INSTRUCTION MANUAL

FOR

ONAN DIESEL ELECTRIC GENERATING PLANTS

SERIES

DRP

SPEC. A THROUGH G

ALTERNATING CURRENT BATTERY CHARGING

D. W. ONAN & SONS INC. MINNEAPOLIS 14, MINN.
912-5


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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.

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PLANT RUNNING HOURS COMPARED TO AUTOMOBILE RUNNING MILES

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

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

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

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

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

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

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

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

GENERATING PLANT RUNNING HOURS		AUTOMOBILE RUNNING MILES
DAILY AVERAGE	1 Hr.	41 Miles
	4 Hrs.	164 "
	6 "	246 "
	8 "	328 "
WEEKLY AVERAGE	7 "	287 "
	28 "	1,148 "
	42 "	1,722 "
	56 "	2,296 "

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.

GENERAL. - The Diesel powered electric generating plants to which this manual applies are complete electric generating sets. Each plant includes and engine, generator and necessary accessories. Each plant is thoroughly tested before leaving the factory to assure that all parts are in good condition and that each plant will produce its rated output.

This manual contains instructions on installing, operating, servicing, adjusting and repairing your unit. Read all instructions carefully. Correct installation, operation and servicing are important in assuring long hours of trouble free operation.

All instructions apply to 50 cycle a-c (alternating current) plants as well as to 60 cycle a-c plants unless otherwise noted. The main difference is in the current frequency. Most electrical appliances can be used on either frequency but is is advisable to check appliances to be used with 50 cycle plants before purchasing to assure that they are adaptable to the current frequency.

Instructions also apply to battery charging d-c (direct current) plants.

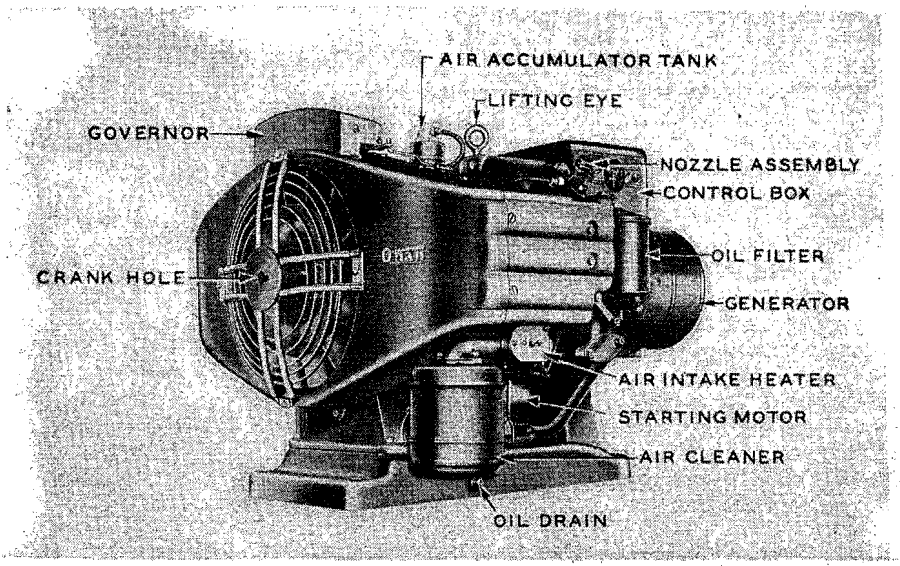


FIG. 1 - TWO CYLINDER DIESEL ELECTRIC GENERATING SET

ENGINE

TYPE. - 4 cycle; opposed two cylinder; 3-1/2" bore; 3-1/2" stroke; 67.3 cubic inch piston displacement. 17.3:1 compression ratio; 11.0 horsepower at 1800 rpm air cooled; solid injection full diesel

CYLINDERS-CRANKCASE: Cast integral to form a rugged one piece unit; cylinder fins conduct heat rapidly from the cylinders to maintain normal operating temperature. Ventilated crankcase.

VALVES: Special alloy steel; overhead type; stellite faced exhaust valves; solid stellite exhaust seat inserts; replaceable.

PISTON: Aluminum alloy; 5-ring. Cooled by oil spray. Taper and cam ground.

CRANKSHAFT: Forged steel; short; extra heavy, unusually rigid; fully counterweighted; drilled oil passages.

BEARINGS: Main bearings - aluminum alloy; 2-3/4" diameter. Connecting rod bearings are integral on aluminum alloy connecting rods. Trimetal bearings and bronze pin bushings on forged steel rods. Large surface (2-3/8" diameter), long wearing.

FUEL SYSTEM: Cartridge type fuel filter; diaphragm type transfer pump; air accumulator tank; two cam-operated, high pressure, throttling type injection pumps (one for each cylinder); solid injection type nozzles. (Models prior to "Spec F" used a primary and secondary fuel filter instead of the cartridge type and no air accumulator tank was used).

RECOMMENDED FUELS: No 2 furnace oil. Premium Diesel fuels are not required.

AIR CLEANERS: Two large oil bath air cleaners.

INTAKE AIR HEATERS: Two electric heater coils (one built into each manifold) preheat the intake air for low-temperature starting.

IGNITION: Compression starting and running. Two glow plugs (one installed in each cylinder head) help ignite the fuel during the starting period. (Glow plugs not used on models prior to Spec F.)

GOVERNOR: Centrifugal ball type; enclosed; accessible for adjustment; governor solenoid gives positive stopping of plant.

LUBRICATION: Gear type oil pump; main bearings, connecting rod bearings, wrist pins and rocker arms pressure lubricated; other internal moving parts spray lubricated; oil pressure gauge; oil sump capacity (including filter), 6 qts. U. S. Measure; oil pressure cut-off switch. (Oil pressure cut-off switch not used on models prior to spec F.)

COOLING: Air-cooling, axial flow type blower; housing directs cooling air over and around the cylinder and cylinder heads.

STARTING REMOTE: Electric cranking controlled by start-stop switch from a remote station or at the plant.(Starting is at the plant only on Battery Charger.)

GENERATOR

The generator is an air cooled, four pole, self-excited, revolving armature type. It is easily removable from the engine.

The single ball-bearing armature is driven by a disc which is directly and solidly connected to the engine flywheel to assure permanent alignment. (Models built previous to specification letter "F" used a drive hub, an armature through stud and some used a roller-bearing instead of a ball-bearing.)

The brush rig position is adjustable, and a witness mark designates the neutral brush position.

A-C PLANTS. - The a-c windings of the armature are connected to the collector rings, while the d-c windings are connected to the commutator. The d-c windings provide excitation and charge the 12 volt starting battery. Engine cranking is by a separate automotive type starting motor. The rated capacity is 5,000 watts, plus a generous short period overload for 60 cycle plants, but no overload available for 50 cycle plants.

BATTERY CHARGING PLANTS. - The field coils have a series winding for cranking the engine. The rated capacity is 5,000 watts with short period overloads available.

CONTROLS

The control panel, mounted over the generator is equipped with ammeter, switches relays, and resistors necessary for the operation of the plant. On alternating current plants, optional equipment may be connected, such as an automatic line failure control or remote control switches.

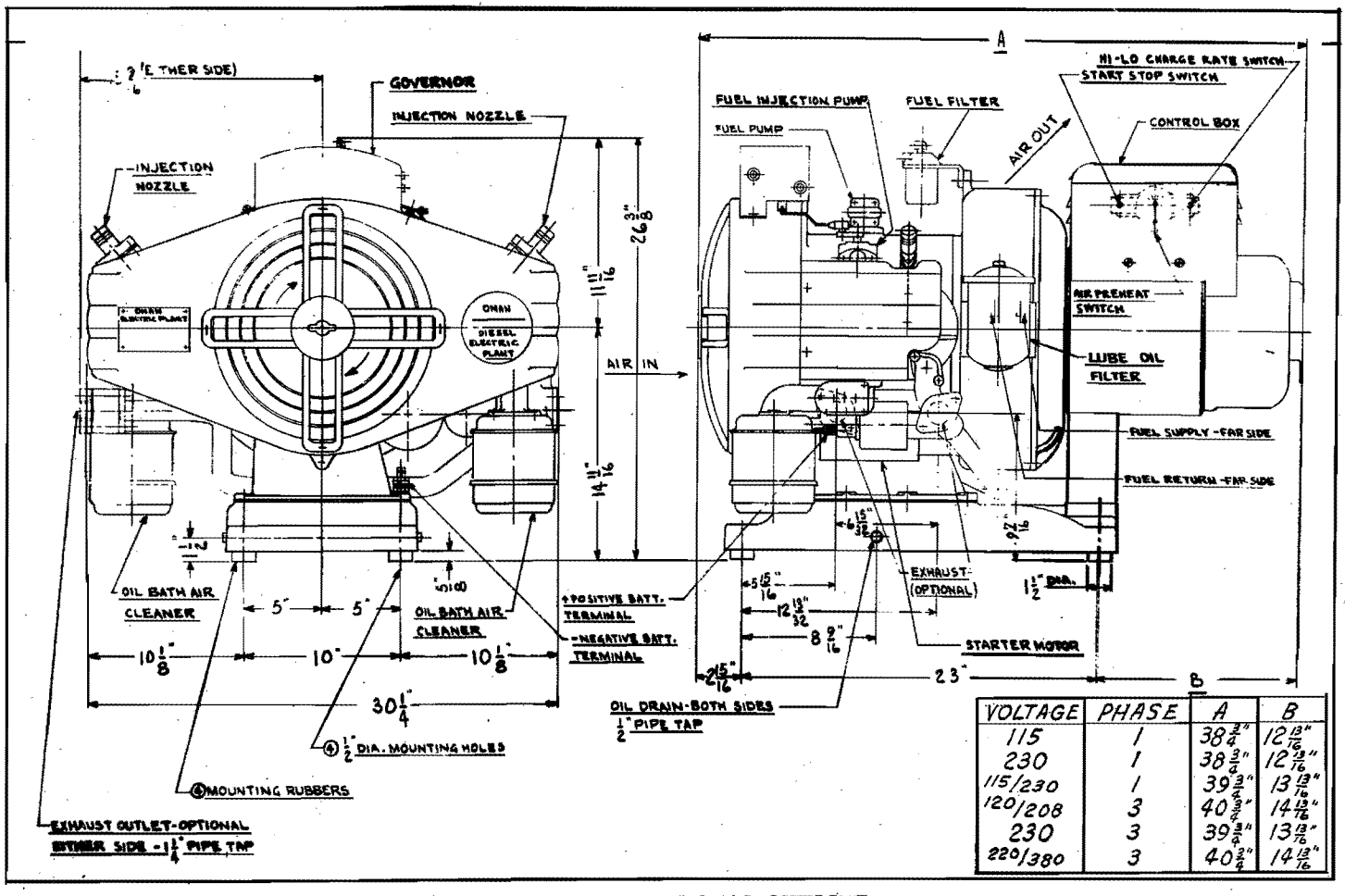
SPECIAL ACCESSORIES

The following accessories are available.

55 GALLON UNDERGROUND FUEL TANK AND FITTINGS. - Underwriters approved tanks of heavy-gauge galvanized steel complete with tank fittings. Specify Part Number 415B3.

FUEL LINES AND FITTINGS. - 25 feet of 5/16" copper tubing complete with fittings. Specify Kit Number 415K7 (2 kits required).

PRIMING KIT. - Designed for cold weather starting. Easily installed. Simple to operate. Incorporated using a special ethyl-ether starting fluid in capsule form by atomizing the fluid into the engine induction system.



VOLTAGE	PHASE	A	B
115	1	38 3/4"	12 13/16"
230	1	38 3/4"	12 13/16"
115/230	1	39 3/4"	13 13/16"
120/208	3	40 3/4"	14 13/16"
230	3	39 3/4"	13 13/16"
220/380	3	40 3/4"	14 13/16"

FIG. 2 - DIMENSIONAL OUTLINE

KEEP FUEL *Clean!*

DIRTY FUEL IS ONE OF THE MAJOR CAUSES OF PLANT FAILURE.

REMEMBER-EVEN A TINY PARTICLE OF DIRT IN THE INJECTION SYSTEM MAY STOP YOUR PLANT!

GENERAL. - The correct installation of your Diesel powered electric generating plant is of great importance to you. Its economy of operation, the ease with which it can be serviced and the life expectancy of the plant itself are a few of the main points affected by the installation.

Probably the most important single factor is proper ventilation. The plant is cooled entirely by air being drawn into the blower housing by the blower and forced at high speed over and around the cooling fins of the cylinder and cylinder head, carrying away heat from the engine at a rapid rate. As long as the air being drawn into the blower is cool and of ample volume, the engine maintains a normal operating temperature. However, if the air inlet and air outlet of the enclosure are not large enough to supply ample ventilation, heated air from the engine is recirculated and is again drawn into the blower housing and circulated over the engine. Thus the air becomes hotter each time it is recirculated, the engine temperature rises and damage from overheating is likely to occur.

The following instructions should be followed as closely as possible. If the instructions cannot be followed as given, use them as a guide and make the best installation that conditions permit.

LOCATION. - The location selected for your plant should be as near to the center of the electrical load as practicable. For example: If several buildings are to be serviced with electricity, it is much better and costs less to run lines from a central point to each of the building, than to run lines from one building to another. Not only will the voltage-drop from plant to load be less but smaller wire can be used to carry the same amount of current without much voltage loss between the plant and the point of service.

The enclosure should be clean, dry, well ventilated, and if necessary, heated in very cold weather.

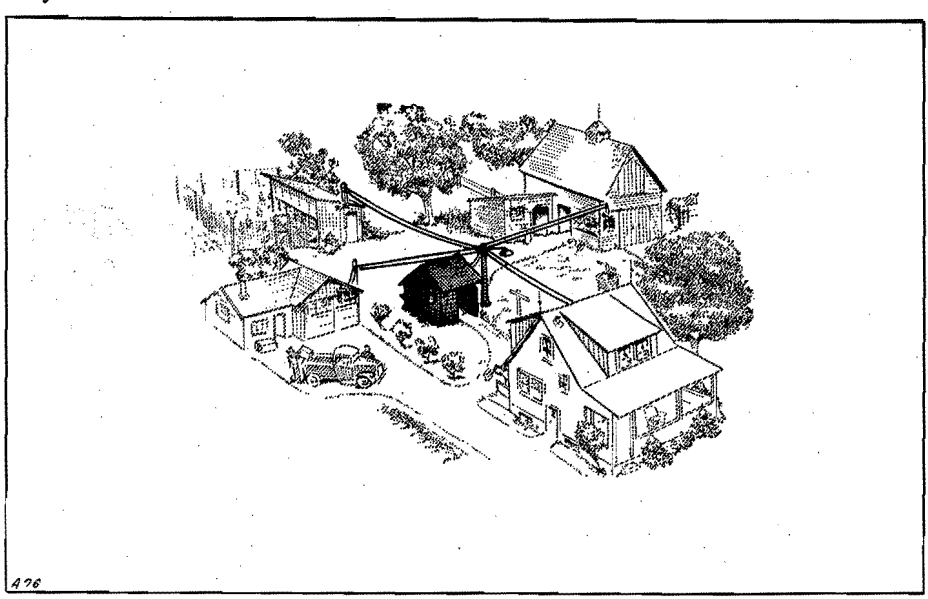


FIG. 3 - LOCATION

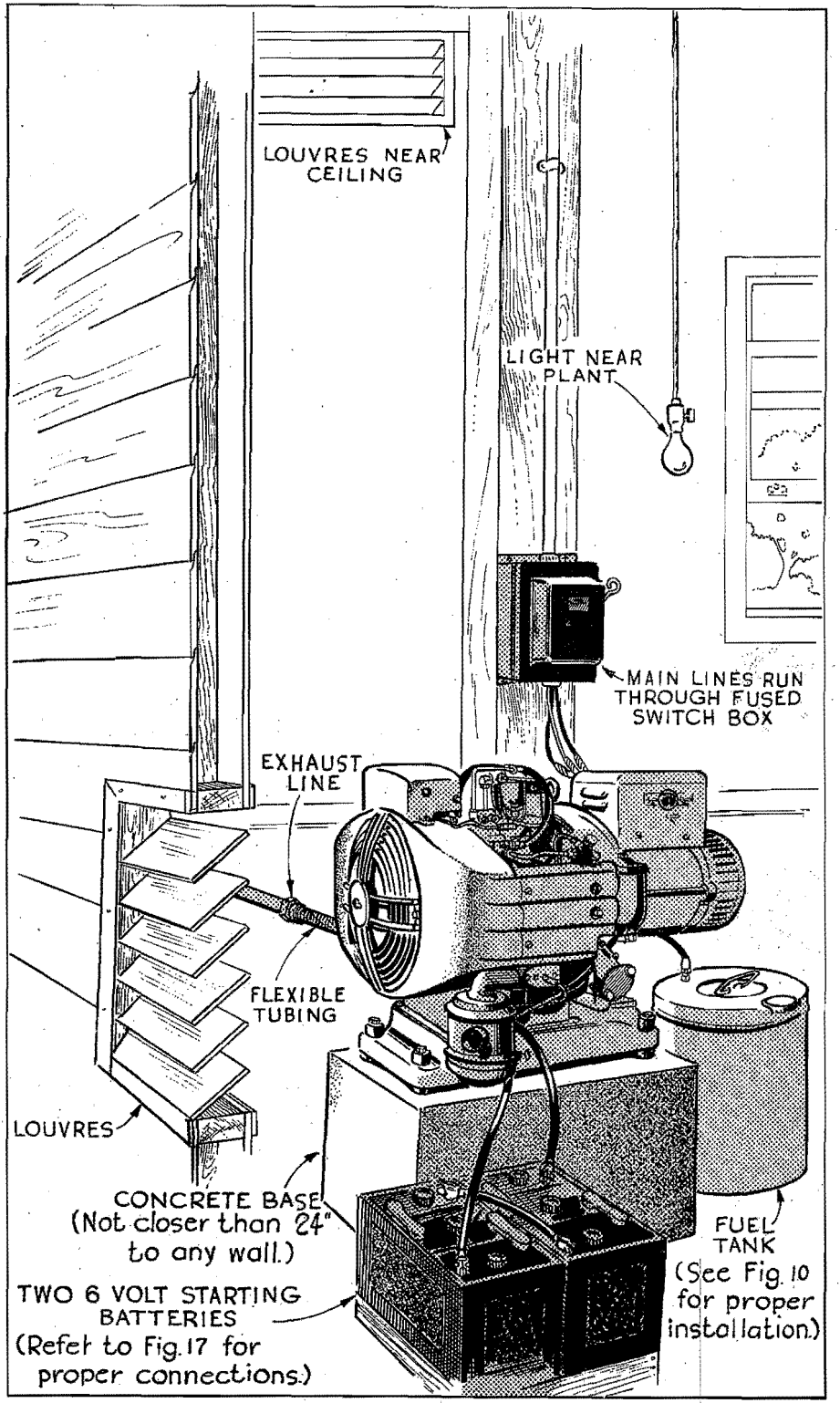


FIG. 4 - TYPICAL INSTALLATION

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

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

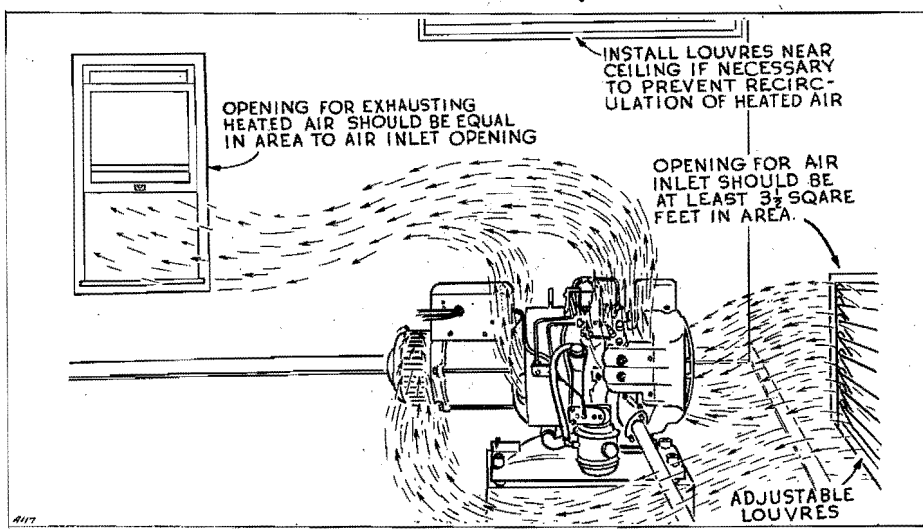


FIG. 5 - VENTILATION

Where possible these openings should be made with reference to the prevailing winds so that a minimum amount of dust reaches the engine, particularly if the unit is operated where flying lint or chaff is likely to be carried to the intake air stream. In such installations the air inlet should be screened and the screen kep clean to prevent restriction of the air flow.

MOUNTING BASE. - The plant should be mounted on a permanent base of timber or concrete. The base should be at least two inches larger on all sides than the plant base and about 12 inches high. The base should not be located closer than 24 inches to any wall or partition.

The plant base mounting hole centers are 10" x 23". If a concrete base is used, set 5/16" x 6" bolts into the concrete. Make cleats and place them across the form to hold the bolts in position until the cement hardens. Adjust the bolts on the cleats so that not more than 4" extends above the concrete. A mixture of 1 part cement, 2 parts sand and 4 parts gravel or crushed stone will make a good base. Be sure the mounting surface of the base is smooth and level. Allow the cement to harden for 3 days before mounting the plant on the base.

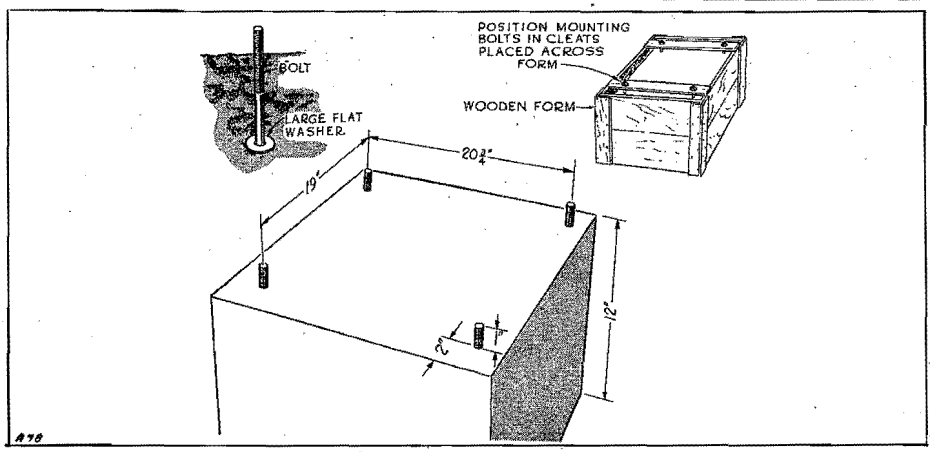


FIG. 6 - MOUNTING BASE

If timbers are used as a mounting base, they should be large enough to adequately support the plant and allow space for draining the oil. The timbers should also be securely fastened to the foundation they are to rest on.

MOUNTING THE PLANT. - Shock mounting cushions are supplied with your plant. Install at each of the four mounting holes in the base as shown in the illustration SHOCK MOUNTING.

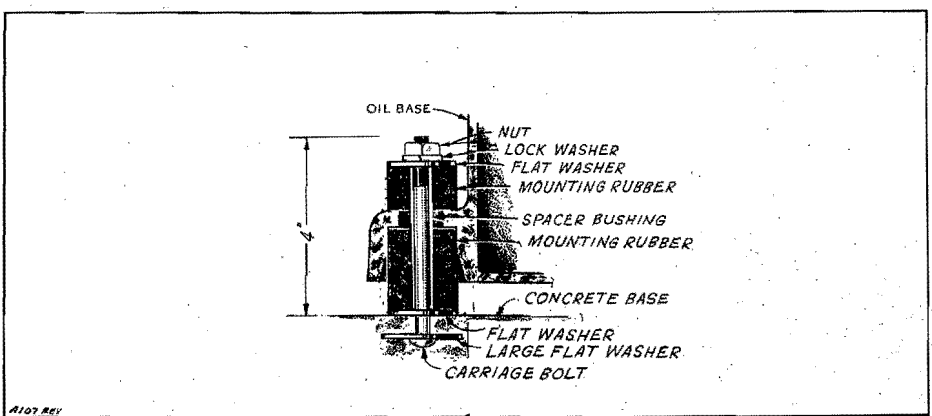


FIG. 7 - SHOCK MOUNTING

EXHAUST LINE. - Pipe all exhaust gases out of doors. Two exhaust outlets are provided for convenience, one on each side of the plant. Use the most convenient outlet, covering the other outlet with the plate provided. The exhaust outlet is 1-1/4" I. P. S. Connect flexible exhaust hose between plant and iron pipe. Use 1-1/4" pipe for the first 10 feet, increasing the pipe size one size for each additional 10 feet used. Support the exhaust line with metal shields backed with asbestos wherever it passes through a wall or partition, the opening for the shields being at least 2" larger on all sides than the exhaust line. Install the exhaust muffler on the exhaust line outside of the enclosure. Support the muffler if necessary. Provide a suitable cover to prevent rain or snow from entering the exhaust muffler, or point end of muffler downward. This cover must not restrict the flow of exhaust gases from the plant.

If the exhaust line must be pitched upward at any point, construct a condensation trap of suitable pipe fittings and install it at the point where the upward pitch begins. See the illustration EXHAUST INSTALLATION.

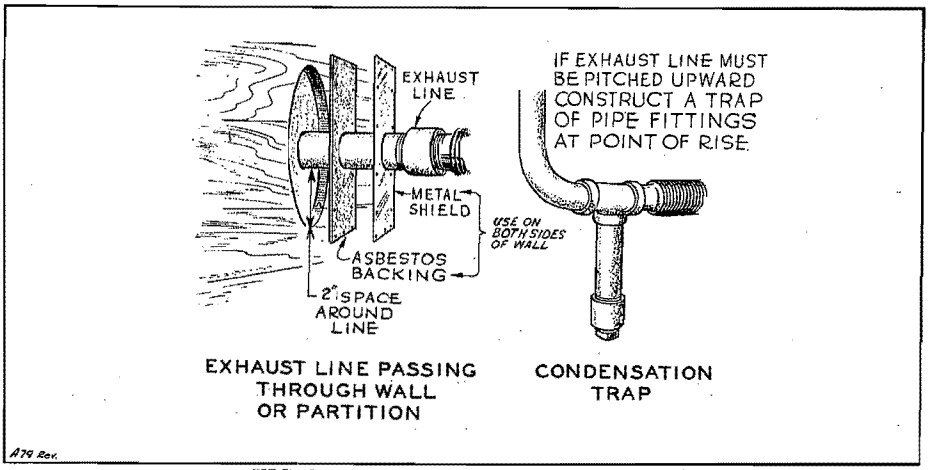


FIG. 8 - EXHAUST INSTALLATION

FUEL TANK. - The fuel tank supplied with your plant should be installed so that the top of the tank is at least 6 inches below and the bottom of the tank not more than 6 feet below the transfer pump inlet. These figures also apply if a different fuel tank is used. Fuel lines supplied with the plant are 24" long and the tank must be within this distance unless additional line is installed.

If a different fuel tank is used, be sure the fuel outlet is near the bottom of the tank and the opening for the return fuel line is in the top of the tank. See the illustration FUEL SYSTEM.

To remedy or help locate air leakage, raise the fuel supply 2 feet above the pump level, then watch for leaks.

FUEL LINES. - Two flexible fuel lines are supplied with each unit, one for the supply line and one for the return line. Connect the supply line from the base of the fuel tank to the fuel filter. Connect the return line from the fitting on the bracket to the top of the fuel tank. Metal fuel lines may be used from the tank to a point near the plant and the flexible lines connected at this point.

Be sure all fuel line connections are leak proof. Air leaks in the supply line will cause hard starting and inefficient operation.

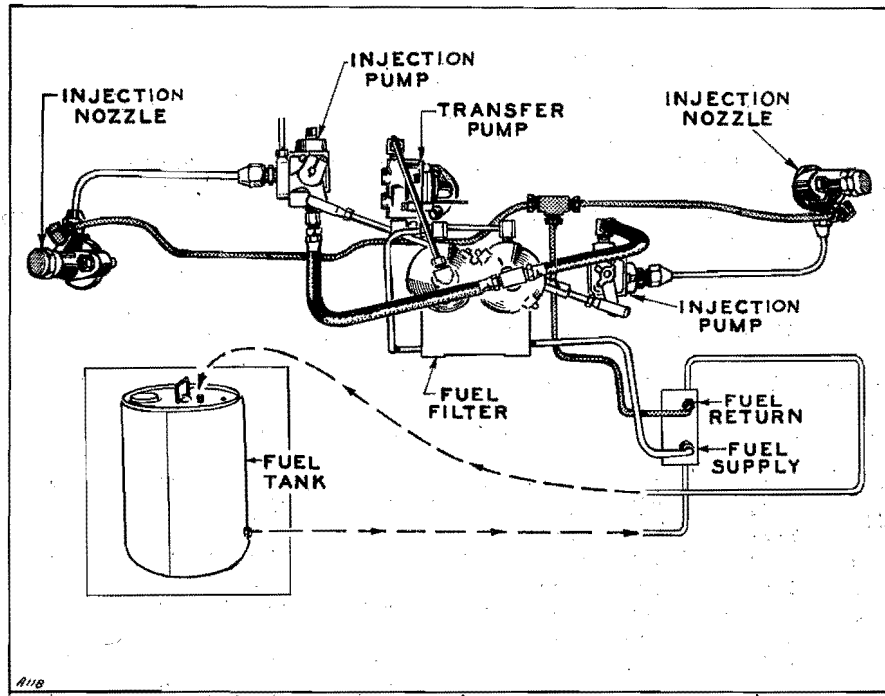


FIG. 9 - FUEL SYSTEM (Units Prior to "Spec F")

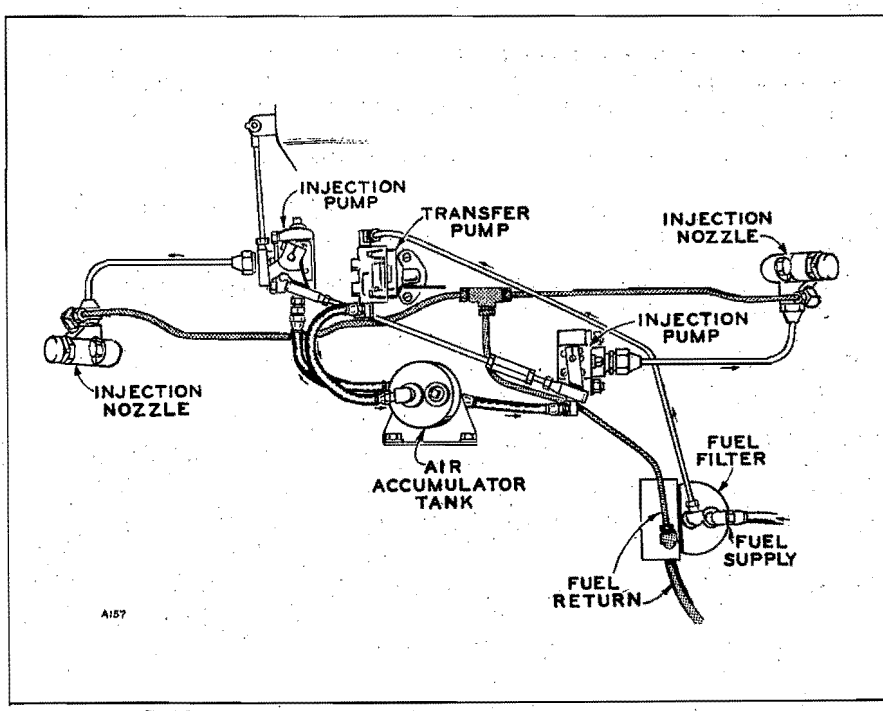


FIG. 10 - FUEL SYSTEM (Units Beginning with "Spec F")

WIRING. - Use sufficiently large insulated wire to connect the load to the generator leads at the plant. The wire size will depend largely on the distance and permissible voltage drop between the plant and the load and the amount and kind of load. Consult a competent electrician to help you plan your wiring. Check National and local codes before purchasing and installing electrical supplies. Include in your purchases a circuit breaker or fused switch between the plant and the first load circuit. Be sure the rating and type is correct for your unit.

WIRING TABLE

Unity Power Factor. 2% Voltage Drop (2.3 Volts)

WIRE SIZE NO.		14	12	10	8	6	4	2
Watts	Amps	* Distances expressed in feet per wire size.						
100	.87	510	810	1280	2040	3250	5300	8200
200	1.74	255	405	640	1020	1625	2650	4100
300	2.61	170	270	430	680	1080	1770	2730
400	3.48	125	200	320	510	810	1325	2050
500	4.35	100	160	255	410	650	1060	1640
750	6.52	65	100	170	275	430	710	1090
1000	8.69	50	80	125	205	325	530	820
1500	13.04	35	55	85	140	215	350	550
2000	17.38	25	50	65	100	160	265	410
2500	21.73	20	35	50	80	130	210	350
5000	43.36			25	40	65	105	160

* Above figures represent a point to point distance for a 2 wire run. If 4% voltage drop is permissible, double the distance listed. If only 1% voltage is allowable, divide the distances listed by 2.

Single Phase 115 Volt A.C. - Use 115 Volt table above.

Single Phase 115-230 Volt, A.C. 3 Wire - Use 115 Volt table above for each 115 Volt circuit.

Single Phase 230 Volt A.C. - Double the distances listed in the 115 Volt table above. Use Amps Column.

Three Phase 230 Volt circuit - Multiply the distances in the 115 Volt Table by 2-1/4 for the same load. Use the Amps Column.

CONNECTING THE LOAD. - Where connections are made by joining two wires, always be sure to tape the connections thoroughly. Apply two layers of half-lapped electrician's tape and two layers of half-lapped friction tape, extending both well beyond the ends of the connection.

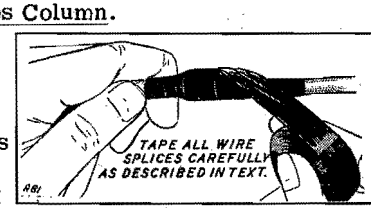


FIG. 11 - TAPING WIRE CONNECTIONS

1 PHASE-2 WIRE PLANT. - The two main generator leads extend out from the back side of the control box. Each lead has a terminal on the end. It is advisable to install like terminals on the leads from the fused switch or circuit breaker so that a good solid connection can be made by bolting the terminals together. The leads may also be connected by using solderless connectors if the terminals on the generator leads are removed.

The generator leads are marked "M1" and "M2". The lead marked "M1" is the hot lead and is to be connected to the "hot" side of the fused switch or circuit breaker. The lead marked "M2" is the "grounded" lead and is to be connected to the ground terminal of the switch or circuit breaker. The main line wires are then connected at the main fuse or circuit breaker. Be sure to connect the "hot" side of the main line to the "hot" side of the fused switch or circuit breaker.

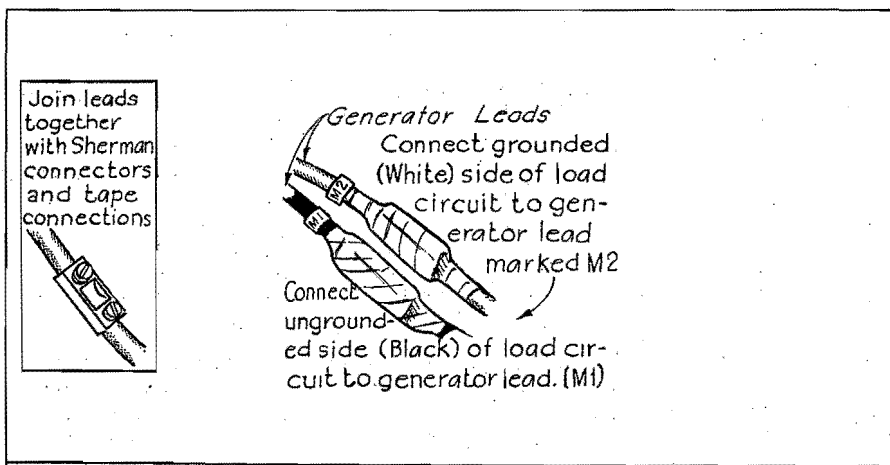


FIG. 12 - 1 PHASE - 2 WIRE LOAD CONNECTIONS

1 PHASE-3 WIRE PLANTS. - The method of connecting leads together is the same as given for 1 phase, 2 wire plants. However, these plants have three wires coming out of the generator marked "M1", "M2", and "M3". Both 115 volt current and 230 volt current are obtainable. The lead marked "M2" is grounded and is to be connected to the grounded terminal of the fused switch or circuit breaker. The leads marked "M1" and "M3" are "hot" and are to be connected to the hot terminals on the plant side of the fused switch or circuit breaker, one lead to each terminal.

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

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

Both 115 volt current and 230 volt current may be used at the same time. However, the total load on all circuits should not exceed the plant capacity. For example: A total of 2500 watts is available on each 115 volt circuit of a 5000 watt, single phase, three wire plant. If 1000 watts of current is used from each 115 volt circuit, only 3000 watts of 230 volt current can be used at the same time. If 2000 watts of 230 volt current is used, only 1500 watts of 115 volt current is available on each 115 volt circuit.

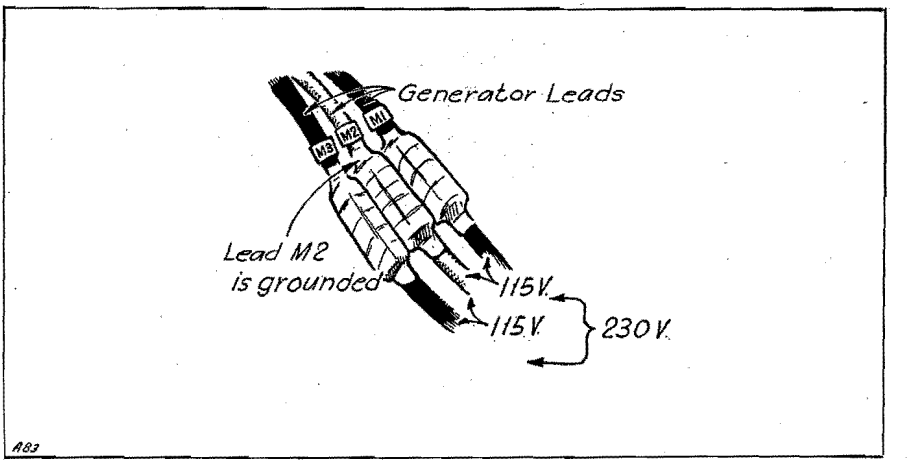


FIG. 13 - 1 PHASE - 3 WIRE LOAD CONNECTIONS

3 PHASE-3 WIRE PLANTS. - The method of connecting leads together is the same as given for 1 phase, 2 wire plants. However these plants have three leads coming out of the generator marked "M1", "M2" and "M3". Connect these leads to the terminals on the plant side of the fused switch or circuit breaker, one lead to each terminal. Single phase, 230 volt current and three phase, 230 volt current are obtainable. None of the leads are grounded.

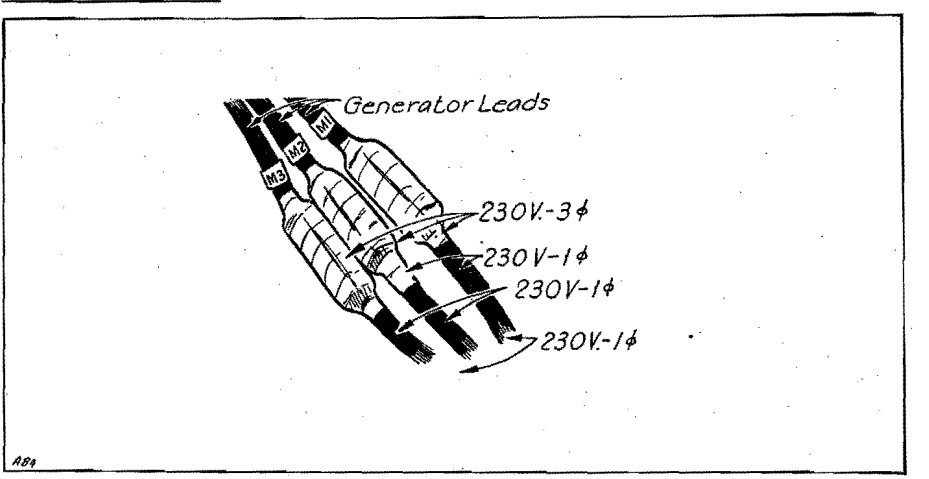


FIG. 14 - 3 PHASE - 3 WIRE LOAD CONNECTIONS

For 3 phase, 3 wire current, connect one main line wire to each of the three output terminals of the fused switch or circuit breaker. If the direction of rotation of the connected load is not correct after the plant is started, reverse the connections between any two terminals to correct the direction of rotation. To assure in phase connections, use a phase sequence indicator.

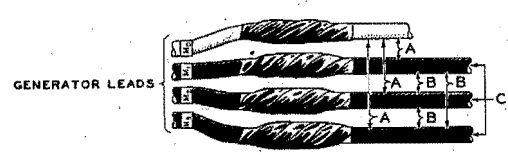
Three, 230 volt, single phase circuits may be obtained by connecting the two load wires of any single phase 230 volt circuit to any two of the three output terminals of the fused switch or circuit breaker. It is not advisable to use only one of the three, 230 volt single phase circuits. Use all three and connect an equal load to each of the three circuits to prevent unbalancing the generator. The load on any one of the three single phase circuits must not be more than 1/3 the rated capacity of the plant.

3 PHASE - 4 WIRE PLANT. - The method of connecting leads together is the same as given for 1 phase, 2 wire plants. However, these plants have four leads coming out of the generator marked "M1", "M2", "M3" and "MO", the lead marked "MO" being the ground lead. Both single phase and three phase current are available.

Connect one "hot" generator lead to each of the three "hot" terminals of a fused switch or circuit breaker. Connect the ground lead "MO" to the neutral terminal of the fused switch or circuit breaker.

For a 3 phase circuit, connect one main line wire to each of the three output terminals of the fused switch or circuit breaker. Do not connect any lead to the "neutral" terminal. If the direction of rotation of the connected load is not correct after starting the plant, reverse any two of the three load connections at the switch to correct the direction of rotation. To assure in phase connections, use a phase sequence indicator.

Three, 1 phase circuits may be obtained by connecting the "hot" wire of each single phase circuit to one of the output terminals (one "hot" lead to each terminal) of the fused switch or circuit breaker and the ground lead of each single phase circuit to the "neutral" terminal of the fused switch or circuit breaker. It is not advisable to use only one of the three, single phase circuits. Use all three and connect an equal load to each of the three circuits to prevent unbalancing the generator. The load on any one of the three, single phase circuits must not be more than 1/3 the rated capacity of the generator.



PLANT VOLTAGE	A	B	C
120/208 VOLT	120 V.-1 PHASE	208 V.-1 PHASE	208 V.-3 PHASE
220/380 VOLT	220 V.-1 PHASE	380 V.-1 PHASE	380 V.-3 PHASE

A119

FIG. 15 - 3 PHASE - 4 WIRE LOAD CONNECTIONS

REMOTE CONTROL CONNECTIONS. - If so desired, remote control start-stop stations may be installed at various points. Use No. 18 wire up to 250 ft., No. 16 wire up to 500 ft. and No. 14 wire up to 1000 ft.

Refer to the illustration REMOTE CONTROL CONNECTIONS. Note that there is a terminal block marked "Remote Control", B+, 1, 2, and 3. Terminal No. 1 is a common ground, terminal 2 is in the stopping circuit and terminal 3 is in the starting circuit. The terminal marked B+ is not to be used.

One remote start-stop switch is supplied with each plant. The terminals on the switch are numbered 1, 2 and 3. Connect a lead wire from terminal 1 of the switch to "Remote Control" terminal 1 in the control box, a lead from 2 to 2 and a lead from 3 to 3 to complete the installation. Additional start-stop stations may be installed either in parallel with the remote control switch or directly at the terminal block in the control box.

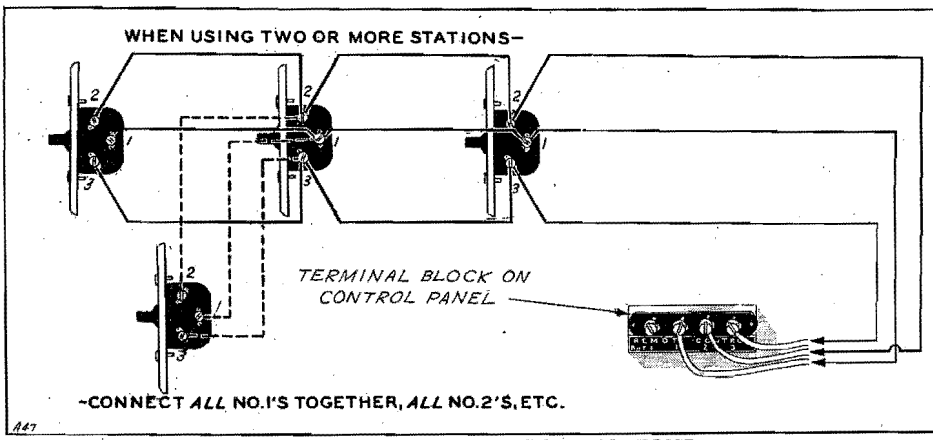


FIG. 16 - REMOTE CONTROL CONNECTIONS - A-C MODELS ONLY

CONNECTING THE STARTING BATTERY. - When starting batteries are supplied with the plant, they are shipped ready for use in the United States, Canada and Mexico. These batteries are in a well charged condition when shipped from the factory. However, if they are not placed in service within 30 to 40 days, they may become partly discharged. If such is the case, they should be given a freshening charge before being placed in service. Batteries supplied for use in other countries must be prepared for use according to the instructions given on the tag attached to the battery.

Batteries should always be installed on a wooden or metal rack to permit a free circulation of air around the battery.

Cables for making connections between the plant and the battery are supplied with all remote start plants even though the starting batteries are not. If necessary, spread the cable lug open slightly. Don't use a hammer to drive the cable lugs onto the battery terminal posts, because the battery may become damaged. Cable lugs should make clean full contact on the battery terminal posts to prevent loss of current at this point. Coat lugs and terminal posts with a thin coating of vaseline to help prevent corrosion.

If a single 12 volt battery is used, connect the long battery cable with the larger lug from the positive (+) post on the battery to the terminal on the starter. Connect the other long cable from the negative (—) post on the battery to the oil base stud as illustrated. The short jumper cable is not used with a single 12-volt battery. Secure cable connections at all points.

If two 6-volt batteries are to be connected in series to form a 12-volt battery, connect the short jumper cable from the negative (—) post of one battery to the positive (+) post of the second battery. Then make the longer cable connections as described in the foregoing paragraph.

CAUTION: DO NOT POSITIVE GROUND THE BATTERY OR A DEAD SHORT WILL BURN UP THE CHARGE CIRCUIT AS THE GENERATOR HAS NEGATIVE POLARITY.

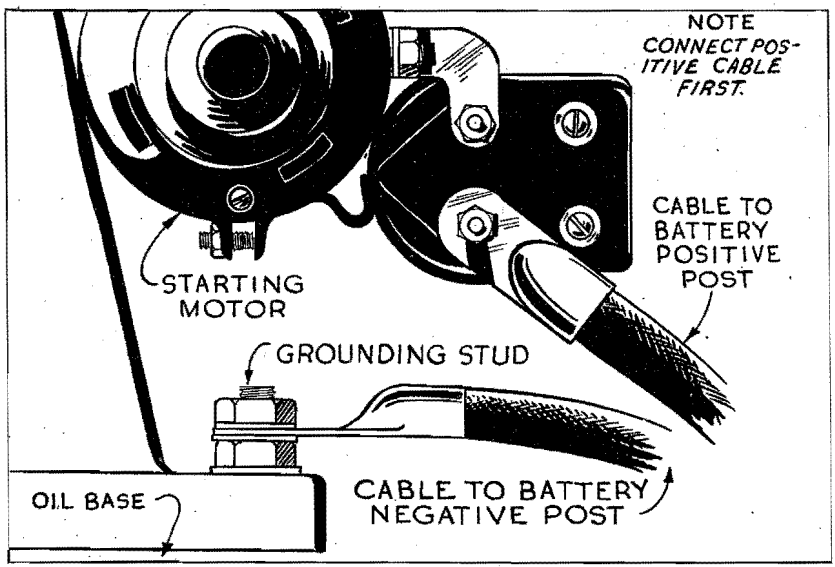
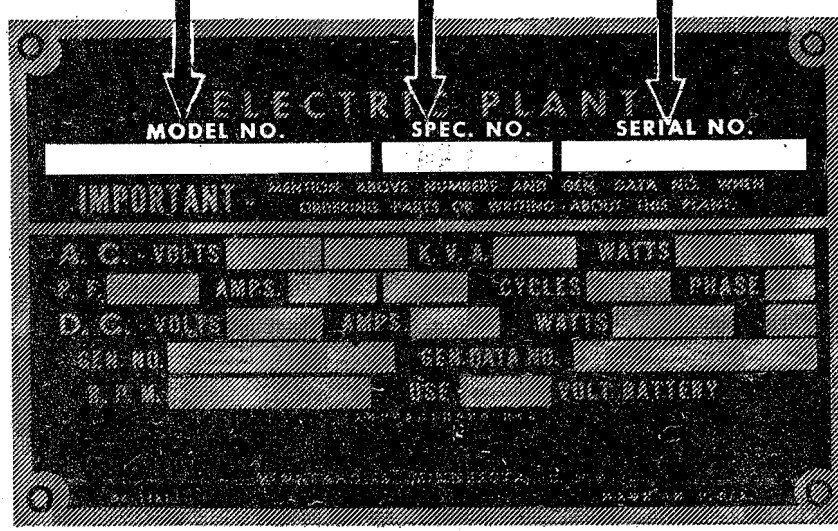


FIG. 17 - CONNECTING THE STARTING BATTERY

Important !

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

WRITE IN NUMBERS SHOWN ON PLANT NAMEPLATE



RECOMMENDED FUEL. - No. 2 Furnace Oil. Premium Diesel fuels are not required.

Alternate Fuel - No. 1 furnace oil (distillate and range oil) and kerosene may be used but one quart (U. S. Measure) of SAE No. 30 lubricating oil should be added to each 25 gallons of such fuel to provide lubrication for fuel injection equipment.

SPECIFICATIONS. - *

GRAVITY (Minimum) A. P. I. - - - - - - -	30°
VISCOSITY (Sagbolt Universal at 100° F.)	30. 5 to 45 Seconds
CETANE NUMBER - - - - - - - - - - - -	43 Minimum
SULPHUR (by weight) - - - - - - - - - -	1. 0% Minimum
CONDRADSON CARBON (10% Bottoms) -	0. 15% Maximum
FLASH POINT - - - - - - - - - - - - - -	130°F. Minimum or legal Mimimum
WATER AND SEDIMENT (by volume) - -	None
POUR POINT - - - - - - - - - - - - - - -	Must be 10° lower then minimum temperature at which fuel oil is to be used.

* Specifications may be changed without notice.

Keep fuel supplies in clean containers and adequately protected from rain, snow and dirt. KEEP THE FUEL SYSTEM CLEAN. If removal of any part becomes necessary, wrap it in clean paper, never in cloth or waste. Use clean diesel fuel for cleaning parts.

RECOMMENDED OIL. - Use heavy duty detergenty oil SAE No. 30 for crankcase, air cleaners and governor linkage except as noted for cold temperatures. If detergent oil is not available, use the best grade of SAE No. 30 oil available.

If sulphur content of fuel is higher than recommended maximum, "Series 2" detergent lubricating oil must be used. More frequent oil changes are also recommended. CAUTION - DO NOT START ENGINE UNTIL CRANKCASE IS FILLED - CHECK OIL LEVEL INDICATOR BEFORE STARTING ENGINE.

OIL CAPACITIES - Crankcase (Includes Filter) - 6 qts. U. S. Measure
Oil Filter - 1 pt. U. S. Measure
Air Cleaner - Fill to level indicated

PREPARATION FOR STARTING

FUEL. - Fill the fuel tank with clean recommended fuel.

CRANKCASE. - Fill the crankcase with 6 quarts (U. S. Measure) of heavy duty detergent SAE No. 30 oil. This includes oil for the filter. If the preparation is for cold temperature operation, don't put oil into the crankcase until just before starting. See COLD TEMPERATURES under Abnormal Operating Conditions. SAE No. 10 oil may be used at temperatures below 40°F.

CAUTION: Always be sure to replace the oil filler cap securely. A partial vacuum is created in the engine crankcase when the unit is in operation. Air leakage at the oil filler cap or gumming up of the flapper valve in the crankcase breather tube would destroy this partial vacuum and may result in oil leakage at the oil seals.

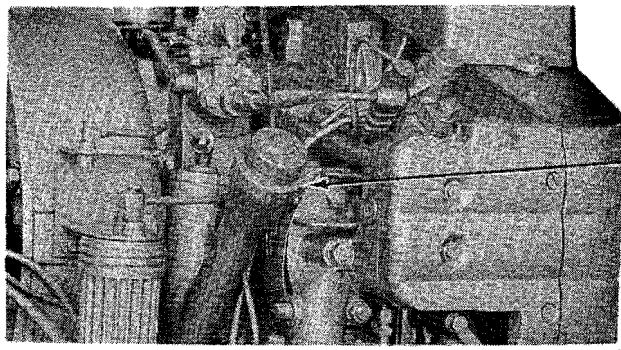


FIG. 18 - OIL FILL AND INDICATOR

AIR CLEANERS. - Fill the cups of both air cleaners to the level indicated with oil of the same SAE No. as used in the engine crankcase, except as noted for cold temperature operation. DON'T OVERFILL. The excess oil will be drawn into the combustion chamber by the air stream and may result in serious damage due to too heavy a charge in the combustion chamber causing the engine to "run away" (Exceed its maximum safe operating speed).

CIRCUIT BREAKER. - See that the main line switch or circuit breaker is at OFF position.

GOVERNOR LINKAGE. - Place a drop of SAE No. 30 oil on governor linkage joints.

FUEL VALVE. - Open the fuel shut-off valve at the fuel tank.

BLEED FUEL SYSTEM. - Before starting a new engine, an engine that has been idle for a long period of time or an engine that has run out of fuel, it is necessary to bleed the fuel system.

Remove the bleed plug from the air accumulator tank. Then work the primer lever on the transfer pump until fuel fills the tank. Do not replace the plug until the injection pumps are bled. Remove the bleeder plug on the left hand injection pump. Allow fuel from the air accumulator tank to flow freely at the opening until there are no air bubbles in evidence. Then replace the plug. Bleed the right hand pump in the same manner. Again operate the transfer pump primer lever to refill the air accumulator tank. Replace the bleed plug on the air accumulator tank. See the illustration BLEEDING THE FUEL SYSTEM.

NOTE: If the cam is on the high side the transfer pump will not operate. To correct, turn the crankshaft over one complete revolution. Leave the primer lever at the down position when through priming the fuel system. The pump will not operate with the lever at up position.

Models built prior to "Spec Letter F" do not have an air accumulator tank. Therefore, it is necessary to work the primer lever on the transfer pump during bleeding of each injection pump.

FUEL FLOW, PRIOR TO "SPEC LETTER F" MODELS. - Fuel flow is from the fuel tank to the primary filter, to the transfer pump, to the secondary filter, to the injection pumps, to the nozzles and to the combustion chambers. Fuel used to lubricate the nozzle pintle, drips back to the fuel tank through the return line.

FUEL FLOW, BEGINNING WITH "SPEC F" MODELS. - Fuel flow is from the fuel tank to the fuel filter, to the transfer pump, to the air accumulator tank, to the injection pumps, to the nozzles and to the combustion chamber. Fuel used to lubricate the nozzle pintle, drips back to the fuel tank through the return line.

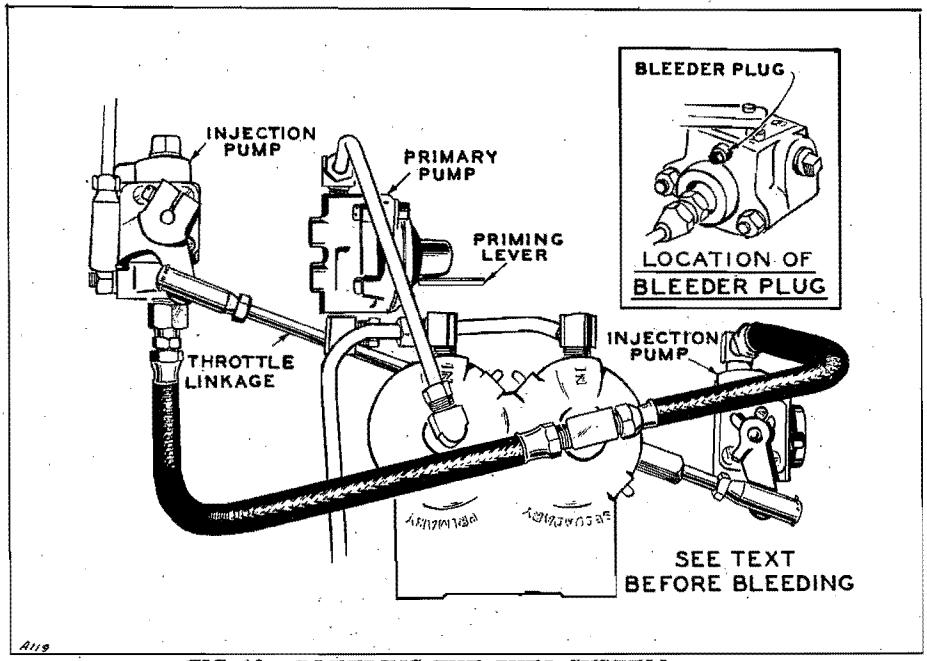


FIG. 19 - BLEEDING THE FUEL SYSTEM
(Units Prior to "Spec F")

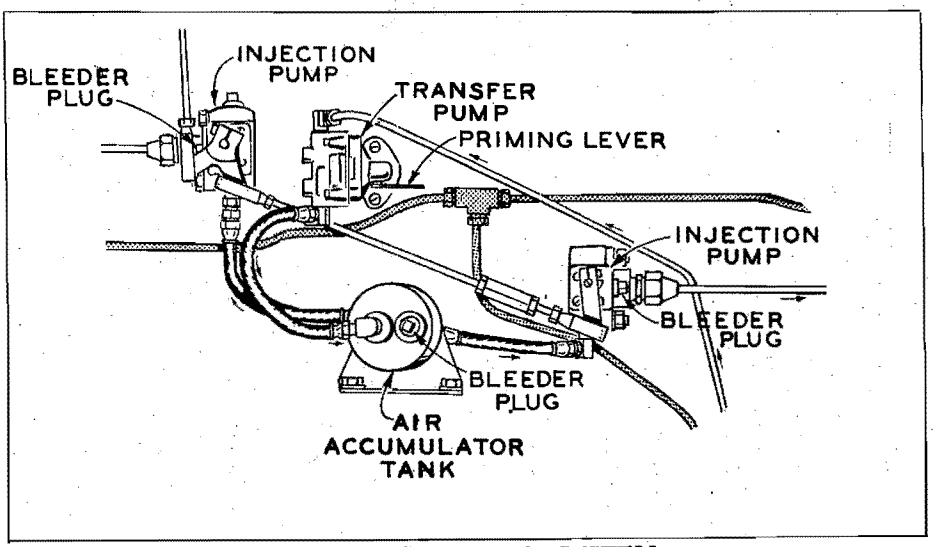


FIG. 20 - BLEEDING THE FUEL SYSTEM
(Units Beginning with "Spec F")

STARTING THE PLANT

GENERAL. - Starting instructions as described apply to starting at temperatures of 50°F. and above. Instructions for starting at lower temperatures are given under Abnormal Operating Conditions.

Check the entire installation to see that all connections and preparation have been made.

PRE-HEAT. - Hold the pre-heat switch at ON position up to two minutes if necessary.

CRANK. - Throw the momentary contact switch to START position and hold there until the engine is running fast enough to build up generator voltage. The engine will stop if the start switch is released too soon as current to the governor solenoid will be cut off. The engine cranks against compression and starts on compression. A sharp knock will be heard as the engine fires until it has warmed up. This is a normal condition. This sharp knock at starting diminishes as hours of operation rise.

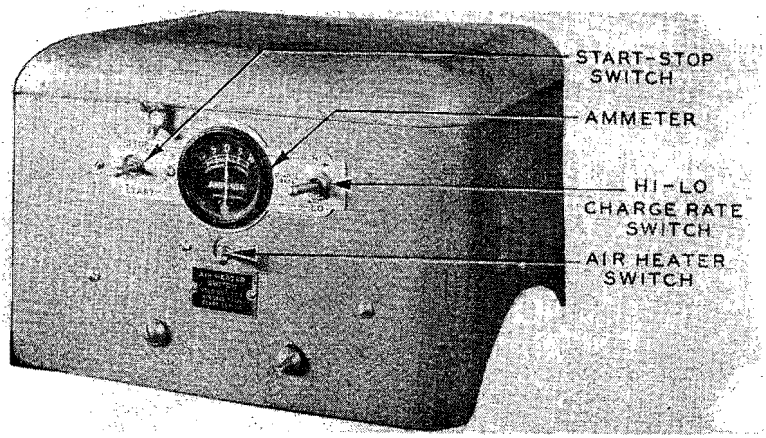


FIG. 21 - CONTROL PANEL

CHECK. - Should the engine fail to fire within about 1 minute, release the start switch and check the fuel system before attempting to start the unit again. Check the heating elements. These elements are located in the intake manifold. The elements and glow plugs heat only when the start switch is at START position or the pre-heat switch at ON position. A glow plug is installed in each cylinder head on models beginning with "Spec F".

If the engine fires but fails to keep running, chances are that the fuel system has an air leak or air pocket in the suction line at some point or the start switch is being released too soon. Bleed the fuel system and check fuel connections for leakage. Then repeat the starting procedure, holding the start switch at START position until the engine picks up speed.

Fuel leakage may occur at the nozzle base when a new engine is being started the first few times after the initial start has been made. To correct, tighten the nozzle mounting nuts, or cap screws when used. NOTE: Should trouble occur with nozzle or injection pump, no attempt should be made to repair the part in the field. Install a new part.

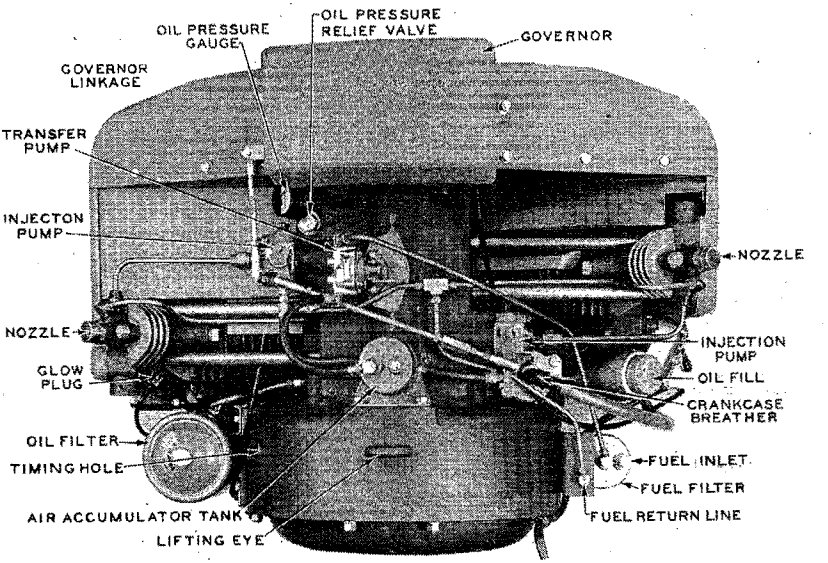


FIG. 22 - TOP VIEW OF ENGINE

MAIN CAUSES OF FAILURE TO START

DISCHARGED BATTERY. - The battery must have sufficient charge to operate the heating elements and to crank the unit against compression. If the battery is in a well charged condition and the unit fails to crank when the start switch is thrown to ON position, check for loose connections.

FUEL SYSTEM. - Air pockets, air leaks and dirty fuel are three of the main causes of trouble in a diesel engine. Check the fuel system regularly for leaks, correcting any found. When bleeding the fuel system, do a thorough job. When storing and handling fuel, use every precaution to keep it clean.

INJECTION PUMPS AND NOZZLES. - Very little trouble should be had with the injection pumps or nozzles unless dirty fuel is used. However, if trouble should occur, don't attempt to make repairs in the field. Install a new part.

OTHER CAUSES. - Refer to TROUBLES AND REMEDIES section.

POINTS TO CHECK AFTER STARTING THE PLANT

OIL PRESSURE. - The pressure reading on the gauge should be between 20 and 30 pounds at normal operating temperature. The reading will be higher than this with a cold engine but should fall to within these limits when it warms up. Should the oil pressure drop to 10 pounds or less, shut the plant off at once and determine the cause. Correct the trouble before restarting the plant. Before making any other tests, check the gauge. Beginning with "spec F" plants, the low-oil pressure cut-off switch will automatically stop the plant when the oil pressure drops dangerouly low.

OIL LEAKAGE. - If oil leakage occurs at the oil seals, check the breather tube check valve and the oil filler cap. The check valve must work freely. The oil filler cap must be air tight.

BATTERY CHARGING RATE (AC PLANTS). - A two way switch permits the selection of two charging rates, a high rate of 5 amps. and low rate of 1 to 2 amperes. Use the high rate if the battery condition is down or the plant is to be run for only a short period of time. Use the low rate if the battery condition is up or the plant is to be run for a long period of time.

Keep the battery in a well charged condition at all times. The gravity reading of a fully charged battery is about 1.280. The battery needs recharging if the gravity reading is 1.200 or lower. Keep the level of the fluid in the battery above the separators at all times. Unless the battery manufacturer specifies a different level, fill each cell with clean distilled water to a point 3/8 of an inch above the separators.

BATTERY CHARGING RATE (D.C. PLANTS). - Charge rate is controlled by a rheostat. To increase the charge rate, turn the rheostat clockwise. Follow battery manufacturer's specifications.

ENGINE SPEED. - Engine speed was set at the factory. Adjust only when necessary. Refer to SPEED ADJUSTMENT under Special Adjustment section.

BLACK SMOKY EXHAUST. - Black smoke coming from the exhaust outlet is an indication of trouble. Should this condition occur, shut the plant off at once and determine the cause. Correct the trouble before restarting the plant.

Main causes of black smoke are overloading the generator, poor grade or dirty fuel, improper operation of an injection pump or nozzle or improper injection pump timing.

Black smoky exhaust is a normal condition with an overloaded generator. This condition can be easily remedied by simply reducing the load.

Black smoky exhaust at less than rated generator capacity indicates faulty combustion. Continued operation of the plant under this condition may result in stuck rings, blow-by at the rings, or premature blackening of the crankcase oil from carbon. Faulty combustion is a direct result of loss of compression or faulty injection.

Also refer to the TROUBLES AND REMEDIES section for trouble diagnosis.

ENGINE RACES. - Stop the engine at once. This may require several steps. What usually happens when an engine races is that more fuel is drawn into the combustion chamber than can be safely burned. This extra fuel is usually drawn from the air cleaner because the cup was overfilled with oil or because the flapper valve in the breather tube is gummed up and not working properly allowing the oil to be drawn into the intake air stream. The first step in stopping the engine is to turn the governor arm toward idling position as far as it will go to cut off the normal fuel supply. Then remove the oil cup from both air cleaners. If necessary disconnect and remove the end of the hose at the breather tube. Another means of holding back engine speed is to apply a heavy electrical load to the generator. Disconnect this load when the engine has slowed down to a safe speed. Allow the engine to stop, determine what caused the engine to race and correct the trouble before starting the plant again.

VALVE CLEARANCE. - Check the valve clearance at the end of the first 50 hours of running time. Check only as needed thereafter. Refer to TABLE OF CLEARANCES under Maintenance and Repair.

FUEL KNOCK

Reference is made under starting instructions to a sharp knock that occurs when the engine is first started. This knock will usually diminish gradually as the engine warms up. However under such conditions as a cold engine, too much or too little fuel metered into the combustion chamber by the nozzle, an air leak in the suction side of the fuel system or to a change in the type of fuel used, the engine may continue to knock even after it is thoroughly warmed up. To remedy, proceed as follows.

FUEL SYSTEM. - Check for air leaks in the suction side of the fuel system. Any air leaks that are found should be corrected and the fuel system bled to remove all air from the system. The transfer pump should be checked. The pump must provide a continuous supply of fuel at all times. Replace or repair pump if necessary.

INJECTION. - Adjust the nozzle for best operation for the type of fuel being used. Nozzles are adjusted at the factory according to the type of fuel used for the test run. The type of fuel used for test runs is changed from time to time in order to assure that these units will operate properly on any of the recommended fuels. Make the nozzle adjustment as described under the heading NOZZLE ADJUSTMENT under the Special Adjustments section of this manual.

VENTILATION. - Close ventilator openings as necessary during cold weather operation to allow the engine to warm up to normal operating temperature. Care should be taken not to close these ventilators too much. Even though the unit is installed in a room without heat it will generator a large amount of heat itself and may eventually overheat unless sufficient ventilation is provided. Readjust ventilator openings from time to time until the unit operates best without overheating. Best operating conditions are with room temperatures of 50° F. to 70°F. for cold weather operation.

WHEN TO OPERATE THE PLANT

Alternating current plants supply current directly to the load and the plant must be operated whenever electricity is required.

The battery charging plant delivers current to the battery. The amount of electrical load which may be connected while the plant is not running will of course depend upon the capacity and charge condition of the battery. The amount of load which may be connected while the plant is running will be equal to the plant capacity plus the battery output. Operate the plant whenever it becomes necessary to recharge the battery or when a combined plant plus battery output is desired. To avoid possible damage to the generator, NEVER OPERATE THE PLANT WITHOUT THE BATTERY CONNECTED TO THE PLANT.

Most battery manufacturers recommend "cycling" the battery. This means a fully charged battery should be used without recharging until at least 85% discharged, then recharge fully. Repeat through complete cycles of charge and discharge for maximum life of the battery. Keeping a battery at a full state of charge at all times, without permitting it to cycle, may shorten its life by as much as 75%.

STOPPING THE PLANT

Disconnect the load from the plant and let the plant run for a few minutes at no load to allow the engine time to cool gradually before stopping the plant.

Throw the Start-Stop switch to STOP position. This grounds out the coil of the governor operating solenoid and the spring pulls the governor arm to stop position, shutting off the fuel supply.

If for any reason the plant will not stop when the start-stop switch is thrown to STOP position, stop the plant by pulling the governor arm to stop position by hand.

CONTROLS AND THEIR FUNCTIONS (AC PLANTS)

GENERAL. - Each part in the control box has a duty to perform, sometimes more then one. The following paragraphs describe the purpose of these parts and their functions. By carefully reading each paragraph and tracing out the circuits on the wiring diagram, a better understanding of the operation of your plant will be gained. You will also be better prepared to correct any troubles that might occur with the control circuits.

STARTING PILOT RELAY. - This relay operates only while the start switch is at start position. It closes the circuit of the governor solenoid relay, the manifold heater and glow plug relay, and the start solenoid. All four of these relays operate on battery current. Its purpose is to assure positive action of the other relays, especially when the unit is started from a remote station. Voltage loss from plant to station might otherwise affect relay operation.

GOVERNOR SOLENOID RELAY. - This relay operates only while the start switch is at the START position. Its purpose is to complete the circuit through the governor solenoid coil during cranking. This releases the governor stop lever, allowing the governor to function, the throttle opens and fuel is supplied to the cylinders. The start switch must be held in until generator voltage is built up enough to operate the governor solenoid. Otherwise the plant will stop as soon as the start button is released.

MANIFOLD HEATER AND GLOW PLUG RELAY. - This relay operates to complete the circuit through the manifold heaters, warming the intake air stream to aid starting. Glow Plugs are connected in the Manifold Heaters Circuit, beginning with "Spec F" models. Glow plugs, installed one in each cylinder head, help to ignite the fuel in the combustion chamber during the starting period. This relay operates whenever the start switch is at START position or the heater switch is at ON position.

START SOLENOID. - This relay, mounted on the starting motor, completes the circuit from the battery to the field windings of the starter. Current from the battery causes the starter armature to rotate, cranking the unit.

START DISCONNECT RELAY . - This relay operates to break the circuit through the start solenoid as soon as the engine fires and has gained speed. Operating current for this relay comes from the generator. This relay operates to stop cranking even though the start switch is held at START position after the engine fires.

STOP RELAY. - This relay operates to break the circuit to the governor solenoid. Throwing the start-stop switch to STOP position grounds out the coil of the stop relay, its contacts open, and the circuit to the governor solenoid is broken releasing the governor stop lever. The governor stop spring pulls the stop lever against the governor arm, forcing the arm to close the throttle and stop the plant.

CHARGE RELAY. - This relay acts as a switch to open and close the battery charging circuit. When the plant is idle the charge relay points remain open, preventing discharging of the battery. When starting the plant, the relay points remain open until generator voltage is high enough to energize the coil of the charge relay in the generator circuit, closing the points, completing the battery charging circuit.

HI-LO CHARGE SWITCH. - This switch regulates the charging current to the starting battery by cutting resistance in or out of the circuit.

MANIFOLD HEATER AND GLOW PLUG SWITCH. - This switch permits manual operation of the heaters and glow plugs prior to starting.

CHARGE AMMETER. - The ammeter indicates ampere rate of charge to or discharge from the starting battery.

START-STOP SWITCH. - This switch completes the start circuit at START position and the stop circuit at STOP position.

REMOTE TERMINAL BLOCK. - The terminal block facilitates installation of remote start-stop stations at convenient points.

CONTROLS AND THEIR FUNCTIONS (BATTERY CHARGING PLANTS)

GENERAL. - The Battery Charging Plant does not use a Starting Pilot Relay; Start Disconnect Relay; Charge Relay; or Hi-Lo Charge Switch, and the engine is cranked by Generator Excitation instead of a separate starter as used with the alternating current plants.

GOVERNOR SOLENOID RELAY. - This relay operates only while the start switch is depressed. It's purpose is to complete the circuit through the governor solenoid coil during cranking.

This releases the governor stop lever, allowing the governor to function, the throttle opens and fuel is supplied to the cylinders. The start switch must be held in until generator voltage is built up enough to operate the governor solenoid. Otherwise the plant will stop as soon as the start button is released.

MANIFOLD HEATER AND GLOW PLUG RELAY. - This relay operates whenever the start switch is at START position or the heater switch is at ON position. This relay operates to complete the circuit throught the manifold heaters and glow plugs. The manifold heaters warm the intake air stream to aid starting. The glow plugs, mounted one on each cylinder head, help ignite the fuel during the starting period. The glow plugs are resistance units and are connected in the manifold heater circuit. Current voltage at the glow plug, is reduced to 12 volts by first passing through the manifold heater. Don't operate the glow plug on voltage above 12 volts.

MANIFOLD HEATER AND GLOW PLUG SWITCH. - This switch permits manual operation of the heaters and glow plugs prior to starting the plant.

START SOLENOID. - This solenoid completes the circuit from the battery to the series windings of the generator. Current from the battery causes the generator armature to rotate, cranking the unit. This Solenoid Switch operates only when the start switch is at START position.

STOP RELAY. - This relay operates to break the circuit to the governor solenoid. Depressing the stop switch to STOP position grounds out the coil of the stop relay, its contacts open and the circuit to the governor solenoid is broken releasing the governor stop lever. The governor stop spring pulls the stop lever against the governor arm, forcing the arm to close the throttle and stop the plant.

CHARGE AMMETER. - The ammeter indicates ampere rate of charge to the battery.

START-STOP SWITCH. - This switch completes the start circuit at START position and the stop circuit at STOP position.

300 AMPERE FUSE. - The fuse is used in the battery charge circuit to protect against overload.

RESISTORS. - Resistors are used to limit the voltage in the circuits to the Start Solenoid, the Stop Relay, and the Governor Solenoid.

FIELD RHEOSTAT. - The rheostat, connected in series with the shunt field winding of the generator, controls the output of the generator by varying the strength of the shunt field. This is done by varying the amount of resistance in the field circuit through different settings of the rheostat; the more resistance in the field circuit, the less the generator output.

SHUNT. - Shunt is used in the output circuit to permit use of the d-c ammeter.

COLD TEMPERATURES

Full Diesel engines fire on compression alone and starting problems may occur at temperatures of 50° F. and below. We suggest that you read the following paragraphs carefully. They contain many helpful hints on cold weather starting.

Drain the crankcase oil while the engine is warm and refill the crankcase with heavy duty detergent SAE No. 5 oil. Start the engine and let it run for 1/2 hours. For heavy duty operation or continuous service, change to SAE No. 30 oil and provide some means of heating the space in which the plant is located.

If the oil in the air cleaners tends to congeal, clean the air cleaner and refill the air cleaner to the level indicated with SAE No. 5 oil. Continue to use SAE No. 5 oil until temperatures return to normal.

In extremely cold weather, heating the oil used in the air cleaners to around the boiling point of water should be helpful. The oil should be heated and then poured into the air cleaner cups. Heating should not be attempted while the oil is in the air cleaner as direct heat will damage the air cleaner unit.

CAUTION: DON'T HEAT OIL OVER AN OPEN FLAME AND DON'T OVERHEAT IT.

Any other means of increasing the temperature of the air being drawn into the combustion chamber will aid starting.

The fuel in the combustion chamber is ignited by the rise in temperature of the air in the chamber due to compression. Heating elements are provided to preheat the air before it enters the combustion chamber. Beginning with Spec F models, Glow Plugs are provided to help ignite the fuel during the starting period. Glow plugs are connected in the air heater circuit. These heating elements operate whenever this start-stop switch is in the START position. A separate switch is also provided so that the heating element can be energized before attempting to start the plant. Throw this switch to the ON position for a period of about 2 minutes just before the plant is to be started.

BE SURE THE FUEL USED HAS A LOW POUR POINT (at least 10 degrees lower than the prevailing temperature) AND WILL FLOW FREELY AND NOT CONGEAL IN THE LINES. Fuel tends to form wax crystals and congeal in the filters and fuel lines at low temperatures. If trouble of this nature occurs, warm the fuel or change to a Diesel fuel having a lower pour point. The lowest temperature at which the fuel will flow through a pipe is known as the pour point or congealing point.

Keep all fuel tank screens clean. Clogged screens interrupt the flow of fuel and may cause air leaks.

Keep fuel supplies free of water. If fuel containing water is used, it may freeze and close off the fuel supply.

Air locks may occur often in cold weather due to fuel not flowing freely. When bleeding the fuel system be sure to clear all air pockets.

The fuel filter is a cartridge type, on models beginning with "Spec F". With clean fuel and normal operating conditions the cartridge needs replacement only every 1000 operating hours. With temperature close to the fuel pour point give more frequent attention to the filter so that fuel flow is not restricted by sludge or wax crystals.

Keep the battery fully charged at all times. Under extremely cold conditions the terminal voltage of a battery drops as much as 30% and does not have power enough to crank a cold engine fast enough to start it. A temporary addition of a 12 volt battery, connected in parallel, during the starting period will improve cranking speed. Remove this booster battery as soon as the plant is started.

Check the charged condition of the battery often with a hydrometer. Batteries will freeze between temperatures of 20^{O} F. above zero and 50^{O} F. below zero, depending on the state of charge.

Let the engine warm up slowly before applying the load. Watch the oil pressure carefully. Don't apply any load until the oil circulates freely.

HIGH TEMPERATURES

Keep the level of the oil in the engine crankcase at or near the full mark at all times.

Be sure there is ample ventilation so that radiated heat from the engine is not recirculated causing the engine to overheat. Provide more or larger air inlets or air outlets if necessary.

Keep all cooling surfaces clean and free of dust, dirt, grease and oil.

DUST AND DIRT

Check plant operation more often and service as needed.

Clean the air cleaners as often as necessary to assure a free passage of air to the combustion chambers.

Check the commutator and brushes of the generator and see that the brushes ride freely in their holders and make good contact. See **GENERATOR** under Maintenance and repair for service instructions.

Keep supplies of fuel and oil in air tight containers.

Keep the plant as clean as practicable.

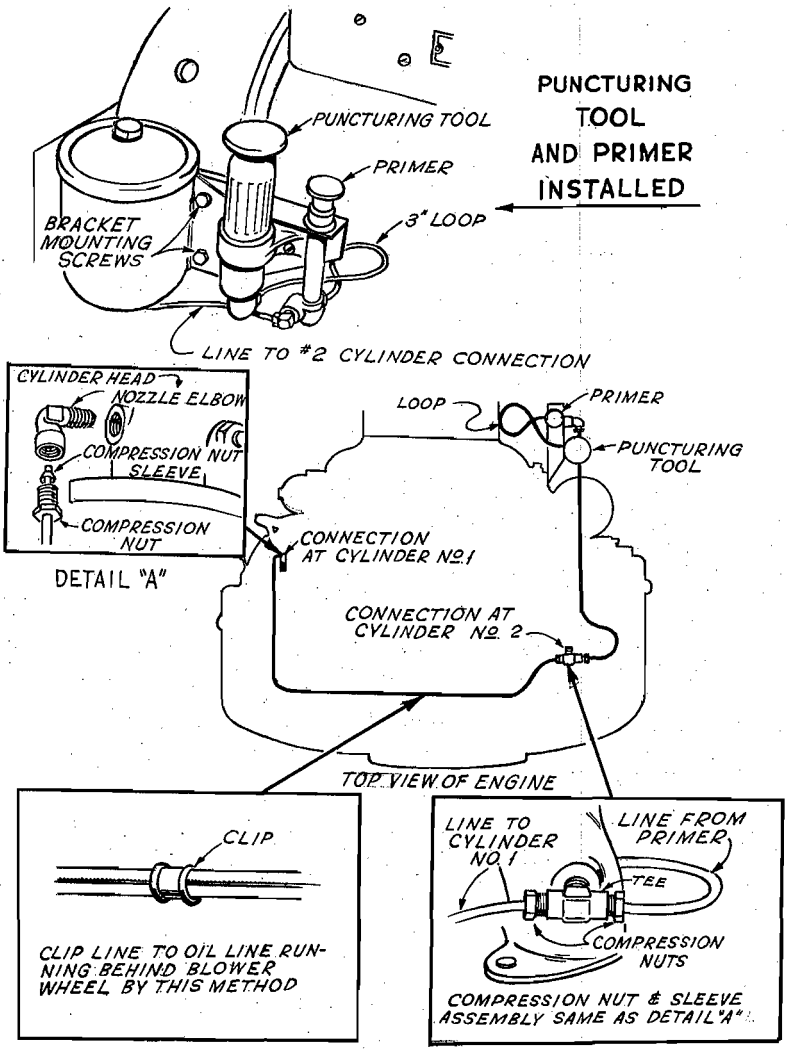
SPECIAL PRIMING KIT FOR COLD WEATHER STARTING

Compact • Easily Installed • Simple to Operate

Incorporates using special starting fluid in capsule form by atomizing fluid into engine induction system.

Permits starting if temperature permits cranking!

Old engines no longer hesitate to start!



The ability to start a diesel engine in cold weather is limited by several factors among which are engine condition, fuel pour point, ability to pass fuel through filter and ability to crank.

The low kindling point fuel used with the primer permits starting at lower temperatures.

GENERAL. - Certain services must be performed periodically if your plant is to continue operating efficiently and economically. Service periods are based on hours of running time under normal operating conditions. For extreme conditions of load, temperature, dust, dirt, etc., service more often.

DAILY SERVICE

Perform the following services daily or at the end of each 8 hours of running time, whichever occurs first.

FUEL. - Check the fuel supply often enough to avoid running out of fuel. Use only recommended fuel.

CRANKCASE OIL LEVEL. - Check the oil level as indicated on the bayonet type gauge. Add recommended oil if necessary. Always be sure to replace the oil fill cap securely. Air leakage at this point may cause oil leakage at the seals.

AIR CLEANER. - Check the oil level in the air cleaner cups. If necessary add oil of the same SAE No. as used in the engine crankcase.

CLEANING. - Keep The plant clean. A clean plant will give longer and more satisfactory service.

WEEKLY SERVICE

Perform the following services weekly or at the end of each 50 hours of running time, whichever occurs first.

CRANKCASE OIL. - Change the crankcase lubricating oil every 100 hours of running time. If sludge formation or condensation forms during cold weather operation, then change oil more often. Change the oil filter cartridge each time the crankcase oil is changed. Remove the drain plug from the oil filter and drain the old oil before installing the new cartridge.

GENERAL LUBRICATION. - Place a drop of SAE No. 30 oil on each joint of the governor to throttle linkage.

STARTING BATTERIES. - Check the fluid level in the starting batteries. Add distrilled water to bring the fluid to 3/8" above the separators if necessary.

AIR CLEANERS. - Thoroughly clean the air cleaner cups in Diesel fuel and refill the cups to the level indicated on the cup with oil of the same SAE No. as used in the engine crankcase, except as notes under Abnormal Operating Conditions.

GENERAL INSPECTION. - Tighten all loose nuts, bolts, connections, etc.

VALVE CLEARANCE. - Check the valve clearance at the end of the first 50 hours of running time. Reset the valve clearance if necessary.

FUEL FILTER (For Plants With Cartridge Type Fuel Filter). - The fuel filter cartridge normally requires replacement only every 1000 operating hours. Refer to the illustration SERVICING THE FUEL FILTER.

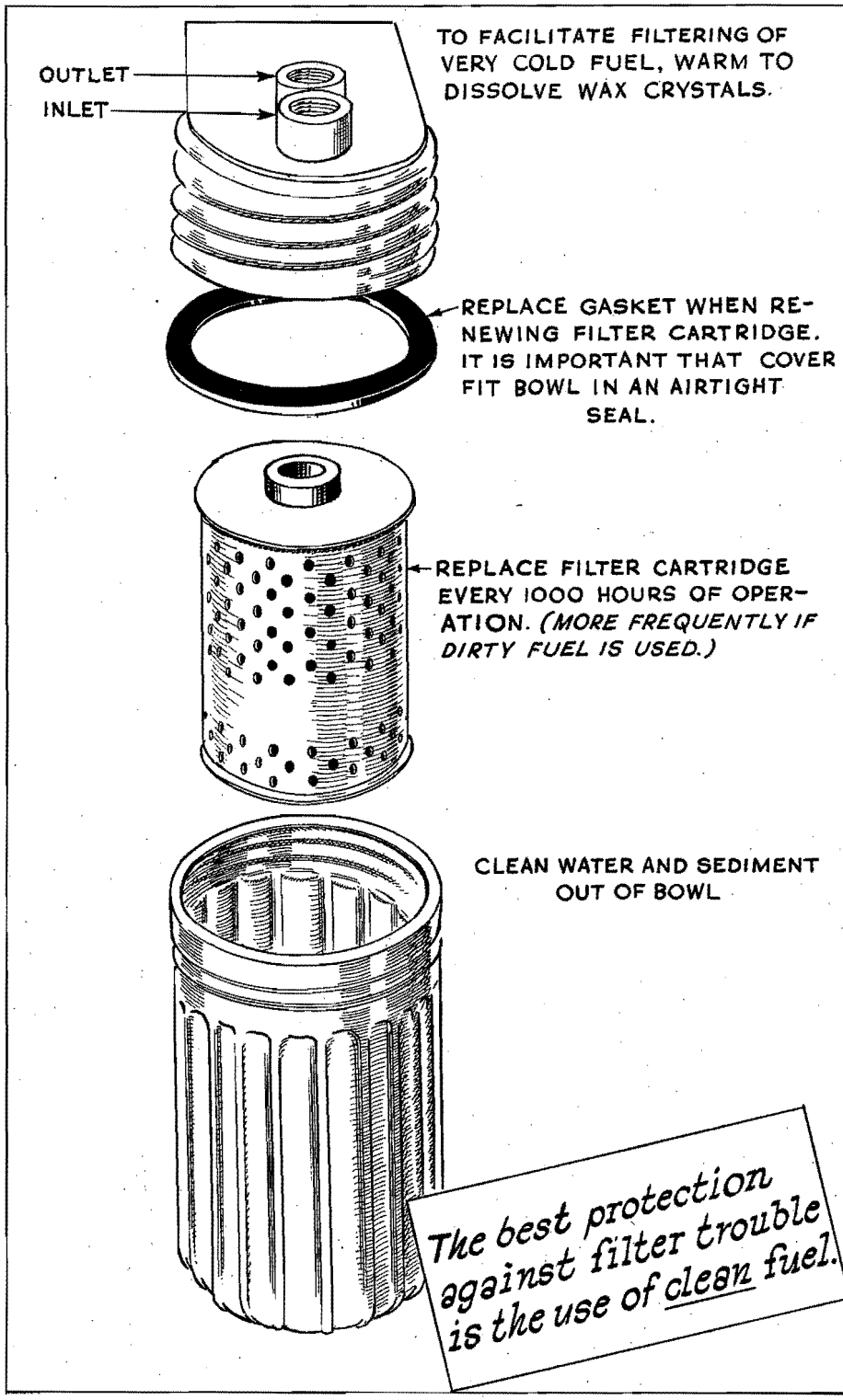
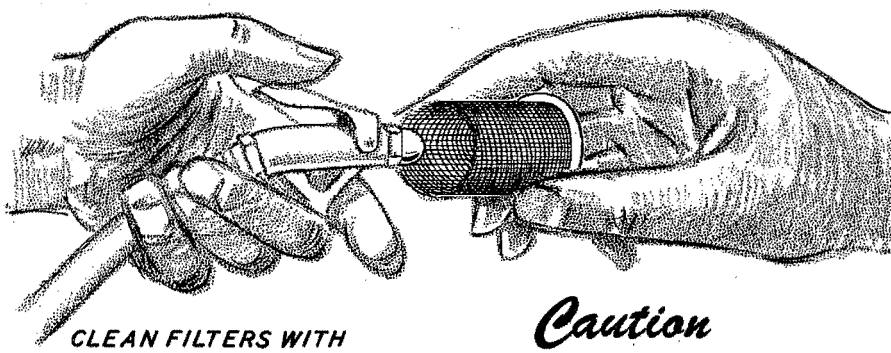


FIG. 23 - SERVICING THE FUEL FILTER
(Units Beginning with "Spec. F")

THE BEST PROTECTION AGAINST FILTER TROUBLE IS THE USE OF CLEAN FUEL

Note- FILTERS SHOULD BE CLEANED ONLY WHEN NECESSARY. THE PRIMARY FILTER MAY HAVE TO BE CLEANED SEVERAL TIMES BEFORE IT BECOMES NECESSARY TO CLEAN THE SECONDARY FILTER.



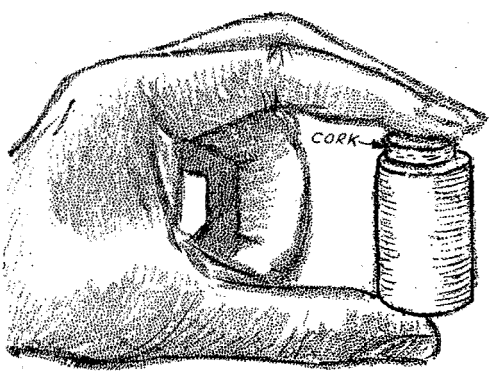
CLEAN FILTERS WITH COMPRESSED AIR IF AVAILABLE, BLOWING AIR FROM INSIDE OF ELEMENT TO THE OUTSIDE.

Caution

BE SURE AIR PRESSURE TANK AND LINES DO NOT CONTAIN WATER. ALWAYS OPEN NOZZLE TO CLEAR WATER FROM LINES BEFORE CLEANING FILTER ELEMENT. DO NOT DAMAGE SCREEN.

Gasket-

ALWAYS INSTALL A NEW GASKET WHENEVER THE FILTER BOWL IS REMOVED.



IF FILTER ELEMENT MUST BE CLEANED BY SUBMERGING OR SWISHING IN CLEAN DIESEL FUEL CLOSE TOP SO THAT SOLUTION CAN NOT GET INSIDE AND LEAVE SEDIMENT.

FIG. 24 - SERVICING THE FUEL FILTER
(Units Prior to "Spec F")

FUEL FILTER (For Plants With Primary and Secondary Fuel Filters). - Check the fuel filter bowls visually for water or sediment. Don't clean unless the visual inspection indicates it's necessary or engine operation indicates the fuel system is dirty. The primary filter screen may have to be cleaned many times before it's necessary to clean the secondary filter element.

Water in the primary filter bowl will show in the bottom of the bowl when the plant is stopped. Water in the secondary filter bowl will give the fuel a misty or cloudy appearance when the plant is running. Sediment in either filter will settle to the bottom of the bowl when the plant is idle.

Refer to the illustration SERVICING THE FUEL FILTER.

MONTHLY SERVICE

Perform the following services monthly or at the end of each 200 hours of running time, whichever occurs first.

GENERATOR. - Check the generator brushes. Brushes worn to 5/8" in length should be replaced.

Check the commutator and collector rings. A glossy brown color is normal. Brush surfaces must be smooth and cylindrical to assure good brush contact. See GENERATOR under the heading Maintenance and Repair for instructions.

EXHAUST SYSTEM. - Inspect exhaust connections. Tighten or replace parts requiring it.

ENGINE COMPRESSION. - Valve grinding is a service that must be performed periodically if your plant is to continue operating efficiently. There is no set period for performing this service. However, it is recommended that the following tests be made whenever the plant begins to lose power or consume an excessive amount of fuel or oil.

Insert the crank into the opening provided for this purpose at the front of the engine. Engage the crank dog and crank the engine over slowly. If compression is good it will require a lot of strength to crank the engine past the compression stroke. If compression is poor, the engine can be cranked past the compression stroke although not easily due to the high compression ratio of the engine.

Loss of compression may be due to a poor valve condition, worn or sticking pistons rings, worn piston ring grooves or to worn cylinder walls. If an exhaust valve is leaking, it can be heard at the exhaust outlet on the plant. If the intake valve is leaking, a hissing noise will be heard at the air cleaner opening. A compression leak past the piston rings can be heard at the oil filler opening.

SEMI-YEARLY SERVICE

Perform the following services every six months or after each 1200 hours of running time, whichever occurs first.

GENERATOR BEARING. - Clean all dirt from around the generator bearing cover and remove the cover. On some models the cover is pressed into the bearing support and is removed by prying it out. Other models have a cover held in place by screws.

NOTE: (When Lubricating with **Lithium Base Grease Refer to the Next Paragraph)** After removing the cover clean all old grease from the bearing with a clean finger and work about one tablespoonful of new bearing lubricant well into the bearing. Again clean the bearing and refill the lower half of the bearing about 1/2 full of new grease, packing it well into the lower half of the bearing. See the illustration SERVICING THE GENERATOR BEARINGS. Use only a good ball bearing lubricant such as supplied with your plant. Take care to avoid getting dirt into the bearing. Replace the bearing cover.

When Lithium Base Grease is used, fill only 1/4 the bearing with new grease. Do not build up a reserve supply since this would not permit the bearing to cool properly. (Refer to instructions included with lubricant).

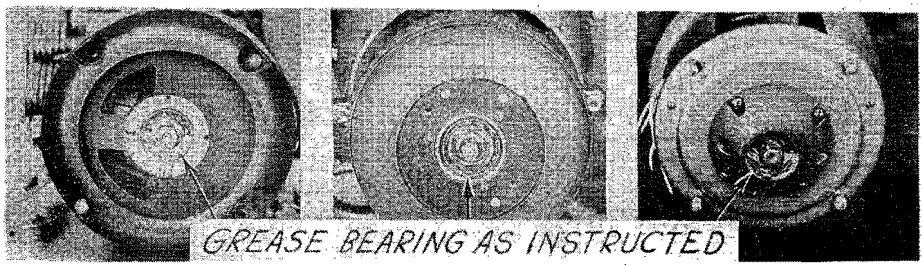


FIG. 25 - SERVICING THE GENERATOR BEARINGS

BRUSH RIG. - Check the generator brush rig to see that it has not shifted from its original position. Operation of the generator with the brushes out of neutral position causes rapid brush wear and excessive arcing of the brushes. Instructions for adjusting are described in the GENERATOR section of Maintenance and Repair.

GOVERNOR

GENERAL. - The governor is set at the factory to maintain a preferred regulation. Before attempting to make any adjustments on the governor it is recommended that the following paragraphs be carefully studied and that each point be checked in the order given.

LINKAGE, GOVERNOR ARM AND THROTTLE - The linkage between the two throttle levers should be adjusted so that at full rated load both cylinders will pull equal load and at stop position still fully close the throttle of both pumps. Apply a load of about 6000 watts (5000 watts for 50 cycle units) and check the exhaust for a smoky condition. If one cylinder is getting too much fuel it will tend to smoke. Loosen the linkage adjusting turnbuckle lock nut and turn the turnbuckle a little at a time until smoky exhaust clears. Then tighten the lock nut. See the illustration THROTTLE LEVER POSITIONS. Remove all load and press the stop button on the plant. If the plant stops the setting is correct. If the plant does not stop, the adjustment made at full load probably holds one throttle open at stop position. If the throttle stops on both pumps do not touch the stop screw at the closed position and again at the wide open position, the arcs made by the throttle levers must be synchronized by adjusting one of the levers.

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

The linkage and the position of the governor arm must synchronize the travel of the governor arm and throttle levers so that the governor is wide open when the throttle levers are wide open and closed when the throttle levers are closed. The position of the governor arm is fixed and adjustment is made through the connecting linkage. Turn the governor arm away from the injection pump as far as it will go to place the governor shaft yoke against the governor cup. Then with the tension of the governor spring holding the arm at wide open position, adjust the linkage to hold the throttle levers at wide open position. See the illustration GOVERNOR ADJUSTMENT. Be sure there is no looseness or binding at any point.

Although the factory sealed position of the throttle lever stop on the inection pump is adjustable, the position should never be changed or altered in any manner as it fixes the position of the shaft which in turn determines the flow of fuel to the injection pump. If necessary to reset the stop, due to accidental loosening, refer to RESETTING THE INJECTION PUMP THROTTLE STOP under Special Adjustments.

GOVERNOR SPRING. - Due to the fact that springs become fatigued and lose their original tension from long usage, it sometimes becomes necessary to install a new governor spring to get proper regulation. It is difficult to determine whether or not a spring is fatigued. Usually if all other adjustments have been properly made and regulation is still erratic, the trouble can be corrected by installing a new governor spring and resetting the sensitivity and speed adjusting screws.

SENSITIVITY ADJUSTMENTS. - The position of the sensitivity adjusting screw controls the travel and leverage of the governor spring and determines the rpm between no load and full load. This rmp difference should not be more than 105 nor less than 45 rpm. Check with a tachometer. To increase rpm between no load and full load, turn the sensitivity screw out, to decrease, turn the screw in. See the illustration GOVERNOR ADJUSTMENT. Always recheck engine speed after making a sensitivity adjustment.

A hunting condition (engine alternately increasing and decreasing speed) may result from the rpm between no load and full load being too low. Should this condition exist, turn the sensitivity screw out until the condition is corrected. Regulation is better with the end of the spring held closer to the governor shaft but the tendency to hunt is increased. Make the adjustment that gives the best regulation with no hunting. A more likely cause of the engine hunting is lack of fuel due to improper adjustment or blockage of the fuel system.

SPEED ADJUSTMENT. - The speed at which the engine operates is determined by the tension applied to the governor spring. Engine speed also determines current frequency and output voltage of the generator. Increasing spring tension increases engine speed and generator voltage. Decreasing spring tension decreases engine speed and generator voltage. Check engine speed with a tachometer. Check voltage with a voltmeter. Nominal engine speed and generator voltage should be as follows.

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

MAXIMUM NO LOAD ENGINE SPEED should not be more than 1890 rpm for 60 cycle units nor more than 1710 rpm for 50 cycle units.

MAXIMUM NO LOAD VOLTAGE should not be more than 126 volts for 115 volt circuits nor more than 252 volts for 230 volt circuits.

MINIMUM ENGINE SPEED at full rated generator capacity should not be less than 1710 rpm for 60 cycle units nor less than 1500 rpm for 50 cycle units.

MINIMUM VOLTAGE at full rated generator capacity should not be less than 107 volts for 115 volt circuits nor less than 218 volts for 230 volt circuits.

MAXIMUM SPEED DROP from no load to full load should not be more than 105 rpm nor less than 45 rpm.

If a speed adjustment is needed, turn the speed adjusting nut in to increase engine speed and generator voltage or out to decrease it. See the illustration GOVERNOR ADJUSTMENT. Be sure to lock the adjustment with the other hex nut.

For battery-charging plants use the speed shown for 60 cycle units.

GOVERNOR STOP SOLENOID AND SPRING. - The governor stop solenoid operates on voltage from the battery during starting, then from the d-c winding of the generator while the unit is running. The tension on the coil spring is adjustable to regulate the response of the solenoid when stopping the unit. Correct tension is applied when the solenoid will have just enough pull while the unit is running to overcome spring tension. The solenoid should release the spring the instant the stop button is pressed to stop the unit but should not release because of spring tension alone while the unit is running.

Beginning with "Spec F" models, the governor stop solenoid assembly was designed to eliminate the following flat spring! The flat spring that engages the stop lever when at stop position prevents the governor arm from creeping while the unit is losing speed during the stopping cycle. Any movement of the governor arm tends to keep the unit running although only at a very low speed. The end of the stop lever should fit closely into the offset of the spring. The spring position is adjustable at its mounting point.

GOVERNOR ADJUSTMENT PROCEDURE. - Disconnect the stop lever spring from the bracket.

Check the position of the governor arm and the linkage to the throttle lever. Make adjustments as described in paragraph LINKAGE - GOVERNOR ARM AND THROTTLE if necessary.

Check the linkage between throttle levers. Make adjustments as instructed in paragraph LINKAGE - GOVERNOR ARM AND THROTTLE if necessary.

Start the unit and check the no-load rpm. Correct as instructed in paragraph SPEED ADJUSTMENT if necessary.

Check the rpm between no load and full load. Make adjustments as described in paragraph SENSITIVITY ADJUSTMENT if necessary. Always correct the speed after a sensitivity adjustment.

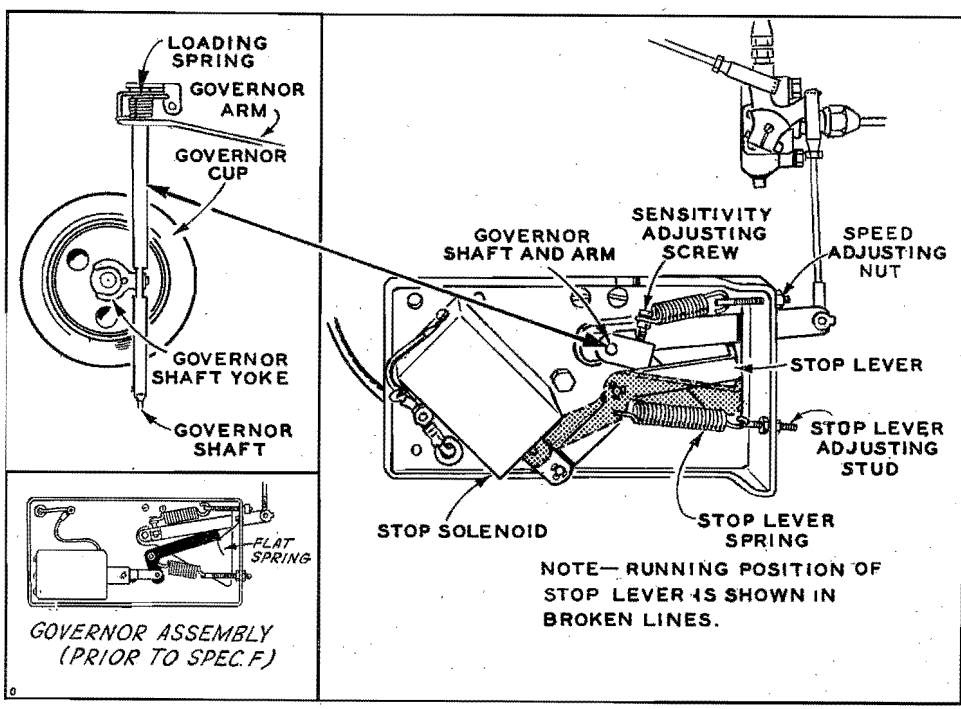


FIG. 26 - GOVERNOR ADJUSTMENT

OTHER ADJUSTMENTS

ADJUSTING VALVE CLEARANCE. - Remove the cover plate from the cylinder heads.

Turn the crankshaft until the valves of the left hand cylinder open and close and continue about 1/2 turn until the TC (Top Center) mark on the flywheel and the pin or mark inside the flywheel housing timing hole are in alignment.

Loosen the lock nut on the rocker arm slotted head screws.

Refer to TABLE OF CLEARANCES under Maintenance and Repair. Valve clearance given is for cold setting. Place a feeler gauge between the exhaust valve stem and the rocker arm and turn the adjusting screw in or out with a screwdriver until correct clearance is obtained. The feeler gauge should have a slight drag on it when moved back and forth if clearance is correct. Recheck the clearance after tightening the lock nut.

Repeat above step for the intake valve.

Turn the flywheel over one complete revolution and again align the TC mark and indicating pin or timing hole mark. Then adjust valve clearances for the right hand cylinder as described above.

Replace all parts removed.

TIMING THE INJECTION PUMPS TO THE ENGINE. - The fuel injection pumps are timed to the engine at the factory and should not require retiming at any time. However, should retiming of the pumps become necessary, proceed as follows:

Crank the engine until the left hand cylinder (when facing the blower housing) sucks in air. This can be felt by placing your hand over the air cleaner air inlet while cranking the engine.

Continue to crank the engine until the PO (Port Opening) mark on the flywheel and the indicating pin, or mark in the flywheel timing hole, align. See the illustration INSTALLING A NEW FLYWHEEL under Maintenance and Repair section.

Remove the injection pump and measure the distance from the tappet, inside the pump mounting hole, to the top of the boss. See the illustration TIMING INJECTION PUMP TO THE ENGINE. Use the timing gage or a depth micrometer. This distance must be 1.552" ± .002". Adjust if necessary by turning the tappet screw. The tappet screw is self locking and will stay where set.

Install the injection pump on the engine. CAUTION (Just pull the nuts up snug. The casting may distort causing a binding condition in the injection pump shaft or pump plunger if the nuts are tightened too much. Connect the fuel lines. Tighten fuel line nuts only enough to prevent leakage.)

For timing the other injection pump, turn the flywheel over one complete revolution and again align the PO mark and indicating pin or mark. Then repeat the above procedure.

Replace all parts removed.

Bleed the fuel system as instructed under Preparation.

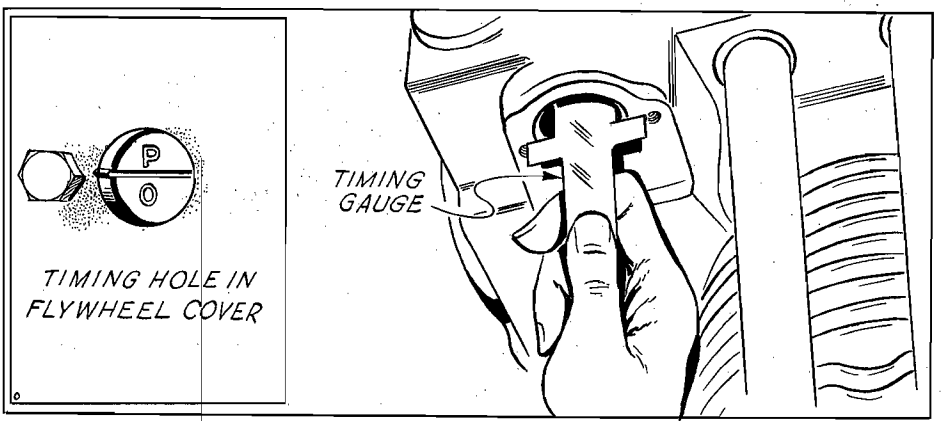


FIG. 27 - TIMING THE INJECTION PUMPS TO THE ENGINE

OIL PRESSURE BY-PASS. - The oil pressure by-pass is non-adjustable. However its internal parts can be removed for cleaning should they become gummy or sticky. The cap is located just to the rear of the oil gauge. Remove this cap and the spring and valve can be removed for cleaning. Clean the chamber before replacing the valve, spring and cap.

CRANKCASE BREATHER VALVE. - A partial vacuum is created in the engine whenever the engine is running. The purpose of the crankcase breather valve is to help maintain this partial vacuum and prevent oil leakage. If your engine begins to leak oil at the oil seals, the flapper valve in the breather tube may be gummed up. Remove the breather tube cap, unscrew the screw from the inside center of the breather tube, lift out the disc and flapper valve and clean the valve retainer, disc and valve with diesel fuel. Inspect the flapper valve carefully. Replace if necessary. Reassemble as shown in the illustration CRANKCASE BREATHER VALVE.

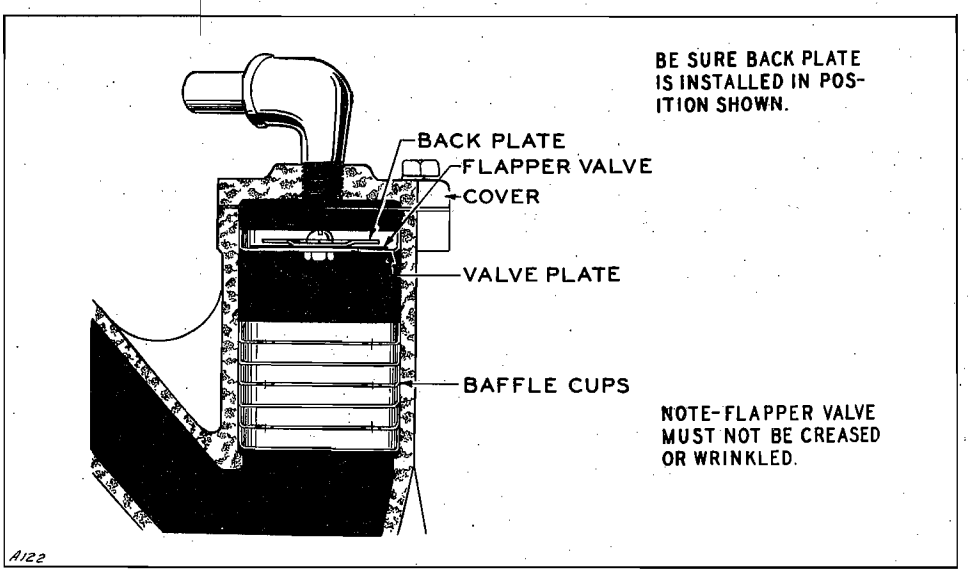


FIG. 28 - CRANKCASE BREATHER VALVE

TRANSFER PUMP. - A transfer pump of the diaphragm type is used to transfer fuel from the fuel tank through the filter and to the injection pumps. If fuel does not reach the filter, make the following checks before removing the transfer pump. Check the fuel tank to see that there is enough fuel in it and the shut-off valve is open. Disconnect the fuel line at the transfer pump outlet and work the lever on the pump. Fuel should spurt out of the pump outlet. If there is enough fuel in the tank, the shut-off valve open, the lines between the tank and pump are clear, but fuel does not spurt out of the pump outlet when working the primer, repair or replace the pump. Pump failure is usually due to a leaking diaphragm, a valve or valve gasket, a weak or broken spring or wear in the driving linkage.

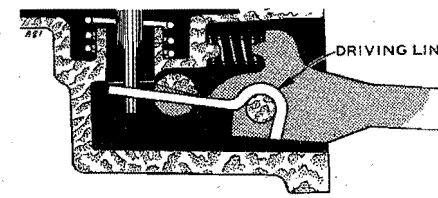


FIG. 29 - TRANSFER PUMP LINKAGE

Should a new drive link be required, install as shown in the illustration TRANSFER PUMP LINKAGE.

ROCKER ARM REMOVAL. - Remove the blower housing, the valve box cover plates, and the oil feed lines from both heads.

Turn the flywheel until the valves of the left hand cylinder open and close and continue about 1/2 turn until the TC mark on the flywheel is aligned with the indicating pin or mark in the flywheel housing timing hole.

Back off the valve adjusting screws.

Remove the pin from the rocker arm shaft.

Use a brass rod and drive the rocker arm shaft out toward the blower housing end of the unit until the "O" ring can be removed from the shaft. Then remove the "O" ring and drive the shaft out toward the generator end of the unit. The rocker arms, springs and bushings can then be removed.

For right hand rocker arm removal, turn the flywheel over one complete revolution and again align the TC mark and the indicating pin or mark. Then repeat the above procedure except the direction of shaft removal is opposite.

ROCKER ARM INSTALLATION. - See that the TC mark on the flywheel and the indicator mark at the timing hole are aligned for the cylinder for which the rocker arms are being installed.

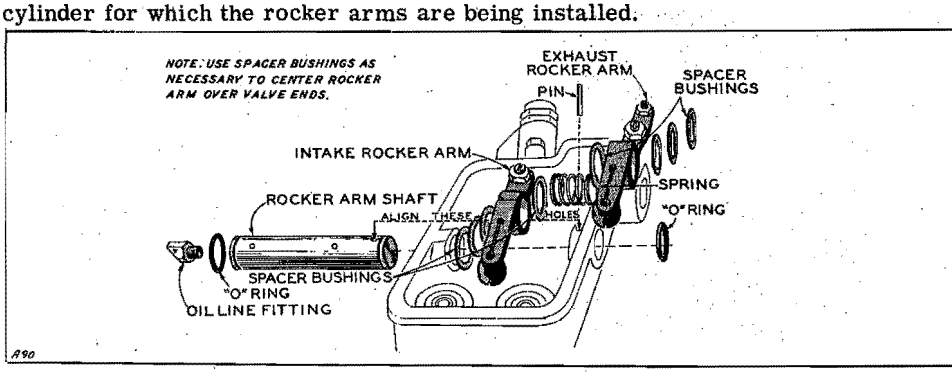


FIG. 30 - ROCKER ARM INSTALLATION

Note that there is a small hole near one end of the rocker arm shaft. There is also a small hole in one of the shaft bosses in the cylinder head. Insert the end of the shaft having the drilled hole, into the shaft boss opposite the boss having the hole. Start the shaft so the holes in the shaft and boss will align when the shaft is in place. See the illustration ROCKER ARM INSTALLATION. Start the shaft by hand, keeping the holes in alignment.

Tap the shaft gently with a lightweight soft faced hammer and drive the shaft through the boss until about one inch extends beyond the boss on the inside.

Place bushings on the shaft as needed to center the rocker arm over the push rod and then the rocker arm for the intake valve. Hold them in place and drive the shaft about half way through the valve box.

Place one bushing on the shaft, then the spacer spring, one more bushing, then the other rocker arm. Drive the shaft through just far enough to engage the rocker arm. Then insert bushings as needed between the rocker arm and the boss to center the arm over the push rod. These can be held in place by inserting a finger through the shaft boss until contact is made with the shaft.

Install an "O" ring on the shaft groove at the exposed end of the shaft and drive the shaft through the boss until the shaft groove on the other end of the shaft is in evidence on the opposite side of the head.

Install the other "O" ring on the shaft and drive the shaft back into the boss until the hole in the shaft and in the boss are aligned, then drop the pin into place.

Install the oil line fitting on the end of the shaft and connect the oil line. Make sure, on plants with flow plugs, that the oil line does not short out the glow plug.

Reset valve clearances.

Replace other parts removed to complete the installation for this head.

For the other head, turn the flywheel over one complete revolution and again align the TC mark and the indicating mark. Then repeat the above procedure.

PUSH RODS. - The disassembly and assembly of the rocker arm push rods is self-evident. However, the tappets that operate the push rods will come out much easier if it is known that each tappet has a hole drilled part way down its length into which a bent wire can be inserted and the tappet lifted out.

NOZZLE ADJUSTMENT. - A nozzle adjustment is recommended only as a measure of correcting a fuel knock resulting from a change in the type of fuel used. Then both nozzles may require adjusting. Otherwise the original setting should not be disturbed. The adjustment is made as follows.

Start the unit and allow it to run until thoroughly warmed up. Then apply a full load.

Remove the top cover (A) from the nozzle holder. See the illustration NOZZLE ADJUSTMENT.

Loosen the locknut (B) just enough to allow the adjusting screw (C) to turn.

Insert a screwdriver into the screwdriver slot of the adjusting screw (C), hold a wrench on locknut (B) and turn the screw (C) in the first one direction and then the other until fuel knock is least noticeable. CAUTION: Do not turn the adjusting screw (C) more than one turn in either direction from its original position.

Lock the adjusting screw locknut (B) securely after making an adjustment. Then replace the cover (A) securely, being sure the two thin washers are in place under the cover and locknut.

NOTE: Nozzles are adjusted at the factory to operate at 1500 pounds pressure. Nozzle pressure should be the same for both nozzles. If necessary, have the nozzles checked on a nozzle tester to assure even pressure.

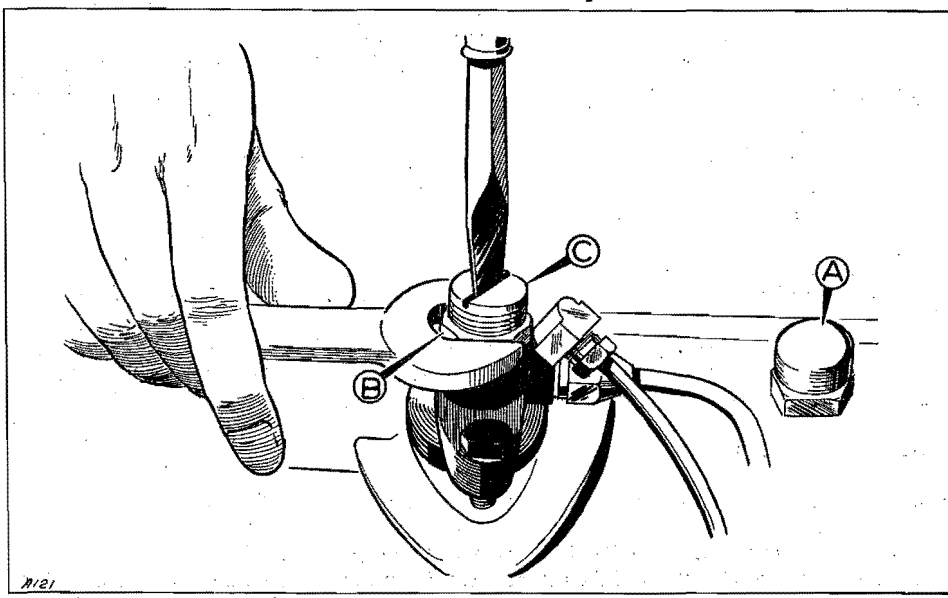


FIG. 31 - NOZZLE ADJUSTMENT

CORRECTING INJECTION PUMP THROTTLE LEVER POSITION

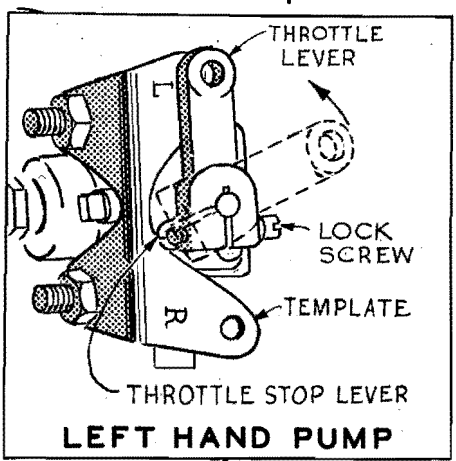
Should it become necessary to remove the throttle lever from either pump or should the throttle lever work loose, use the template as shown to correctly position the throttle lever on its shaft. NOTE: If a new pump is being installed, always time the pump to the engine before positioning the throttle lever.

LEFT HAND PUMP. - Remove mounting nuts and washers from injection pump.

Install template on studs and secure with pump mounting nuts.

Remove the ball joint stud from the throttle arm.

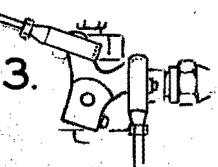
Align hole in lever with hole marked "I" in template. Put linkage stud through holes in both the lever and template before tightening lever lock screw. Then remove template.



CAUTION

WHEN POSITIONING ARM ON SHAFT, TURN THROTTLE LEVER IN A COUNTER CLOCKWISE DIRECTION ONLY STARTING FROM THE APPROXIMATE POSITION INDICATED BY BROKEN LINES.

Smooth engine performance by turning turnbuckle on linkage. Do not turn more than one turn in either direction.



Align hole in lever with hole marked "R" in template. Put linkage stud through holes in both the lever and the template before tightening lever lock screw. Then remove template.

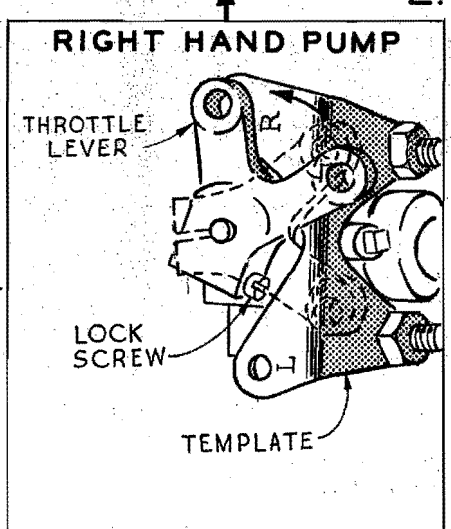


FIG. 32 - THROTTLE LEVER POSITIONS

Loosen throttle lever lock screw just enough to permit turning and turn lever against throttle stop position (See the illustration THROTTLE LEVER POSITIONS-reference 1) until hole in lever aligns with hole in template marked "L". Throttle lever stop must be hard against stop pin in stop position when holes align.

Insert the ball joint stud through throttle lever and template holes to hold alignment and secure the throttle lever to the shaft by tightening the locking screw.

Remove ball joint stud and template.

Secure pump with nuts and washers.

Connect ball joint stud on throttle lever.

RIGHT HAND PUMP. - Remove mounting nuts and washers from injector pump.

Install template on studs and secure with pump mounting nuts.

Remove the ball joint studs from both arms.

Loosen throttle lever lock screw just enough to permit turning and turn the lever against throttle stop position (See the illustration THROTTLE LEVER POSITIONS reference 2) until the hole in the second arm aligns with the hole in the template marked "R". Throttle lever stop must be hard against stop pin in stop position when holes align.

Insert governor linkage ball joint stud through throttle lever and template holes to hold alignment and secure the throttle lever to the shaft by tightening the locking screw.

Remove ball joint stud and template.

Secure pump with nuts and washers.

Connect ball joint studs to throttle lever.

CORRECTING LENGTH OF THROTTLE ROD

Adjusting the throttle linkage between the two injection pumps may be necessary to smoothen out engine performance. If one pump supplies more fuel to its cylinder than the other pump, the cylinder receiving the most fuel will tend to carry more of the load and operation will be uneven. To smoothen out engine performance, adjust as follows:

Allow the engine to warm up thoroughly. Then apply almost a full load to the generator.

Loosen the turnbuckle locknut (See the illustration THROTTLE LEVER POSITIONS - reference 3)and rotate turnbuckle slowly back and forth until engine performance is smoothest. CAUTION: DO NOT ROTATE TURNBUCKLE MORE THAN ONE TURN IN EITHER DIRECTION.

RESETTING INJECTION PUMP THROTTLE STOP

Should the throttle shaft stop lever ever work loose or be loosened accidentally, reset as follows:

Crank the engine over by hand until the TC mark on the flywheel and the mark on

the flywheel housing are in line on the compression stroke of the left hand cylinder for adjustment of the left hand pump, or the compression stroke of the right hand cylinder for adjustment of the right hand pump. Then back up about 1/6 of a turn (60^{o}) against rotation.

Disconnect the fuel line from the injection pump outlet.

Remove the valve from the injection pump outlet.

Remove the throttle lever and loosen the throttle stop socket head screw so the shaft will be free to turn.

Place a .030" feeler gauge over the throttle stop screw or pin and turn the throttle stop to the left (counterclockwise) until it rests against the gauge.

Have someone work the manual primer on the transfer pump. Use a steady motion so that the flow of fuel will be fairly steady.

Slowly turn the shaft to the right until fuel flows freely from the injection pump outlet.

Slowly turn the shaft to the left (counterclockwise) until fuel just stops flowing.

NOTE: If the flywheel has been turned too far or not far enough before TC mark, the fuel may not stop flowing at any point. If this happens turn the flywheel a few degrees one way or the other to correct the condition.

Without disturbing the position of the shaft, righten the throttle-stop socket head screw securely to lock the shaft in place.

Replace the throttle lever and reset the position described in the illustration THROTTLE LEVER POSITIONS.

Replace the valve in the injection pump outlet and connect the fuel line to complete the job.

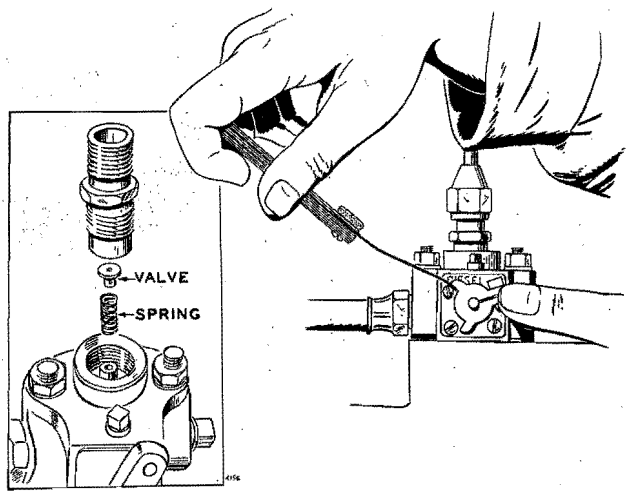


FIG. 33 - RESETTING THROTTLE STOP

RUNNING TIME METER

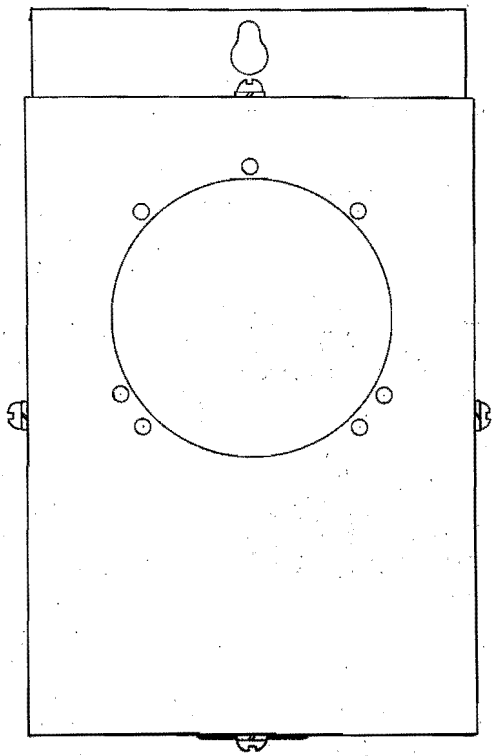
Don't Guess - Know how many hours your plant runs, so that you can change oil and service the plant at proper intervals.

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

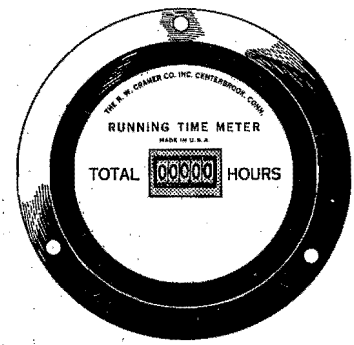
PART NO.	USED WITH PLANT	PRICE
302-68	60 Cycle, 115 V. A.C.	$17.50
302-102	50 Cycle, 115 V. A.C.	17.50
304-99	Resistor - adding to either meter above makes it suitable for 230 V. use.	1.00

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

301-500	Instrument Box	3.00



INSTRUMENT BOX



RUNNING TIME METER

ENGINE

GENERAL. - Certain new engines when leaving the factory have a .005" oversize cylinder bore. This oversize is indicated by the addition of a letter to the engine serial number. For example: Serial No. 48.382425E, the letter E indicating .005" oversize. The piston oversize is stamped on the top of the piston.

Pistons and rings are available in various oversizes for rebore jobs. Piston pins are also available in an oversize. Main bearings and connecting rods are available in an undersize. See the parts list. Before ordering any repair parts in an oversize or undersize and before doing any repair work on your unit, turn to the parts list and see if the parts needed are available in an oversize or undersize.

CYLINDER BLOCK INSPECTION. - The oil must be drained from the oil base and the oil base removed before the inner parts of the engine can be inspected. Visually inspect all parts in the block. Feel the fit of working parts. If your experience with engine is limited, your dealer or any good local mechanic should be able to help you decide on the need for repairs.

Always drain the oil whenever servicing bearings, timing gears, rods, pistons or rings. Thoroughly clean the oil pump suction screen and oil reservoir before reassembling the engine. Refill the crankcase with proper oil before attempting to start the engine.

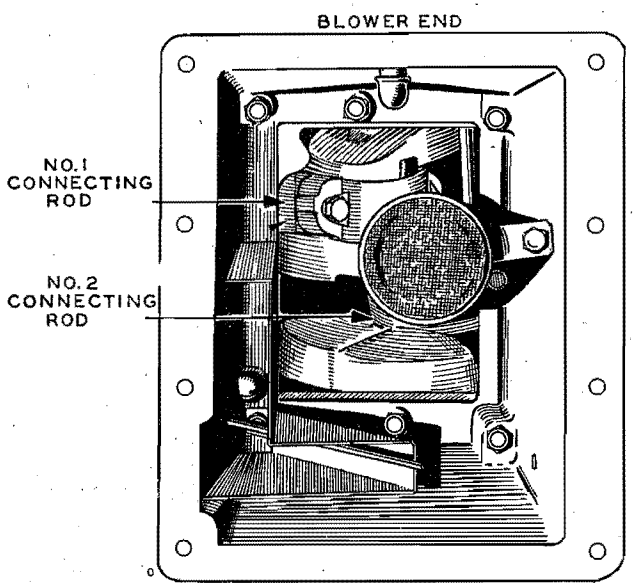


FIG. 34 - CYLINDER BLOCK INSPECTION

CYLINDERS. - When making major repairs to your unit it is well to have the cylinders measured for wear. This requires the use of a dial gauge. Your dealer or any good local mechanic should be able to check the cylinders for wear. The cylinder bore of a new engine is 3.5015" to 3.5025". If the cylinder bore measures more than .005" out of true, the cylinder should be refinished to

use the next available oversize piston. Pistons are available in .010", .020", and .030" oversize. Piston rings are available in .010", .020", and .030" oversize. If the cylinders don't need refinishing, it is advisable to remove the ridge from the top of the cylinder walls before replacing pistons and rings. Also read the following on Piston and Piston Ring Service.

PISTON AND PISTON RING SERVICE. - Each piston has three (some early models used four) compression rings and two (models prior to "Spec F" used one) oil control rings. The top compression ring is chrome faced. Pistons are cam ground and taper ground. To measure piston wear, or piston to bore clearance, piston must be measured at bottom of the skirt which is at right angle to the piston pin.

Inspect each ring carefully for fit in piston groove, for tension and for seating on the cylinder walls. If there is any doubt as to the condition of old piston rings, install new rings. It is advisable to roughen up the cylinder walls before installing new rings. The rings will seat much faster and better. The cylinder walls can be roughened with a wire brush or an abrasive such as emery cloth. Be very careful to remove all abrasive from the engine.

Clean all carbon from pistons, rings, cylinders, cylinder heads, valves, gasket surfaces etc. before installing any parts.

Carefully inspect the pistons. If pistons are badly scored or burned, very loose in the cylinder, have badly worn ring grooves or are otherwise not in good condition, install new pistons. A new piston should also be installed if the old one is loose on the piston pin and an oversize pin will not correct the fit. Handle pistons carefully to avoid nicking the walls. Any raised surface of this type must be carefully dressed down with a fine stone. CAUTION: BE CAREFUL NOT TO FLANGE END OF PISTON PIN WHEN REASSEMBLING PISTON AND ROD.

When installing piston rings fit each ring singly to the cylinder from the top. See the illustrations PISTON AND PISTON RING SERVICE. The correct ring gap while in the cylinder is between .010" and .015" for all rings except the top compression ring. The gap for this ring is from .010" to .020". Rings usually

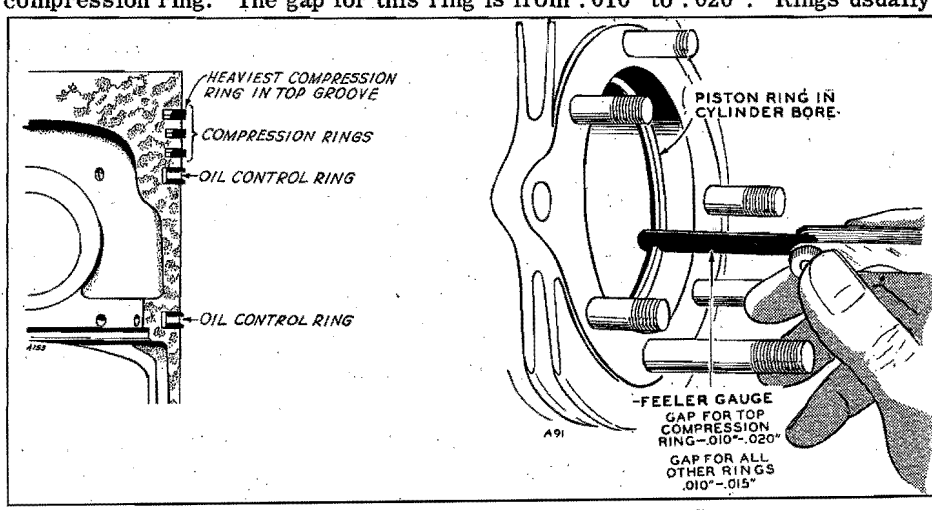


FIG. 35 - PISTON AND PISTON RING SERVICE

require some filing at the ends to obtain the right gap. Don't use rings that need a lot of filing at the ends to obtain the right gap as they will not seat properly on the cylinder walls. Install all rings on the piston before installing the piston in the cylinder. Coat cylinder walls with a thin coating of lubricating oil for cylinder lubrication when restarting the unit. Rings of the tapered type will be marked "TOP" or marked in some other manner and this mark must be placed nearer the top of the piston.

Chrome compression rings, when used, are used in the top groove. Compression rings fit into the three top grooves of the piston, the oil control rings in the bottom two grooves. The top compression ring is slightly heavier than the other two compression rings of each piston. This ring must be placed in the top piston groove. By inspecting the rings carefully you can tell which of the three are the thickest. Another means is by the ring gap. The heaviest ring will have a slightly wider gap when free. Space ring gaps 1/4 of the way around the piston from each other, being sure no ring gap is directly in line with the piston pin. Install the piston (assembled to the connecting rod) in the cylinder from the top. Compress each piston ring carefully so that it will enter the cylinder without damaging the ring. Don't use excessive force. Push the piston in until the top is flush with the block. Be sure the reference marks on the connecting rods and caps are aligned and face the oil base and that the rod fits easily into place on the crankshaft journal. See the illustration CYLINDER BLOCK INSPECTION. Coat the crankshaft bearing journals with oil before securing the rod. Apply oil liberally to the cylinder walls and rings.

CONNECTING RODS. - The connecting rods should be serviced at the same time as the pistons or piston rings as the rod must be removed with the piston. Drain the oil from the oil base, disconnect fuel lines and oil lines necessary, remove cylinder heads, then the connecting rods are exposed for removal. Note the manner in which the rods are secured to the crankshaft. Mark each rod and cap if necessary to assure assembling to the correct journal when reassembling. Then remove the cap screws, lockwashers and cap from each rod and push the piston and rod assembly out through the top of the cylinder. Carefully hold the piston so that it doesn't hit against something as it clears the cylinder, resulting in damage to the piston or rings.

Two types of connecting rods have been used. For proper weight balance, use either both forged steel or both aluminum alloy rods.

The aluminum alloy connecting rod does not use separate bearings. Proper clearance between the rod bearing surface and the crankshaft bearing surface is obtained by dressing the connecting rod cap. See the illustration REDUCING CONNECTING ROD CLEARANCE. For correct clearance refer to Table of Clearances herein. Place a small amount of suitable abrasive on a smooth flat surface such as a piece of plate glass. Set the connecting rod cap, ends down, on the abrasive material and carefully work the cap back and forth to dress the ends as needed. Be sure the cap is held perfectly straight. Remove all abrasive from the cap before installing it.

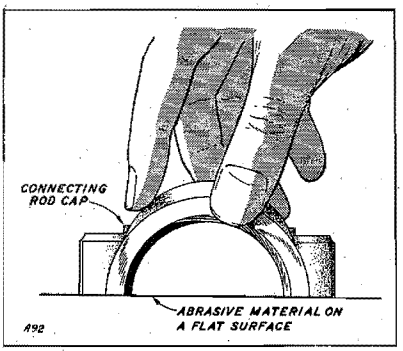


FIG. 36 - REDUCING CONNECTING ROD CLEARANCE

The forged steel rods use two bronze bushings at the piston pin end. The bushing ends must be installed flush with the sides of the rod to permit a 1/16" oil groove between the bushings. These bushings must be line reamed or bored to undersize or standard as desired. Make sure the oil passage through the rod is unrestricted. The tri-metal bearings in the crank end of the rod are precision size requiring no reaming. They are available in standard or .020" undersize. See the parts list. For clearance see the Table of Clearances in this book.

The connecting rod and cap for the left hand cylinder (facing the blower) are numbered 1, those for the right hand cylinder are numbered 2. Install connecting rods and caps with the numbers aligned, the cap toward the oil base. See that the rod is centered on the piston pin. Coat the crankshaft journal bearing surfaces with oil before installing and securing the rods. Turn the engine over by hand to see that the rods are free. If necessary, rap the rod cap sharply with a heavy soft hammer to set the rod square on the crankshaft. Check valves before replacing the heads. See VALVE SERVICE. Replace all parts removed.

VALVE SERVICE. - Valves are of the overhead type and are located in the cylinder heads. The blower housing, valve cover plates, fuel lines (pump to nozzle and return lines), exhaust outlet, air cleaners and air heater leads must all be removed before the cylinder heads can be removed. CAUTION: Cover the openings of all fuel lines, oil lines, injector pumps and nozzles or trouble may result when restarting the unit. If the cylinder heads stick, rap sharply with a heavy soft hammer to loosen. Don't use a pry.

Remove the rocker arm, valve locks, retainer washers, valve springs and valves. Refer to paragraph ROCKER ARM REMOVAL under Special Adjustments. Mark each part so that it can be assembled in its original location.

Clean all carbon from the cylinders, heads, valves, valve seats, valve stems and valve guides. Clean gasket surfaces of cylinders and heads. Check all valves. Replace valves that are badly burned or pitted, have badly worn or warped stems, or that will have a very thin edge when refaced. Inspect valve guides for wear. Replace worn guides.

Valves and seats must be refinished to a 45° angle, the seat band being from 3/64 to 1/16" wide. Where possible an approved valve grinding machine should be used. This is especially important where stellite faced valves and seats are used. When installing a new exhaust valve seat, maintain a .030 minimum clearance from valve head to face of cylinder head by grinding the seat.

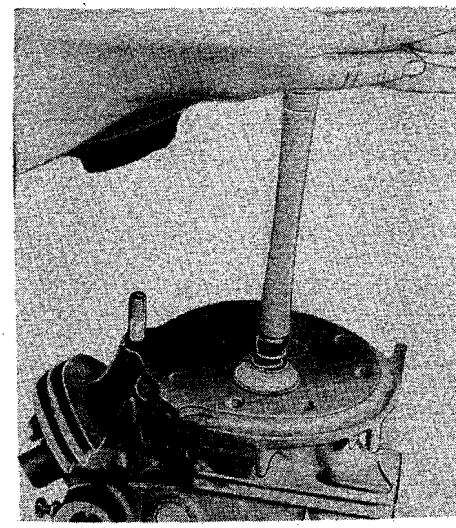


FIG. 37 - VALVE GRINDING

If a valve grinding machine is not available, the valves can be ground by using a vacuum cup type tool. Use a fine grade of valve grinding compound on the valve face and set the valve in place in its guide. Each valve must be ground to its own seat. Place the vacuum tool on the valve and turn it back and forth several times about 1/3 of a turn with a light pressure (Hold the hands open, press them together with the handle of the vacuum tool in between the palms and rub the hands back and forth to give the tool the right motion). Then lift the valve off enough to clear the seat, turn about 1/4 turn to a new position and repeat the grinding. After several cycles of these operations, remove the valve and clean the compound from the valve and seat. Inspect both and if necessary repeat grinding until a bright uniform band 3/64" to 1/16" wide extends around valve face and seat. Check each valve for a tight seat by making pencil marks across the face at intervals. Then rotate the valve part of a turn against the seat with a firm pressure. Lift the valve and see if the pencil marks are all rubbed out. Regrind if necessary. Remove all grinding compound from engine parts. Replace each valve in the seat to which it was ground. Reassemble the engine.

VALVE ADJUSTMENT. - See ADJUSTING VALVE CLEARANCE under Special Adjustments.

FLYWHEEL REMOVAL. - The control box, the generator frame, the armature and the generator end of the adapter housing must be removed to expose the flywheel. If the generator leads marked A1 and A2 are disconnected inside the control box and the AC output leads disconnected and pulled back through the control box to the generator, the control box can be loosened from the generator and tilted forward making it unnecessary to disconnect other leads at the control. Turn to the section on GENERATOR for instructions on removing the generator. When the flywheel is exposed, turn the flywheel until the keyway is downward, place a heavy punch against the crankshaft just above the keyway and hit the punch a hard blow with a heavy hammer. Repeat if necessary. See the illustration REMOVING THE FLYWHEEL.

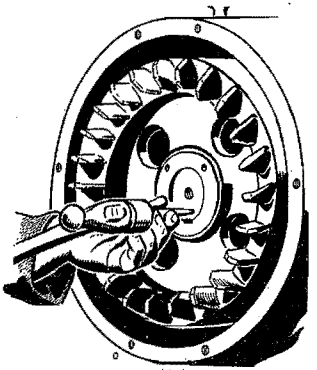


FIG. 38 - REMOVING THE FLYWHEEL

RING GEAR INSTALLATION. - If removal of the ring gear is necessary, cut through the ring with a hacksaw. The ring will usually snap before the cut is very deep. If it does not, a few sharp raps with a cold chisel and heavy hammer should cause the ring to break.

Should the installation of a new ring gear become necessary, place it in an oven heated to 380 - 400° F. for 30 to 40 minutes. CAUTION: DO NOT HEAT WITH A TORCH. When heated properly the ring will fall into place on the flywheel. If it does not go on all the way by itself, drive into place with a hammer. Do it fast. The ring will contract rapidly and may shrink to the flywheel before it's in place. If this occurs, a new ring gear will be needed since the ring gear cannot be removed without damage. When using a hammer on the ring to drive it into place, be very careful not to damage the teeth.

FLYWHEEL INSTALLATION. - When installing a new flywheel the TC (top center) and PO (port opening) marks should be marked on the flywheel. A dial gauge should be used as shown in the illustration INSTALLING A NEW FLYWHEEL. Proceed as follows.

Install the flywheel on the crankshaft and turn the flywheel with rotation until the valves of the right cylinder open and close and continue about 1/2 turn until the piston of that cylinder is at the top of the cylinder.

Remove the right cylinder head and place the dial gauge (must read from 0 to 25 in thousandths) as shown in the illustration INSTALLING A NEW FLYWHEEL.

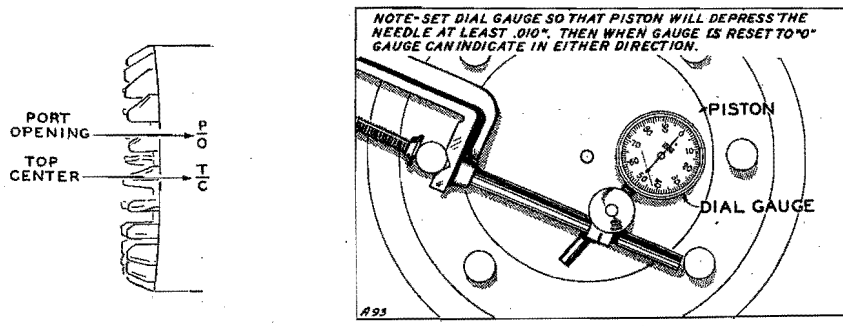


FIG. 39 - INSTALLING A NEW FLYWHEEL

Turn the flywheel slightly until the dial gauge needle indicates the piston is exactly on top center. Use a straight edge and a scratch awl and mark the flywheel at the indicating pin. This is the TC mark.

Turn the dial gauge until the 0 mark and the needle on the gauge are directly in line.

Turn the flywheel against rotation until the dial gauge needle points to 9 on the dial. Again mark the flywheel at the indicating pin with a straight edge and scratch awl. This will be the PO mark. **This is 4^{o} before top center.**

Remove the flywheel, deepen the marks with a chisel, and place identifying letters at each mark.

Install the flywheel (be sure the key is in place), remove the dial gauge and reassemble the unit.

NOTE: If a dial gauge is not available, use this alternate method. Make a chalk mark on the flywheel (opposite the indicating pin) at the point where the piston just reaches the top of the cylinder. Then continue to slowly turn the flywheel in the same direction until the piston just begins to move downward and make another chalk mark on the flywheel opposite the indicating pin. Make a permanent mark across the flywheel with a scratch awl at a point half way between these two chalk marks. This is the TC mark. To locate the PO mark, measure exactly 27/64 to the right (with rotation) from the TC mark. Mark permanently with a scratch awl. This results in 4^{o} BTC (before top center).

BLOWER. - The blower housing and crank dog must be removed before the blower can be removed. Then grasp the blower with both hands and work back and forth until free.

STARTER. - The starter can be removed by first removing the blower housing and air shroud.

The starter is an automotive type and repairs usually are minor such as replacing brushes or turning down the commutator.

To remove the starter from very early models, the flywheel must first be removed. Then disconnect leads from the starter and remove the starter and flywhell housing as a unit.

GEAR COVER. - All parts necessary to remove the blower, and the blower wheel itself, must be removed before the gear cover can be removed. Then disconnect the governor linkage. Remove the gear cover mounting screws, tap the gear cover gently with a soft hammer to loosen it and remove the gear cover.

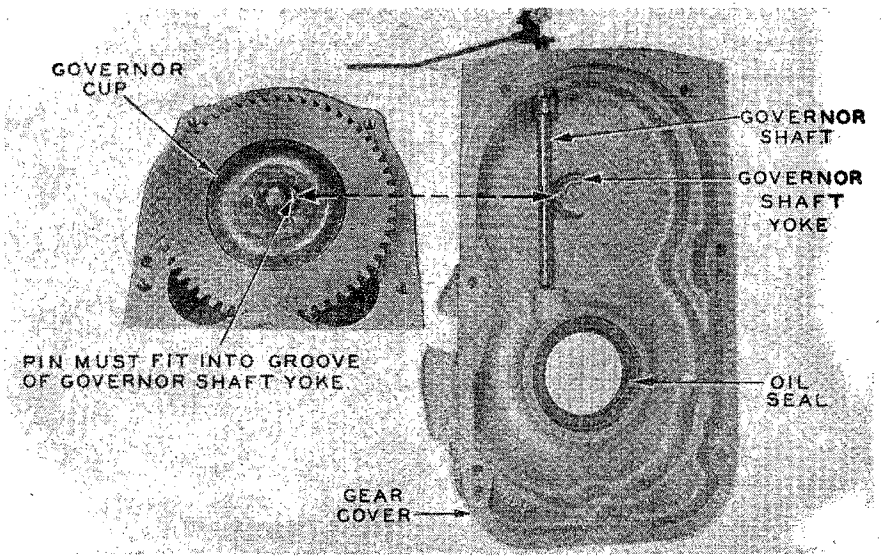


FIG. 40 - REPLACING THE GEAR COVER

When replacing the gear cover, turn the stop pin on the governor cup to the point where it agrees with the 3 o'clock position on the face of a clock. See the illustration REPLACING THE GEAR COVER. Then turn the governor arm and shaft counterclockwise as far as it will go and hold it in this position until the gear cover is flush against the block. Be careful not to damage the gear cover oil seal.

The governor stop pin must fit into the slot in the governor shaft yoke to permit smooth governor regulation. If the pin is not in place, the gear cover must be removed and the installation repeated.

GOVERNOR CUP. - With the gear cover removed the governor cup can be taken off by removing the snap ring from the camshaft center pin and sliding the cup off. Be sure to catch the flyballs (10 in all) as they will probably fall out when the cup is removed.

When installing a new governor cup, tip the plant upward from the blower end, place the flyballs in their places, and install the cup and snap ring on the center pin. The distance from the snap ring to the governor cup sleeve when the cup is flush against the flyballs must be exactly 7/32" for proper governor operation. See the illustration GOVERNOR CUP ASSEMBLY. If it is less than 7/32" remove the cup and carefully dress down the face of the sleeve until this clearance is obtained. If more than 7/32" the camshaft must be removed and the center pin carefully pressed in by means of an arbor press to allow 7/32" travel. Leave the cup and snap ring on the pin to measure by. Be very careful not to bend the center pin.

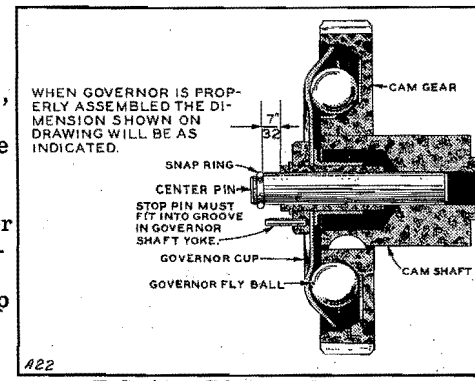


FIG. 41 - GOVERNOR CUP ASSEMBLY

CRANKSHAFT GEAR. - With the gear cover removed the crankshaft gear is easily removed after taking off the snap ring and special washer. The gear is recessed and a conventional gear puller having thin jaws can be used in removing the gear. Apply the puller carefully to avoid damaging the gear if it is to be used again.

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

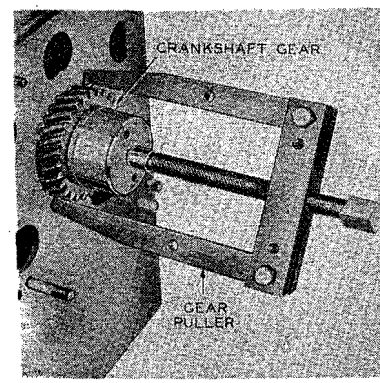


FIG. 42 - REMOVING THE CRANKSHAFT GEAR

Should it become necessary to replace the crankshaft gear, the camshaft gear must also be replaced as these gears are sold only as a matched set.

CAMSHAFT GEAR. - The camshaft and gear should be removed from the engine as an assembly. Before this can be done all parts necessary to expose the camshaft gear must be removed from the engine. In addition the transfer pump, valve tappets, injection pumps and injection pump tappets must be removed from the engine. Insert a screwdriver between the block and gear and apply a little pressure to loosen the camshaft.

If the gear is to be removed from the shaft, remove the snap ring from the center pin and then the governor cup and flyballs. Then place the camshaft and gear in an arbor press and remove the gear. Be very careful not to damage the center pin.

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

CHECKING CAMSHAFT AND CRANKSHAFT ENDPLAY. - Correct endplay of the camshaft is not less than .003" nor more than .018". Push in on both the camshaft and crankshaft gears and insert a .003" feeler gauge between the camshaft gear and the retainer washer. See the illustration CHECKING CAMSHAFT ENDPLAY. If the gap is less than .003", a thinner spacer washer is needed behind the camshaft gear. If the gap is more than .003", a thicker washer is needed. The maximum camshaft endplay is determined by adding the maximum crankshaft endplay to the minimum camshaft endplay.

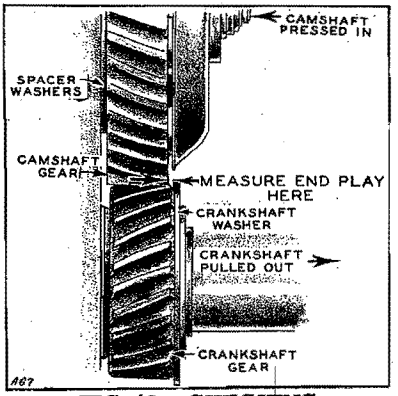


FIG. 43 - CHECKING CAMSHAFT ENDPLAY

Crankshaft endplay is .010" to .015". This should be checked when installing the bearing plate. Insert a .010" feeler gauge between the bearing flange and the crankshaft thrust surface with the crankshaft pushed inward. The .010" gauge should pass freely between these surfaces but a .015" gauge should not. Use gaskets as needed behind the bearing plate to correct the endplay.

TIMING GEAR MARKS. - The crankshaft gear and the camshaft gear form the "timing chain". These gears are matched and are sold only as a set. Both gears must be replaced at the same time. Timing marks must be aligned as shown in the illustration TIMING GEAR MARKS, or the engine will be out of time.

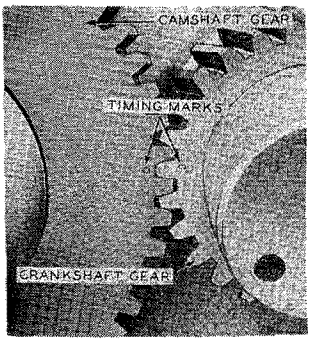


FIG. 44 - TIMING GEAR MARKS

CRANKSHAFT. - The engine must be completely disassembled to remove the crankshaft. Whenever making major repairs on the engine always inspect the drilled passages of the crankshaft. Clean them, if necessary, to assure proper lubrication of the connecting rods. Inspect crankshaft bearing journals. If they appear scored and cannot be smoothed out by dressing down, the crankshaft should be ground down to accomodate .020" undersize main bearings and connecting rod bearings (or connecting rods complete if bearings are integral with rods) or a new crankshaft should be installed.

Correct crankshaft endplay is .010" to .015". Adjust as described under CHECKING CAMSHAFT AND CRANKSHAFT ENDPLAY.

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

When installing crankshaft bearings, install the front bearing in the cylinder block with the oil hole in the bearing aligned with the oil hole in the bearing boss. The slot in the bearing flange must also be aligned with the pin. Install the rear bearing in the bearing plate before installing the bearing plate on the engine. Align the oil holes and the pin and slot. Use a press or a suitable drive plug to install bearings and press or drive both bearings in from inside the block until the flange is flush with the bearing boss. Use oil on the outer bearing shell to reduce friction when installing.

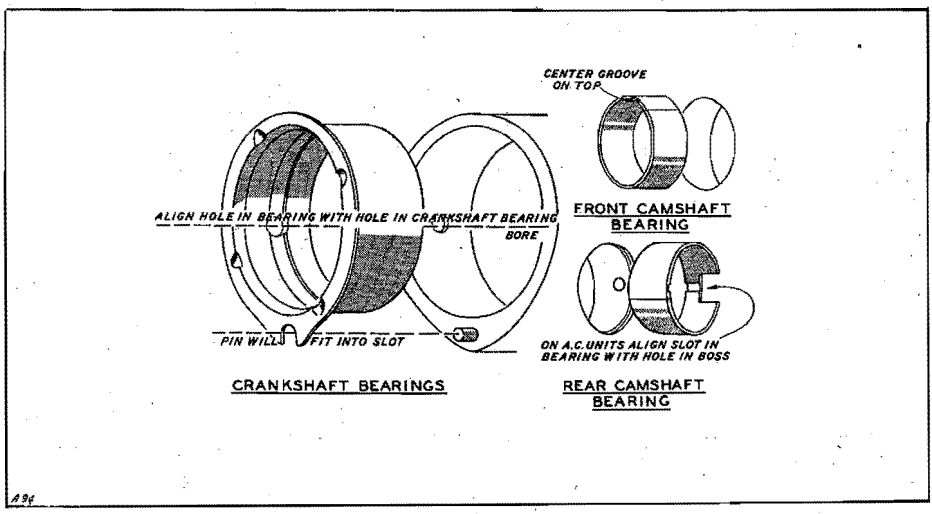


FIG. 45 - BEARING INSTALLATION

The bearings must be line bored or reamed after being installed in the block and bearing plate and with the bearing plate mounted on the block. The crankshaft main bearing journals should be measured with a micrometer and the bearings line bored or reamed to allow a clearance of .0025" to .004". Clearance for camshaft bearings is .001" to .003". Any reliable machine shop should be able to perform this service. If not, contact your dealer for help.

When installing camshaft bearings, the oil groove in the front bearing should be centered at the top and the oil groove in the rear bearing centered on the left. Press or drive the front bearing in flush with the bearing boss and the rear bearing in flush with the welch plug groove. Replace the welch plug.

Coat bearing journals with light oil before installing the camshaft or crankshaft.

NOTE: Crankshaft bearings and connecting rods are available in .020" undersize. Forged steel rods have precision size replaceable bearings. See the **parts list.**

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

The bearing plate must be removed before its oil seal can be removed. Drive the oil seal out from the inside toward the outside of the bearing plate.

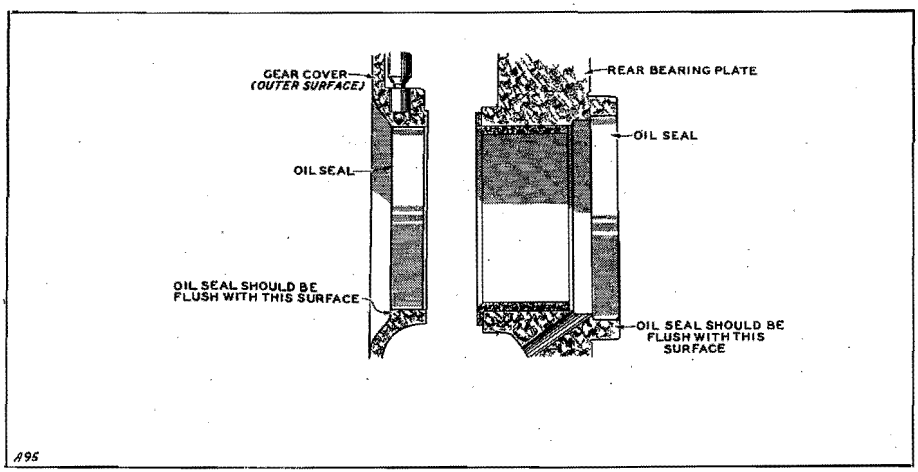


FIG. 46 - OIL SEAL INSTALLATION

When installing the gear cover oil seal, lay the gear cover on a board so that the bearing boss is supported, otherwise the gear cover may be distorted when installing the oil seal. Tap the oil seal into place until it is flush with the box. Cover the crankshaft keyway with shim stock when installing the gear cover. Remove the shim stock when the gear cover is in place.

When installing the bearing plate oil seal, drive the seal into the bearing plate until flush with the outer end of the boss. Use a piece of hollow pipe that will fit over the crankshaft and contact the oil seal near the outer edge. Drive the seal in evenly all the way around. A piece of shim stock placed over the crankshaft keyway will protect the seal from damage at this point.

OIL PUMP. - Remove all parts necessary to expose the gear cover. Also remove the oil base. Remove the stud or screw running through the intake cup bracket, turn the intake cup 1/4 turn to the left, remove other nuts and washers securing the oil base adapter, remove the adapter and turn the intake cup out. Then remove the oil pump assembly from the front of the engine.

Check the oil pump thoroughly for worn parts. Should any part need replacing, install a complete assembly. Oil pumps are sold only as a complete unit. See the parts list. When installing the oil pump, reverse the order of removal.

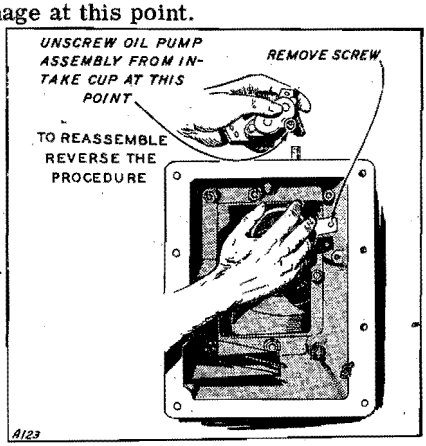


FIG. 47 - OIL PUMP REMOVAL

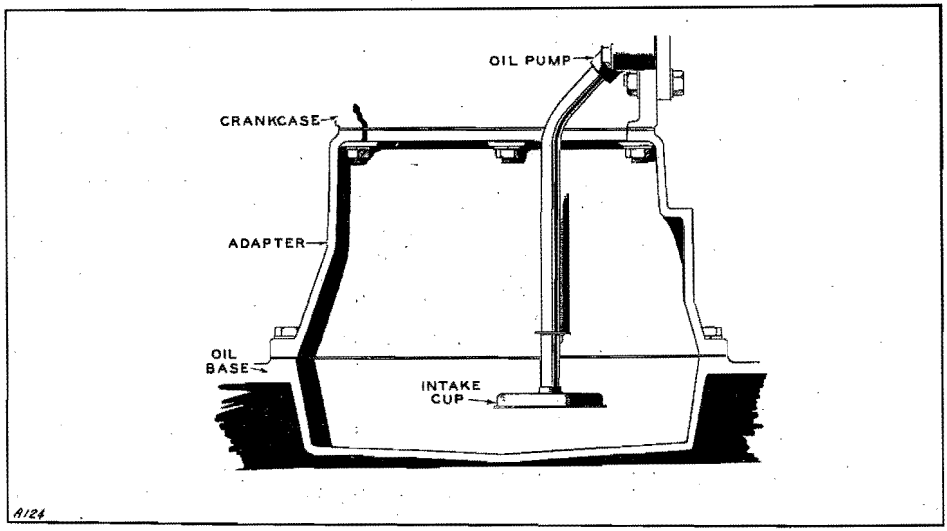


FIG. 48 - OIL INTAKE CUP LOCATION IN THE ADAPTER

FUEL SYSTEM. - Instructions for servicing various parts in the fuel system are given under Periodic Service and Special Adjustments. Whenever any part is disconnected from its line or mounting, protect it from getting dirty by wrapping it in clean paper or by plugging openings with cork. Never use waste or rags.

Lubricate the transfer pump linkage whenever the pump is removed for servicing or if a new pump is installed.

ROCKER ARM PUSH RODS AND PUSH ROD SHIELDS. - Push rod shields are a drive fit into the collars at the cylinder block and a loose fit into the cylinder heads. "O" rings must be installed in the shields after the cylinder head is in place. Turn the crankshaft until the rocker arm lifts and press "O" rings into place with a blunt tool. Be careful not to scratch or tear "O" rings.

GASKETS. - Always use new gaskets when replacing any part that requires a gasket. Clean surfaces the gasket contacts before installing the gasket. Gaskets are listed singly and in kit form in the parts list.

ASSEMBLY TORQUES

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

CYLINDER HEAD STUDS AND NUTS. - 40 to 50 lbs. ft. torque.

CONNECTING ROD BOLTS. - 40 to 50 lbs. ft. torque.

ARMATURE DRIVE DISC SCREWS. - 35 to 40 lbs. ft. torque.

ARMATURE THRU STUD AND NUT (when used). - 45 to 50 lbs. ft. torque.

NOZZLE HOLDER SCREWS. - 15 lbs. ft. torque.

Tighten other studs and nuts just enough to assure tightness.

TABLE OF CLEARANCES

	MINIMUM	MAXIMUM
Valve Clearance - COLD (with steel push rods) - Beginning with Spec. F Models	.015"	
Valve Clearance - COLD (with aluminum push rods) - Prior to Spec. F Models	.020"	
Valve Stem Clearance in Guide	.003"	.0045"
Valve Seat Width	3/64"	1/16"
Crankshaft Main Bearing Clearance	.0025"	.004"
Crankshaft Main Bearing Journal - Standard Size	2.7495"	2.7500"
Crankshaft Rod Bearing Journal - Standard Size	2.3745"	2.3750"
Crankshaft Endplay	.010"	.015"
Camshaft Bearing Clearance	.001"	.003"
Camshaft Endplay	.003"	.018"
Connecting Rod Bearing Clearance Aluminum Alloy Rod with Bearing Intregral	.003"	.004"
Forged Steel Rod with Precision Size Bearings - Measured Parallel to Length of Rod	.001"	.003"
Connecting Rod Endplay	.002"	.011"
Timing Gear Backlash	.001"	.006"
Oil Pump Gear Backlash	.003"	.005"
Piston Clearance in Cylinder (at bottom of skirt)	.0035"	.0055"
Piston Pin Clearance in Piston - Tap Fit	.0000"	.0003"
Piston Pin Clearance in Rod (Aluminum Alloy Rod)	.0002"	.0006"
Piston Pin Clearance in Rod (Forged Steel Rod)	.0002"	.0007"
Top Compression Ring Gap - In Cylinder	.010"	.020"
Other Comp. Rings and Oil Rings Gap - In Cylinder	.010"	.015"
Injection Pump Tappet Setting	1.552"	± .002"
Injection Pump Timing - Port Opening	4^{0} BTC	
Exhaust Valve Head to Face of Cylinder Head (Maintain by grinding new seat)	.030"	

GENERATOR

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

GENERATOR DISASSEMBLY. - The generator should be disassembled in the following manner and all leads that must be disconnected should be tagged and marked before removal.

Disconnect the battery to prevent accidental starting of the unit.

Remove the band from the end bell and lift all brushes into their holders. Pull each brush into its holder until the spring rests against the side of the brush to hold it in place. NOTE: On certain units built between serial #410955 and 447000, it is also necessary to remove the outer bearing cover and gasket and the three round head screws that retain the inner bearing cover before the generator can be disassembled.

Remove the cap nuts at the outboard end of the end bell, place a pinch bar against the generator adapter and pry against the generator frame until loose. Alternate from one side to the other if necessary.

Carefully slide the frame (together with coils, end bell and brush rig) off the studs, being careful not to let it rest or drag on the armature. Hold the end bell along with the frame as the end bell is loose on the frame.

FOR UNITS PRIOR TO "MODEL SPECIFICATION LETTER F", the armature is mounted with a through-stud, and driven by dowel pins in the flywheel. If the armature is to be removed, back the armature nut out 3 or 4 turns and hit the nut an endwise blow with a heavy soft hammer. Should the armature fail to come loose by this method, place a piece of brass rod against the armature shaft at the top, between the commutator (collector rings on a-c plants) and the bearing, and strike a sharp downward blow on the rod with a heavy soft hammer. Turn the armature over 1/2 turn if necessary to repeat.

FOR UNITS BEGINNING WITH "SPEC. LETTER F", the armature has a disc drive, and is removed by detaching at the flywheel.

If necessary to remove the brush rig, disconnect all leads necessary (be sure they are marked), remove the end bell from the frame assembly, remove the four cap screws that mount the brush rig ring and remove the brush rig.

SERVICING THE GENERATOR

BRUSHES. - Keep a close check on the generator brushes. Brushes worn to 5/8" should be replaced. If brushes appear to wear rapidly check the commutator and collector rings (a-c plants only). If they become pitted or rough or if the mica between the commutator bars comes in contact with the brushes, brush wear will be rapid. An improperly adjusted brush rig will also cause rapid brush wear.

NEUTRAL BRUSH POSITION. - The brush rig must be set at the neutral brush position, to prevent arcing at the brushes and rapid brush wear, to assure steady voltage and current, and to prevent overheating of the generator.

Markings were made at the factory to indicate the "neutral brush position".

The location of the "neutral brush position" mark, either yellow paint or chisel mark, on the brush rig ring should be flush with the brush rig mounting boss as shown in the illustration NEUTRAL BRUSH POSITION. If it is not, loosen the brush rig mounting screws and shift the whole brush rig assembly as needed to align the mark. Tighten the mounting screws securely after making an adjustment.

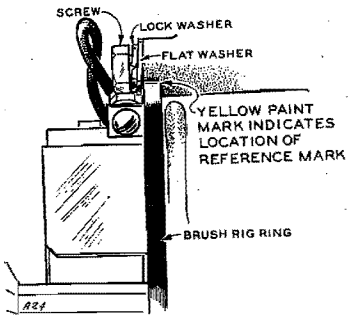


FIG. 49 - NEUTRAL BRUSH POSITION

If a new brush rig or armature is installed, the "neutral brush position" must be relocated and remarked. Full instructions for performing this service are included with all new armatures and brush rigs.

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

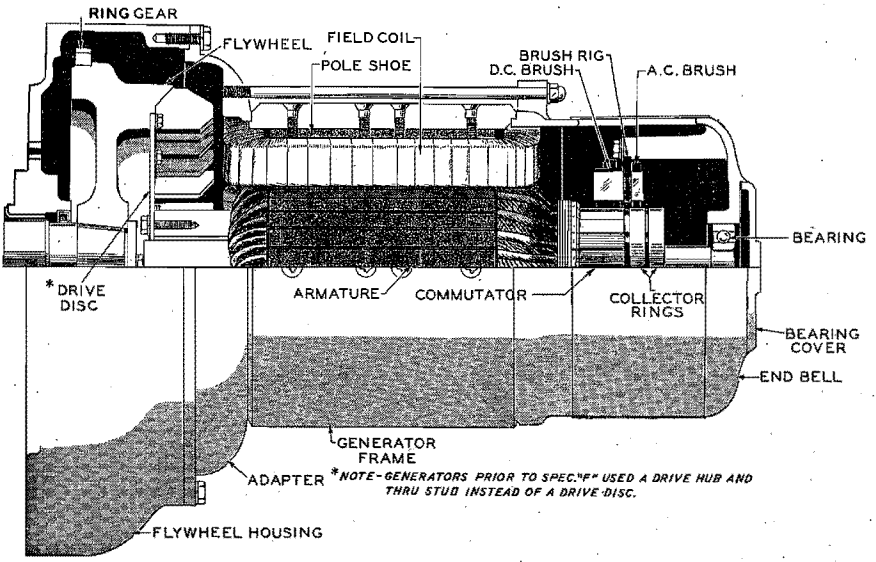


FIG. 50 - CUTAWAY VIEW OF GENERATOR

COMMUTATOR. - The commutator bars wear down with usage so that the mica between them must be undercut. This should be done whenever the mica on any part of the commutator touches the brushes. A suitable under-

cutting tool can be made from a used hack saw blade. Use it as shown in the illustration CARE OF COMMUTATOR AND BRUSHES. Avoid injury to the surfaces of the commutator bars. Leave no burrs along the edges of the bars. The mica must also be undercut whenever the commutator is refinished.

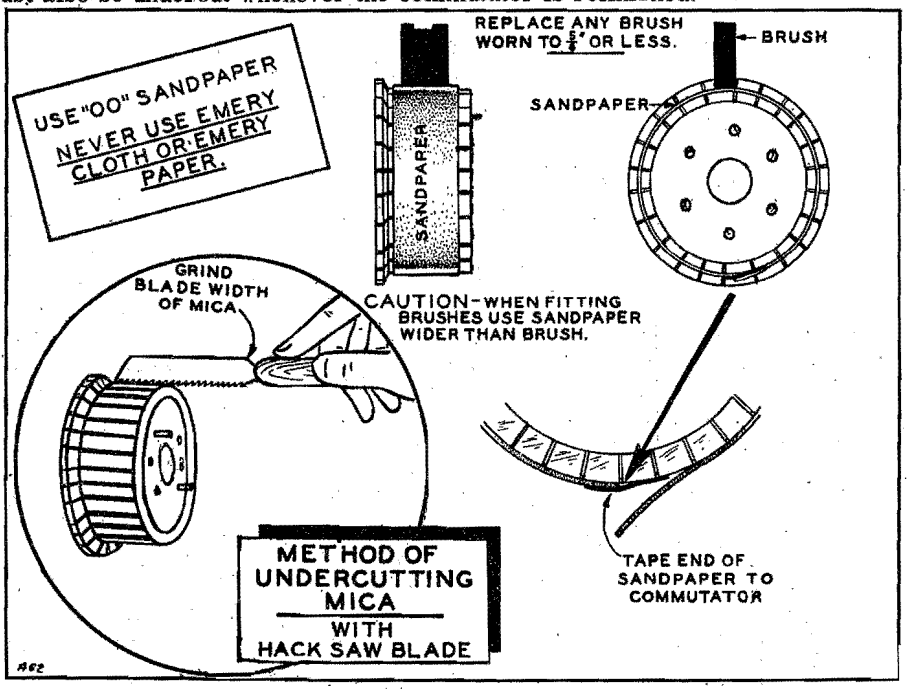


FIG. 51 - CARE OF COMMUTATOR AND BRUSHES

ARMATURE INSTALLATION. - When installing the armature, the runout at the bearing end should not exceed .012". This runout can be checked by one of the methods shown in the illustration CHECKING GENERATOR BEARING RUNOUT. Excessive runout may be caused by a nick foreign matter on the flange or disc surfaces. Take any steps necessary to correct.

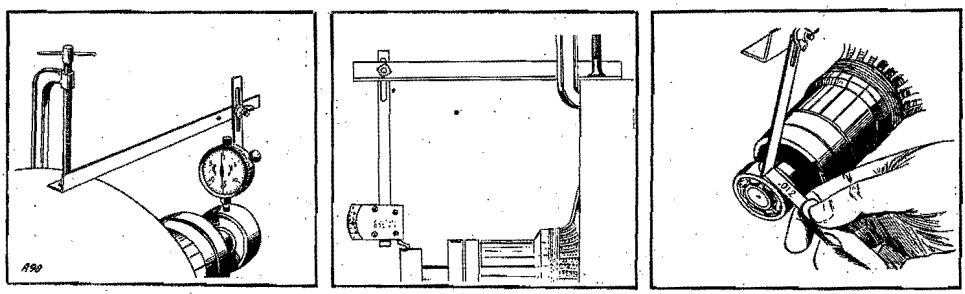


FIG. 52 - CHECKING GENERATOR BEARING RUNOUT

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

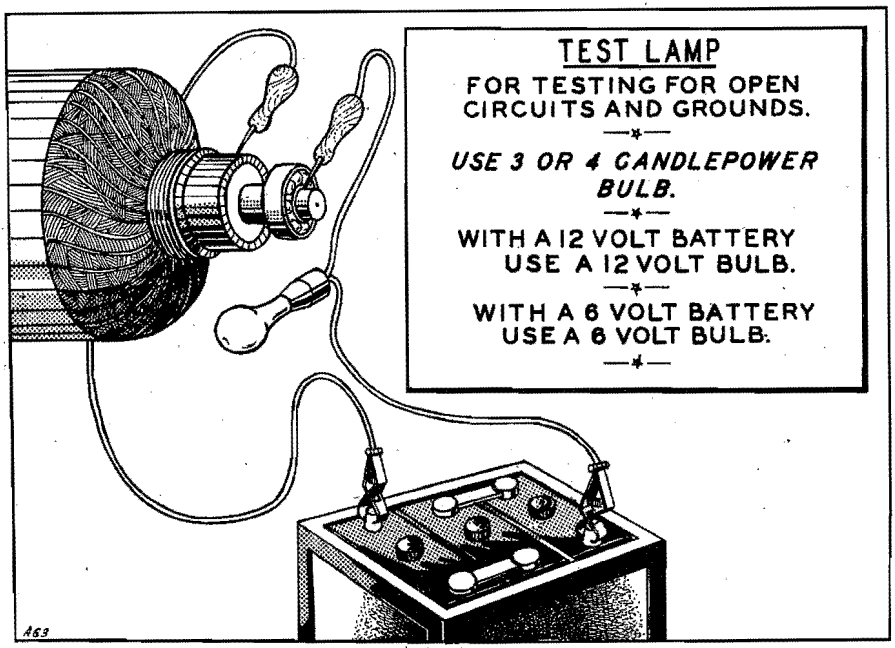


FIG. 53 - TEST LAMP SET

TESTING ARMATURE WINDINGS FOR OPEN OR SHORT CIRCUITS. - This test requires the use of an armature growler. The armature assembly must be removed from the plant. Then follow the instructions given by the manufacturer of the armature growler.

TESTING ARMATURE WINDINGS FOR GROUNDS. - Use a test lamp set. Touch one test prod to the armature shaft and the other to the commutator. On an a-c plant, touch each collector ring in turn after checking the commutator. Be sure the test prods make good contact. If the lamp lights, the armature is grounded.

TESTING FIELD WINDINGS . - Use a test lamp set for all tests except a short circuit. Plants which do not have a separate starting motor, have a series field winding in addition to the shunt field winding. Disconnect all external leads of the coil assembly from the brush rig before testing. Tag and mark each lead before disconnecting to assure proper connections when reassembling.

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

TESTING FIELD WINDINGS FOR SHORT CIRCUIT. - If one coil is short circuited it will run cooler than the others and it may be possible to locate the short-circuited coil by placing your hand on the generator frame at each of the poleshoe positions and noting at which poleshoe position the frame is cooler than normal. A more definite test is a comparative resistance test or a comparative voltage drop test. If the coil windings are short-circuited, replace the entire coil assembly.

FIELD COIL INSTALLATION. - The generator frame assembly must be removed from the unit before the field coils can be removed from the poleshoes. Tag and mark all external leads before disconnecting to assure correct connections when reassembling. When removing the poleshoes and coils, be sure to keep the shims used under each poleshoe together to assure correct air gap when installing the coil assembly and poleshoes.

When installing a coil assembly, be sure it is in the original position in the frame. If it is not, the coil leads cannot be properly connected. Insert the poleshoe into the coil (be sure the poleshoe shims are in place) and secure the poleshoe to the frame. Tighten the poleshoe mounting screws securely. If they should work loose serious damage to the generator would result. Install each of the other coils and poleshoes in the same manner. Connect external leads as marked on the tags. If a new coil assembly is being installed, make the connections the same as marked for the oil coil assembly.

POLESHOE INSTALLATION. - Follow the instructions given for FIELD COIL INSTALLATION.

GENERATOR ASSEMBLY. - Whenever installing a new armature, pole shoe, coil assembly or generator frame assembly, it is recommended that the field windings be repolarized to prevent a possible short circuit from occurring. If the polarity is not the same as the starting battery, the charge circuit will burn out. The field windings of the generator is polarized for a negative grounded starting system. This is done by lifting all generator brushes into their holders and momentarily touching the positive cable lug of a 12-volt battery to any positive brush terminal and the negative cable lug to the generator frame. This magnetizes the poleshoes with correct polarity for a negative grounded starting system. The poleshoes retain this magnetism (residual) indefinitely although it is possible for the poleshoes to lose it. It is this residual magnetism in the poleshoes that starts the current flowing in the proper direction in the field windings when the generator starts to operate.

CONTROLS

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

Always disconnect the battery before servicing any control parts to avoid accidentally starting the unit. When removing any control part, tag and mark the connection point of each lead that has to be removed to assure correct connections when reassembling.

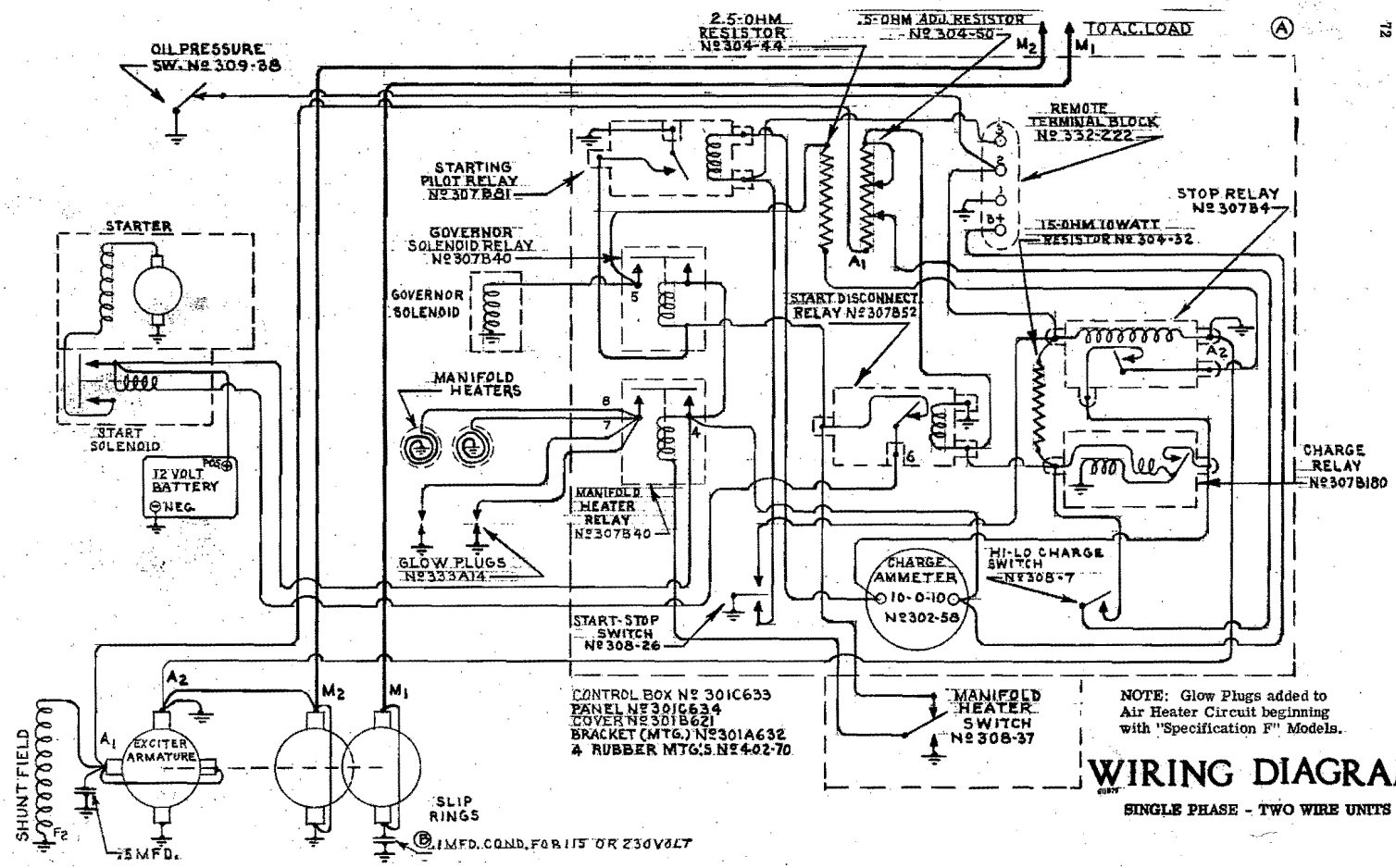
POSSIBLE CAUSE	REMEDIES
ENGINE CRANKS TOO STIFFLY	
Load not disconnected from unit.	Disconnect load from unit when starting.
Too heavy oil in crankcase.	Use only recommended grades.
Engine stuck.	Disassemble and repair.
ENGINE WILL NOT START WHEN CRANKED	
Air in fuel system.	Bleed the fuel system.
Lack of fuel or faulty injection caused by dirty fuel.	Keep fuel tank filled. Keep fuel clean. Use only recommended fuels.
Clogged fuel filter.	Keep supplies of fuel clean. Replace fuel filter element.
Poor fuel.	Use only recommended grades.
Poor compression due to leaky gasket, loose head, worn valves or piston rings.	Tighten cylinder head. Replace cylinder head gasket if necessary. Grind valves, replace if necessary.
Wrong injection pump timing.	Check the injection pump timing.
ENGINE CRANKS SLOWLY OR WILL NOT CRANK	
Defective or discharged battery.	Replace or recharge battery.
Loose connections or broken wire in starter circuit.	Tighten loose connections. Replace terminals or wire where necessary.
Corroded battery terminals.	Clean corroded terminals. Replace cable if necessary.
Starter brushes worn excessively or making poor contact.	Replace brushes. See that brushes make good contact.
Short circuit in generator or load circuit.	Repair as needed.
Dirty or corroded points in start solenoid switch.	Replace switch.
ENGINE FIRES BUT FAILS TO KEEP RUNNING	
Air in fuel system.	Bleed the fuel system. Check for air leakage. To help locate air leakage, raise the fuel supply 2 feet above pump level, if practical.
Governor stop solenoid de-energized and closing the throttle.	Allow engine to gain running speed before releasing the start switch. Check for open circuit to stop solenoid.

POSSIBLE CAUSE	REMEDIES
ENGINE RUNS BUT VOLTAGE DOES NOT BUILD UP	
Poor brush contact.	See that brushes seat well on commutator and collector rings (where used), are free in holders, are not worn shorter than 5/8 inch and have good spring tension.
Open circuit, short circuit or ground in generator.	Check and repair or replace as described under GENERATOR in the Maintenance and Repair section.
VOLTAGE UNSTEADY BY ENGINE NOT MISFIRING	
Speed too low.	Adjust governor to correct speed.
Injection pump fuel metering shaft not properly adjusted.	Adjust as instructed under SPECIAL ADJUSTMENTS.
Poor commutation or brush contact.	Refinish commutator or undercut mica if necessary. See that brushes seat well on commutator and collector rings (where used), are free in holders, are not worn shorter than 5/8" and have good spring tension.
Loose connections.	Tighten connections.
GENERATOR OVERHEATING	
Short in load circuit.	Correct short circuit.
Generator overloaded.	Reduce load.
Improper brush rig position.	Adjust to "neutral" position.
ENGINE OVERHEATING	
Improper lubrication.	See Low Oil Pressure.
Poor ventilation.	Provide ample ventilation at all times.
Dirty or oil cooling surfaces.	Keep the engine clean.
Retarded injection timing.	Retime.
Generator overloaded.	Reduce load.
VOLTAGE DROPS UNDER HEAVY LOAD	
Engine lacks power.	See Engine Misfires at Heavy Loads.
Poor compression.	Tighten cylinder head, grind or replace valves, replace piston rings - as needed.

POSSIBLE CAUSE	REMEDIES
VOLTAGE DROPS UNDER HEAVY LOAD (CONT.)	
Faulty injection.	Check fuel system. Dirty fuel is main cause. Use only recommended fuels.
Dirty air cleaner.	Clean. Refill with proper oil.
Dirty fuel filter.	Keep fuel clean. See SERVICING THE FUEL FILTER under Periodic Service.
Restricted exhaust line.	Clean or increase the size.
ENGINE MISFIRES AT LIGHT LOAD	
Faulty injection.	Dirty fuel is main cause. Use only recommended fuels.
Poor compression.	Tighten cylinder head, grind or replace valves, replace piston rings - as needed.
Poor grade of fuel.	Use only recommended fuels.
ENGINE MISFIRES AT HEAVY LOAD	
Faulty injection.	Dirty fuel is main cause. Use only recommended fuels.
Dirty air cleaner.	Clean. Refill with proper oil.
Dirty fuel filters.	Refer to SERVICING FUEL FILTER under Periodic Service.
ENGINE MISFIRES AT ALL LOADS	
Leaky valves.	Refer to VALVE SERVICE under Maintenance and Repair
Broken valve spring.	Replace.
Defective or dirty nozzle.	Install new nozzle.
LOW OIL PRESSURE	
Defective oil pressure gauge.	Replace.
Oil too light or diluted.	Drain. Refill with proper oil.
Oil too low.	Add oil.
Oil relief valve not closing.	Check by-pass. Clean or replace as needed.
Badly worn bearings.	Replace.

POSSIBLE CAUSE	REMEDIES
LOW OIL PRESSURE (CONT.)	
Sludge on oil cup screen.	Remove and clean screen and oil reservoir.
Badly worn oil pump.	Replace.
HIGH OIL PRESSURE	
Defective oil pressure gauge.	Replace.
Oil too heavy.	Drain. Refill with proper oil.
Clogged oil passage.	Clean all lines and passages.
Oil relief valve stuck.	Clean by-pass. Replace if needed.
EXCESSIVE OIL CONSUMPTION - LIGHT BLUE SMOKY EXHAUST	
Poor compression. Usually due to worn piston, rings, or cylinder.	Refinish cylinder. Install oversize piston and rings.
Oil too light or diluted.	Drain. Refill with proper oil.
Too large bearing clearance.	Replace bearings necessary.
Engine misfires. Usually due to leaky valve or broken valve spring.	Reseat or replace as needed.
Faulty injection timing.	Check injection pump timing.
Too much oil in cylinder block.	Drain excess oil.
Crankcase breather valve sticking.	Free up disc. Replace valve if necessary.
Air leak at oil filler cap gasket.	See that cap fits tightly and gasket is O. K.
BLACK, SMOKY EXHAUST - EXCESSIVE FUEL CONSUMPTION - POSSIBLE LACK OF POWER UNDER LOAD.	
Generator overloaded. Black smoky exhaust normal condition with overload.	Reduce load to within rated capacity. If smoky condition does not clear up, stop the unit at once and check for further trouble. Serious damage may result if trouble is not corrected.
Poor compression.	Tighten cylinder head, grind or replace valves, replace piston rings - as needed.
Poor grade or dirty fuel.	Use only clean recommended fuel.
Injection pump or nozzle not operating properly.	Install new nozzle or injection pump.
Faulty injection timing.	Check injection pump timing.

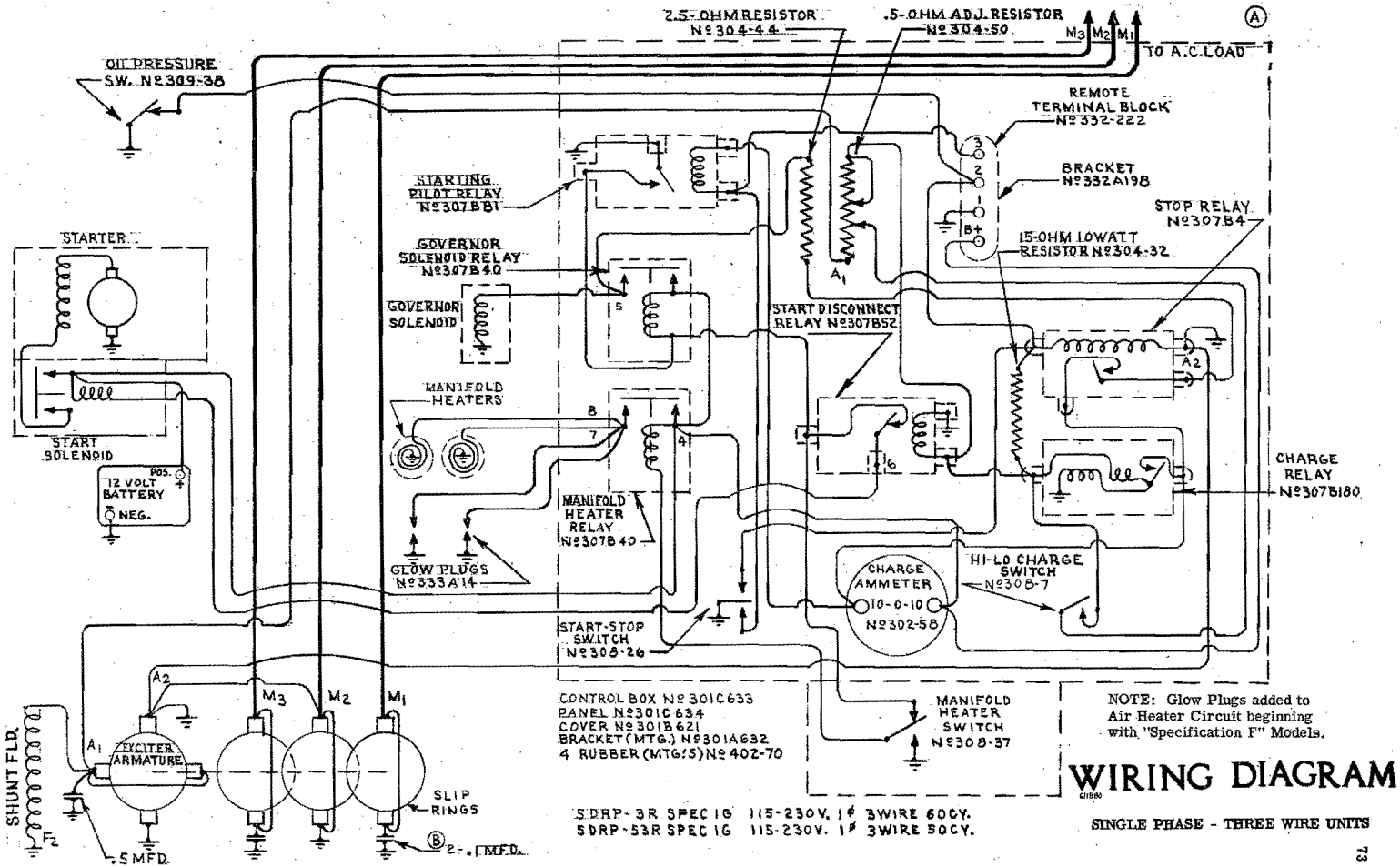
POSSIBLE CAUSE	REMEDIES
ENGINE RACES (STOP UNIT AT ONCE AND DETERMINE CAUSE!!)	
Governor linkage disconnected.	Replace linkage. Tighten mounting nut securely.
Too much oil in air cleaner.	Correct oil level. Check breather tube check valve, free disc or replace valve.
ENGINE STOPS UNEXPECTEDLY	
Empty fuel tank.	Refill fuel tank as often as needed to prevent running out of fuel.
Dirt in fuel system.	Use only recommended fuel. Refer to SERVICING FUEL FILTER under Periodic Service. Clean fuel tank. Fill with clean fuel. Bleed fuel system. Install new nozzle or injection pump if trouble not corrected.
Stop solenoid defective or open stop solenoid circuit.	Operate solenoid manually or repair, adjust, or replace parts needed.
Low oil pressure causing switch to operate.	See Low Oil Pressure.
Defective Oil Pressure Switch.	Replace Switch.
LIGHT POUNDING KNOCK	
NOTE: DO NOT CONFUSE WITH NORMAL KNOCK FROM FIRING OF FUEL.	
Loose connecting rod.	Adjust clearance or replace.
Low oil supply.	Add oil. Change if necessary.
Oil badly diluted.	Drain. Refill with proper oil.
Low oil pressure.	See Low Oil Pressure.
VOLTAGE LOW AT FAR END OF LINE BUT NORMAL NEAR UNIT	
Too small line wire used for load and distance.	Install extra or larger wires or reduce the load.



NOTE: Glow Plugs added to Air Heater Circuit beginning with "Specification F" Models.

WIRING DIAGRAM

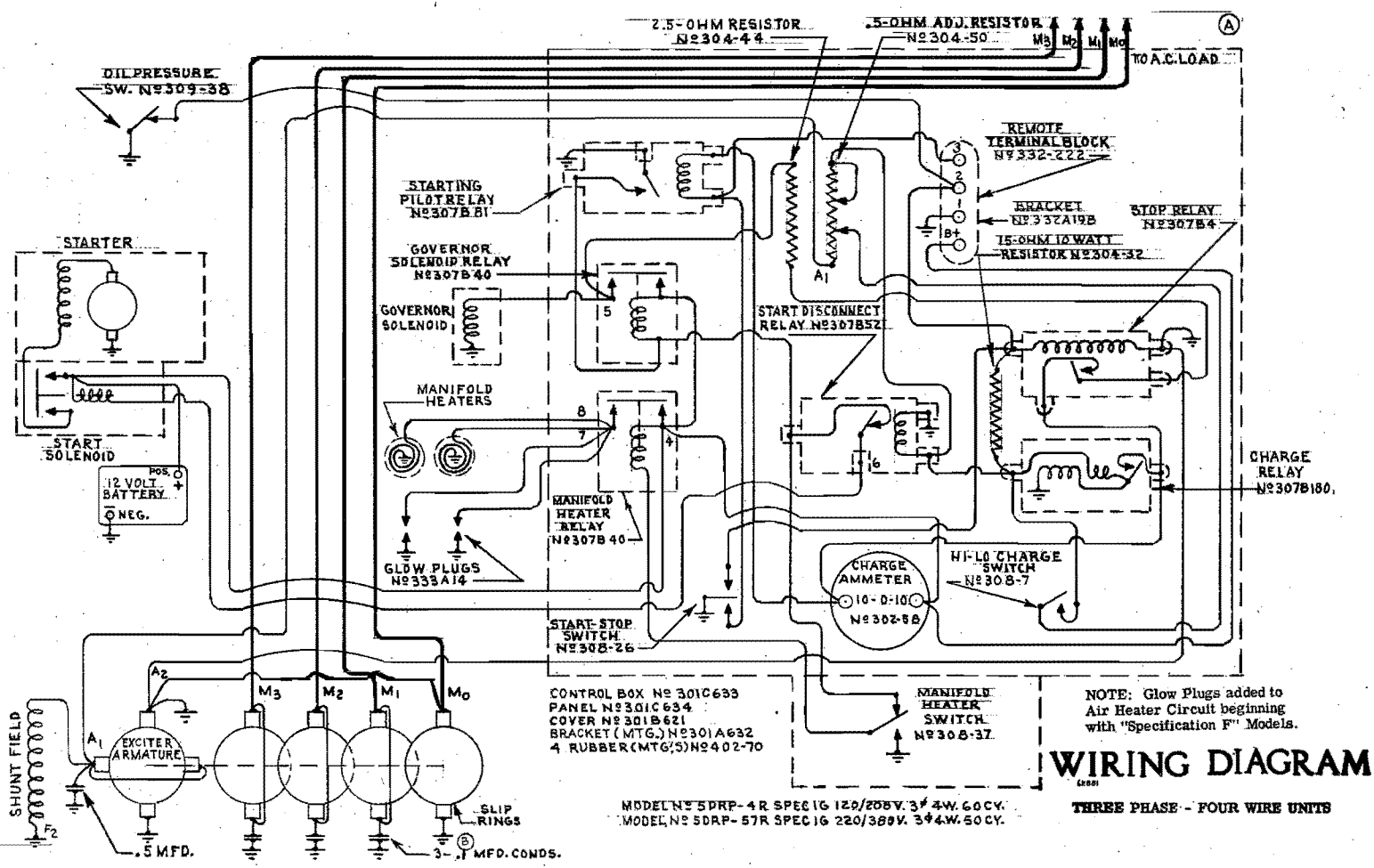
SINGLE PHASE - TWO WIRE UNITS

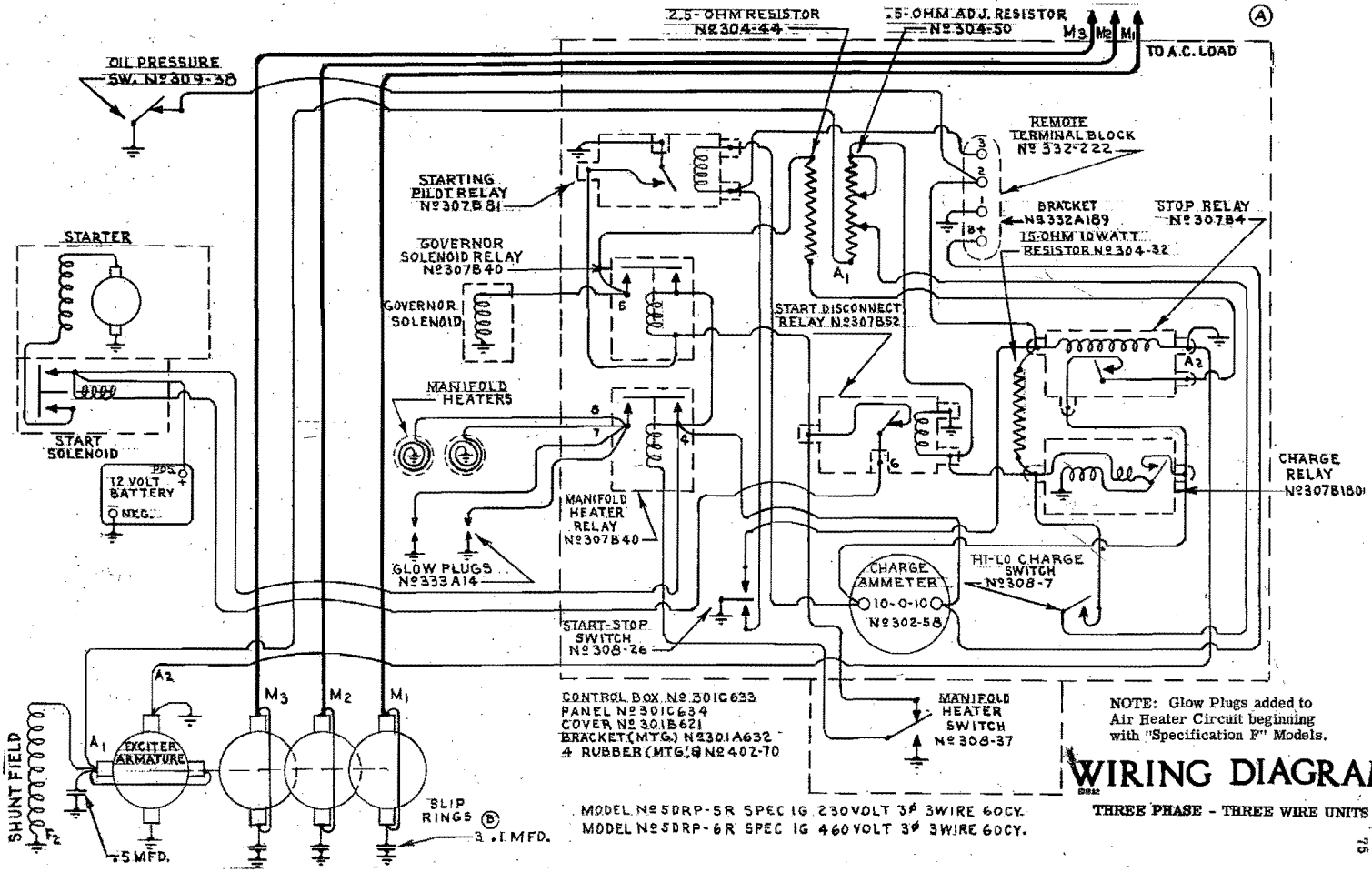


NOTE: Glow Plugs added to Air Heater Circuit beginning with "Specification F" Models.

WIRING DIAGRAM

SINGLE PHASE - THREE WIRE UNITS

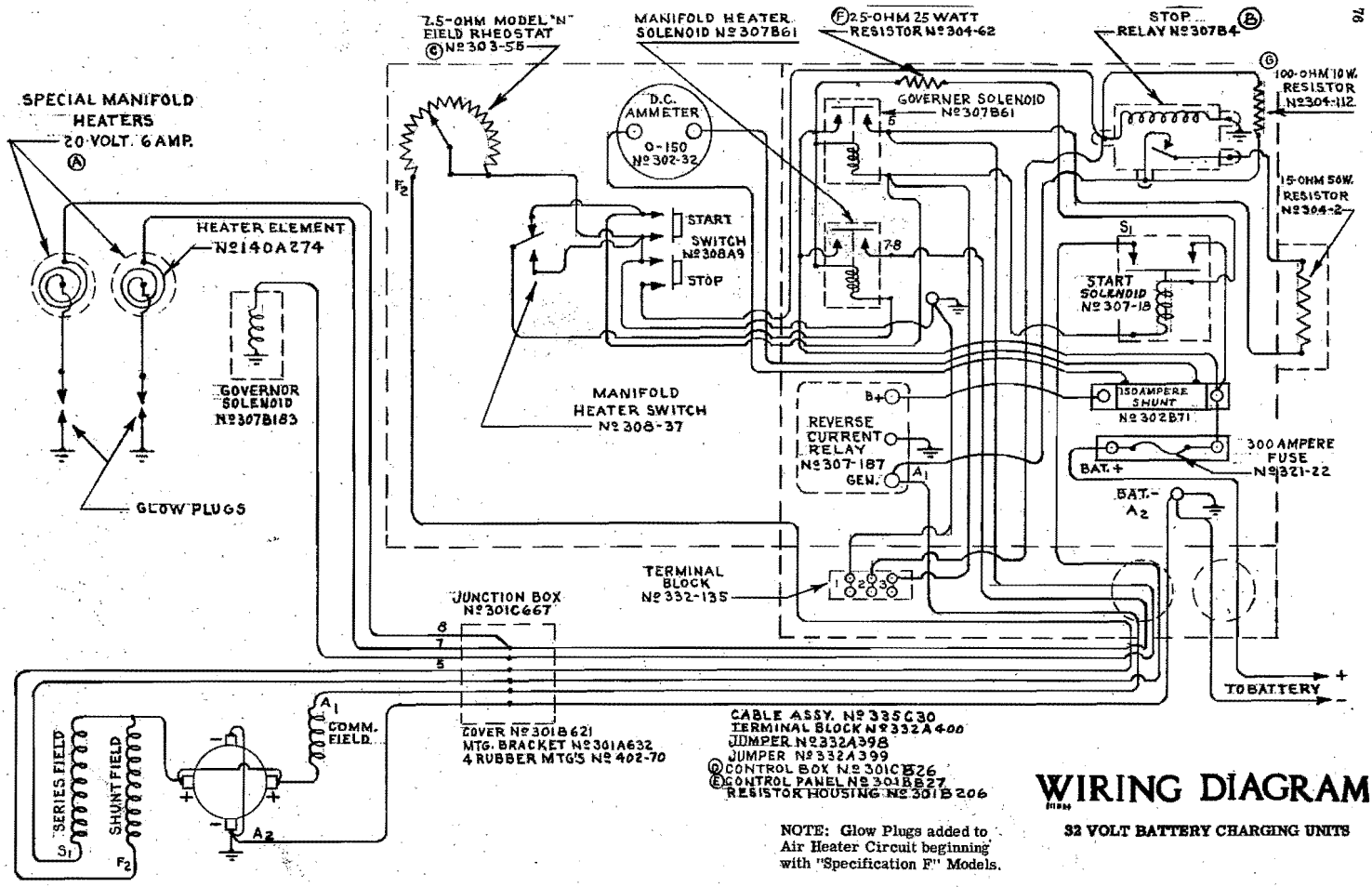

2.5-OHM RESISTOR Nº304-44
.5-OHM ADJ. RESISTOR Nº304-50
M3 M2 M1 M0
TO A.C. LOAD
A
OIL PRESSURE SW. Nº309-38
REMOTE TERMINAL BLOCK Nº332-222
STARTING PILOT RELAY Nº307B81
BRACKET Nº332A19B
STOP RELAY Nº307B4
15-OHM 10 WATT RESISTOR Nº304-32
STARTER
GOVERNOR SOLENOID RELAY Nº307B40
GOVERNOR SOLENOID
START DISCONNECT RELAY Nº307B52
MANIFOLD HEATERS
START SOLENOID
12 VOLT BATTERY
POS.
NEG.
MANIFOLD HEATER RELAY Nº307B40
GLOW PLUGS Nº333A14
CHARGE RELAY Nº307B180
CHARGE AMMETER 10-0-10 Nº302-88
HI-LO CHARGE SWITCH Nº308-7
START-STOP SWITCH Nº308-26
MANIFOLD HEATER SWITCH Nº308-37
CONTROL BOX Nº301C633
PANEL Nº301C634
COVER Nº301B621
BRACKET (MTG.) Nº301A632
4 RUBBER (MTG) (5) Nº402-70
SHUNT FIELD
EXCITER ARMATURE
SLIP RINGS
.5 MFD.
3-1 MFD. CONDS.
MODEL Nº 5DRP-4R SPEC 16 120/208V. 3φ 4W. 60CY.
MODEL Nº 5DRP-57R SPEC 16 220/380V. 3φ 4W. 50CY.
NOTE: Glow Plugs added to Air Heater Circuit beginning with "Specification F" Models.
WIRING DIAGRAM
THREE PHASE - FOUR WIRE UNITS



NOTE: Glow Plugs added to Air Heater Circuit beginning with "Specification F" Models.

WIRING DIAGRAM

THREE PHASE - THREE WIRE UNITS



WIRING DIAGRAM

32 VOLT BATTERY CHARGING UNITS

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