change oil at the regular periods, as recommended under PERIODIC SERVICE.

NOTE

When using a heavy duty (detergent) type oil, always use oil of the same brand when adding oil between changes. When mixed together, detergent oils of different manufacturers sometimes form chemical compounds harmful to internal engine parts.

ALWAYS TIGHTEN THE OIL FILL CAP SECURELY. A slight vacuum is normally maintained in the engine crankcase. If the oil fill cap is loose, or if the gasket is damaged, an air leak at this point will destroy the vacuum. Loss of the vacuum may result in excessive oil consumption or in an oil leak past the crankshaft oil seals.

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

NOTE

If the plant is to be used for standby service, do not fill the air cleaner cup with oil. Under average conditions, very little dust is present, and the plant can be operated safely without oil in the air cleaner.

AIR CLEANER, DRY PACK TYPE. - After removing the air cleaner cover, lift out the pack element and dip in clean oil, of the same SAE number as used in the crankcase. Allow the excess to drip off. Reinstall the pack element and cover.

AIR PREHEATER HOSE KIT. - An air preheater kit is supplied for use in temperatures below 50°F. (10°C.). If the plant is to be operated in temperatures below 50°f., particularly if high humidity prevails, install the preheater kit. Refer to Fig. 13. Remove the sheet metal plug from the upper left corner of the engine blower housing. Assemble the hose to the air tube and insert the tube into the blower housing opening. Attach the other end of the air hose as shown, according to the type of air cleaner used.

NOTE

For best operation, disconnect the air heater hose when the surrounding air temperature is 60°F. or higher. No harm will result from leaving the hose connected at higher temperatures, but a slight drop in power and lowered efficiency may be noted.

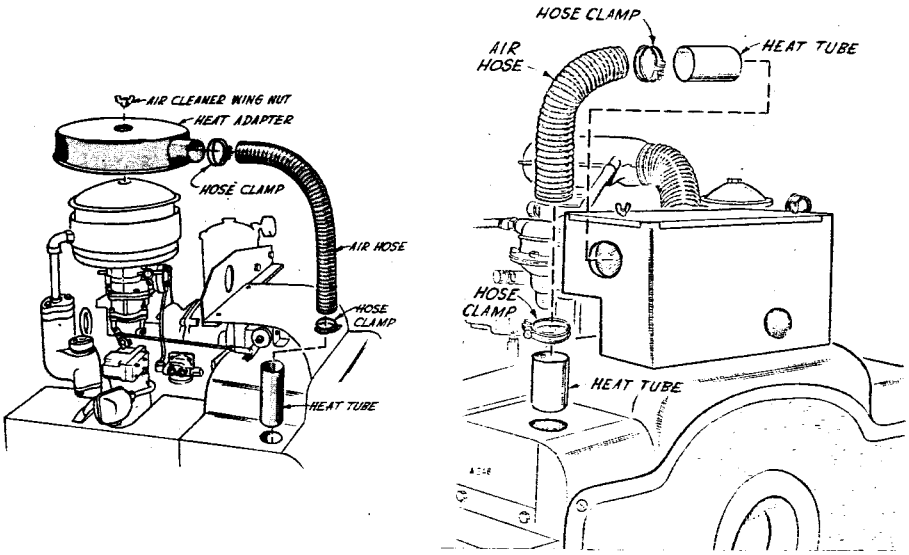


Fig. 13 Air Preheater Hose

GASOLINE FUEL. - Fill the fuel tank nearly full with a good grade of fresh, clean, "regular" automotive type of gasoline. Do not use a highly leaded "premium" type of gasoline. The use of any gasoline which has a high lead content will require more frequent carbon or lead removal, spark plug, and "valve grind" servicing. However, do not use a low octane gasoline, such as "stove gas", as its use will cause low power, excessive "spark knock", and damage to the engine.

CAUTION

Observe the usual safety precautions in handling gasoline. Special precautions must be taken when the fuel tank is near the plant. Never fill the tank while the plant is running, and do not fill completely full. Cold gasoline expands with heat, and as the plant warms up the gasoline may overflow from the tank, causing a fire hazard.

GAS FUEL. - If gas fuel is to be used, be sure that all connections are leak proof. See that the line pressure at the regulator inlet is 4 to 6 ounces. In some localities, presence of foreign matter in the fuel may require installation of a trap or filter. If LPG (bottled) fuel is used, be sure a proper pressure regulator is installed to reduce the gas pressure as it enters the regulator supplied with the plant to not more than 6 ounces.

PLANT RUNNING HOURS COMPARED TO AUTOMOBILE RUNNING MILES

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

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

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 "

GENERATING PLANT RUNNING HOURS		AUTOMOBILE RUNNING MILES
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.

PRELIMINARY. - Before starting the plant, be sure that it has been properly installed, and that all requirements under PREPARATION have been met. Starting batteries MUST BE CONNECTED to a plant designed for electric starting unless special precautions are taken as explained below under OPERATING WIYH BATTERIES DISCONNECTED.

CAUTION

ALWAYS BE SURE THAT ALL AIR HOUSING PARTS (cylinder air covers, blower housing) ARE PROPERLY INSTALLED BEFORE STARTING THE PLANT. The air housings direct the air flow to properly cool the engine and generator. UNLESS EACH AIR HOUSING PART IS CORRECTLY FASTENED IN PLACE, SERIOUS DAMAGE FROM CVER HEATING WILL RESULT.

STARTING THE PLANT ELECTRICALLY. - See that the small toggle switch is at the "ELECT. START" position. Push the "START-STOP" switch to the "START" position. THE PLANT MAY HESITATE FOR SEVERAL SECONDS BEFORE CRANKING PAST COMPRESSION ON THE FIRST REVOLUTION HOLD THE STARTING SWITCH CLOSED FOR THIS HESITATION PERIOD. THE ENGINE WILL CRANK OVER COMPRESSION AND THEN GAIN NORMAL CRANKING SPEED. A sharp, distinct clicking sound will be heard as the engine is cranking, indicating that the magneto impulse coupling is operating. The sound will disappear as soon as the engine starts and picks up running speed.

NOTE:

On the initial start, or if the plant has run out of fuel, the engine must turn over enough times to pump fuel to the carburetor and fill it, before the plant willl start.

Oil was sprayed into the cylinders before the plant was shipped, and it may be necessary to remove the spark plugs and clean them with gasoline before the plant will start the first time. Dry the plugs thoroughly before reinstalling them.

A thermostat device has been incorporated in the cranking winding of the generator. This thermostat acts as a cranking limiting switch to protect the generator against over-heating during cranking. The thermostat contact points may open and break the starting circuit if the cranking load is exceptionally heavy or if the cranking period is prolonged. The contact points of the thermostat will automatically close and permit normal cranking again as soon as the temperature of the cranking winding returns to normal, which may require 3 to 12 minutes.

If the plant starting batteries do not have sufficient cranking power, or if the plant can not be cranked electrically for other reasons, the plant can be started manually. Disregard manual choking instructions when

hand cranking a plant designed for electric starting. However, do not disconnect the starting batteries unless a wire in the control box is first disconnected, as explained below.

OPERATING WITH BATTERIES DISCONNECTED. - If operation with batteries disconnected becomes necessary on a plant designed for electric starting, the generator dc output must be disconnected. Disconnect the single wire (marked "B" on some models) which connects at one end of the three charge circuit resistors, Fig. 14. Disconnect also the wire at the electric carburetor choke.

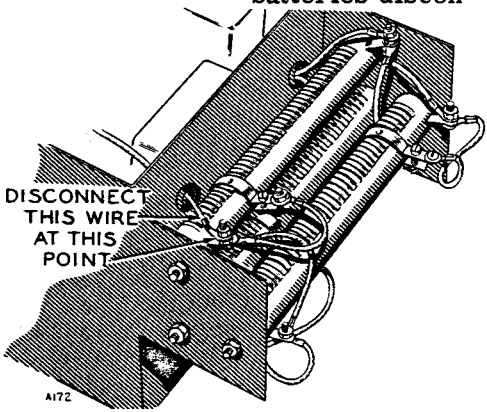


Fig. 14 DC Output Disconnect Point

CAUTION!

BURNED OUT RELAYS IN THE BATTERY CHARGING CIRCUIT WILL RESULT IF THE PLANT IS RUN WITHOUT BATTERIES UNLESS THIS WIRE IS DISCONNECTED

Tape up the ends of the disconnected wires, to prevent a short circuit. After the dc output wire is disconnected, the plant can be started and safely operated without batteries. Be sure to reconnect the wires when batteries are again connected to the plant. Throw the small toggle switch to the "HAND CRANK" position, to permit starting and running.

STARTING THE PLANT MANUALLY. - Adjust the manual choke control (manual starting models only) to choke the carburetor according to temperature conditions. When starting an engine which has been standing idle in cold weather, full choking may be necessary. Little or no choking will be necessary in extremely hot weather, or if the engine is still warm from recent running.

Manual starting models (and some electric starting models) are equipped with a primer on the fuel pump. On the initial run, or if the plant has run out of fuel, operate the fuel pump primer 10 to 20 strokes to

properly fill the carburetor.

If the plant is the electric starting type, throw the small toggle switch on the control box to the "HAND CRANK" position. Return the switch to the "ELECT. START" position as soon as the plant starts, unless "operating with batteries disconnected".

Slip the starting crank over the pilot shaft at the center of the blower wheel and engage the crank. Crank the engine with a quick upward pull on the crank handle. A sharp clicking sound will be heard, indicating that the magneto impulse coupling is functioning. This sound disappears as soon as the engine starts. Do not "spin" the engine nor push downward on the crank. Repeat the cranking as necessary, using only upward pulls on the crank handle. Remove the crank as soon as the plant starts.

WARM UP PERIOD. - As soon as the plant starts (manual type), adjust the manual choke control to the point of smoothest operation. As the plant warms up, gradually push the choke control inward. Be sure the choke is all the way in when the plant is fully warmed up. If operating an electric starting model without batteries, it will be necessary to loosen the electric choke at the carburetor and rotate the choke housing manually.

Check the oil pressure as indicated on the oil pressure gauge. The oil pressure should be between 20 and 30 pounds, but may be somewhat higher until normal running temperature is reached.

If conditions permit, allow the plant to warm up before connecting the electrical load. If the plant tends to alternately speed up and slow down, it is usually an indication that more warm up time is needed before connecting a heavy electrical load.

DURING OPERATION. - The generator is designed so that a temporary heavy over load, such as exists while starting an electric motor, will not injure the generator. However, continuous heavy over loading of the generator will cause the generator temperature to rise to a dangerous point, and may lead to failure of the windings. The generator is designed to produce its rated capacity continuously, or a 25% over load for a period of less than 2 hours, under normal temperature conditions.

On single phase plants, if two 115 volt circuits are used, not more than 1/2 the rated capacity of the plant should be connected to either ONE circuit. On three phase plants, if part of the load is single phase, the total load on any one circuit should not exceed 1/3 the rated capacity of the plant. Refer to INSTALLATION (LOAD WIRE CONNECTIONS).

OPERATION BELOW 50°F (10°C). - Under conditions where the air temperature is 50°F. or lower, and the humidity is quite high, ice formation inside the carburetor may occur. Such icing consists of actual building up of ice around the carburetor throttle plate and is due to the refrigerating action of the carburetor causing moisture in the air to freeze and collect on the throttle plate and surrounding parts. Icing may result in a gradual drop in engine speed (and generator voltage) and binding of the throttle. Under such conditions, connect the air preheater hose to direct hot air to the air cleaner. Refer to PREPARATION (AIR PREHEATER HOSE).

STOPPING THE PLANT. - If conditions permit, disconnect the electrical load before stopping the plant. To stop the plant, press the START-STOP switch to the STOP position, holding contact until the engine comes to a complete stop. If the STOP switch is released too soon, the engine may pick up speed again and continue to run.

NOTE

The STOP switch on manual starting models is a small button on the rear of the magneto.

If an electric starting model is being operated with the starting batteries disconnected, throw the small toggle switch to the ELECT. START position, to stop the plant. The STOP switch (and all other control box equipment) is by-passed when the toggle switch is at the HAND CRANK position.

GAS FUEL OPERATION. - A special carburetor is used on plants equipped for gas fuel operation. See that the float lock screw (B, Fig. 17) is turned up tightly to prevent the float from vibrating inside the carburetor. If an emergency source of gasoline fuel is also connected, see that the gasoline shut off valve is closed. See that the choke lock wire (A, Fig. 17) is properly inserted through the choke shaft hole, to hold the choke in its wide open position.

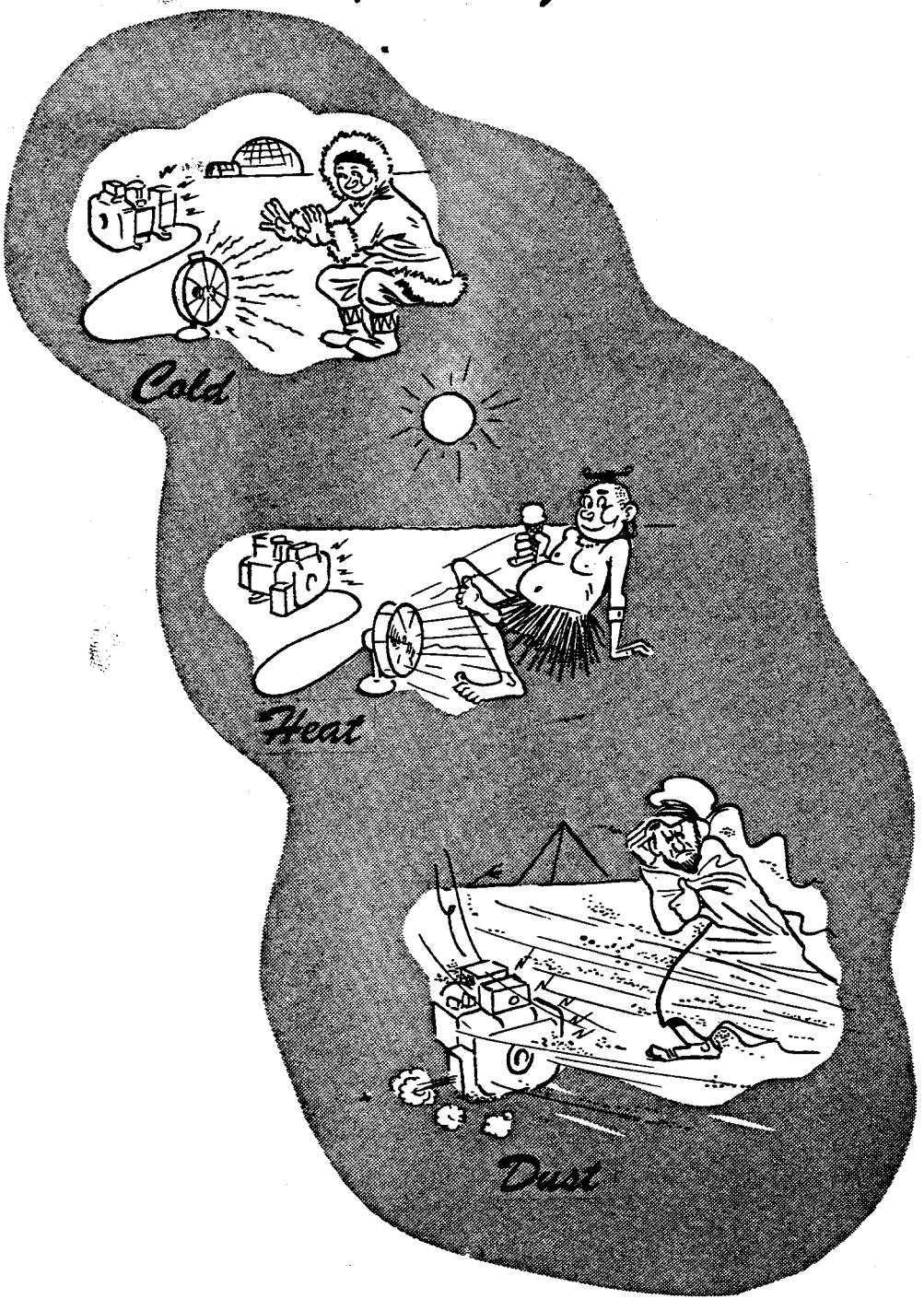
To start the plant the first time, it may be necessary to press the regulator priming button (Fig. 12). The plant was test run on 1000 BTU gas, and some adjustment of the carburetor may be necessary if a different BTU content gas is used. Refer to ADJUSTMENTS.

If gasoline fuel is going to be used to operate a plant equipped for gas fuel, a few preliminary change-over steps are necessary.

1. Be sure the gas fuel supply is turned off. If the gas supply line is disconnected, install a plug in the regulator inlet. If the gas connection hose is disconnected, close the carburetor gas adjusting screws to prevent any entry of air through the gas inlet opening.

2. Pull the choke lock wire out of the choke shaft hole, to permit normal choke operation.
3. Back off the float lock screw (B, Fig. 17) until it seats firmly in the down position. Turn the gasoline shut off valve to its open position.

Unusual Operating Conditions



LOW TEMPERATURES

COOLING. - When the plant is operated in temperature of 32°F(0°C) or lower, over cooling will result unless the hot air discharge is partially restricted. Refer to INSTALLATION (VENTILATION AND COOLING). Failure to partially restrict the air flow in cold weather will cause the engine to run too cool, condensation will form in the crankcase, and the breather valve may become inoperative from sludge or condensation.

CRANKCASE OIL. - For cold weather operation, select the SAE number of the crankcase oil according to the lowest temperature expected before the next oil change. See PREPARATION. If an unexpected drop in temperature takes place, use caution in starting the plant after a shut down period. Do not attempt to start a plant which is so "stiff" that it is difficult to hand crank. Congealed oil may not flow readily, resulting in lack of lubrication to vital parts and causing serious damage. In an emergency, apply heat gradually directly to the oil base to warm the oil, using care as there is danger of cracking the oil base due to rapid expansion of the metal. When the oil is sufficiently fluid, start the plant and allow it to thoroughly warm up. Stop the plant and change the oil to the proper SAE number as recommended for the expected temperature conditions under PREPARATION. After changing to a lighter oil, always run the plant for a few minutes to circulate the lighter oil through the engine.

If SAE 5W oil is not obtainable, dilute SAE 10W oil with 10% kerosene (approximately 1 pint of kerosene to 5 quarts of oil). Thoroughly mix the oil and kerosene just before pouring it into the engine. Immediately start the engine and run it for at least 10 minutes to circulate the mixture through the engine. NEVER ADD KEROSENE ALONE TO THE CRANKCASE TO DILUTE THE OIL.

NOTE

Always change the oil filter element when changing to a lighter oil for cold weather operation. After running the plant for a few minutes, stop and check the oil level. Add sufficient oil to compensate for that absorbed by the new element.

AIR CLEANER. - Use the same SAE No. of oil to service the air cleaner as is used in the engine. If temperature conditions cause congealed oil to restrict the flow of air through the air cleaner, remove and clean the air cleaner. Reassemble and use the air cleaner without oil until temperature conditions permit the use of oil in the normal manner.

GASOLINE FUEL. - Use fresh, clean, winter grade (not highly leaded premium) gasoline for best starting in cold weather. Keep the fuel tank nearly full in order to cut down on the condensation of moisture inside the fuel tank. Such moisture condensation inside the tank can cause considerable trouble from ice formation in the fuel system. Condensation is most likely to occur if the temperature at the fuel tank varies considerably. Avoid filling the fuel tank entirely full of cold gasoline for expansion of the gasoline as it warms up may cause the fuel to overflow and create a fire hazard.

GAS FUEL. - Certain types of LPG fuel do not vaporize readily at low temperatures. Consult the fuel supplier if lowered performance is observed at low temperatures.

SPARK PLUGS. - Due to the cool operating characteristics of the engine, it is particularly important to use a "hot" range spark plug. Use Champion COM 8 or equivalent - never a "colder" type. A "colder" type spark plug will soon become fouled.

BATTERIES. - If starting batteries are used, check their charge condition often enough to assure that they are always well charged. The charge regulator in the plant control box regulates the charge rate for normal service, but frequent starting with short operating periods may cause the battery charge condition to drop to a point where there will not be enough power to crank the engine at low temperatures.

The cranking power of a battery drops to about 2/5 of its normal power at 0°F., and the cranking load is greatly increased. If practicable, remove the batteries to a warm place during shut-down periods in extremely cold weather. It takes but a few minutes to connect the batteries for starting, and their cranking power will be much greater if warm.

HIGH TEMPERATURES

LUBRICATION. - Use the correct SAE number oil in the oil base, as recommended under PREPARATION. Keep the oil level at or near, but never above, the "F" mark on the level indicator. Use the same SAE number oil to service the air cleaner.

COOLING. - A constant supply of fresh air must be provided for proper cooling. See that nothing obstructs the flow of air to the plant, and see that the air outlet is not obstructed in any way. Be sure that all air housing parts are undamaged and are fastened securely in proper place. Do not allow dust, dirt, chaff, etc. to accumulate on cooling fins.

BATTERY. - If starting batteries are used, check the level of the electrolyte frequently. Add approved water as often as necessary to keep the electrolyte level 3/8 inch above the plate separators, or as recommended by the battery manufacturer.

NOTE

REDUCING BATTERY SPECIFIC GRAVITY FOR LONGER BATTERY LIFE

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

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

1. Fully charge the battery. DO NOT BRING AN OPEN FLAME OR BURNING CIGARETTE NEAR THE BATTERIES ON CHARGE BECAUSE THE GAS RELEASED DURING CHARGING IS VERY INFLAMMABLE.
2. While battery is on charge, use a hydrometer or filler bulb to siphon off all of the electrolyte above the plates in each cell. Don't attempt to pour off!! Dispose of the removed electrolyte. AVOID SKIN OR CLOTHING CONTACT WITH ELECTROLYTE.
3. Fill each cell with pure distilled water, to the recommended level.
4. Recharge the batteries for one hour at a 4 to 6 ampere rate.
5. Use a reliable battery hydrometer, to test each cell. If the specific gravity is above 1.225, repeat steps number 2, 3, and 4 until the highest specific gravity reading of the fully charged battery is not over 1.225. Most batteries require repeating steps 2, 3, and 4 two times.

DUST AND DIRT

Keep the plant as clean as practicable. Service the air cleaner as frequently as conditions require. Wipe off accumulations of dust or dirt. Keep cooling fins clean and free of obstructions. Serious damage from over-heating may occur if the cooling fins are not kept clean. Keep the commutator, collector rings, and brushes of the generator clean. Keep supplies of fuel and oil in air tight containers.

STANDBY SERVICE. - If the generating plant is used for standby or emergency service only, it should be "exercised" regularly. Once or twice a week, start the plant and allow it to run long enough to thoroughly warm up (at least 15 minutes).

If the plant stands idle for an extended period without such an exercise period, gasoline has a tendency to evaporate out of the carburetor, making starting more difficult.

NOTE

A special reservoir tank which feeds gasoline by gravity to the carburetor is available as an accessory. This reservoir tank will keep the carburetor full for an extended period of idleness, if the plant can not be attended regularly.

Frequent exercising also contributes toward better lubrication, keeps moisture condensation to a minimum, and helps to keep the starting batteries in a well charged condition.

GENERAL. - Follow a definite schedule of inspection and servicing to help in keeping the plant in good running condition, and to keep operating expenses to a minimum. Service periods outlined in this section are for normal service and operating conditions. For extreme conditions, such as continuous heavy duty, extremely high or low temperatures, etc., service more frequently. For periods of little use, service periods can be lengthened accordingly. Keep a record of the operating hours each day to assure servicing at the proper periods.

DAILY SERVICE

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

FUEL. - Check the fuel supply often enough to avoid running the tank dry. If the fuel tank is run dry, it will be necessary to pump fuel to fill the carburetor, before the plant will start again. All manual start models (and some remote control models) have a manual priming lever on the fuel pump. Operate the priming lever to fill the carburetor, being sure to leave the lever in the down position when through priming. On electric cranking models without the primer, a few seconds of cranking will refill the carburetor.

CRANKCASE OIL. - Check the oil level, on the level indicator. Do not allow the oil level to fall below the lower level "L" mark on the indicator. Add oil of the proper SAE number as necessary to bring the level to the upper level "F" mark. Do not overfill the crankcase. Tighten the oil fill cap securely.

AIR CLEANER. - Service the air cleaner as often as required by the operating conditions. Under extremely dusty conditions, it may be necessary to service the air cleaner several times a day. Under dust-free conditions, every 100 hours or even less frequent servicing may be sufficient.

To service the oil bath type air cleaner, clean out the reservoir cup and refill to the indicated level with clean oil of the same SAE number as used in the oil base. Clean the filter element in solvent, dry it, and reassemble the air cleaner.

To service the "dry" type air cleaner, remove the filter packing element. Clean the element in solvent, dry, and dip in engine oil (same SAE number as used in the oil base). After allowing the excess oil to drain off the element, reassemble the air cleaner.

CLEANING. - Keep the plant clean. A clean plant will give better service, and it is easier to service a clean plant. Wipe off spilled oil, dust, dirt, etc.

WEEKLY SERVICE

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

CRANKCASE OIL. - If the plant has been operating under LOW TEMPERATURE conditions or for short operating periods, oil dilution or sludge formation may occur. Under such conditions, change the engine oil each 50 operating hours. Under normal temperature and operating conditions change the oil each 100 operating hours. Always drain the oil, when changing it, only when the plant is warm from running.

GOVERNOR LINKAGE. - Inspect the governor link ball joint and the point where the link engages the carburetor throttle arm. Keep these points free of dust. Lubricate with a "dry" type of lubricant, such as powdered graphite, if there is any binding. If a "dry" lubricant is not obtainable, use only a light machine oil of non-gumming quality.

SPARK PLUGS. - Remove the spark plugs, clean them, and adjust the gap to 0.025 inch (0.018 inch for plants operating on natural gas or LPG fuel). Replace with a new one any plug which will not pass a standard compression firing test. Be sure the wire terminal faces upward, when connecting to the plug. If the terminal faces downward, the spark may jump to the shield clamping screw, causing the plug to misfire.

BATTERIES. - If starting batteries are used, see that the connections are clean and tight. Corrosion at the terminals can be removed by flushing with a weak baking soda and water solution. Flush clean with clear water and dry thoroughly. A light coating of grease or asphalt paint will retard such corrosion. Keep the electrolyte at the proper level above the plate separators by adding clean water which has been approved for use in batteries. In freezing weather, run the plant for at least 20 minutes after adding water, to mix the water with the electroylte and prevent its freezing.

MONTHLY SERVICE

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

FUEL SYSTEM. - If the 5 gallon fuel tank is used, drain and clean to remove any sediment or water condensation. "Breathing" of the fuel tank may draw dust into the tank, or condensation

may collect, particularly under cold or damp conditions. Such a contaminated fuel system may cause hard starting or uneven operation. Remove the drain plug at the bottom of the carburetor to drain off any sediment. After servicing is completed, inspect carefully against leaks.

EXHAUST SYSTEM. - If an exhaust extension is used, inspect all connections carefully for leaks. Tighten or make any necessary repairs.

OIL FILTER. - Remove the oil filter element for inspection. If it appears to be filling with sludge, install a new element. Do not attempt to clean and re-use an element. Differences in operating conditions may lengthen or shorten the time intervals between necessary oil filter replacements. Always clean out old oil and sludge from inside the oil filter body before installing the element. A new element will absorb a pint or more of oil when the plant is started. After a few minutes of running, stop the plant and add enough oil to bring the level up to the "F" mark on the indicator.

COOLING FINS. - Remove the cylinder air covers. Clean the cooling fins of the cylinders and cylinder heads. Dirty or obstructed cooling fins will cause over heating and may lead to serious damage. BE SURE AIR HOUSINGS ARE PROPERLY REPLACED.

MAGNETO. - Remove the end cap from the magneto. Inspect the breaker contact points. Slight burning or pitting can sometimes be corrected by resurfacing smooth on a fine stone, removing for such servicing. If the points are badly burned or pitted, replace with a new set. Severe or frequent burning or pitting is usually an indication of a defective magneto condenser, which should be replaced with a new one.

Keep the contact points clean and free of oil. Adjust the gap, with the rubbing arm on the "high" side of its cam, to 0.020 inch. Put a drop of light oil on the cam oil wick. Do not over lubricate.

When installing the end cap, be sure its gasket is undamaged and properly in place.

VALVE TAPPETS. - Remove the valve compartment covers and check the tappet clearances. Adjust as necessary to a clearance of 0.012 inch for both intake and exhaust valves, at room temperature (cold setting).

CRANKCASE BREATHER VALVE. - The crankcase breather valve helps to maintain a slight vacuum inside the engine crankcase while the engine is running. If the flapper type valve becomes gummed up or otherwise inoperative, the crankcase vacuum will be destroyed and excessive oil consumption or oil seal leakage may result. After removing the valve, Fig. 15, clean thoroughly in gasoline or other solvent. Replace the valve with a new one if the flapper diaphragm is worn or otherwise damaged so as to prevent proper seating to the perforated disc.

When installing the breather valve, be sure the perforated disc faces downward, with the diaphragm upward. See that the cap is properly installed, so that there can be no air leak at this point.

CARBON REMOVAL. - The frequency of necessary carbon or lead deposits removal will vary with operating conditions. If the plant is operated at light load consistently, under cool operating temperatures, or if highly leaded gasoline is used, the combustion chambers must be cleaned frequently. Remove carbon or lead deposits as experience indicates the necessity. After removing the cylinder air covers, remove the cylinder heads and gaskets. Scrape all carbon and lead deposits from the cylinder heads and ends of the pistons, valves, etc. If a cylinder head gasket is damaged, install a new one. Install the cylinder heads, tightening the nuts evenly to 25-30 lb. ft. torque. Be sure air covers are properly replaced.

GENERATOR. - Remove the inspection plates from the generator end bell and inspect the commutator, collector rings, and brushes. In service, the commutator and collector rings acquire a brown finish, which is a normal condition. Do not attempt to maintain a bright newly machined appearance. Wipe clean with a dry, lint free cloth. Slight roughness or heavy coating may be remedied by lightly sanding with #00 sandpaper. Do not use emery or carborundum cloth or paper. If scratches or grooves are present, refinishing will be necessary. Refer to MAINTENANCE

Brushes eventually wear too short to perform their function. Brush wear will be more rapid under dusty operating conditions. Replace brushes with new ones only when worn to 1/2 inch in length. The brush springs provide equal pressure as the brushes wear shorter in use. Each spring is permanently attached to a metal plate which snaps into place. To replace a commutator brush, first remove the spring by pushing the spring plate inward and away from the brush guide, Fig. 16. To replace a collector ring brush, first remove the spring by pulling straight outward on the spring plate. When inserting a new brush in its guide, be sure that the "low" or shorter side of the beveled top of the brush is toward the spring-plate side of the guide. Be sure each brush is free in its guide. Keep the brush rig and end bell cleaned of carbon dust, etc.

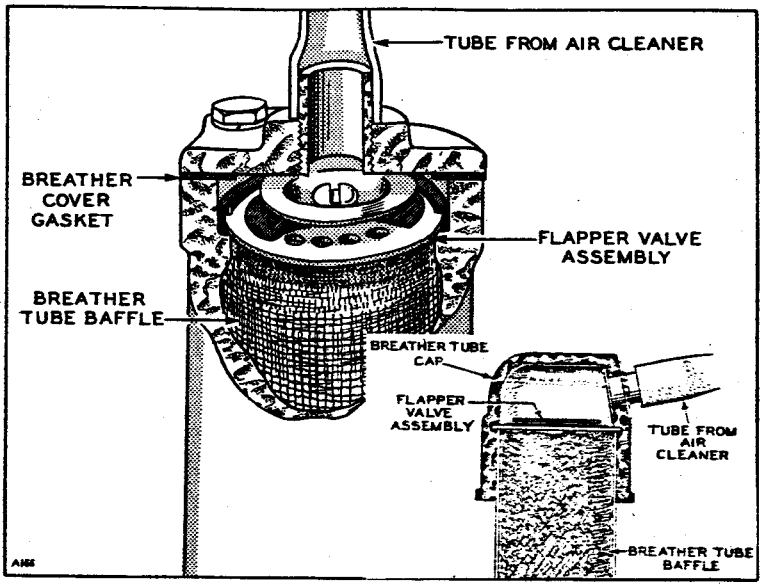


Fig. 15 Crankcase Breather Valve

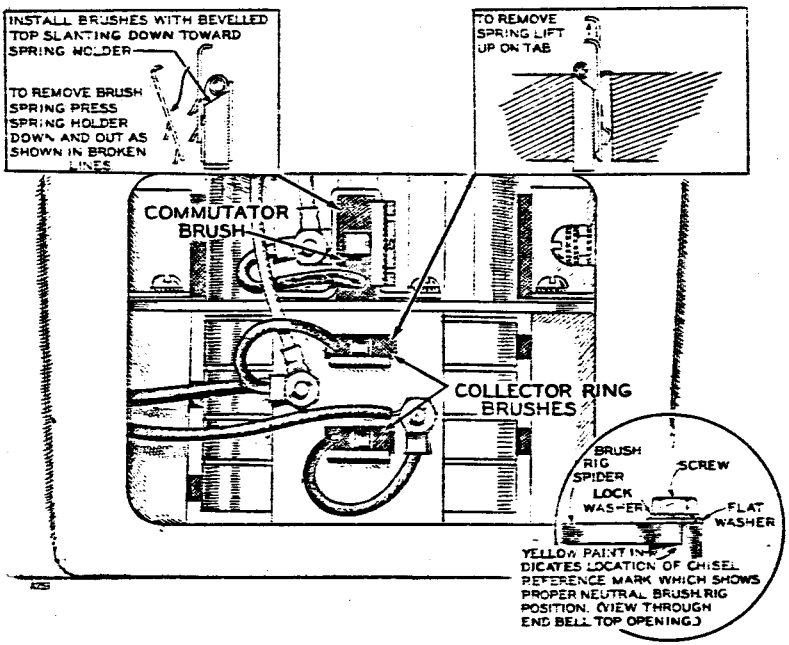


Fig. 16 Brush Rig

GENERATOR BEARING. - The generator bearing was lubricated at the factory with a lithium base grease meeting military specification MIL-G-10924. Unless dirt has gained entrance to the bearing, no further lubrication of the bearing should be necessary for 2 years, or 5,000 operating hours. If dirt has gotten into the bearing, remove the bearing, clean thoroughly in a good solvent, dry, and relubricate according to the type of lubricant used.

If lithium base grease is used, fill only a 1/4 section of the bearing with grease, with no excess or reserve in the bearing recess or cover.

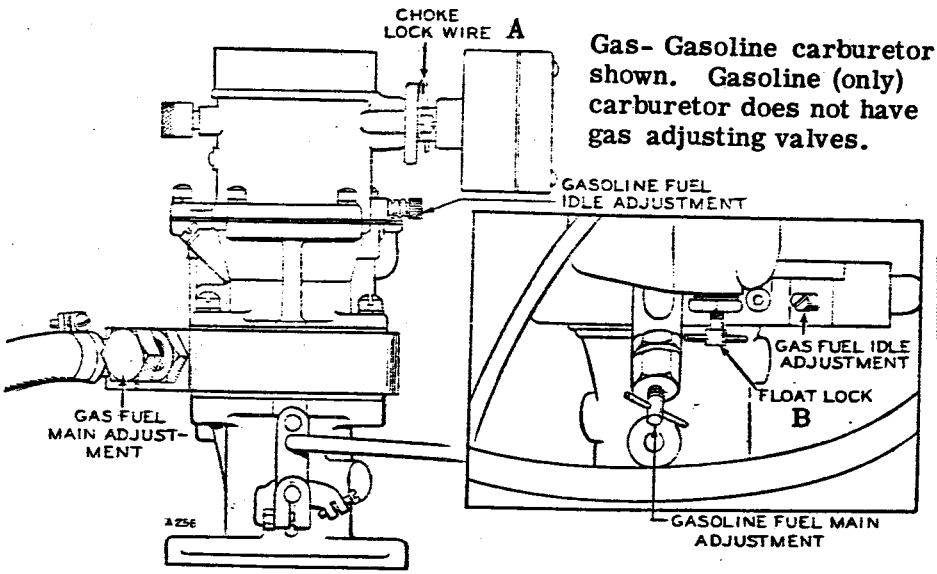
If standard ball bearing grease is used, fill a 1/2 section of the bearing with grease. Fill the bearing recess and cover 1/2 full. When using a grease other than lithium base, relubricate the bearing every six months or approximately 1200 operation hours.

GENERAL INSPECTION. - Thoroughly inspect the entire plant for oil leaks, loose electrical connections, worn parts, or loose bolts or nuts. Make any necessary repairs.

CARBURETOR, GASOLINE. - The carburetor has main and idle adjusting needle valves (Fig. 17). The main adjusting needle, at the bottom of the carburetor, affects the operation at the heavier load conditions. The idle adjusting needle, at the side of the carburetor, affects the operation at light or no load conditions.

Under normal circumstances, the factory carburetor adjustments should not be disturbed. If the adjustments have been disturbed, an approximate setting of 1-1/2 turn open for the idle needle and 1 turn open for the main adjusting needle will permit starting. Before final adjustment allow the engine to thoroughly warm up. Adjust the idle needle with no load connected to the generator. If available, connect a voltmeter of the proper range to the generator output. Slowly turn the idle adjusting needle out (counterclockwise) until the engine speed (or generator voltage) drops slightly below normal. Then turn the needle in (clockwise) until the speed (or voltage) returns to normal.

To adjust the main needle, apply a full electrical load to the generator output. Turn the main needle in (clockwise) until the engine speed (or generator voltage) drops slightly below normal. Then turn the needle out (counterclockwise) until the speed (or voltage) returns to normal. Proper carburetor adjustment can not be assured unless the governor is properly adjusted.



Gas- Gasoline carburetor shown. Gasoline (only) carburetor does not have gas adjusting valves.

Fig. 17 Carburetor Adjustments

CARBURETOR, GAS. - If the plant is equipped for gas fuel, see that the gasoline shut off is closed and that the float lock screw at the bottom of the carburetor is turned upward to its limit. See that the electric choke is locked in its wide open position.

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

Remove the electrical load and repeat the adjusting process, using the "idle" adjusting screw. For other than 5,000 watt plants, little or no "idle" screw adjustment from its closed position will be necessary.

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

ELECTRIC CHOKE. - The choke was adjusted at the factory and should operate satisfactorily at average temperatures. If the choke does not open as the engine warms up, check the heating element to be sure it is operating. In extremely cold temperatures, the choke may close so tightly that it will cause over-choking. In extremely high temperatures, the choke may not choke enough. If over-choking occurs, loosen the choke housing clamping screw and turn the housing slightly to the left (counterclockwise). Do not turn too far; a few degrees is usually sufficient. Tighten the clamp. To increase the choking action, turn the choke housing slightly to the right (clockwise).

GOVERNOR. - The governor controls the engine speed, and therefore the voltage and frequency of the generator output. 60 cycle plants are adjusted at the factory to a maximum no load speed of 1890 rpm. 50 cycle plants are similarly adjusted to 1590 rpm. maximum. These are maximum figures, and may sometimes be as low as 1800 rpm for 60 cycle or 1500 for 50 cycle plants. A voltmeter or frequency meter (preferably both) should be connected to the generator output in order to correctly adjust the governor.

PRELIMINARY STEPS

1. With the plant stopped, check the clearance of the carburetor throttle stop lever. The clearance between the lever and stop pin should be approximately 1/32", Fig. 18. This clearance can be adjusted by loosening the linkage ball joint and turning the ball joint on the linkage threads as necessary to lengthen or shorten the over-all length of the linkage. Be sure that the lever to which the link connects is securely

clamped on the carburetor throttle shaft.

Pull the governor arm gently toward the front of the engine several times. Any binding, sticking, or excessive looseness in the travel will cause erratic governor action. The action must be smooth, subject only to the tension of the governor spring.

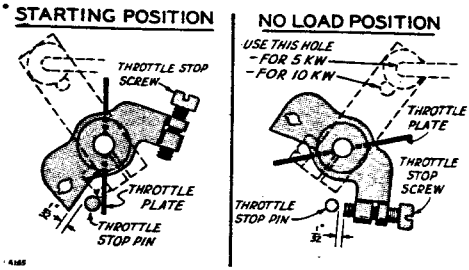


Fig. 18 Throttle Lever and Stop Pin

2. Start the plant and run at a light electrical load for long enough to thoroughly warm up. If the governor is completely out of adjustment, make a preliminary adjustment at no load to first attain a safe voltage operating range, as directed below under ADJUSTMENT. The plant must be thoroughly warmed up before a satisfactory final governor adjustment can be made.

ADJUSTMENT 5,000 WATT PLANT

1. With the plant operating at no load, turn the speed adjusting nut, F Fig. 19, to obtain a frequency reading of between 60 and 63 cycles for a 60 cycle plant (50 to 53 cycles for a 50 cycle plant). The voltage should be within the limits shown in the table III according to the rated voltage shown on the plant nameplate.

TABLE III GOVERNOR ADJUSTING LIMITS

PLANT RATED VOLTAGE	NO LOAD VOLTS (MAXIMUM)	FULL LOAD VOLTS (MINIMUM)	NO LOAD FREQUENCY (MAXIMUM)	FULL LOAD FREQUENCY (MINIMUM)
115/230V. SINGLE PHASE	124/248V.	112/224V.	63	58
230V. 3 PH.,3 WIRE	248	*224		
460V. 3 PH.3 WIRE	496	*448		
120/208V. 3 PH.,4 WIRE	224 (3 PHASE)	*202 (3 PHASE)		
220/380V. 3 PH.4 WIRE	409 (3 PHASE)	*370 (3 PHASE)		

* NOTE: 3 PHASE FULL LOAD VOLTAGES SHOWN ARE WITH .8 POWER FACTOR LOAD.

2. Connect a full electrical load to the generator. The governor should act smoothly and quickly to keep the voltage and frequency within the limits shown in the table. However, there should be not more than a spread of 3 cycles between the no load frequency and the full load frequency. For example, if the frequency was 62 cycles at no load, then the full load frequency should be not less than 59 cycles. If the cycle spread is more than 3 cycles, turn the sensitivity adjustment screw, Fig. 19, in (clockwise) a half turn. This will, in turn, necessitate a slight compensating speed nut adjustment. Repeat the process until the cycle spread is within 3 cycles, and voltage is within the limits shown in the table.

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

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

5. After long service, the governor mechanism parts may become worn enough to prevent correct governor adjustments. If the engine and generator are otherwise in good condition and all other adjustments are properly made, but governor action is still erratic, inspect for worn parts. Remove the gear cover to inspect the fly balls, shaft-and-yoke assembly, etc. Refer to MAINTENANCE AND REPAIR.

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

ADJUSTMENT - 8,000, 9,000 and 10,000 WATT PLANTS

1. The models 8CW, 9CW and 10CW are equipped with an auxiliary speed booster device. The speed booster is adjusted to increase governor action as the load on the generator is increased. The booster serves to maintain or increase the speed at the higher loads. This results in more nearly constant voltage.

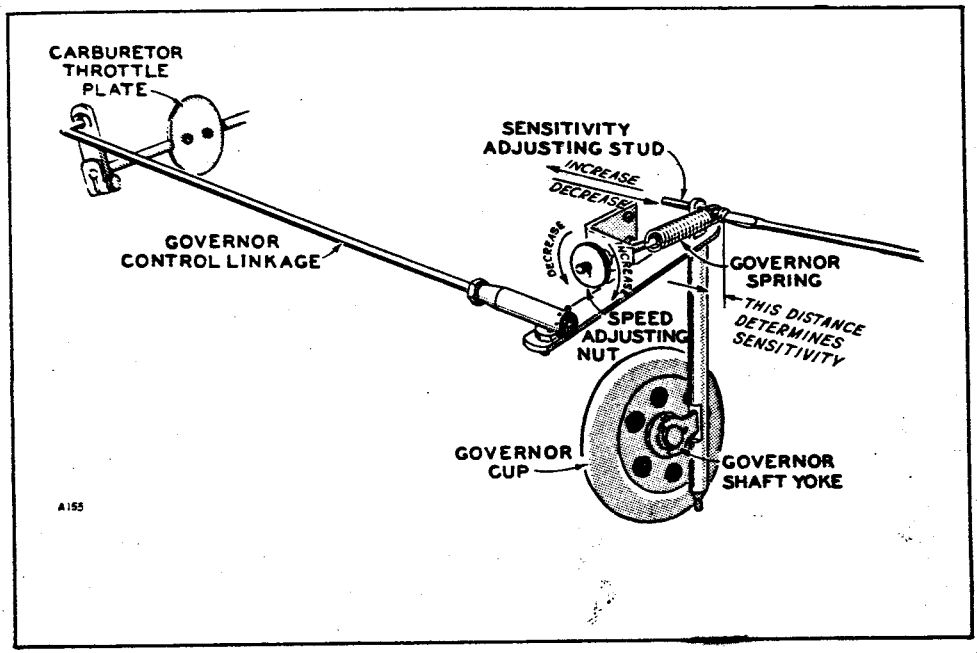


Fig. 19 Governor Adjustments

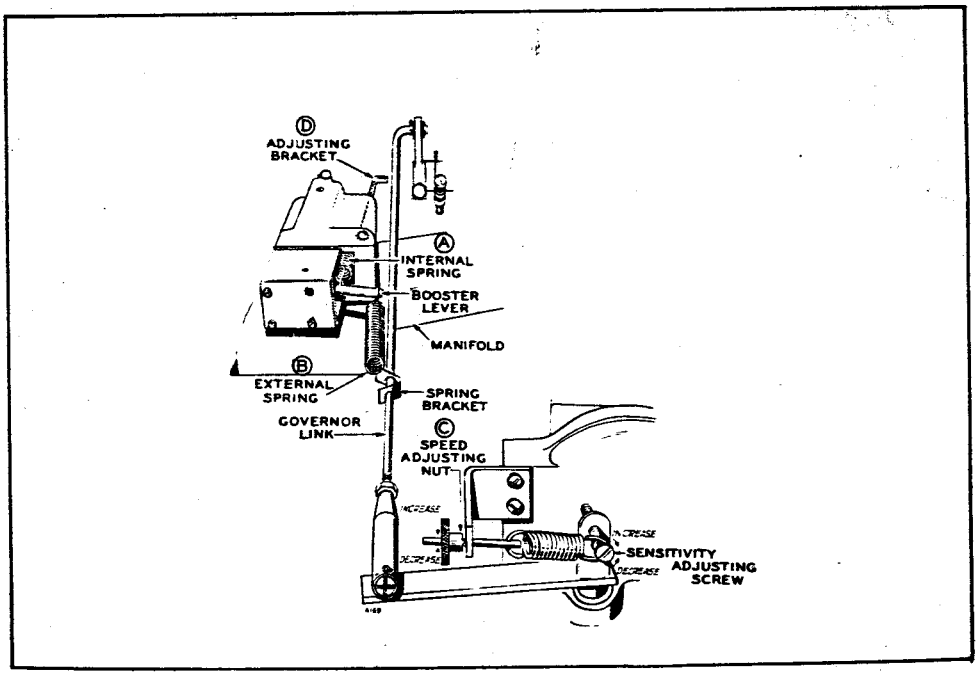


Fig. 20 Governor Booster

The booster is mounted on the intake manifold and is operated by engine vacuum through a small passage in the manifold. See Fig. 20. When the plant is operating at about half load or less, the engine vacuum is sufficient to cause the diaphragm to overcome the tension of the internal booster spring (A). Under these conditions, there is no tension on the booster external spring (B) and the booster does not affect the governor operation.

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

2. With the plant operating at no load, disconnect the booster external spring (B), Fig. 20. Turn the speed adjusting nut (C) to obtain a frequency reading of 60 to 61 cycles for a 60 cycle plant (50 to 51 cycles for a 50 cycle plant). The voltage should be within the limits shown in the table IV, according to the rated plant voltage shown on the plant nameplate.

TABLE IV GOVERNOR ADJUSTING LIMITS

PLANT RATED VOLTAGE	NO LOAD VOLTS (MAXIMUM)	MINIMUM FULL LOAD VOLTS WITHOUT BOOSTER	MAXIMUM NO LOAD TO FULL LOAD VOLT. DROP WITH BOOSTER
115/230	124 OR 248	112 OR 224	7 OR 14
230 3 PH. 3 WIRE	248	*224	14
460 3 PH. 3 WIRE	496	*448	28
120/208 3 PH. 4 WIRE	224 (3 PHASE)	*202 (3 PHASE)	13
230/380	409 3 PHASE	*370 3 PHASE	25

* NOTE: 3 PHASE FULL LOAD VOLTAGES SHOWN ARE WITH .8 POWER FACTOR LOAD

3. Connect a full electrical load to the generator. As the electrical load is connected, the governor should act smoothly and quickly to keep the voltage within the limits in the table. However, there should be not more than a spread of 3 cycles between the no load frequency and the full load frequency. For example, if the frequency was 60 cycles at no load, then the full load frequency should be not less than 57 cycles. If the cycle spread is more than 3 cycles, turn the sensitivity screw, Fig. 20, in (clockwise) a half turn. This will, in turn, necessitate a slight compensating speed nut adjustment. Repeat the process until the cycle spread is within 3 cycles and voltage is within the limits shown in the table.

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

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

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

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

8. After satisfactory performance has been attained under various loads, the booster can be connected. With the plant operating at no load, connect the booster external spring, Fig. 20. Adjust the bracket on the governor link just to the position where there is no tension on the spring.

9. Now connect a full electrical load to the generator. The frequency should stabilize at a point 1 to 2 cycles HIGHER THAN the no load frequency. For example, if the no load frequency is 60 cycles, the frequency under full load should be 61 to 62 cycles. If the rise in frequency is more than 2 cycles, lessen the internal spring tension. If there is a drop in the frequency, increase the internal spring tension. Adjust the tension of the internal spring by pulling out on the spring bracket (D), and moving the pin to a different hole.

10. With the booster disconnected, a maximum drop of 3 cycles from no load to full load is normal. With the booster in operation, a maximum INCREASE of 2 cycles from no load to full load is normal. A drop of 1 cycle at 1/4 load is permissible, giving an over all spread of 3 cycles, maximum.

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

12. The booster requires little maintenance other than using a fine wire to clean the small hole in the short vacuum tube which fits into the hole in the top of the engine intake manifold. Do not enlarge this hole. If there is tension on the external spring Fig. 20, when the plant is operating at no load or light load, it may be due to improper adjustment, restricted hole in the small vacuum tube, or a leak in the booster diaphragm.

ENGINE

GENERAL. - Refer to the SERVICE DIAGNOSIS section for assistance in locating and correcting servicing situations which may occur. The information in this MAINTENANCE AND REPAIR section is intended to assist in properly maintaining the generating plant. If major repairs should become necessary, it is recommended that such services be performed by a competent mechanic who is thoroughly familiar with modern internal combustion engines and revolving armature type generators.

GASKETS. - It is always good practice to use a new gasket when installing a part which requires a gasket. Be sure to thoroughly clean the surfaces that the gasket contacts before installation.

BLOWER HOUSING, REMOVAL. - To remove the blower housing, remove the flat head screws mounting the front cover casting and pull the cover off straight forward. Remove the blower wheel from its hub. Remove the nuts and lock washers mounting the dual exhaust pipe to the cylinders, and 3 screws which mount the blower housing to the front of the engine. The blower housing, with the exhaust pipe loose inside it, can then be removed.

BLOWER HUB. - Remove the nut and lock washer from the center of the blower wheel hub. Remove the crank pilot by pulling it straight forward. If the blower hub proves to be too tight for easy removal, tap lightly in a forward direction to loosen it.

VALVE SERVICE. - The proper seating of all the engine valves is essential to good engine performance. If any one valve is leaking, service all four valves. After removing the cylinder heads, and valve compartment covers, disassemble the valves. Keep the valves in order so that each can be reassembled to its original seat. Each valve, its guide, piston tops, end surfaces of the cylinder castings and the cylinder heads should be thoroughly cleaned of all carbon or lead deposits. Replace with a new one any valve of which the stem is worn or the head is warped or badly burned. Reface valves which are to be used again. Valve face and seat angle is 45° for both intake and exhaust. Be sure to clean away all traces of abrasive or grinding compound. Oil the valves and guides lightly before reassembly.

VALVE TAPPETS. - The valve tappets are adjustable, having self locking adjusting screws. Set the tappets for clearance of .012" for intake and exhaust valves, at room temperature (cold setting). Tappets set too close may cause burned or warped valves or seats, or scored tappets or camshaft lobes.

Be sure when checking the tappets, that the tappet being checked is riding on the low point of its cam lobe. Watch the valve to be checked as the engine is slowly hand cranked. As the valve closes, turn the crankshaft one complete turn beyond the valve closing point. This will assure that the tappet is then on the low point of its cam lobe.

IGNITION TIMING. - Correct ignition timing is important to good engine performance. The ignition timing should be checked after servicing or replacing the magneto contact points. Refer to Fig. 21.

Remove the end cap from the magneto. Adjust the magneto breaker points to a gap of .020 inch at full separation. Remove the air cover from the engine right hand cylinder, to expose the timing hole in the flywheel housing.

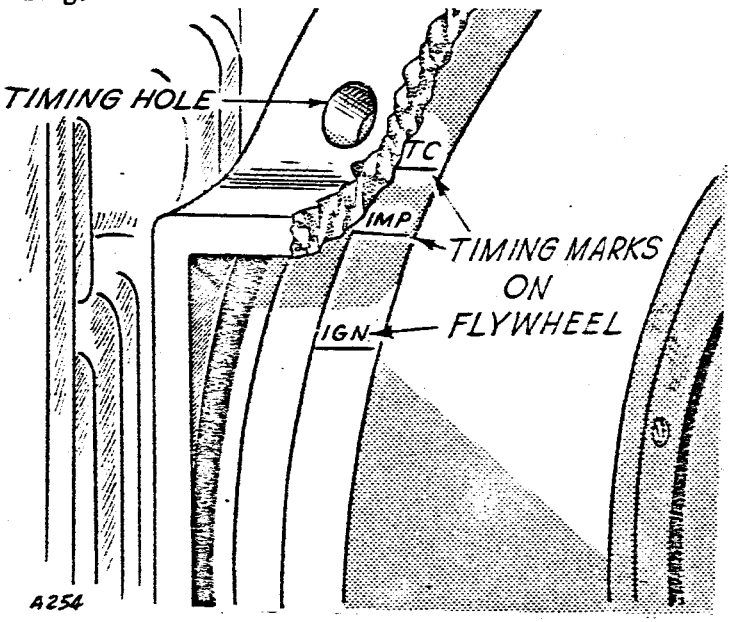


Fig. 21 Ignition Timing Marks

With the hand crank, slowly turn the engine, until the IMP timing mark on the outside edge of the flywheel can be seen through the timing hole. As the timing mark centers in the timing hole, a sharp click should be heard from the magneto. This click is caused by the magneto impulse as it trips, and is the instant the spark occurs. If this click occurs before the IMP mark is visible through the timing hole, the ignition timing will be "fast". If the click occurs after the IMP mark passes the center of the timing hole, the ignition timing will be "slow". Loosen the two magneto mounting screws a few turns each and turn the magneto slightly, to advance or retard the spark timing as necessary. Repeat the checking operation until proper timing is attained.

When the plant is running, the impulse coupling is no longer in operation and the spark is automatically advanced. If a neon timing light is used to check the timing, the spark should occur as the IGN. mark on the flywheel aligns in the timing hole.

MAGNETO INSTALLATION. - If the magneto has been removed from the engine, turn the flywheel to the point where the IMP mark is visible through the timing hole. Holding the magneto in the hands, turn its drive gear in a clockwise direction until the impulse coupling trips, taking care not to touch either of the contact strips on the coil. Carefully turn the drive gear a few degrees in the reverse direction (counterclockwise) to the point where the breaker contact points are just breaking open. Without changing this setting, carefully install the magneto to the engine, making sure the setting does not change as the gears mesh together. Check the timing as previously described.

GEAR COVER INSTALLATION. - If the gear cover has been removed, turn the governor cup so that two of the holes are lined straight up and down. When the gear cover is installed, a pin in the cover must enter the bottom hole in the cup. See that the convex surface of the yoke is turned to face the governor cup. Install the cover carefully, so as not to damage the oil seal.

CYLINDERS. - The cylinders are removable from the crankcase. If cylinders become worn more than 0.005" out of round or tapered, or are scored, they can be refinished to fit oversize pistons. If cooling fins are broken, or other damage occurs, replace the damaged cylinder with a new one. New engine cylinder bore is 4.000" 4.001", unless oversize cylinders and pistons are used, in which case the bore is 4.005 - 4.006".

PISTONS AND RINGS. - The pistons and connecting rods may be removed outward through the cylinders, or the cylinders can be removed over the pistons without loosening the connecting rods. Full floating type piston pins are used.

The top compression ring has a chrome plate face. Both compression rings have one edge beveled on the inside and this bevel must be installed toward the closed end of the piston. Proper ring gap, when fitting rings, is 0.013 inch to 0.025 inch. Space the ring gaps equally around the piston, with no gap directly in line with the piston pin. Use standard size rings if 0.005 oversize pistons are installed, and oversize rings for larger oversize pistons.

CONNECTING RODS. - The forged steel connecting rods have precision type bearing inserts easily replaceable. Do not dress the rod cap to compensate for any bearing wear; replace with new bearings. Correct bearing clearance to the crankshaft journal is 0.001 inch to 0.003 inch, and should be measured at a point in line with the length of the rod, Fig. 22. If new piston pin bushings are installed in the upper end of the rod, the bushings must be pressed in only flush with the sides of the rod, to permit a 1/16 inch oil groove at the center. Finish ream to 1.879 - 1.1882 inch for a new piston pin, or to give a clearance of 0.0002" to 0.0007" if a used pin is continued in service.

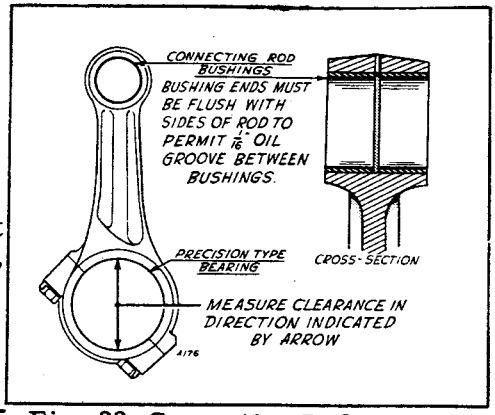


Fig. 22 Connecting Rod Bearings

MAIN BEARINGS. - The crankshaft main bearings are of the sleeve type, flanged to take the crankshaft end thrust. Main bearings are available in standard, 0.002 inch and 0.020 inch undersizes, and do not require finishing to size after installation. The oil holes in the bearing must align with the oil passage openings in the crankcase or bearing plate, and a pin fits a slot in the bearing flange, Fig. 23. Use care to start and press the bearing in straight, to prevent any distortion.

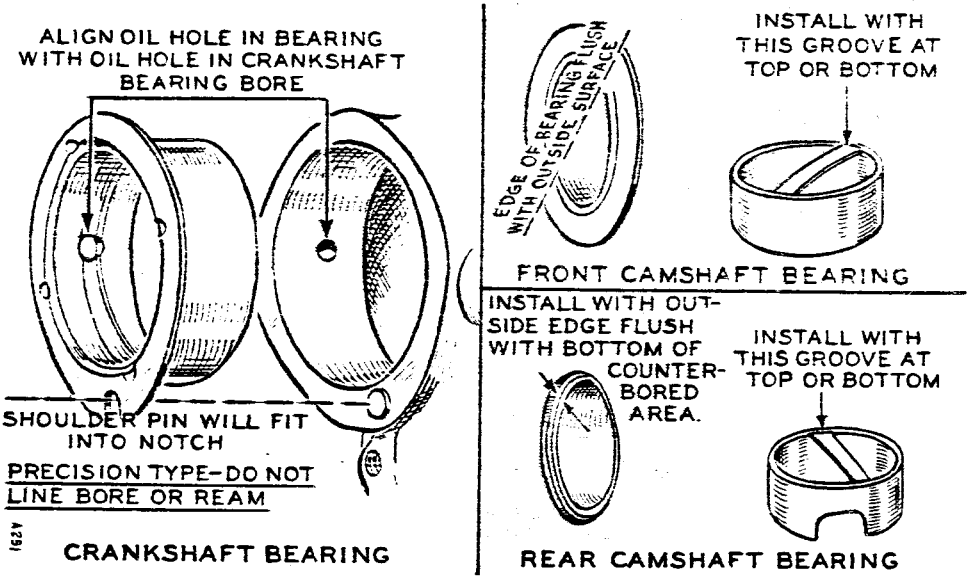


Fig. 23 Main and Camshaft Bearings

CAMSHAFT BEARINGS. - The camshaft bearings are babbitt lined sleeves, pressed into the crankcase. Press new bearings in from the outside of the crankcase, forcing the old bearing from the bore in the same operation. Oil grooves can be positioned toward either the top or bottom of the crankcase. Press the front bearing in flush with the front surface of the crankcase, and the rear bearing in flush with the bottom of the plug recess. Camshaft bearings must be finished to size after installation, for a clearance of 0.001" to 0.003". Install a new plug, using sealing compound and expanding into place with sharp blows at its center.

CRANKSHAFT. - See that the oil passages of the crankshaft are clean and free of obstructions. These oil passages conduct oil from the main bearing journals to the connecting rod journals. If the bearing journals become worn out of round or scored, refinish to use undersize bearings. If either oil seal contact surface becomes grooved or scored, refinish and polish smooth.

When installing the rear bearing plate, use sufficient gaskets to provide crankshaft end play of 0.006" to 0.012". Use care not to damage the oil seal during the bearing plate installation.

CAMSHAFT. - If a lobe of the camshaft has become slightly scored (too close tappet adjustment sometimes causes this), dress smooth with a fine stone. A badly worn or scored camshaft must be replaced with a new one.

The camshaft center pin can not be pulled outward nor removed without damage. The center pin is a very tight fit, and the 3/4 inch distance it extends beyond the end of the camshaft is quite critical. For this reason, never press or tap on the center pin, except as directed in the GOVERNOR CUP paragraph.

GOVERNOR CUP. - The governor cup can be removed from the camshaft and gear after first removing the small snap ring from the camshaft center pin. Slide the governor cup forward over the center pin, catching the governor fly balls in the hand.

Replace with a new part any fly ball which is grooved or has a flat spot, if the ball spacer arms are worn or otherwise damaged, or if the fly ball contact surface of the cup is grooved or rough. The governor cup must be a free spinning fit on the camshaft center pin, but without any excessive looseness or wobble.

When assembling the governor cup to the camshaft and gear, be sure all twelve fly balls are installed in the spacer openings. After installing the snap ring to the center pin, hold the governor cup in toward

the gear. The distance from the snap ring to the front surface of the governor cup must be 7/32", Fig. 24. If the distance is more than 7/32 inch, use an arbor press to carefully press the center pin in the required amount. If the distance is less than 7/32", it will be necessary to remove the center pin and install a new one, pressing in only the required amount.

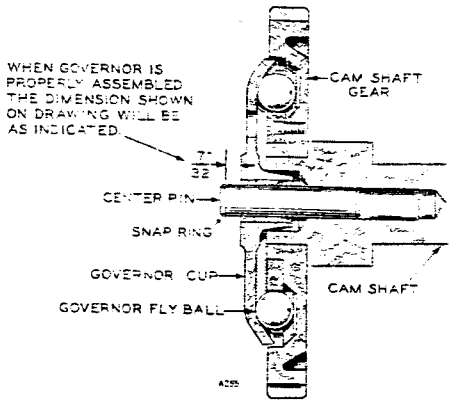


Fig. 24 Governor Cup

CAMSHAFT GEAR . - The camshaft gear is keyed and pressed on to the camshaft. If replacement becomes necessary, the gear can be pressed off the camshaft. After removing the governor cup, fly balls, spacer, etc., use a hollow tool or pipe of the proper diameter to fit inside the gear bore and over the camshaft center pin. Press the camshaft out of the gear bore, taking extreme care not to press on the camshaft center pin.

When installing a camshaft gear to the camshaft, be sure the key is properly in place, and press on up to the camshaft shoulder. Assemble the governor ball spacer, balls, cup, etc. before installing to the engine.

When installing to the engine, be sure the marked tooth meshes with the marked tooth of the crankshaft gear, Fig. 25. Do not omit the thrust washer behind the camshaft gear.

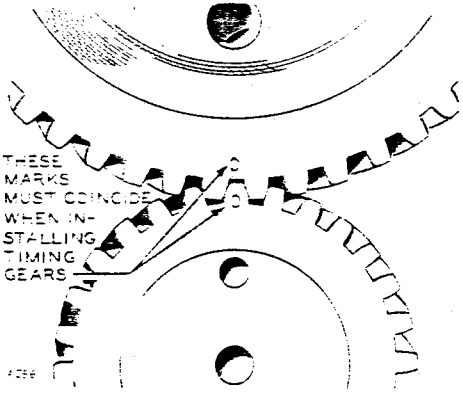


Fig. 25 Gear Timing Marks

CRANKSHAFT GEAR. - The crankshaft gear is keyed and a drive fit to the crankshaft and is fastened with a lock ring. Use a gear puller to remove the gear, taking care not to damage any teeth if the gear is to be used again. The gear is slotted for puller jaws.

When installing a crankshaft gear, see that its key is in place, face with the "0" timing mark outward, and drive the gear on up to the crankshaft shoulder. Be sure the marked tooth ("0" timing mark) meshes with the marked camshaft gear tooth.

OIL PUMP. - If the oil pump is to be removed, it must be turned off the oil intake pipe. If the oil pump fails to function properly, install a complete new pump. Except for the intake assembly, component parts of the oil pump are not available separately.

When installing the oil pump, be sure its mounting gasket is in good condition, and properly in place. Turn the intake pipe and cup in tightly and at the correct angle to have the intake cup parallel to the bottom of the crankcase.

NOTE

Be sure the oil pump is primed with oil.

OIL PRESSURE RELIEF VALVE. - The oil pressure relief valve is not adjustable. If the valve should become stuck open or closed, remove and clean. Remove the hex head screw and copper washer, Fig. 26. Lift out the pressure spring. The valve can be removed with a long 3/8" -16 screw.

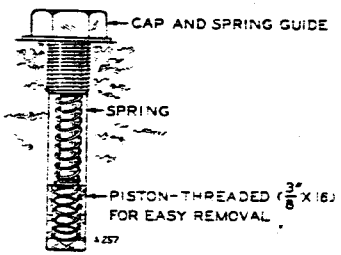


Fig. 26 Oil Pressure Relief Valve

FLYWHEEL. - The flywheel is keyed and a taper fit to the crankshaft. After removing the flywheel attaching screw, if the flywheel proves difficult to remove, reinstall the flywheel screw and leave it a few turns loose. Hit the screw sharply to jar the flywheel loose.

When installing the flywheel, be sure the key is in good condition and is properly fitted in place. See that the taper surfaces of the crankshaft and of the flywheel are clean and free of nicks. The flywheel must run true. Any unbalance will set up harmful vibration. Tighten the mounting screw securely, to a torque wrench reading of 50-55 lb. ft.

OIL SEALS. - Install the rear bearing plate oil seal flush with the outer surface of the plate. Install the gear cover oil seal flush with the outer edge of the oil seal opening. Both seals must be installed with the open side of the seal facing inward.

ASSEMBLY TORQUES. - As a general rule, tighten bolts or nuts securely, using reasonable force only, and using a wrench of normal length. The assembly torques shown in table V will assure proper tightness without danger of stripping theads.

TABLE V - ASSEMBLY TORQUES

Cylinder Head Nuts	25 - 30 lb. ft.
Connecting Rod Bolts	25 - 30
Armature Mtg. Bolts	10 - 12
Flywheel Mtg. Bolt	50 - 55
Crank Pilot Mtg. Nut	50 - 55

TABLE OF CLEARANCES. -The clearances given in table VI are the factory standards. A comparison between the standard clearances shown, and clearances as determined during repair operations will usually indicate which parts should be replaced with new ones. As a general rule, when the clearance exceeds by 50% the maximum factory limit (or nearly so), the worn parts should be replaced with new ones. For example, if connecting rod bearing clearance is 0.003" or more (factory maximum clearance 0.002"), new connecting rod bearings should be installed. For those clearances which are adjustable, keep the clearances within the factory tolerance.

TABLE VI
TABLE OF CLEARANCES

	MINIMUM	MAXIMUM
Valve tappet (Cold)	.012	.012
Valve stem in guide	.0015	.003
Valve seat width	3/64	5/64
Crankshaft main bearing	.0025	.004
Crankshaft endplay	.010	.015
Camshaft bearing	.001	.003
Camshaft endplay	.003	.018
Connecting rod bearing	.001	.003
Connecting rod endplay	.002	.011
Timing gear backlash	.001	.006
Oil pump gear backlash	.003	.005
Piston to cylinder (90^{O} to pin)	.0045	.0065
Piston pin in piston (tap-in fit)	.0000	.0003
Piston pin in con. rod	.0002	.0007
Compression ring gap, Top	.013	.025
Compression ring gap, 2nd	.013	.025
Oil ring gap	.013	.025
Magneto breaker points gap	.020	
Spark plug gap (Gasoline Fuel)	.025	
Spark Plug gap (Gas Fuel)	.018	

GENERATOR

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

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

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

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

COMMUTATOR AND COLLECTOR RINGS. - The mica insulation between the commutator bars, or segments, was originally undercut to a depth of 1/32 inch below the commutator surface. After a long period of service, the surface of the commutator may become worn down level with the mica. This condition would cause noisy brushes, sparking of the brushes, and pitting of the commutator. The mica should again be undercut to 1/32 inch depth. Remove the brush springs and pull all the brushes out of their guides. After tagging any leads disconnected (to assure correct reconnection) remove the end bell. With a mica undercutting tool, or an improvised tool fashioned from a hack saw blade (Fig. 27), carefully cut the mica between all of the commutator bars down to the 1/32 inch depth. Use care to avoid scratching the surface. Remove any burrs which may be formed along the edges of the bars, and clean all spaces between bars completely free of any metallic particles, Fig. 28.

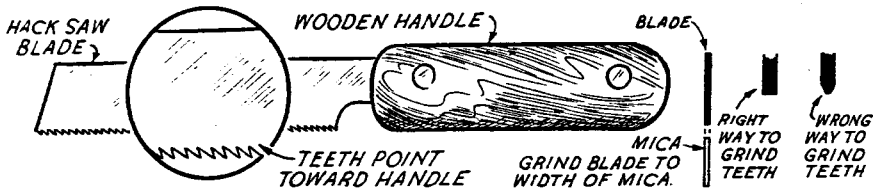


Fig. 27 Mica Undercutting Tool

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

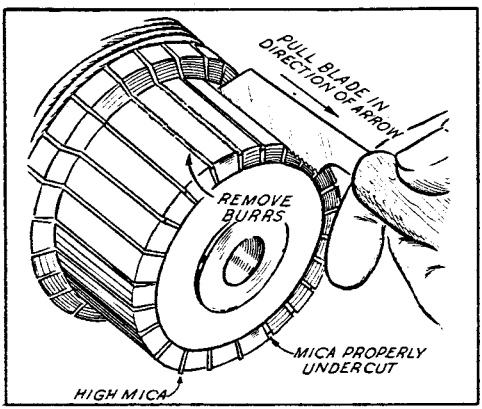


Fig. 28 Undercutting Mica

BRUSH RIG. - It is unnecessary to loosen or remove the brush rig from the end bell for average generator servicing. However, if the brush rig has been loosened or removed for any reason, the brush rig must be returned to its exact original position. This original position was marked at the factory in the test run and must be maintained as long as the original brush rig and armature are continued in service. The position can be identified by a mark across the outer edge of the brush rig supporting ring, which mark must align with the marked support in the end bell (Fig. 16). Improper positioning of the brush rig will cause excessive arcing of the brushes, burning of the commutator, low generator output, and possible serious damage to the generator windings from over-heating.

GENERATOR WINDINGS TEST PROCEDURE

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

NOTE:

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

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

FIELD COIL TESTS

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

If the plant is an electric cranking model which uses the generator as a cranking motor, the field coils are wound with two separate windings to each coil. The series (cranking) winding is of very heavy wire and its leads, marked S1 and F+, are easily identified. Two smaller size leads, marked 5 and 7, connect to the cranking limiter switch imbeded in one coil. The shunt field leads are marked F- and F+. Temporarily connect the two F+ leads together, for test purposes. Manual cranking models have only the F- and F+ shunt field leads.

OPEN CIRCUIT TEST. - To test for an open circuit, connect one test lamp lead to the F+coil terminals, and the other test lamp lead to the F - coil lead. If the test lamp fails to light, an open circuit in the shunt winding is indicated. Repeat the test, between the S1 and F+ terminals. If the test lamp fails to light an open circuit in the cranking winding is indicated. Test the cranking limiter in the same manner using the leads marked 5 and 7.

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

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

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

ARMATURE TESTS

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

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

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

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

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

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

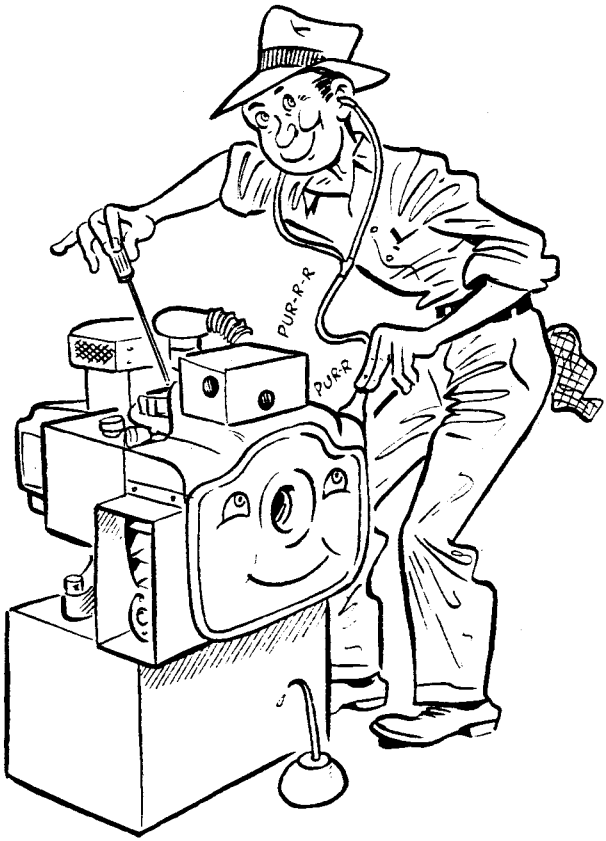
DC WINDING, OPEN OR SHORT CIRCUIT TEST. - An armature growler is required to make a satisfactory test. Follow the test procedure recommended by the growler manufacturer.

CONTROL BOX EQUIPMENT

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

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

Service Diagnosis



POSSIBLE CAUSE	REMEDY
SYMPTOM	
ENGINE CRANKS TOC STIFFLY	
Too heavy oil in crankcase.	Drain. Refill with light oil. See PREPARATION.
Engine stuck.	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 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.
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 piston rings if necessary.
Wrong ignition timing.	Reset breaker points or retime ignition. See IGNITION TIMING.
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 1/2 inch, and have good spring tension.

SYMPTOM POSSIBLE CAUSE	REMEDY
ENGINE RUNS BUT VOLTAGE DOES NOT BUILD UP	
Open circuit, short circuit, or ground in generator.	Refer to the GENERATOR section of Maintenance.
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 1/2 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.	Refer to the GENERATOR section of MAINTENANCE - See Brush Rig.
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.
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.

SYMPTOM

POSSIBLE CAUSE	REMEDY
VOLTAGE DROPS UNDER HEAVY LOAD (CONT.)	
Faulty carburetion.	Check the fuel system. Clean, adjust or repair as needed.
Dirty carburetor air cleaner.	Clean. Service with proper oil.
Choke partially closed.	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.
Improper governor adjustment.	Refer to ADJUSTMENTS.
ENGINE MISFIRES AT LIGHT LOAD	
Carburetor idle jet clogged or improperly adjusted.	Clean or adjust.
Spark plug gaps too narrow.	Adjust to correct gap - .025" (.018" for gas operation).
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 LOAD	
Defective spark plug.	Replace.
Faulty ignition.	Clean, adjust, or replace breaker points, spark plugs, condensers, etc. or retime ignition.
Clogged carburetor.	Clean carburetor.
Clogged fuel screen.	Clean.
Defective spark plug cable.	Replace.
ENGINE MISFIRES AT ALL LOADS	
Fouled spark plug.	Clean and adjust.
Defective or wrong spark plug.	Replace. Use Champion Com. 8.
Leaking valves.	See VALVE SERVICE.

SYMPTOM

POSSIBLE CAUSE	REMEDY
ENGINE MISFIRES AT ALL LOADS	
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	
Lean fuel mixture.	Clean carburetor. Adjust jets.
Clogged fuel filter.	Clean.
Air leak at intake manifold or carburetor flange.	Tighten mounting screws. Replace gaskets if 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.

SYMPTOM

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 Loads"
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. Service with proper oil.
LIGHT POUNDING KNOCK	
Loose connecting rod.	Replace rod bearings.
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.
Fuel pump failure.	Repair or replace.

SYMPTOM POSSIBLE CAUSE	REMEDY
DULL METALLIC THUD, IF NOT BAD, MAY DISAPPEAR AFTER FEW MINUTES OPERATION. IF BAD, INCREASES WITH LOAD.	
Loose crankshaft bearing.	Replace, unless one of the next two remedies permanently corrects the trouble.
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.
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 TAPPETS.
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.
SHARP CLICK WHEN CRANKING ENGINE	
Magneto impulse coupling.	Normal condition - should stop as soon as engine starts.

POSSIBLE CAUSE	REMEDY
SYMPTOM	
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.
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 PLUGS FOUL UP RAPIDLY	
Engine running "cold".	Restrict air flow. Install pre-heater hose.
Wrong plugs.	Use Champion Com 8.
Carburetor too "rich".	Adjust.
OIL DILUTION	
One spark plug fouled.	Clean plugs.
Leaky carburetor valve.	Clean.
OIL SEAL LEAK	
Worn oil seals.	Replace.
Fouled breather valve.	Clean or replace.
Loose oil fill cap.	Tighten - replace if gasket is damaged.