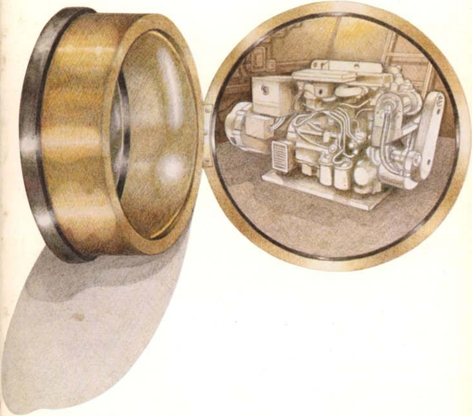
Onan

Marine Training Manual



ONAN PLANT — Fridley, Minnesota

ONAN PLANT — Huntsville, Alabama

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MARINE SAFETY PRECAUTIONS

Throughout this manual you will notice WARNING and CAUTION symbols which alert you to potentially dangerous conditions to the operator, service personnel, or the equipment itself.

WARNING **Onan uses this symbol throughout the text to warn of possible injury or death.**

CAUTION **This symbol is used to warn of possible equipment damage.**

Before operating the generator set, read the operator's manual and become familiar with it and your unit. Safe and efficient operation can be achieved only if the unit is properly operated and maintained. Many accidents are caused by failure to follow simple and fundamental rules or precautions.

- Do not fill fuel tanks with the engine running. Do not smoke around generator set area. Wipe up any oil or gas spills. Do not leave oily rags in engine compartment or on the generator set. Keep this and surrounding area clean.
- Equip the engine fuel supply with a positive fuel shutoff for a remote fuel supply source.
- Provide adequate ventilation (preferably power exhausters) to expel toxic gas fumes and fuel vapors from the engine compartment. Be sure propulsion and generator engine exhaust systems are free of leaks.
- Perform thorough, periodic inspections of the exhaust system and repair leaks immediately. Exhaust gases are deadly.
- Coolants under pressure have boiling points over 212 F (100 C). Do not open a coolant pressure cap while the engine is running. Always bleed off the system pressure first.
- Do not remove any belt guards or covers with the unit running.
- Keep hands and loose clothing away from moving parts. Do not wear jewelry while servicing any part of the generator set.
- Never step on the generator set (as when entering or leaving the engine compartment). It can stress and break unit components, possibly resulting in dangerous operating conditions . . . from leaking fuel, leaking exhaust fumes, etc.
- Before performing any maintenance on the set, disconnect its batteries to prevent accidental starting. Disconnect the ground lead first. Do not smoke while servicing batteries. Hydrogen gas given off during charging is explosive. Make sure you connect the battery correctly. A direct short across the battery terminals can cause an explosion. Connect the ground lead last.
- Do not make adjustments in the control panel or on engine with unit running. High voltages are present. If you must work around unit while it is running, stand on dry surfaces to reduce shock hazard.
- Keep a fire extinguisher available in or near the engine compartment and in other areas throughout the vessel. Use the correct extinguisher for the area. For most types of fires, an extinguisher rated ABC by the NFPA is available and suitable for use on all types of fires except alcohol.
- Onan suggests posting these suggestions in potential hazard areas of the vessel. Most important, exercise caution and use common sense.

INTRODUCTION

Every Onan marine model is designed, built and tested specifically for marine service. Many features such as radio suppression, full-pressure lubrication, hard faced valves and seats, low oil pressure and high water temperature cut-out switches, drip pans, vibration dampeners, neoprene impeller water pumps to name a few are standard.

All features, necessary to provide dependable day-in, day-out electric power aboard your vessel are built into every Onan marine unit.

Standard models are available in 1, 2, or 4 cylinder gasoline or diesel engines in sizes up to 50 kW. There are three main types of cooling systems available. Direct water cooling, heat exchanger cooling using two separate water systems, and keel cooling using a closed water system.

The contents of this training manual are assembled with three specific objectives in mind.

1. To aid the instruction in teaching this material.
2. A means of self instruction for student learning.
3. A dual purpose guide to be used with available slides to assist the instructor and as a future reference for the student to use when necessary.

The purpose of this training manual in covering marine service is to give the student a general over-all knowledge of all aspects of service and to enable the service personnel to become proficient in many areas of marine service such as:

- Installation
- Theory of Operation
- Adjustments
- Preventive Maintenance
- Troubleshooting
- Controls
- Rules and Regulations

For all Onan electric generating sets, engine end is the front, generator end is the rear. Right and left sides are determined by facing the set from the engine (front) end

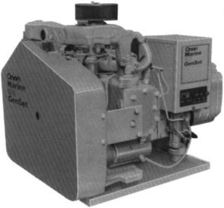
The following pages contain a general description by model of the size and features of the various units covered in this manual. Reference is made throughout the manual to various other Onan publications which deal specifically with one area of this manual in detail and will serve to supplement the information contained in this manual.

All metric dimensions are given in parentheses following the U.S. customary unit.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. Onan reserves the right to make changes at any time without notice.

GENERAL DESCRIPTION

MARINE SERIES 4.0 AND 6.5 MCCK - 4,000 or 6,500 WATTS



The 4.0 and 6.5 kW MCCK is a 4-cycle, two cylinder horizontally opposed, water cooled 1800 rpm engine. The 4-pole, self-excited revolving armature generator is inherently regulated. The sets have a mounted control box, and may be connected to optional equipment for remote starting or automatic load demand start-stop controls.

These units meet all the USCG 183 requirements.

MODEL SELECTION AND RATING TABLE

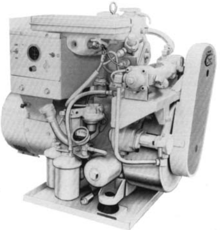
MODEL NUMBER	GENERAL MARINE RATING							ENGINE	
	VOLTS	AMPS	kW	kVA and PF	PHASE	WIRE	HERTZ	RPM	STARTING
4.0MCCK-3CR*	120/240	33/17	4	4.0 at 1.0 PF	1	4	60	1800	Remote
6.5MCCK-3CR*	120/240	54/27	6.5	6.5 at 1.0 PF	1	4	60	1800	Remote

* - These models are connected 120-240-volt, 3-wire and are reconnectible to deliver rated output at 120-volt, 2-wire or 240-volt, 2-wire.

MARINE SERIES 3.0MDJA - 3,000 WATTS

The 3.0MDJA is a 4-cycle, single cylinder, vertical design, water cooled 1800 rpm generator set. The 4-pole, self excited revolving armature generator is inherently regulated, and is a starting motor for the engine. The illustration is a unit with optional heat exchanger cooling.

This model cannot be operated in a gasoline environment unless installed per USCG regulation 183.410.



MODEL SELECTION AND RATING TABLE

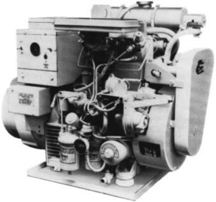
MODEL NUMBER	GENERAL MARINE RATING						REMOTE START
	VOLTS	AMPS	KW	PHASE	WIRE	HERTZ	
3.0MDJA-IR	120	25	3	1	2	60	12-volt
3.0MDJA-3CR*	120/240	12.5	3	1	4	60	12-volt

*Reconnectible to deliver rated output at 120-volt, 2-wire, 240-volt, 2-wire or 120/240-volt, 3-wire.

MARINE SERIES 6.0 and 7.5 kW MDJE

This diesel is a 4-cycle, two cylinder, overhead valve, 1800 rpm, vertical in line design water cooled engine, driving a revolving field generator. The new models are solid state voltage regulated. Older models are Magneciter (static) excited.

This model cannot be operated in a gasoline environment unless installed per USCG regulation 183.410.



MODEL SELECTION AND RATING TABLE

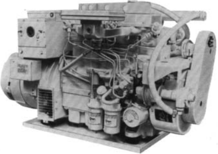
MODEL NUMBER	GENERAL MARINE RATING							REMOTE START
	VOLTS	AMPS	KW	KVA and PF	PHASE	WIRE	HERTZ	
6.0MDJE-53CR*	120/240	50/25	6.0	6.0 at 1.0PF	1	4	50	12-volt
6.0MDJE-518R**	—	—	6.0	7.5 at 0.8PF	3	4	50	12-volt
7.5MDJE-3CR*	120/240	64/32	7.5	7.5 at 1.0PF	1	4	60	12-volt
7.5MDJE-18R**	—	—	7.5	9.37 at 0.8PF	3	4	60	12-volt

* - These 120/240-volt models are reconnectible to deliver full rated output at 120-volt, 2-wire or 240-volt, 2-wire.
** - This is a 12 lead, broad range reconnectible alternator which user connects for required voltage and amperage.

MARINE SERIES 12.0 MDJC and 15.0 MDJF

This series is a 4-cycle, four cylinder, overhead valve, vertical in-line design, water cooled 1800 rpm engine, driving a revolving field generator. The new models are solid state voltage regulated. Older models are Magneciter (static) excited.

This model cannot be operated in a gasoline environment unless installed per USCG regulation 183.410.



MODEL SELECTION AND RATING TABLE

MODEL NUMBER	GENERAL MARINE RATING							REMOTE START
	VOLTS	AMP	KW	KVA and PF	PHASE	WIRE	HERTZ	
12.0MDJF-53CR	120/240*	100/50	12	12.0 at 1.0PF	1	4	50	12-volt
12.0MDJC-3CR	120/240*	100/50	12	12.0 at 1.0PF	1	4	60	12-volt
15.0MDJF-3CR	120/240*	125/62.5	15	15.0 at 1.0PF	1	4	60	12-volt
15.0MDJF-3CR4	120/240*	100/50	15	15.0 at 1.0PF	1	4	60	12-volt

* - These 120/240-volt models are reconnectible to deliver full rated output at 120-volt, 2-wire or 240-volt, 2-wire.

SECTION I
INSTALLATION

- **Introduction**
- **How To Estimate Electrical Load**
- **Mounting and Location**
- **Ventilation Requirements**
- **Exhaust Systems**
- **Fuel Systems**
- **Cooling Systems**
- **Batteries**
- **Summary (Practice Safety)**

WHAT IS A GOOD MARINE INSTALLATION?

A boat owner considers the marine electric generating set well installed if it supplies electricity quietly, safely and efficiently.

The installation must be safe. The United States Coast Guard, National Fire Protection Association and American Boat and Yacht Council have established safety standards which you should always follow. All installations must be made to conform with the applicable standards.

Our recommendations for the proper installation of a marine electric set are based on years of experience in the manufacture of generator sets. We offer these recommendations through this training manual so you can be assured the Onan unit selected for your boat will operate quietly and efficiently for many years to come. For further recommendations see Technical Bulletin T-021.

HOW TO ESTIMATE THE ELECTRICAL LOAD

To determine the correct size or model Onan marine set required for the vessel, total the wattage of all the equipment and appliances which will be operated at the same time. Usually the wattage is available on the nameplates of the equipment and appliances. If the amperage is given, multiply the amperage by the voltage to get the wattage. If the wattage or amperage is not given on your appliances, use the watt loads shown below for estimating purposes.

The electric generating set selected must be capable of supplying maximum load during starting for each motor and continuous load when motors are running. Motor, incandescent lamps and many other loads require several times full load current (inrush current) under starting conditions. If the motor loads are large, voltage dip may cause lights to dim or relays to chatter because of the starting load of some motors. When determining the size of the unit, consider the fact that electricity usage has doubled approximately every ten years. Consideration should be given to future electrical requirements necessary because of additional equipment being added to the vessel. Characteristics of conductors, effects of voltage drops, normal ampere ratings of the generating set and correct wire sizes are factors to be considered for almost all installations.

CIRCUIT BREAKERS: Onan recommends that fuses or circuit breakers be installed to protect the generator windings in case of an overload due to unbalanced loads or a short circuit in one of the load circuits. The 4.0 kW and 6.5 kW MCCK models are self limiting and do not require extra circuit protection.

BALANCE ALL LOADS: Divide the loads you intend to operate at one time equally between the generator output leads. The current loads for any one output lead must not exceed the nameplate rating. Overloading either output lead can damage the generator windings. Even though the generator outputs are affected, the engine has enough reserve power so it will not be sensitive to unbalanced loads.

It may be easier to understand why generator load circuits must be balanced if you think of a generator as having two legs (windings). Heavily loading one leg of the generator may result in higher than normal voltage outputs from the lighter-loaded leg as the generator attempts to offset the unbalanced loads.

MOTOR LOADS

Motors and motor driven applicances require up to five times more wattage while starting than while running. When figuring total watt requirements for motors, take five times the running watt rating of the largest motor and add the running watt ratings of all the smaller motors. This general listing applies to capacitor-start motors.

Motor Size	Starting	Running
1/6 horsepower	900 watts	200 watts
1/4 horsepower	1300 watts	300 watts
1/3 horsepower	1500 watts	360 watts
1/2 horsepower	2200 watts	520 watts
3/4 horsepower	3400 watts	775 watts
1 horsepower	4000 watts	1000 watts

Repulsion-induction motors require less starting wattage than capacitor-start motors, split-phase motors require more starting wattage than capacitor start motors.

Universal motors run satisfactorily on AC or DC.

APPLIANCE AND EQUIPMENT LOADS

Air Conditioner	See Motor Loads
Battery Chargers (Rectifier)	Up to 800watts
Blankets (electric)	50 to 200 watts
Coffee makers	550 to 700 watts
Electric drill	See Motor Loads
Electric Range (Per Element)	550 to 1500 watts
Fans	25 to 75 watts
Fry pan	1000 to 1350 watts
Heater (space)	1000 to 1500 watts
Hot plate (per element)	350 to 1000 watts
Iron (electric)	500 to 1200 watts
Lights (AC)	as marked
Refrigerator	See Motor Loads
Television	200 to 300 watts
Toaster	800 to 1150 watts
Vacuum cleaner	See Motor Loads
Waffle iron	650 to 1200 watts
Water heater	1000 to 1500 watts
Electronic oven	750 to 1500 watts

MOUNTING

Onan marine electric generating sets are supplied with vibration isolator mounts and on some models, a drip pan. A mounting base must be prepared to mount the unit to engine stringers or other strong supports in the vessel. The base should be strong enough to support several hundred pounds, and withstand considerable vibration and shock effects such as rocking of the vessel in heavy seas. See Figure 1-1. Table 1-1 gives maximum operating angle of Onan marine units.

TABLE 1-1. MAXIMUM OPERATION ANGLE OF ONAN MARINE UNITS

ELECTRIC GENERATING SET	MAXIMUM OPERATION ANGLE (ANY DIRECTION)
MCCK, MDJA, MDJE	20°
MDJC, MDJF	30°

UNIT LOCATION

A generator set may be installed in the propulsion engine compartment if specific conditions are met.

U.S.C.G. regulation 183.410 requires a generator set operating in a gasoline fuel environment be "ignition protected". This is a set capable of operating in an explosive environment without igniting that environment.

Diesel generator sets are not required to meet the 183.410 regulation when used in a diesel fuel environment, but are not certified to operate in a gasoline fuel environment.

Most propulsion engine compartments are already ventilated, and have access to the fuel supply. Keep the generator set away from living quarters, and away from bilge splash and vapors. Select a location that will allow adequate space on all sides for servicing the set.

FIGURE 1-1. VIBRATION ISOLATORS

VENTILATION REQUIREMENTS

Electric generating sets must have free air circulation while operating to provide combustion air for the engine and cooling air for the generator. Table 1-3 lists minimum air requirements for Onan marine units.

If the generator set fuel tank is in a separate compartment, it should be ventilated the same as the engine compartment. For passenger vessels, the Coast Guard recommends a powered exhausting system to meet requirements as shown in Table 1-2. The airflow should be sufficient to prevent recirculation of generator cooling air.

TABLE 1-2. PASSENGER VESSEL VENTILATION REQUIREMENTS

SIZE OF COMPARTMENT IN CU. FT. (m^3)	MINUTES PER AIR CHANGE
Less than 500 (14)	2
500 to 1000 (14 to 28)	3
1000 to 1500 (28 to 42)	4
1500 (42) and Up	5

TABLE 1-3. AIR REQUIREMENTS CUBIC FEET PER MINUTE (m^3)

GENERATOR SET	GENERATOR COOLING AIR 1800 RPM	COMBUSTION AIR 1800 RPM	TOTAL
3.0MDJA	75 (2.1)	16 (0.5)	91 (2.6)
7.5MDJE	135 (3.8)	32 (1)	167 (4.7)
12.0MDJC, 15.0MDJF	125 (3.5)	64 (1.8)	189 (5.4)
4.0, 6.5MCCK	120 (3.4)	32 (0.9)	141 (4)

EXHAUST SYSTEM

GENERAL

All exhaust systems for water-cooled marine installations must meet these requirements:

1. Except for vertical dry stack systems, exhaust systems must be water cooled, the water injected as near to the generator set as possible.
2. All exhaust system sections preceding the point of cooling water injection must be either water jacketed or effectively insulated.
3. The exhaust line must be installed so as to prevent back flow of water to the engine under any conditions, and the exhaust outlet must be above the load waterline. Water flowing back to the engine will damage it.
4. The generator set's exhaust system must not be combined with the exhaust system of any other engine.
5. An approved, flexible, non-metallic exhaust line section should be used near the engine to allow for engine movement and vibration during operation.
6. Vertical dry stack exhaust systems must have spark arresters. The exhaust system between engine manifold and spark arrester must be either water jacketed or well insulated.
7. Be of sufficient size to prevent excessive back pressure.

WARNING **Use extreme care during exhaust system installation to ensure a tight exhaust system. Exhaust gases are deadly.**

MATERIAL

Use material recommended by ABYC in "Safety Standard for Small Craft", Section P1. The exhaust line should be at least as large as the engine exhaust outlet (Table 1-4).

Most installations today use flexible rubber hose for the water cooled section of the exhaust line for ease of installation and flexibility. Be sure the hose is designed and approved for marine exhaust line.

Provide adequate support for rubber hose to prevent sagging, bending and formation of water pockets. Use automotive type pipe hangers to keep vibration from transmitting to the hull. Two hose clamps having minimum width of 1/2 inch (12.7 mm) should be used at each end of hose. See Figures 1-2 and 1-3.

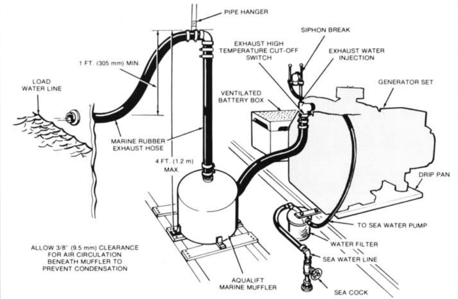


FIGURE 1-2. TYPICAL SMALL UNIT EXHAUST SYSTEM

TABLE 1-4. ELECTRIC GENERATING SET EXHAUST OUTLET SIZES

UNIT MODEL	EXHAUST OUTLET SIZE (IN.)
MCCK Thru SPEC "G"	1
MDJA, MDJE, MCCK "H"	1-1/4
MDJC, MDJF	1-1/2

WARNING Don't use the manifold as a muffler support because it puts excessive strain on the connecting exhaust line and can cause it to break allowing poisonous exhaust fumes to escape.

To help break up the momentum of backwashing water in the exhaust lines before the water backflows to the engine, the muffler can be installed near the unit. Water rushing forward will pour into the muffler, dissipating its momentum.

WARNING Do not install rubber hose with sharp bends as this will reduce efficiency and may cause hose failure. Do not use rubber hose on dry type exhaust applications.

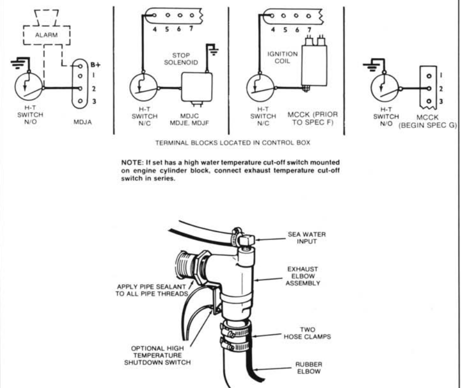


FIGURE 1-3. HIGH EXHAUST TEMPERATURE SHUTDOWN SWITCH

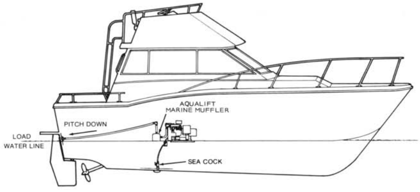


FIGURE 1-4. TYPICAL ABOVE WATER LINE INSTALLATION

EXHAUST COOLING WATER INJECTION

When installing a separate system to cool the exhaust, a device is required to indicate if the system fails. Mount a temperature operated switch on the exhaust elbow and connect it to operate either an alarm or to shut off the unit if the exhaust overheats (approximately 200°F (93°C). Onan recommends a high-temperature exhaust shutdown switches for all types of marine installations. See Figure 1-3.

An important consideration of water injection is keeping water from flowing back through the exhaust system into the engine. The two most frequent causes of water entering the engine are:

1. Momentum built by water sloshing in the exhaust line causing the water to rush forward into the engine when the boat pitches forward.
2. Engine stopping creates a vacuum and can draw water back into the engine.

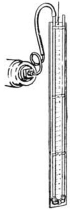
EXHAUST BACK PRESSURE

Exhaust back pressure is an important criteria of an adequate exhaust system. If the installation is excessively long or questionable, back pressure should be checked before putting the unit into operation. Most Onan marine electric generating sets with a separate water-cooled exhaust manifold have a 1/8 inch pipe-tapped hole with pipe plug on one end of the manifold. An adapter will have to be made to check back pressure on other Onan units.

Use a manometer or pressure gauge on the manifold to check back pressure. See Figure 1-5.

CAUTION **Excessive back pressure will cause loss of power.**

The exhaust back pressure ratings for the MDJF Series are considerably higher than those shown below. Consult your operator's manual for acceptable limits on the MDJF Series.



UNITS OF MEASUREMENT	BACK PRESSURE AT FULL LOAD
INCHES OF WATER	40
INCHES OF MERCURY	3
OUNCES/SQ. IN.	23.0 OZ.
KILOPASCAL	10

FIGURE 1-5. MANOMETER INSTALLATION

ONAN AQUALIFT MUFFLER

Onan recommends the Onan Aqualift muffler (Figures 1-6 and 1-7) for marine generator sets installed above or below the load water line. Because of installation variables, customers must provide the brackets, hoses and clamps required for installation. Complete instructions are included with the Aqualift muffler.

CAUTION **If the Aqualift muffler is used, the hull strainer furnished with the muffler must be used. It is designed for this muffler to prevent back pressure or vacuum on the engine cooling system.**

Be sure any muffler is well supported, and in the case of a neoprene muffler, completely separated from the vessel's structure. If a neoprene muffler touches the vessel, it increases exhaust noise.

Because the Aqualift has relatively little water in it during normal operation, it doesn't have to be drained for winter conditions. Freezing temperatures will not damage it.

CAUTION **DO NOT USE SCOOP TYPE WATER INLET FITTINGS when installing an Aqualift muffler. Forward facing scoops develop sufficient ram pressure to force water past the set's water pump, flooding the exhaust system where it may flow back, flooding the engine cylinders. This can happen only if the electric set is not running and vessel is underway.**

WARNING **Welding on the muffler will damage the interior protective coating decreasing the life expectancy.**

WARNING **Be sure all fittings are tight to prevent poisonous exhaust fumes from escaping.**

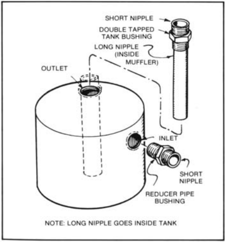


FIGURE 1-6. AQUALIFT MUFFLER CONSTRUCTION

FIGURE 1-7. AQUALIFT MUFFLER

FUEL SYSTEM

FUEL TANKS

If the generator set and propulsion engines use the same fuel (gasoline or diesel), the generator set can usually be supplied from the main fuel tanks. See Figure 1-8.

WARNING Leakage of gasoline in or around the compartment is a definite hazard. The ventilation system should provide a constant flow of air to expel any accumulation of fuel vapor.

CAUTION Operating the electric set from a tee in the main fuel line can cause erratic operation. The set's fuel pump has neither the capacity nor the power to overcome the draw of propulsion engine fuel pump.

Position the tank fill and vent pipes so there is no chance of fuel or vapor escaping into the bilge. Run the vent and fill pipes from separate opening in the tank. If a flexible section of fill pipe is used, install a separate ground wire between the deck plate and fuel tank. Install the vent opening as far from any other hull opening as possible and with a gooseneck so water will not enter the pipe. Install a flame arrestor on the vent opening.

Figure 1-8 shows typical method of installing a second dip tube in the original fuel tank outlet. If the fuel tank outlet fitting is large enough to accommodate two dip tubes, the required fitting can be built by a machine shop.

FUEL LINES

1. Use seamless annealed fuel lines approved for marine installations.
2. Run fuel lines at the top level of tank to a point as close to the engine as possible to reduce danger of fuel siphoning from tank if the line should break.
3. Keep fuel lines away from hot engine or exhaust areas. This reduces chance of vapor lock.
4. Line must be long enough to prevent binding or stretching because of generator set movement.
5. Install an approved flexible non-metallic and non-organic fuel line between the solid fuel line and engine to absorb vibration.
6. Install lines so they are accessible and protected from injury.
7. Use nonferrous metal straps without sharp edges to secure the fuel lines.
8. If fuel line is metallic, ground with a suitable ground strap to the boat common bond conductor.

FUEL SYSTEM SIPHON PROTECTION

A carburetor float valve must not be trusted to hold back fuel if there is a gravity feed from the fuel tank. When the tank is installed above the engine level on gasoline units, a siphon break is necessary to prevent the fuel from emptying into the carburetor if the float valve is not closed. This also prevents the fuel from siphoning if the fuel line breaks at a point below the fuel level.

Siphon protection can be provided by an anti-siphon valve, or an electrically operated fuel stop valve at the tank withdrawal fitting (Figure 1-9). The electric stop valve is connected to the engine ignition circuit and allows fuel flow only during engine operation. To comply with USCG regulations, the valve must have manual override for emergency operation.

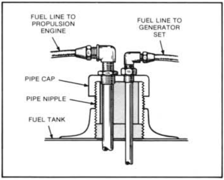


FIGURE 1-8. TWO FUEL LINES IN ONE TANK OUTLET

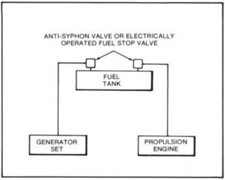


FIGURE 1-9. SIPHON PROTECTION

COOLING SYSTEM

Throughout this manual, floatation water drawn into the boat for engine cooling will be called sea water. Water recirculated through a closed system will be called captive water. Use of the term "sea water" does not necessarily imply that the water is salty. In fact, use of salt water in the engine block for cooling may result in severe corrosion problems. Units operating in a salt water environment should use either a keel type or heat exchanger type closed cooling system.

Three types of cooling in general use today are: direct (sea) water cooling (Figure 1-12); heat exchanger (captive water) cooling (Figure 1-10); and keel or skin (captive water) cooling (Figure 1-11).

DIRECT WATER COOLING

Direct Sea Water Cooling Systems use a rubber impeller pump to draw water directly from the lake or river, circulate the water through the engine's cooling system and out through the exhaust system. Water flow is controlled by a thermostat. A high water temperature cut-off switch protects the engine.

HEAT EXCHANGER COOLING

Heat Exchanger Cooling has two separate water systems, a captive water and a sea water system. The metal impeller pump circulates captive water through the engine's block, heat exchanger shell, water-cooled exhaust manifold and expansion tank.

The rubber impeller pump circulates sea water through the heat exchanger's core (cooling the captive water) and out through the water-cooled muffler.

KEEL COOLING

Keel Cooling, a captive water system, uses a metal impeller pump to circulate captive water through the engine's water jacket, exhaust manifold, expansion tank, and keel cooler tubing. The cooling tubes are attached to the vessel's hull, below the water line, so that sea water (floatation water) cools the captive water.

A rubber impeller pump circulates sea water for exhaust cooling.

WATER PUMP

Two types of pumps are in general use today, the metal impeller pump and the rubber impeller pump. Each has special advantages and disadvantages. See Figure 1-13.

CAUTION **Do not use the existing rubber impeller pump in the hot water side of the cooling system. Heat or soluble oil (in many rust inhibitors and antifreezes) will damage the impeller. Instead, connect the rubber impeller pump on the sea water side. Use a metal impeller pump (Onan #132-0110 or equal) in the captive water side.**

If the boat is used extensively in contaminated water where a strainer can't remove most of the dirt, install a centrifugal pump and filter below the water line as a sea water pump. Dirty water can still cause block plugging; therefore heat exchanger, keel cooling or skin cooling should be used under these conditions.

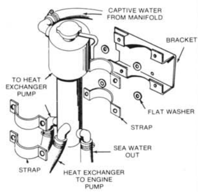


FIGURE 1-10. HEAT EXCHANGER COOLING SYSTEM

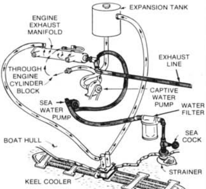


FIGURE 1-11. KEEL COOLING SYSTEM

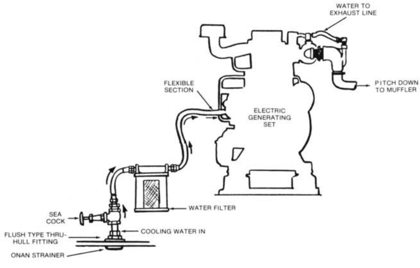


FIGURE 1-12. DIRECT COOLING SYSTEM

Use line of the proper size, following recommendations in Table 1-5. Increase the line size for runs over 5 feet (1.5 m) in length. One pipe size for each additional 10 feet (3 m) in length.

Water lines can be either copper tubing or flexible hose. In any case, use a section of flexible hose on the water inlet next to the generator set. Use another flexible section on the water outlet before it enters the exhaust line. This flexible section must be long enough to stop transfer of vibration.

Onan recommends using a water filter in the water line to protect the cooling system (Figure 1-12).

CAUTION **The flush-type thru-hull water inlet must have an opening at least as large as the water inlet line.**

Standard Onan marine sets are equipped for direct water cooling. Installation requires a through-hull fitting, sea cock and strainer.

TABLE 1-5. COOLING SYSTEM CONNECTING SIZES AND RECOMMENDED HOSE SIZES

ELECTRIC GENERATING SET	INLET SIZE (INCH)	OUTLET SIZE (INCH)	MINIMUM RECOMMENDED HOSE INSIDE DIAMETER IN INCHES(mm)
MDJA	1/2 OD hose adapter	Connected to exhaust elbow	1/2 (12.7)
MCCK, MJC, MDJE	1/2 OD hose adapter	3/8 (hose adapter furnished)	1/2 (12.7)
MDJC, MDJF	3/4 OD hose adapter	3/8 (hose adapter furnished)	3/4 (19)

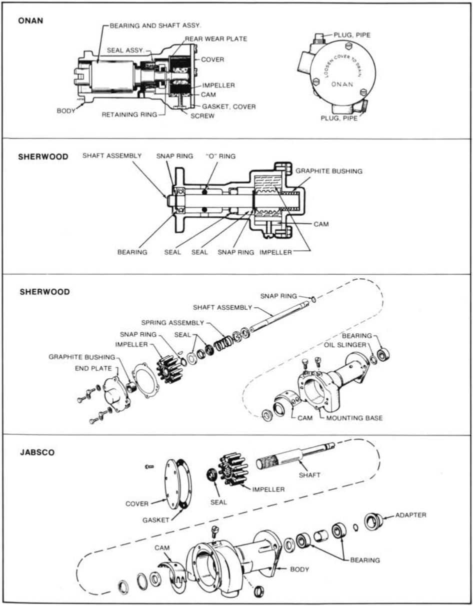


FIGURE 1-13. SEA WATER PUMPS

BATTERIES

Battery size is determined by the amount of power required to start the generating set. Position the battery where operation of the unit won't be impeded and air flow to and from the unit won't be restricted. Keep the battery well charged and the terminals clean and free of corrosion. See Table 1-6 for battery cable size and length. Refer to Table 1-7 for battery size recommendations. For further detailed information on the care and servicing of batteries, see *Miscellaneous Service Bulletin #2.*

POSITIVE CONNECTION

Connect the B+ cable to the start solenoid. When the solenoid is located inside the control box, run the control cable through the grommeted hole in the box clearing any metal parts of the control box or the generator.

CAUTION **Never disconnect the battery with either engine running and never crank both engines simultaneously.**

NEGATIVE CONNECTION

Connect the negative battery cable to the generator through-bolt using a shakeproof washer. Ground the set by connecting a separate cable to clean, bare metal on the frame. Use shakeproof washers between the cable lug and the frame. Use the same size cable for ground as for the negative battery terminal connection.

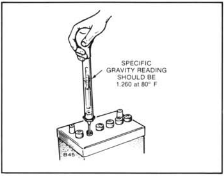


TABLE 1-6. BATTERY CABLE REQUIREMENTS FOR 12 VOLT ELECTRIC GENERATING SETS (MAX. LENGTH OF ONE CABLE)

CABLE SIZE	2	1	0	00	000	0000
MJC MDJC MCCK, MDJA MDJE, MDJF	4 ft.	5 ft.	7 ft.	9 ft.	11 ft.	14 ft.

TABLE 1-7. ONAN MARINE BATTERY RECOMMENDATIONS

GENERATOR SET SERIES	AMBIENT TEMP. RANGE	BATTERY SPECIFICATIONS QTY. REQ'D	VOLTAGE	†BCI GROUP SIZE	CAPACITY *COLD CRANKING AMPS @0° F (-18° C)	#*APPROX. AMP-HR (kC)	ONAN PART NO.
MCCK Spec "H"	Entire Temp. range	1	12	60	360	70(252)	416-0365
MCCK Prior to Spec "H"	Entire Temp. range	2	6	1	450	105(378)	416-0457
MDJA MDJE	32° F (0° C) and warmer	2	6	1	450	105(378)	416-0457
	0° F(-18° C) and warmer	2	6	2H	565	135(486)	416-0363
MDJC MDJF	32° F(0° C) and warmer	2	6	2H	565	135(486)	416-0363
	0° F(-18° C) and warmer	2	6	5D	800	190(684)	416-0437
MJC	32° F (0° C) and warmer	1	12	60	360	70(252)	416-0365
	0° F(-18° C) and warmer	2	6	1	450	105(378)	416-0457

† - BCI is abbreviation for Battery Council International
* - Minimum recommended Battery Capacities and Ratings
\# - Specification for Reference Only (No longer included in the SAE Battery Standard)

SUMMARY

PRACTICE SAFETY

Your last responsibility in the installation procedure of any marine electric generator set is to advise the owner/operator that proper maintenance is one assurance of continued safe and efficient performance of any gasoline or diesel fueled engine. The health and safety of their passengers and themselves depends upon thorough periodic inspections and repair when necessary. All repairs should be made by qualified electrical or mechanical service personnel.

NOTES

SECTION 2
OPERATION

- **Introduction**
- **Fuel and Oil Recommendations**
- **Periodic Service Guide Gasoline Engine Generator Sets**
- **Periodic Service Guide Diesel Engine Generator Sets**
- **Starting Methods**
- **Summary**

The theory of operation of gasoline and diesel engines is basically the same regardless of whether it is a 1, 2 or 4 cylinder engine. Onan uses a water cooled engine on all Marine generator sets. The engines are 4 stroke, internal combustion 4 cycle and naturally aspirated. The same is true for Onan generators whether inherently or voltage regulated. They all have the same basic parts for voltage generation: a magnetic field, conducting wire and movement or rotation. The controls do just exactly what the title says they do, they control. Some of the things they control are operating temperature, oil pressure, battery charging and ignition. All Onan generators are designed to give reliable electrical power if properly maintained to Onan specifications. In this section we hope to give the student a general understanding of the principals of operation for gasoline engines and the significant differences between gasoline and diesel engine operation. The same is true for generators whether inherently regulated or statically excited. No references to any particular models are intended, but a general description as applies to all Onan marine units currently in use in the field today.

FUEL AND OIL RECOMMENDATIONS

LUBRICATING OIL SELECTION

Lubricating oils for spark-ignited and diesel engines are made in a variety of service classifications, each in several viscosities. Selection of an oil for a particular engine, considering its fuel and operating conditions, is based on the classification and SAE viscosity grade.

Oil Classification

The requirements of an oil depend on the kind of engine, the operating conditions, and the fuel. A classification system, jointly developed by the American Petroleum Institute (API), the Society of Automotive Engineers (SAE), and the American Society for Testing and Materials (ASTM) is used to identify the classifications for engine service and operation conditions. The newest classification—SE—has been added to cover oils with very high resistance to oil oxidation (oil thickening) caused by high oil temperatures.

Oil Viscosity

Viscosity is a measurement of resistance to flow. For oil, this resistance is affected by temperature. Multiple grade oils are made to provide starting capability when the oil is cold and also to provide engine protection at higher operating temperatures. Viscosity identification is by the SAE grade number.

Gasoline Engines Only

Use oil with the API (American Petroleum Institute) designation SE or SE/CC. Refer to oil chart Figure 2-1 for recommended viscosity according to temperature.

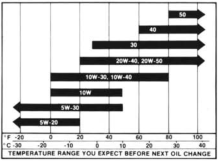
Oil consumption may be higher with a multigrade oil than with a single-grade oil if both oils have comparable viscosities at 210° F (99° C). Single grade oils are generally more desirable unless anticipating a wide range of temperatures.

Diesel Engines Only

Use an oil with the API designation CD/SE. However, to reduce oil consumption to a normal level in the shortest time possible on a new or rebuilt engine, use CC/SE oil for the first fill only (50 hours). Then use the recommended oil only. Select the correct SAE viscosity grade oil by referring to Figure 2-1.

Multigrade oils are recommended for temperatures of 32° F (0° C) and below, but they are not recommended for temperatures above 32° F. On Onan J-series water-cooled diesel engines, SAE 15W-40 or 20W-40 oils may be used in an ambient temperature range of 15° F (-10° C) through 90° F (32° C).

GASOLINE ENGINES ONLY



J-SERIES DIESEL ENGINES ONLY

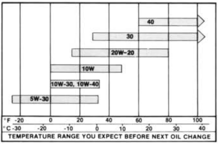


FIGURE 2-1. RECOMMENDED OIL VISCOSITIES

GASOLINE FUEL

Leaded Vs Nonleaded: Onan built engines operating on nonleaded gasoline run better, cleaner, and longer with less maintenance than if using leaded gasoline. We find that using nonleaded gasoline in preference to leaded gasoline helps reduce the following problems:

- Burned Valves
- Sticking Valves
- Spark Plug Fouling
- Piston Wear
- Ring Wear
- Cylinder Wall Wear
- Exhaust System Corrosion

For new Onan engines, most satisfactory results are expected through use of nonleaded gasoline. Use of leaded gasoline in new or old Onan engines will usually cause more wear and require more maintenance. If changing from leaded gasoline to nonleaded, the engine head must be taken off and all lead deposits removed from the engine.

CAUTION If lead deposits are not removed from engine before switching from leaded to nonleaded gasoline, preignition would occur causing severe damage to the engine.

AIR CLEANER AND FLAME ARRESTORS

Properly serviced air cleaners and flame arrestors help ensure long engine life. Air cleaners remove abrasive dirt material from the air before it enters the engine. This increases operating efficiency and fuel economy and reduces engine wear. Restriction of intake air results in over-rich fuel mixture in either gasoline or diesel engines. Refer to individual operators manual for further information on your specific Onan engine. See Figure 2-2.

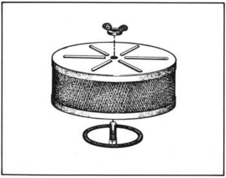


FIGURE 2-2. FLAME ARRESTOR

DIESEL FUELS

The selection of diesel fuel should be made on the basis of overall performance as well as economy. Diesel fuel serves two main purposes.

1. Supplies energy for the work done by the engine.

2. Lubricates all components in the diesel fuel system such as pumps, nozzles, etc.

Recommended Fuel

Use ASTM 2-D or 1-D fuel with a minimum Cetane number of 45 . Number 2 diesel fuel gives the best economy for most operating conditions; however, use ASTM 1-D fuel during the following conditions:

1. When ambient temperatures are below 32°F (0°C);

2. During long periods of light engine load; or no load.

NOTE: Fuels with Cetane numbers higher than 45 may be needed in higher altitudes or when extremely low ambient temperatures are encountered to prevent misfires.

Use low sulfur content fuel having a pour point (ability to filter) of at least 10°F (6°C) below the lowest expected temperature. Keep the fuel clean and protected from adverse weather. Leave some room for expansion when filling the fuel tank.

FUEL FILTERS

Fuel filters are required for protection of the fuel injection system even though good fuel handling practices are followed. It is absolutely necessary to use filters capable of removing micron-size particles from the fuel. Two-stage filtration is supplied with all Onan diesels. See Figure 2-3.

The fuel transfer pump pulls fuel directly from the storage tank. A metal sediment bowl traps water and most sediment particles. If continuing amounts of water and sediment are seen at the supply outlet, however, install a filter and water trap at this point.

Fuel is pumped through two filters before it reaches the injection pump. Average pore size of the second filter is .0005 smaller than the first filter. This means most particles escaping the first filter are trapped in the second filter.

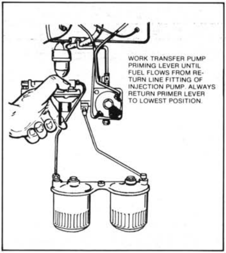


FIGURE 2-3. BLEEDING THE FUEL SYSTEM

PERIODIC SERVICE GUIDE FOR GASOLINE ENGINE GENERATOR SETS

SERVICE THESE ITEMS	AFTER EACH CYCLE OF INDICATED HOURS					
	8	50	100	200	500	1000
Inspect Marine Set	x1					
Check Fuel Supply	x2					
Check Oil Level	x					
Check Cooling System		x3				
Check Flame Arrestor		x6				
Inspect Exhaust System		x				
Check Spark Plug			x4			
Check Governor Linkage			x5			
Change Crankcase Oil			x5			
Check Battery Water Level		x				
Check Brushes				x		
Inspect Breaker Points				x		
Clean Crankcase Breather				x		
Clean Commutator and Collector Rings				x		
Clean Carburetor					x	
Remove Carbon & Lead Deposits					x	
Check Valve Clearance					x	
Clean Generator						x
Remove and Clean Oil Base						x
Grind Valves (If Required)						x
Replace Generator Brushes	As Required					

x1 - With set running, visually and audibly check exhaust system for leaks.

x2 - Check fuel system for leaks or damage.

x3 - Check pump pulley set screws and belts. Replace antifreeze annually in captive system.

x4 - Replace at 250 hours.

x5 - Perform more often in extremely dusty conditions.

x6 - Inspect for physical damage. Wash in suitable solvent.

Use this periodic service guide as a check list for important service requirements of all Onan marine generating sets. Strict observance of the time intervals and procedures in this chart promote long life for the unit and low service cost. Equating hours to miles makes the service intervals more realistic. On an 1800 rpm engine, one hour running time is equal to 40 miles (64 km) driven in an automobile. Keep the unit clean. Cleanliness of the generating set and the compartment directly affects the total operating efficiency of the unit. Blow out the unit and the compartment with clean, dry, compressed air. All time intervals are based on favorable operating conditions. More frequent intervals are necessary under adverse operating conditions. Refer to model operator's manual for detailed information on recommended service intervals.

PERIODIC SERVICE GUIDE FOR DIESEL ENGINE GENERATOR SETS

SERVICE THESE ITEMS	AFTER EACH CYCLE OF INDICATED HOURS					
	8	50	100	200	600	3000
Inspect Marine Set	x1					
Check Fuel	x					
Check Oil Level	x					
Check Cooling System		x3				
Check Flame Arrestor		x5				
Clean Governor Linkage		x4				
Change Crankcase Oil			x4			
Drain Fuel Condensation Traps			x			
Check Battery Electrolyte Level		x				
Replace Oil Filter (If Used)				x		
Empty Fuel Sediment Bowl				x		
Check Slip Rings and Commutator				x		
Check Brushes				x		
Replace Primary Fuel Filter					x	
Check Valve Clearances					x	
Replace Secondary Fuel Filter						x
Clean Generator						x
Inspect Valves, Grind If Necessary						x

x1 - With set running, visually and audibly check exhaust system for leaks.

x2 - Check fuel system for leaks or damage.

x3 - Check pump pulley set screws and belts. Replace antifreeze annually in captive system.

x4 - Perform more often in extremely dusty conditions.

x5 - Inspect for physical damage. Wash in suitable solvent.

The differences between the service items and the time intervals involved between gasoline and diesel engines is due mainly to precise fuel metering, absence of lead deposits and design differences. Examples would be fuel filters and valves in diesel engines which last almost twice as long on the average as similar parts in a gasoline engine. In some cases depending on the part involved, the service time interval for a gasoline engine part might be the same as a diesel part performing a similar function. Examples would be changing of oil, checking batteries or checking generator brushes. Refer to model operator's manual for more detailed information on recommended service intervals.

STARTING METHODS

The electrical starting system for engine-driven generator equipment is the most commonly accepted system. Some advantages of electric starting are: reliability, low cost, easy maintenance, and compatibility with other system controls. The main requirement of a good starting system is that it will crank the engine (gasoline or diesel) fast enough and at high enough voltage for other electrical systems. Most of today's electric starting systems require a battery for cranking power. With the use of built-in trickle charging systems or a separate battery charger; keeping the battery charged and in good condition should be standard procedure.

INITIAL START

Check the engine to make sure it has been filled with oil and fuel. Fill cooling system and prime the water pump. If engine fails to start at first attempt, inhibitor oil used at the factory may have fouled the spark plugs—remove, clean in a suitable solvent, dry thoroughly and reinstall. *Heavy exhaust smoke when the engine is first started is normal,* and is caused by the inhibitor oil.

On diesel engines be sure fuel system is air-free. If not, bleed the air from the fuel system as described in the *Operation* section of your Operator's Manual.

APPLYING LOAD

Allow set to warm up before connecting a heavy load and keep the load within nameplate rating. Continuous generator overloading may cause high operating temperatures that can damage the generator or engine.

Extremes in starting temperatures may require additional preheating. If engine fails to start quickly, rest engine several seconds and repeat starting sequence applying preheat for a longer interval.

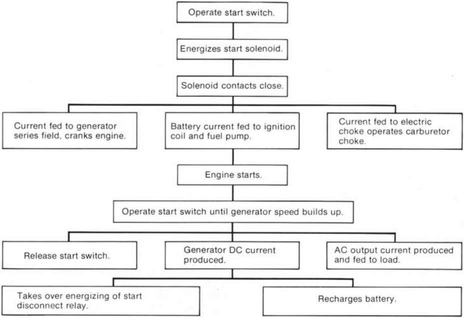
CAUTION **Do not apply overvoltage to the starting circuit at any time. Overvoltage will destroy the glow plugs and air heater in two to three seconds. If it becomes necessary to use an additional source of power to start the unit—use battery of the same voltage connected in parallel.**

IMPORTANT: Never start or run battery charging sets unless the battery is connected. Be sure the set-battery switch is closed and fuses are good.

STARTING SEQUENCE

1. Operator pushes START button, or set is started by remote control.
2. Start solenoid energizes.
3. Battery current flows to
   a) series field for cranking.
   b) STOP relay, completing ignition circuit.
4. Engine cranks.
5. Ignition coil fires spark plugs when breaker points open.
6. Engine starts.
7. Operator releases START button.
8. Start disconnect relay energizes.
9. Engine continues running.

EXCITER CRANKING SEQUENCE OF OPERATION (GASOLINE MCCK ONLY PRIOR SPEC "H")



SUMMARY

When the Marine Electric Generating Set is correctly serviced and maintained, it will provide many hours of safe efficient operation. Service and maintenance includes performing preventive maintenance items at the correct time intervals shown in each operator's manual. All items necessary to prepare the generating set to start, run and test should be checked frequently. Items to be checked are things such as:

- Oil in crankcase
- Extra oil for filter
- Battery connections clean and tight
- Fuel lines tight
- Safe and proper installation
- Engine properly timed
- Rated voltage being produced
- Governor set for correct RPM

Remember, a clean engine looks and runs better than one which is not maintained. This extra care pays off in lower service costs and longer running life, increased performance and fuel economy.

This also enables the skipper to spend more time on the deck, out at sea and less time below deck at the pier.

Happy boating!

Notes

SECTION 3
ENGINE THEORY AND ADJUSTMENT
DIESEL AND GASOLINE

- **Introduction**
- **Basic Differences - Gasoline and Diesel Engines**
- **Onan Diesel Starting Guide**
- **Diesel Fuel Systems**
- **Adjustments (Diesel Powered Units)**
- **Troubleshooting Guide for Diesel Engines**
- **Adjustments (Gasoline Powered Units)**
- **Troubleshooting Guide for Gasoline Engines**
- **Summary**

The principles of operation of a gasoline or diesel engine are basically the same except for the fuel system components and the ignition system. Valves are sometimes referred to as the heart of an engine and the combustion process is called the brain of the engine. In between, the ignition system might be referred to as the pulse of the engine. All three systems must work together for the engine to do any work. If a gasoline and diesel engine of equal size were placed side by side, many parts would bear striking similarities. The key difference between the two types of engines is what happens inside during operation. Improvements in design, strength, light metals, economy and thermal efficiency are all factors which contributed to the growing popularity of diesel engines in the last few years. Pollution control and economy are major areas of improvement in gasoline engines. Some of the basic differences between gasoline and diesel engines are in the following systems:

- FUEL SYSTEM
- COMPRESSION RATIO
- IGNITION SYSTEM
- TIMING
- OPERATION
- EFFICIENCY

In this section the student should gain an understanding as to the significant differences between a gasoline and diesel engine and also the how, when and why certain adjustments are made and what adjustments to make on both types of engines.

BASIC DIFFERENCES BETWEEN GASOLINE AND DIESEL ENGINES

In the following comparison chart we will illustrate some of the major differences between gasoline and diesel engine operation. The chart will also serve to indicate why gas or diesel operation might be better suited to a specific type of usage. The key differences are as follows:

COMPONENT	GASOLINE	DIESEL
Fuel System	A. Consists of Fuel Pump Filter and Carburetor. Fuel and Air Mixture to Intake Manifold. B. Fuel and Air Mixed Before entering Combustion Chamber. Air Fuel Ratio 15-1.	A. Consist of Transfer Pump, Filters, Injection Pump and Nozzle. Air Only to Intake Manifold. B. Only Air Enters Combustion Chamber; Fuel is injected at specific time. Air Fuel Ratio is 18-1 at full load and 100-1 at no load.
Type of Fuel	Gasoline - Flammable Storage Problems - Higher Cost	Diesel Fuel - Not as Flammable - Usually less expensive
Compression Ratio	7 to 1	18 to 1
Ignition System	Battery or Magneto Spark Plugs, Relays, Wires, Condenser, Points.	Compression Ignition at 1000° or more when running. During cranking, compression ignition starts the Onan built units.
Timing	*A. 19° BTC on models 1800 rpm or slower *B. 25° BTC on models 3600 rpm or faster * - MAJ & MCCK Models	(Port Closing) 17° BTC MDJA 21° BTC MDJB Before Spec P 19° Later Models After Spec P 21° BTC MDJC Before Spec P 19° Later Models After Spec P 18° BTC MDJE 19° BTC MDJF
Efficiency	Some wasted or unburned fuel - Less BTU's per gallon.	Good thermal efficiency. More BTU's per gallon converted to useful energy and power.
Operation	Faster Starting, Higher Operating Cost - Shorter Life Span.	A. Slower starting, need glow plugs for preheat, also air heaters. B. Nominal Outside Air Temperature - Very Important. C. Dirt and Air must be kept out of fuel system. D. Longer Life Span.

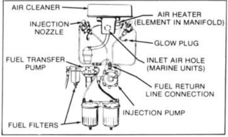
ONAN DIESEL STARTING GUIDE

IMPORTANT!

KEEP ENTIRE FUEL SYSTEM CLEAN AND FREE FROM WATER
- DIESEL INJECTION PUMPS WILL FAIL IF SYSTEM CLEANLINESS IS NEGLECTED

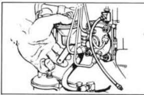
INJECTION PUMPS AND NOZZLES ARE NOT FIELD REPAIRABLE
- WHEN TROUBLESHOOTING, CHECK ALL OTHER COMPONENTS FIRST

WARNING DO NOT USE ETHER STARTING AIDS! ETHER IS EXTREMELY EXPLOSIVE AND MAY CAUSE SERIOUS PERSONAL INJURY. ENGINE DAMAGE IS ALSO LIKELY.



BEFORE STARTING:

CHECK FUEL SUPPLY. BE SURE SHUTOFF VALVES ARE OPEN.



PRIME FUEL SYSTEM IF: FUEL FILTERS WERE DRAINED OR CHANGED, SYSTEM WAS JUST INSTALLED, FUEL TANK RAN DRY.

TO PRIME PUMP, MOVE PRIMING LEVER UP AND DOWN UNTIL FUEL FLOWS STEADILY FROM RETURN LINE (DISCONNECTED).

PREHEAT

PREHEAT COLD ENGINE: PUSH PREHEAT SWITCH AND HOLD —
- 30 SECONDS IF ABOVE 55°F (13°C);
- 60 SECONDS IF BELOW 55°F (13°C).

TO START:

PREHEAT — RELEASE PREHEAT

START / STOP — ENGAGE START SWITCH

LIMIT CRANKING TO 15 TO 20 SECONDS TO CONSERVE BATTERY. ALLOW 1 MINUTE BEFORE RE-CRANKING.

IF ENGINE DOES NOT START:

IF ENGINE FIRED, REPEAT ABOVE PROCEDURES, INCLUDING PRE-HEAT. IF IT STILL DOES NOT START, PROCEED AS FOLLOWS:

TEMPERATURES BELOW 32°F (0°C): USE NUMBER 1 DIESEL FUEL. USE CORRECT VISCOSITY OIL. KEEP BATTERIES FULLY CHARGED. DO NOT USE ETHER STARTING AID.

OBSERVE ENGINE EXHAUST "SIGNALS":

BLUE-WHITE EXHAUST SMOKE: ENGINE IS GETTING FUEL

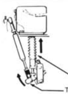
1. OBSERVE AIR HEATER THRU AIR INLET HOLE OR BY REMOVING AIR CLEANER.
2. ENGAGE PREHEAT.
3. IF HEATER ELEMENT DOES NOT GLOW RED WITHIN 30 SECONDS, CHECK AIR HEATER AND GLOW PLUG WIRING:
   - CONNECTIONS TIGHT?
   - FREE FROM CORROSION?

LITTLE OR NO EXHAUST SMOKE: ENGINE IS NOT GETTING FUEL.
- PRIME FUEL SYSTEM AS SHOWN ABOVE:

OBSERVE FUEL FLOW FROM RETURN LINE

FUEL FLOWS STEADILY

CHECK FUEL SOLENOID:
SOLENOID ROD SHOULD PULL IN AND THROTTLE ARM FOLLOW (AS SHOWN) WHEN START SWITCH IS TURNED ON. IF NOT, CHECK FOR
- BINDING LINKAGE
- LOOSE OR BROKEN WIRES



LITTLE OR NO FUEL FLOW

CHECK FUEL SUPPLY SYSTEM:
- FUEL TANK EMPTY?
- SHUTOFF VALVES CLOSED?
- FUEL LINES KINKED?
- LOOSE CONNECTIONS?
- CLOGGED FUEL FILTERS?

IF ENGINE IS STILL NOT GETTING FUEL, CHECK TRANSFER PUMP:
1. CRANK ENGINE AND OBSERVE FUEL FLOW FROM RETURN LINE.
2. IF FUEL DOES NOT SPURT OUT, PUMP MAY BE DEFECTIVE.

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IF ENGINE STILL DOES NOT START, CONTACT AUTHORIZED ONAN SERVICE REPRESENTATIVE

DIESEL FUEL SYSTEMS

FUEL SYSTEM

The fuel system (Figure 3-1) consists of a metal sediment bowl, fuel transfer pump, primary filter, secondary filter, injection pump, injectors, and the connecting fuel lines.

The fuel system, located on the service side of the engine, uses a transfer pump to deliver fuel from the tank to a high pressure injection pump at about 12 to 14 psi (83-97 kPa) (5-6 psi on DJA [35-41 kPa]). The injection lines deliver fuel to the injectors at high pressure and act as fuel distributors to the injectors. The time interval between individual injectors is varied in the pump by engine speed. From the injection pump, metered fuel is forced through a delivery valve to the injector lines at about 1900 psi (13,110 kPa). When the cylinder air reaches about 1000°F (538°C) on the compression stroke, the injector sprays fuel into the hot compressed air where it ignites. The delivery valve in the injection pump and a pintle valve in the injector assists the precision timed injection of fuel into the cylinder.

FILTER SYSTEM

The sediment bowl has a fine mesh screen which blocks dirt and water entry into the transfer pump, Figure 3-2. The dirt and water remain in the sediment bowl which should be removed for cleaning as required. The primary and secondary fuel filters are replaceable spin-on units that clean the fuel of extremely fine particles before it goes to the injection pump.

These filters are mounted on a common casting which bolts to the oil fill tube. Positive filtration is assured because the engine won't run when either filter is loose or missing.

Average pore size of the second filter is .0005 (0.0127 mm) smaller than the first filter. This means most particles escaping the first filter are trapped in the second filter.

CAUTION **A diesel engine cannot tolerate dirt in the fuel system. It is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any part of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly, and install while still wet.**

FUEL TRANSFER PUMP

The fuel transfer pump (Figure 3-3) is a diaphragm and check valve type pump operated by a cam lobe on the engine camshaft. The pump cam follower has a wide surface to prevent wear as it rides on the camshaft lobe. The priming lever is manually operated to prime and bleed the system.

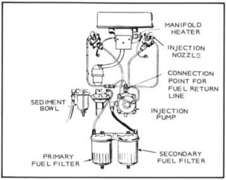


FIGURE 3-1. FUEL SYSTEM—LATEST MODELS

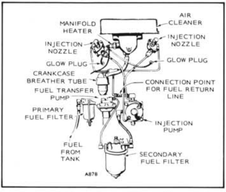


FIGURE 3-2. FUEL SYSTEM—OLDER MODELS

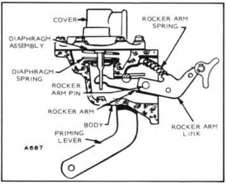


FIGURE 3-3. FUEL TRANSFER PUMP

The diaphrgam spring maintains required fuel pressure to the injection pump. Fuel pressure should be as follows when operating at 1800 rpm:

MDJA.................................. 5 to 6 psi (34.5 to 41.4 kPa)
MDJC, MDJE, MDJF.................. 12 to 14 psi (83 to 97 kPa)

Fuel pump pressure may be checked by connecting a pressure gauge and tee at the fuel outlet. A vacuum gauge connected at the fuel inlet will show whether the pump has enough capacity to lift fuel about 6 feet (1.86 m). The fuel pump should produce 15 to 18 inches (25.4 to 43.4 mm) of vacuum at sea level.

INJECTION NOZZLES

Onan J series diesel engines use hydraulically-operated, non-throttling, pintle-type injection nozzles, Figure 3-4. They are factory adjusted to open at 1900 to 1950 psi (13,110 to 13,455 kPa). However, after several hundred hours of operation the nozzle pressure will decrease to about 1750 psi (12,075 kPa).

Refer to the throttling pintle type nozzle information at the end of this section for information regarding MDJE engines using Bryce/Kiki fuel systems.

Operating Principle

Nozzle operation is as follows:

1. High pressure fuel from the injection pump enters the fuel inlet stud and flows down drilled passages in the body of nozzle holder, Figure 3-5.
2. Fuel enters fuel duct and pressure chamber of nozzle assembly. When fuel pressure overcomes preset pressure of the adjusting spring, the pintle is forced upward off its seat and a fine mist of fuel is injected into the pre-combustion chamber where it atomizes and mixes with the hot compressed air.
3. If compression temperatures are high enough, the fuel-air mixture ignites. Injection continues until the spill port clears the top of the metering sleeve in the injection pump and dumps the high pressure fuel into the sump allowing the pressure spring to close the injector and cut off fuel injection to the cylinder.

CAUTION **Do not disturb the injector pressure adjusting screw; it cannot be reset without proper equipment.**

Excess fuel is returned to the tank after each injection cycle by a return line from the nozzle. A fuel return fitting combines the return fuel from the injectors with the flow-through fuel from the injection pump bleed valve. A return line connected at this point returns the combined fuel back to the fuel supply tank.

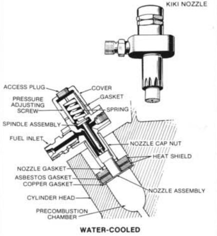
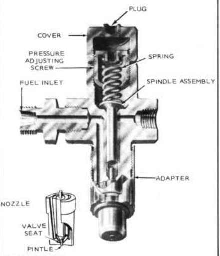


FIGURE 3-4. NOZZLE ASSEMBLY



CAUTION **Do not attempt to disassemble the nozzles or adjust nozzle pressure without the proper test equipment. A nozzle pressure tester is essential to do a satisfactory job.**

FIGURE 3-5. INJECTOR NOZZLE HOLDER

Nozzle Spray Pattern

If one cylinder is misfiring, its nozzle may be operating improperly. Faulty nozzles can be checked by loosening the high pressure line from the injection pump to each nozzle (one at a time).

A suspected nozzle can be checked in the field by removing it from the engine and reconnecting it to the high pressure line. The spray pattern (Figure 3-6) can be observed as the engine is cranked.

WARNING Keep hands away from a spraying nozzle! The nozzle discharge pressure can penetrate the skin and may cause blood poisoning or a serious skin infection.

A second method for determining a misfiring nozzle is to remove the exhaust manifold and run the engine under load. One can readily see by the exhaust which cylinder is not operating properly.

Injection Nozzle Tester

Testing and adjustment can be performed only with a nozzle tester, Figure 3-7. Do not attempt to disassemble the nozzles or adjust nozzle pressure without the proper test equipment.

The cleaning procedure (Figure 3-8) is extremely important when disassembling injection equipment. Always rinse in clean fuel before reassembling.

Opening pressure, leakage and spray pattern can be checked using the tester. If any of the above malfunctions appear (except opening pressure), the nozzle valve and seat can be inspected with a magnifying glass for erosion, scoring, etc. If cleaning with solvent does not correct the malfunctions, a new nozzle tip will be required. The opening pressure can then be set and spray pattern checked.

CAUTION Never use hard or sharp tools, emery paper, grinding powder or abrasives of any kind or the nozzles may be damaged beyond use.

Soak each nozzle in fuel to loosen dirt. Then clean the inside with a small strip of wood soaked in oil and the spray hole with a wood splinter. If necessary, clean the outer surfaces of the nozzle body with a brass brush but do not attempt to scrape carbon from the nozzle surfaces. This can severely damage the spray hole. Use a soft oil-soaked rag or mutton tallow and felt to clean the nozzle valve.

Nozzle cleaning kits are available from Onan Tool Catalog 900-0019.

NOZZLE REPAIR

If cleaning will not eliminate a nozzle defect, replace the nozzle or take it to an authorized American Bosch service station. Do not attempt to replace parts of the nozzle except for nozzle and pintle assembly.

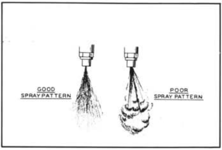


FIGURE 3-6. NOZZLE SPRAY PATTERN

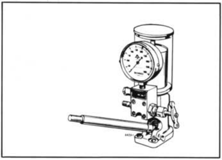
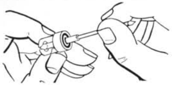


FIGURE 3-7. INJECTION NOZZLE TESTER

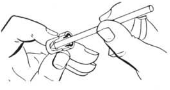
Assembly

Rinse both valve and nozzle thoroughly before assembly and coat with diesel fuel. The valve must be free in the nozzle. Lift it about 1/3 out of the body. It should slide back to its seat without aid when the assembly is held at a 45-degree angle. If necessary, work the valve into its body with clean mutton tallow.

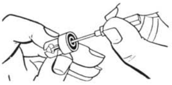
1. Clamp nozzle holder body in a vise.
2. Set valve in body and set nozzle over it.
3. Install nozzle cap nut loosely.
4. Place centering sleeve over nozzle for initial tightening. Then remove centering sleeve to prevent it from binding between nozzle and cap nut.
5. Adjust to specified torque.



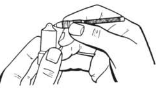
1. Use a brass type scraper tool to remove hard carbon deposits from nozzle body valve seat.



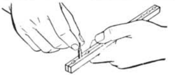
2. After scraping the carbon, polish the valve seat by using a round pointed stick dipped in tallow. Polishing should restore seat to its original finish unless it's scored.



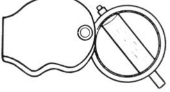
3. Use a special hooked type scraper to clean the nozzle pressure chamber gallery. The hooked end of scraper is inserted into the gallery and then carefully rotated.



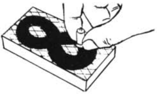
4. Small holes in tip of nozzle body can be cleaned with a fine wire slightly smaller than the size of the hole.



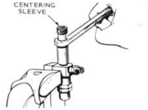
5. Clean nozzle valve and polish with tallow and a wooden polishing fixture. Take care to remove all traces of tallow when finished.



6. Examine nozzle valve and body with a magnifying glass. If erosion and scoring conditions are found, renew the valve and body.



7. Use a lapping plate and compound for flat lapping of nozzle parts which depend on a lapped surface for sealing. A figure "8" motion is used.



8. It is essential that the nozzle body is perfectly centered in the cap nut when reassembling nozzle. A centering sleeve, as shown, is used for this purpose.

FIGURE 3-8. NOZZLE CLEANING

NOZZLE INSTALLATION

Before installing the injection nozzles in the engine, thoroughly clean each mounting recess.

A dirty mounting surface could permit blow-by, causing nozzle failure and a resulting power loss.

1. Install a new heat shield to head gasket in cylinder head recess.
2. Install heat shield, a new nozzle gasket and nozzle adapter.
3. Insert nozzle assembly into recess. Do not strike tip against any hard surface.
4. Install nozzle flange and two cap screws. Tighten cap screws alternately to avoid cocking nozzle assembly. Tighten each to 20-21 foot-pounds (27-28 N•m).

FUEL SOLENOID

The fuel shutoff solenoid (Figure 3-9) is also referred to as a governor solenoid as it over-rides the governor during shutdown. The solenoid is mounted on the cylinder air housing bottom pan and controls the injection pump operating lever. When energized, the plunger pulls into the solenoid body. When de-energized, the solenoid spring forces the plunger out against the operating lever to hold it in the fuel shutoff position.

The solenoid has two coils. Both are energized for pulling the plunger up. When the plunger reaches the top, it opens a set of contacts, de-energizing the pull-in coil. The other coil holds the plunger up while the engine is running and de-energizes when the engine shuts down.

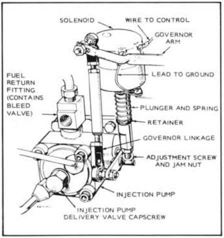


FIGURE 3-9. FUEL SHUTOFF SOLENOID

PREHEATING CIRCUIT

This 12 volt battery circuit consists partly of manifold heaters that heat the combustion air at the intake manifold and a glow plug in each cylinder that heats the precombustion chamber for engine starting, Figure 3-10. The manifold heater and glow plugs are wired in parallel and are controlled by a preheat switch on the control box.

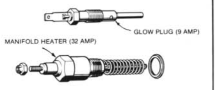


FIGURE 3-10. GLOW PLUG AND MANIFOLD HEATER

FUEL INJECTION PUMPS

Onan DJ series diesels are equipped with American Bosch fuel injection pumps. Single cylinder engines use the model PLB; the four cylinder engines use the model PSU pump. Until recently, the two cylinder diesel engines have been using a PSU pump. Now, the MDJE engines use either a Bryce or a Kiki fuel injection pump. For Bryce/Kiki pump information, turn to the back of this section. The fuel injection pumps are constant stroke, lapped plunger type and operated by the engine camshaft. They deliver an accurately measured quantity of fuel under high pressure to the injection nozzles.

A constant bleed-check valve is furnished with all PLB and PSU pumps. The bleed valve automatically bleeds off a restricted amount of fuel, fuel vapors, and small quantities of air to prevent air accumulation in the fuel sump area of the pumps. This valve should open at pressures between 0.9 and 3.0 psi (6.2 and 20.7 kPa).

CAUTION **Replace injection pumps that troubleshooting procedures prove to be malfunctioning with new pumps. Do not attempt unauthorized repair procedures on the injection pumps.**

Fuel injection pumps must pass stringent quality inspections and tests with precise settings and adjustments in order to meet Onan's performance and reliability requirements. Therefore, it must be clearly understood by the owners and by Onan servicemen that tampering or inept repair attempts can cause irrepairable damage to the pumps that will not be covered by the manufacturers warranties or exchange agreements. Contact an authorized American Bosch Service station or Distributor for expert repair service on the injection pumps.

The repair service should include cleaning, part replacement, static pressure tests for internal and external leaks, internal pump timing, and calibration and adjustment to the manufacturer's specifications.

PLB Injection Pump

The PLB injection pump (Figure 3-11) is used on the DJA Series engines. The cross-sectional view shows the internal parts and the operating lever and control shaft.

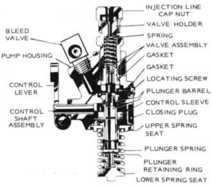


FIGURE 3-11. PLB INJECTION PUMP COMPONENTS

The pump consists of a housing, pump plunger and barrel, the plunger return spring with its seats, and the control sleeve and its operating shaft. The housing contains the fuel sump, delivery valve assembly, delivery valve holder, and the union nut for connection of the high pressure discharge tubing.

Operating Cycle

During operation, when the piston nears the end of each compression stroke, the plunger moves upward, closes its internal ports, and traps fuel that forces the delivery valve off its seat. Fuel flow is up through the delivery valve and spring to the high pressure line leading to the injector nozzle.

The plunger continues injection until the helix on the plunger (Figure 3-12) passes through the sleeve and spills fuel, dropping the pressure rapidly. Delivery valve action aids in dropping line pressure and keeps fuel from draining out of the line.

The amount of fuel delivered is controlled by the sleeve which rotates the plunger, thus changing the length of its effective pumping stroke. The distance the plunger travels is always the same because the cam lift never varies.

Injection timing on the one cylinder DJA Series engine with the PLB injection pump is at 17 degrees BTC.

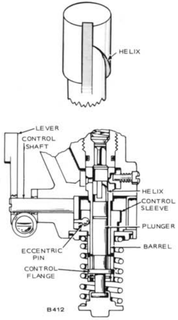


FIGURE 3-12. PLB PUMP

PLB PUMP OPERATION

The pumping action involves both the pumping and the metering principles, Figure 3-13.

Pumping Principle

A. Fuel enters the pump from the supply system through the inlet connection and fills the fuel sump which surrounds the barrel. With the plunger at the bottom of its stroke, fuel flows through ports in the barrel filling the space above the plunger, the vertical slot in the plunger and the cut-away area below the plunger helix.

B. As the plunger moves upward, the barrel ports are closed by the plunger.

C. As the plunger moves further upward, the fuel is discharged through the delivery valve into the high pressure line.

D. Delivery of fuel ceases when the plunger helix passes and opens the barrel spill port and the delivery valve returns to its seat. During the remainder of the stroke, fuel is spilled back into the sump. This termination of fuel delivery controls the quantity of fuel delivered per stroke.

Metering Principle

Fuel metering includes long strokes for maximum delivery, shorter strokes for normal delivery, and non-effective pumping strokes with no delivery for engine shutdown.

The amount of fuel delivered is controlled by rotating the plunger, thus changing the length of its effective pumping stroke.

E. For maximum delivery, the effective part of the stroke is relatively long before the spill port opens.

F. For normal delivery, the effective part of the stroke is shorter before the spill port opens.

G. This view shows the plunger rotated to the OFF position so that the vertical slot on the plunger and the spill port are in line for no delivery even though the pump may continue to stroke, such as during a cranking condition with the fuel control lever at OFF.

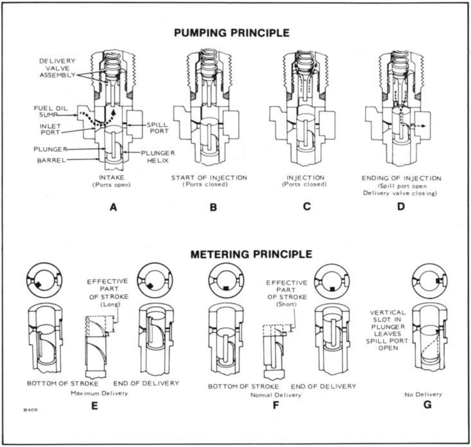


FIGURE 3-13. PLB INJECTION PUMP OPERATION (ALSO BRYCE AND KIKI)

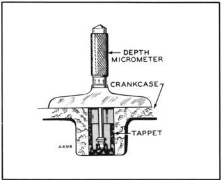


FIGURE 3-14. DEPTH MICROMETER MEASUREMENT

TIMING THE PLB PUMP (DJA)

Pump timing procedures determine the correct thickness of shims between pump and engine so port closing occurs at 17° BTC.

The most accurate method of injection pump timing is with a depth micrometer (Method 1). However, if a depth micrometer isn't available, time it by *Flowing the Pump* (Method 2).

Injection pump must be timed on the compression stroke, not the exhaust stroke.

METHOD 1. DEPTH MICROMETER METHOD

1. Install pump tappet in its recess and position flywheel on port closing mark (PC) of compression stroke.
2. Using a depth micrometer, measure distance from pump mounting pad on crankcase to tappet center. See Figure 3-14.
3. Subtract from the port closing dimension of pump (1.670-inch) the depth obtained in step 2. The result is the thickness of shims necessary to correctly time the pump.

Thickness of shims may vary from 0.006-inch to 0.052-inch. If it does not fall within these limits, check camshaft and tappet for excess wear or improper assembly.

4. Select correct shims for required thickness.
5. Install pump.

METHOD 2. FLOWING THE PUMP

1. Install pump with 0.006-inch (0.152 mm) shims between pump and pad.
2. Loosen delivery valve cap nut and holder to relieve pressure on spring. See Figure 3-15.

TABLE 3-1. SHIM SELECTION

DISTANCE MEASURED STEP 4		ADD THESE SHIMS	
Inch	mm	Inch	mm
0.1	2.54	0.010	0.254
0.2	5.08	0.014	0.355
0.3	7.62	0.018	0.457
0.4	10.16	0.022	0.559
0.5	12.70	0.026	0.660
0.6	15.24	0.030	0.762
0.7	17.78	0.034	0.864
0.8	20.32	0.038	0.965
0.9	22.86	0.042	1.069
1.0	25.40	0.046	1.168
1.1	27.94	0.050	1.270

The PLB injection pump arm must be held on center or to the right of center in order for the fuel to flow through the pump plunger ports to the delivery valve when the transfer pump is operated by hand.

3. Rotate flywheel to about 15 degrees before port closing (PC) point. Operate transfer pump to pump fuel into pump inlet and rotate flywheel slowly clockwise until fuel stops coming out of pump outlet. This is the port closing point.
4. Measure distance from point where port closing occurs to PC mark on flywheel. Find thickness of shims to be added from Table 3-1.
5. Install pump.

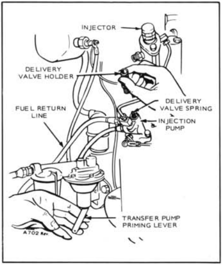


FIGURE 3-15. LOOSENING DELIVERY VALVE HOLDER

INSTALLATION

Prior to mounting the injection pump to the cylinder block, follow steps 1 through 3.

1. Slide shim or shims (using proper thickness of shims for correct timing) over pilot until they are flat on pump flange. See Figure 3-16.

The shim thickness required for each engine block is established at the factory and is stamped on the block near the injection pump mounting. This measurement applies to a replacement pump as well as the original pump.

2. Dip seal ("O" ring) in engine lubricating oil.
3. Slide seal over pilot until tight against shim or shims.
4. With shims and seal in place, insert pump into cylinder block mounting pad, and insert mounting screws.
5. Torque mounting screws (tighten alternately) to 18-21 foot-pounds (24-29 N•m).
6. Install the fuel inlet line and governor linkage.
7. Bleed the pump and then install the fuel outlet line.

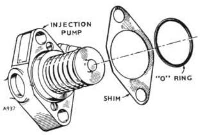


FIGURE 3-16. SHIMMING THE PILOT

PSU INJECTION PUMP

The PSU injection pump (Figure 3-17) is used on Onan 2- and 4-cylinder air-cooled and water-cooled diesels. Pumps that are almost identical with only two injector line outlet ports are used on the two cylinder models. The function of the pump as a distributor and its location on the service side of the engine are the same on both 2- and 4-cylinder engines.

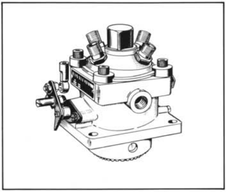


FIGURE 3-17. PSU INJECTION PUMP

PSU Pump Operation

The pump face gear mates with and is rotated by a drive gear on the engine camshaft, Figure 3-18. The face gear, pilot ring, and the reciprocating plunger in the pump are rotated continually to assure positive fuel distribution. The plunger is reciprocated up and down by a multi-lobed cam on the camshaft which bears against a tappet assembly on the pump.

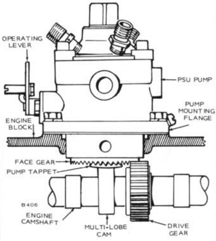


FIGURE 3-18. INJECTION PUMP TO CAMSHAFT RELATIONSHIP

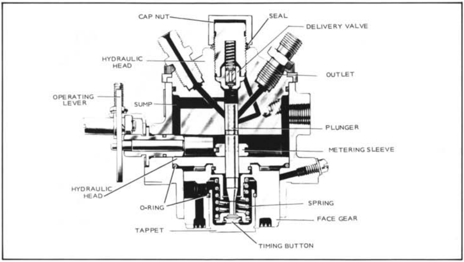


FIGURE 3-19. PSU PUMP (CUTAWAY VIEW)

Pump Cutaway View

The cutaway view in Figure 3-19 shows the control unit operating lever, metering sleeve, delivery valve, plunger and drilled passages to the plunger and injection lines.

A timing button of very precise thickness transmits motion from the tappet to the plunger and adjusts plunger timing for the fuel pumped to each injector during operation. Plunger reciprocation and rotation are so phased that only one fuel injector is served during the affective portion of each plunger up stroke. The high hydraulic pressure developed is required to open the pressure operated fuel injector nozzles which inject the fuel in a fine mist into the combustion chamber. Fuel delivery control, full load, and shutoff are regulated by the up-and-down movement of the fuel metering sleeve. The sleeve is controlled by the operating lever on the outside of the pump. Fuel is injected only during the high velocity portion of each plunger up stroke.

When the tappet slips off each lobe of the camshaft, the spring loaded plunger is forced down opening the fuel supply port to the fuel sump. This allows fuel under low pressure from the transfer pump and fuel sump to fill the cavity between the top end of the plunger and the delivery valve. The plunger is then ready for the up stroke.

Metering Sleeve Operation

The metering sleeve is positioned by the operating lever of the governor control unit, Figure 3-20. An eccentric pin on the end of the control shaft engages a slot in the metering sleeve so that a slight rotation of the control shaft causes the sleeve to ride up or down on the plunger. As the camshaft and face gear rotate, the drive key and a vertical slot in the face gear transmit rotation to the plunger. Rotating the plunger aligns the plunger outlet groove with the proper injection line outlet for the injector to be fired on each pump stroke.

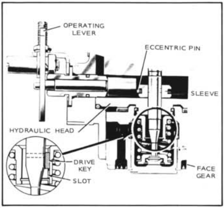


FIGURE 3-20. METERING CONTROL

Plunger and Sleeve Movement

As the plunger is cammed upward, the fuel fill port (A) is closed cutting off the fuel supply to the open center of the plunger, Figure 3-21. This is the critical port closing (PC) point of the injection pump that corresponds with the PC mark on the rim of the flywheel. As the metering sleeve moves upward on the plunger, it closes off the spill port (B). Now, as the plunger moves upward, the fuel trapped above its top end builds up pressure and lifts the delivery valve off its seat and the high pressure fuel is ported via the distributor-groove on the plunger upper end to one injector line. As the plunger reaches the upper end of its movement, the spill port (C) clears the sleeve allowing the high pressure fuel to spill into the sump.

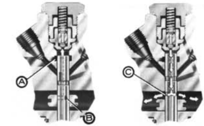


FIGURE 3-21. PORT CLOSING

Sleeve Control

The metering sleeve controls the volume of fuel delivered to the injectors on each stroke of the plunger.

No Delivery: With the metering sleeve in the full downward position, the spill port is open so no fuel is trapped above the plunger. Therefore, no fuel delivery results. As the governor actuates the control shaft to move the metering sleeve upward on the plunger, fuel is trapped above the plunger as the port closes. Fuel delivery corresponds with the load placed on the engine. See Figure 3-22.

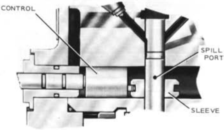


FIGURE 3-22. NO DELIVERY

Normal Delivery: For normal delivery (Figure 3-23) the sleeve moves only part way up before the spill port opens to dump the high pressure.

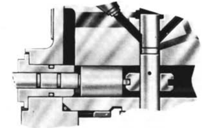


FIGURE 3-23. NORMAL DELIVERY

Maximum Delivery: For maximum delivery (Figure 3-24), the control shaft must position the sleeve fully upward. This increases the fuel delivery time and volume because the spill port doesn't clear the sleeve until a higher portion of the pumping stroke is reached. All engine speed and power control is determined by the governor acting through the control shaft and metering sleeve.

The plunger always makes the same stroke, but varying the position of the metering sleeve regulates the spill port opening, and thus the volume output from the plunger to the delivery valve and injectors.

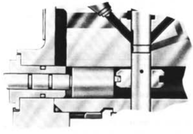


FIGURE 3-24. MAXIMUM DELIVERY

Delivery Valve Operation

The delivery valve assembly regulates flow of controlled amounts of fuel to each injector outlet, Figure 3-25. The valve automatically closes at the end of each plunger stroke due to spring action when the pressure drops at the plunger port.

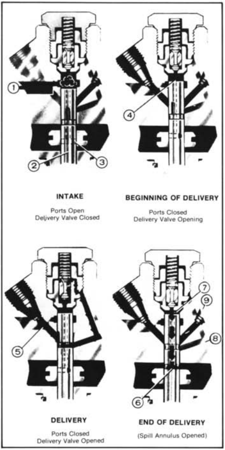


FIGURE 3-25. DELIVERY VALVE OPERATION

Delivery Valve Operating Principles

1. Fuel enters port (1) with rising plunger (2).
2. Notice, spill port (3) is closed.
3. As plunger continues to rise, fill port closes and fuel is trapped above plunger (4).
4. Additional plunger movement opens delivery valve and forces fuel through delivery valve (arrows 5) to outlet for cylinder No. 1.
5. Fuel under high pressure continues to flow with upward movement of plunger until spill port (6) opens. This results in a pressure drop and delivery valve closes (7). Now, residual pressure is trapped in line (8).

Since the plunger is constantly rotating counterclockwise, the above action repeats for cylinder (9) No. 2 when the plunger rotates 180 degrees on next stroke. Injection occurs every 90 degrees of plunger rotation counterclockwise on four cylinder engines.

The relief piston portion of the delivery valve reduces line pressure and automatically provides a sharp cutoff of fuel at the end of each plunger stroke. This prevents secondary injections and nozzle dribble, reduces engine smoke, and prevents nozzle carbonizing.

PUMP COMPONENTS

Figure 3-26 shows the following pump components:

- The plunger tappet assembly.
- The control shaft assembly.
- The pump body.
- The delivery valve assembly.
- The governor stop .

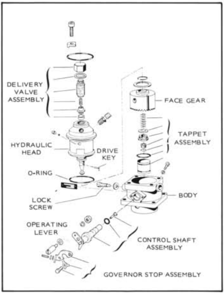


FIGURE 3-26. PSU PUMP (EXPLODED VIEW)

Pump Installation Shims

If the pump is removed from the engine, be sure the steel shims between the pump and the crankcase mounting are the same on reassembly to maintain proper gear backlash, Figure 3-27. The number stamped on the crankcase indicates the proper shim thickness. This thickness does not change when a new pump is installed. It only changes when a new crankcase is installed, and then the thickness of the proper shims is stamped on the new crankcase.

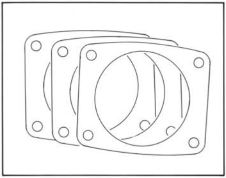


FIGURE 3-27. SHIM THICKNESS

Removing Tappet

CAUTION **Be sure to hold the pump drive securely to the pump body when removing the tappet, Figure 3-28. If not, the pump will come apart and be difficult to reassemble. Also, the metering sleeve may drop off the plunger into the sump when the plunger is removed. If the mechanic is not aware of it, he could put the pump back together, but it will not operate. If the plunger port is not enclosed by the sleeve, there will be no fuel delivery.**

Use a pair of channel lock pliers or a screwdriver to remove the tappet from the O-ring in the drive gear.

Button 12 or M is the mid-range of the button sizes used the most. The button dimension is determined by the number or letter stamped on its side, Figure 3-29.

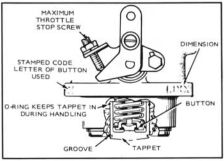


FIGURE 3-28. TAPPET REMOVAL

TABLE 3-2. TIMING BUTTONS

GROUP 1				GROUP 2				GROUP 3			
CODE	PART NO.	SIZE		CODE	PART NO.	SIZE		CODE	PART NO.	SIZE	
		Inch	mm			Inch	mm			Inch	mm
16 or S	147-0186	.134	3.404	1 or A	147-0147	.119	3.023	6 or F	147-0152	.101	2.565
15 or R	147-0187	.131	3.357	2 or B	147-0148	.116	2.946	7 or H	147-0153	.098	2.489
14 or P	147-0188	.128	3.251	3 or C	147-0149	.113	2.870	8 or I	147-0154	.095	2.413
13 or N	147-0189	.125	3.175	4 or D	147-0150	.110	2.794	9 or K	147-0155	.092	2.337
12 or M	147-0190	.122	3.099	5 or E	147-0151	.107	2.718	10 or L	147-0156	.089	2.261
				11 or Std	147-0161	.104	2.642				

Group 1. Used in all late model pumps except 147-0220 (odd firing) beginning Spec R.
Group 2. Used in early models of all pumps.
Group 3. Used in late model 147-0220 (odd firing) pumps.

Pump Kits prior to Spec R—
2 Cyl 147-0218
4 Cyl 147-0231

Pump Kits beginning Spec R—
2 Cyl 147-0219
4 Cyl 147-0232

TIMING BUTTON CODE

The timing button has a code number or letter which corresponds with its dimension in thousands of an inch. See Table 3-2. Figure 3-30 shows the timing button and tappet relationship. Only one button is required to provide the correct port closing.

FIGURE 3-29. TAPPET BUTTON CODE

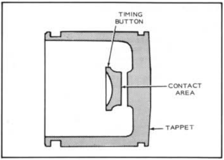


FIGURE 3-30. TIMING BUTTON AND TAPPET

PORT CLOSING FORMULA

The formula for determining the proper port closing (PC) timing button for a new or replacement pump is as follows:

1. Remove old pump.
2. Determine total pump flange and button thickness for old pump.
   a. Write down dimension given on old pump flange. See Example, Figure 3-31.

Formula	Inches	(mm)
Port closing dimension of old pump	1.109	(28.169)
Button thickness of old pump	+.107	(2.719)
Total	1.216	(30.887)
Port closing dimensions of new pump	-1.094	(27.788)
Required button thickness of new pump	.122	(3.099)

FIGURE 3-31. TIMING BUTTON CALCULATION

   b. Remove old pump timing button.

CAUTION **Be careful when removing tappet assembly that the plunger doesn't drop out of the sleeve, because reassembly is difficult.**

   c. Obtain dimension of old timing button from Table 3-1 corresponding with number or letter code on timing button.
   d. Add dimension on old pump flange to timing button dimension from Table 3-1.
   e. Write down total PC dimension for old pump.
   f. Write PC dimension from new pump flange and subtract it from total PC dimension for old pump.

Service Bulletin Engine 34 **is enclosed with each new pump to enable the installer to correctly time the pump to the engine. Table 2 lists buttons by Group 1, 2, and 3 codes, part numbers, and dimensions.**

PREPARATION FOR PUMP INSTALLATION

1. The crankshaft must be set on the compression stroke for No. 1 cylinder.
2. Look into hole in block where pump mounts to verify that one intake valve lobe points outward and down 45 degrees.
3. See that PC mark on flywheel aligns with timing pointer on gear case cover, Figure 3-32.
4. Align PC mark on flywheel to timing pointer by rotating crankshaft clockwise in the direction of engine rotation to take out all gear backlash in that direction.

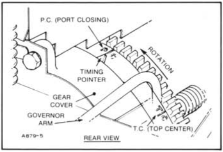


FIGURE 3-32. PORT CLOSING POSITION

POSITIONING PUMP ON ENGINE

Remove the screw shown on the side of the pump, rotate drive gear, and insert a 1/8-inch (3.175 mm) brass rod into the slot in the drive gear to lock the gear for positioning the pump on the engine, Figure 3-33.

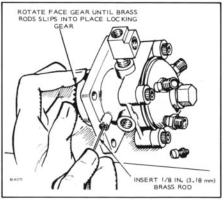


FIGURE 3-33. LOCKING THE DRIVE GEAR

Another method of aligning the drive gear slot for pump installation uses a straight edge as shown. An experienced person can "eye ball" the slot in the screw hole and place the pump on the engine with proper gear teeth meshing.

INSTALLING PUMP

The flat area just above the pump has a number marked on it which refers to the shim thickness required between the pump and its mounting pad for assuring proper backlash in the gearing. Don't forget the shims.

With the pump drive gear locked by the 1/8-inch (3.18 mm) brass rod, position the pump in the hole and firmly apply pressure, Figure 3-34. A slight spring reaction indicates the pump and camshaft gears are meshed. Maintain this pressure, remove brass rod and rotate the crankshaft manually to make sure the gears mesh properly, Figure 3-35.

FIGURE 3-34. INSTALLING PUMP ON ENGINE

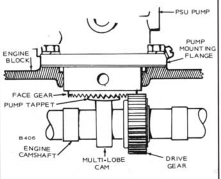
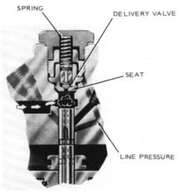


FIGURE 3-35. PSU PUMP INSTALLED

DELIVERY VALVE FUNCTION

The delivery valve maintains 300 to 600 psi (2070 to 4140 kPa) line pressure in the injector lines with the engine running, Figure 3-36. This pressure increases to about 1900 psi (13110 kPa) on each stroke of the injection pump plunger. The trapped fuel is held in the lines at all times, even though the pressure bleeds off during shutdown periods. When the lines are full of fuel, only a couple turns of the crankshaft are required to build up enough line pressure for firing the injectors.



(PSU PUMP ONLY)

FIGURE 3-36. DELIVERY VALVE CLOSED—PLUNGER DOWN

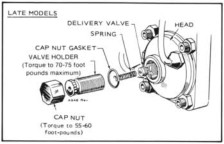


FIGURE 3-37. DELIVERY VALVE ASSEMBLY

FLOW TIMING THE PSU PUMP (DJB-DJC)

Flow timing the injection pump can be done using fuel to determine whether or not the proper timing button has been installed for best operating conditions. In case the pump is removed without recording the PC dimension and the timing button thickness, it is necessary to flow time the pump to establish the exact PC position. Keep everything clean so dust and dirt will not contaminate fuel system.

1. Install No. 12 timing button in PSU pump as previously discussed under preparation for pump installation.
   Remove delivery valve cap and holder; take out spring and replace holder and cap, Figure 3-37.
2. Remove door panel, air cleaner, and top sheet metal cover for access to flywheel marks and fuel system.
3. Remove No. 1 injector line; re-install line with top end of line in pump outlet so other end will direct fuel flow into an open container, Figure 3-38.

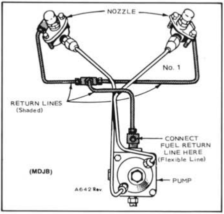


FIGURE 3-38. FUEL LINES TO INJECTORS

4. Place container under open end of No. 1 line.
5. Disconnect governor linkage at ball joint and wedge control arm at maximum fuel position.
6. Rotate flywheel counterclockwise (when facing front of engine) to point where PC mark on flywheel is about 15 degrees before timing pointer (compression stroke No. 1 cylinder).

   Check that front cylinder valve rocker arms (both valves) are free to move indicating the valves are closed.

7. Manually operate fuel transfer pump until air-free fuel flows steady from end of No. 1 line into container.

   If fuel tank is disconnected, use a separate container of fuel and connect a short hose line between the transfer pump inlet and the fuel container. The pump has enough suction to pull the fuel out of the container.

8. Continue transfer pump operation while assistant rotates flywheel slowly in clockwise direction.
9. Stop flywheel rotation at exact point fuel stops flowing from No. 1 line into container (one drop in 2 to 5 seconds). This point is the port closing time of the injection pump plunger regardless of flywheel position, Figure 3-39.

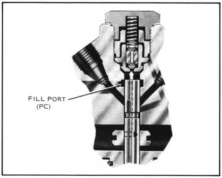


FIGURE 3-39. PORT CLOSING

Timing is correct if port closing occurs when the PC mark on the flywheel aligns with the timing pointer. If it doesn't match, timing is either early or late and another timing button is required, Figure 3-40.

FIGURE 3-40. PORT CLOSING (PC) MEASUREMENT

TIMING BUTTON THICKNESS

Injection pump kits include a pump and four buttons which will time 90 percent of the engines. The standard thickness button and ring spring are no longer assembled, but are loose in kit.

Pump timing is critical. The injection pump on each engine must be timed to that particular engine by using a timing button of specific thickness. Use the method which applies best to determine the correct new button thickness. Each new pump has its own port closing dimension stamped on it.

Procedure

1. Mark flywheel in 0.1-inch (2.54 mm) graduations (about five marks each direction) from PC mark for calculating required change in button thickness.
2. Measure distance in tenths (or mm) from PC mark on flywheel to point of actual port closing.
3. Multiply distance measured times .003 inch (.076 mm) to determine the difference in thickness required for new button.

One degree of crankshaft rotation equals the 0.1-inch graduation or .003-inch button thickness for timing.

TIMING CALCULATION

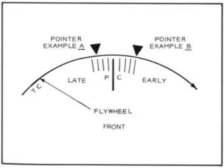


FIGURE 3-41. TIMING MARKS

Example A. The port closing time *is late* by 0.3-inch (7.6 mm) measurement, Figure 3-41.

3 x .003" = .009"
(3 x .076 = .228 mm)

Since .1 inch (2.54 mm) equals .003 inch (.076 mm) button thickness, the installed button is too thin by .009 inch (0.228 mm). This means a button .009 inch (0.228 mm) thicker than the one installed is required to time port closing so PC mark on flywheel aligns at the timing pointer when fuel flow stops.

Example B. If PC timing is *too early* by 0.4 inch (10.2 mm), multiply 4 x .003 = .012 inch (4 x 7.6 mm = 0.305 mm). In this case, a thinner button .012 inch (0.305 mm) less than the one installed is required.

BLEEDING FUEL SYSTEM

Bleed fuel system whenever the filters are changed or when there is air in the lines.

Procedure:

Manually actuate fuel transfer pump until air bubbles are all out and clear fuel flows from the bleed valve automatically, Figure 3-42.

If the transfer pump cam lobe is on the high side, the priming lever will not operate the pump. Rotate the flywheel one revolution before operating the priming lever.

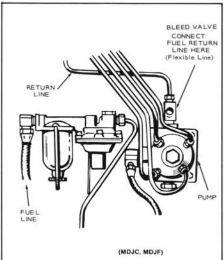


FIGURE 3-42. BLEEDING FUEL SYSTEM

BRYCE/KIKI FUEL SYSTEM

The Bryce or Kiki fuel injection system (Figure 3-43) is located near the center on the left side of the engine crankcase on MDJE Spec AB or later engines. The pump is mounted on an adapter casting and two lobes of the cam shaft operate the pump plungers, one plunger and cam lobe for each cylinder. The fuel is pumped at high pressure by the plungers through the delivery valves to the injection nozzles.

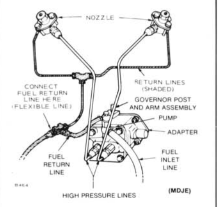


FIGURE 3-43. FUEL LINES TO INJECTORS

The Bryce/Kiki injection pumps operate on the same pumping and metering principles as the American Bosch PLB pump described earlier in this section. Fuel control from idle to maximum speed and power is accomplished by rotating the helix on each pump plunger. Both pump plungers and barrel assemblies are rotated (0 to 180 degrees) by a fuel control arm, yoke, and a rack gear. Rotating the reciprocating plunger changes the effective length of the plunger strokes and hence the amount of fuel it delivers to the injection nozzle.

The fuel transfer pump and the primary and secondary fuel filters in this system are identical to those described for and used on the other DJ-series engines.

NOZZLES

The MDJE fuel injection systems use Diesel Kiki and C.A.V. throttling-pintle type nozzles. The nozzle holders are either Yanmar or Diesel Kiki and have a plated nozzle retaining nut that distinguishes them from Bosch nozzle holders which have a black oxide finish. The nozzle tips are inter-changeable in Kiki and Yanmar holders, but internal components of these holders are not inter-changeable. The opening pressure for new nozzles should be 2133 to 2204 PSI (14707-15196 kPa).

HIGH PRESSURE INJECTION LINES

Both high pressure fuel lines between the injection pump and the two nozzles are designed to be installed without any bending. Lines that fit on Bryce pump installations also fit on Kiki pump installations, and vice versa. Whenever the lines must be removed, disconnect both ends. Do not bend the lines.

BLEEDING FUEL SYSTEM

After replacing or cleaning the filters, bleed the fuel system of air. Bleed air from fuel system as follows:

1. Disconnect fuel return line at the tee near the transfer pump. Use container to catch fuel.
2. Operate hand priming lever on diaphragm type fuel transfer pump until there are no air bubbles in fuel flowing from the fuel return line, Figure 3-44.

   If fuel tank is disconnected, use a separate container of fuel and connect a short hose line between the transfer pump inlet and the fuel container. The pump has enough suction to pull the fuel out of the container.

   If the camshaft's transfer pump lobe is up, crank engine one revolution to premit hand priming. When finished, return priming lever inward (disengaged position) to permit normal pump operaton.

3. Then connect the fuel return line at tee.

CAUTION **A diesel engine cannot tolerate dirt in the fuel system. It is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any part of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly, and install while still wet.**

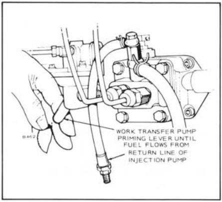


FIGURE 3-44. BLEEDING FUEL SYSTEM

BRYCE/KIKI FUEL INJECTION PUMPS

The Bryce/Kiki Injection Pumps are similar in design, appearance, and performance, Figure 3-45. Both units mount two plunger and barrel assemblies in a single housing and use a common rack (gear) to rotate the control sleeves and regulate the fuel output of both pumps. These pumps are interchangeable on MDJE engines. Internal components of the Bryce and Kiki Pumps are not interchangeable. One external difference is that the Bryce Pump uses an alignment dowel pin to fit it on the adapter assembly.

The delivery valves on both pumps are also similar, but the Bryce has one copper sealing gasket while the Kiki uses a combination sandwich type seal that requires a special delivery valve pulling tool to remove it.

Both pumps use roller type tappets as cam followers which are held in place by pins and lock wire. Each pump has an air bleed fitting to vent air and allow for easy priming.

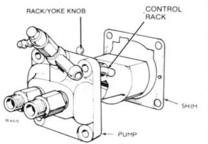


FIGURE 3-45. INJECTION PUMP

INJECTION PUMP ADAPTER

This cast iron adapter (Figure 3-46) is the crankcase mounting fixture for the fuel injection pump and its fuel control arm and yoke and the overfueling control device. A composition gasket is used between the adapter and the crankcase.

The fuel control arm and the shaft and yoke assembly transmit governor action to the injection pump control rack. The overfueling device provides maximum (excess) fuel during engine starting, and limits the maximum amount of fuel and engine power output to protect the engine from excessive loading.

CAUTION **Do not change the adjustment of this device unless absolutely required. The warranty may be voided, if the fuel stop is intentionally altered to increase engine power above 10 percent overload at rated speed and load.**

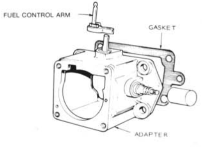


FIGURE 3-46. ADAPTER ASSEMBLY

INJECTION PUMP REPAIR

Most fuel system troubles are not due to a faulty injection pump; test the rest of the fuel system before condemning the injection pump.

Onan discourages field repair of the injection pump because of the exceptionally close tolerances between parts and the specialized equipment necessary for repair. The injection pump is an expensive part of the unit and even a particle of dirt as fine as talcum powder could score its working surfaces.

INJECTION PUMP REMOVAL

If the rest of the fuel system is in working order and fuel delivery abnormal, remove the pump for replacement or repair.

1. Locate injection pump on service side of engine and remove necessary sheet metal and hardware to make pump accessible.
2. Remove fuel inlet and return line, Figure 3-43.
3. Remove high pressure lines between pump and injector nozzles, both ends.
4. Cap all lines and fittings using extreme care to keep all fuel system components clean.
5. Remove four socket head screws holding pump to adapter assembly.
6. Position fuel control shaft and yoke as shown in Figure 3-47. Then, lift pump off of adapter assembly.
7. Carefully clean injection pump assembly and place it in a clean place. Retain shims between pump and adapter as they are needed for reassembly.

CAUTION A diesel engine cannot tolerate dirt in the fuel system. It is one of the major causes of diesel engine failure. A tiny piece of dirt in the injection system may stop your unit. When opening any part of the fuel system beyond the secondary fuel filter, place all parts in a pan of clean diesel fuel as they are removed. Before installing new or used parts, flush them thoroughly, and install while still wet.

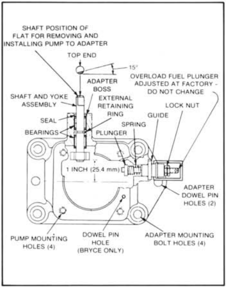


FIGURE 3-47. INJECTION PUMP ADAPTER ASSEMBLY

ADAPTER ASSEMBLY REMOVAL

1. Remove fuel control arm.
2. Remove four mounting bolts and lift adapter assembly off of engine block. It may be necessary to tap assembly with lead or plastic hammer in order to loosen adapter from gasket.
3. Discard old gasket and clean area on engine block. A new gasket is required for reassembly of adapter to prevent oil leaks.
4. Thoroughly clean adapter assembly before replacing new bearings and oil seal.
5. Place adapter assembly in suitable holder for removing and installing bearings and seal.

CAUTION Do not clamp in a vise unless machined surfaces are protected from damage by the jaws of the vise.

BEARING AND SEAL REPLACEMENT PROCEDURE

After adapter assembly has been removed from the engine, replace the bearings and seal on the yoke shaft as follows:

1. Referring to Figure 3-48, press shaft and yoke assembly towards center of adapter until shaft and bottom bearing slips out bottom end.

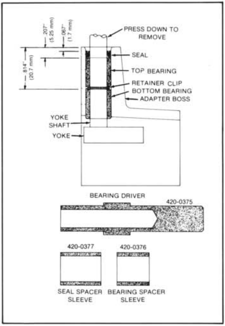


FIGURE 3-48. BEARING INSTALLATION AND TOOL PACKAGE (420-0374)

2. Using solid end of bearing driver, press top bearing and seal out bottom end.
3. Remove external retaining ring and slide bearing off yoke shaft.
4. Thoroughly clean and oil yoke and shaft assembly and adapter for installing new bearings and seal.
5. Install bottom bearing from top of adapter casting using hollow end of bearing driver. Make sure "lettered" side of bearing faces upward and that tool bottoms against top of adapter boss.
6. Slide yoke and shaft assembly up through bearing, then support yoke and shaft assembly for installing the retaining ring.

7. Using hollow end of bearing driver, press retaining ring on shaft, far enough so ring snaps into groove on shaft.
8. Slide bearing spacer sleeve (shortest sleeve) over hollow end of bearing driver; then use tool to press top bearing into adapter. Make sure tool bottoms against top of adapter boss and that "lettered" side of the bearing faces upward.
9. Replace bearing spacer sleeve with seal spacer sleeve (longest sleeve) and then use tool to press oil seal over shaft at top of adapter. Make sure seal is installed with "lettered" side down, facing the bearing, and that tool bottoms against top of adapter boss.
10. Reinstall adapter and injection pump assemblies.

ADAPTER INSTALLATION

Proceed as follows:

1. Place new gasket on engine block dowel pins and install adapter using four socket head screws and lock washers; torque screws to 20-24 ft. lb. 27-33 N•m).
2. Determine shim thickness required between pump and adapter because the new gasket may not be the same thickness as the original one. See Figure 3-49.

The proper shim thickness is stamped on the block for the shim combination required during the original factory installation of the injection pump.

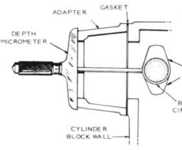


FIGURE 3-49. MEASURING DEPTH FOR SHIM THICKNESS

3. To measure for shim thickness:

   a. Rotate crankshaft to position injection pump cam lobes on the camshaft in a vertical position so the base circle of each lobe faces the adapter opening.

   b. Using a depth micrometer, measure the distance from the mounting face of the adapter to the base circle of either cam lobe.

   The shim kit contains shims in the following thicknesses: .002, .003, .006, .010, .014, and .018 inches. If one shim is not enough, the required shim thickness (between .004 and .020) can be obtained within .001 inch by combining two of the above shims. The thickness is stamped on each shim. For the greatest accuracy, measure the total shim thickness with a micrometer.

4. To calculate the shim thickness, use the following formula:

   Standard installation depth
   of pump is......... 3.2598 *inches (82.8 mm)

   Distance from adapter flange to cam lobe base circle as measured (subtract from above) ______ inches (mm)

   Required shim thickness = ______

*Many earlier spec AB MDJE engines have an installation dimension of 3.2540 (82.652 mm). On these units, a silkscreen print indicates this dimension. If so, 3.2540 should be substituted for 3.2598 in Step 4.

INJECTION PUMP INSTALLATION

Install injection pump on adapter assembly as follows:

1. Rotate crankshaft to position camshaft so that the pump rollers contact the camshaft base circle (low point of the pump cam lobes). One lobe should be up, the other lobe down. See Figure 3-49.
2. Using proper shim thickness (Figure 3-50), install pump to adapter with four socket head capscrews and lockwashers. Torque to 20 to 24 ft-lbs 27-33 N•m).

CAUTION **Be sure the control rack ball fits between the yoke fingers for proper operation. If the rack ball is not properly placed in the yoke, engine operation will be uncontrollable and must be stopped immediately. In such as emergency, the engine can be stopped by blocking the air intake, or by loosening (just cracking) the fuel injector line fittings at the pump end.**

3. Connect flexible fuel inlet line to pump inlet.
4. Connect each high pressure fuel line to proper pump outlet and nozzle inlet. Torque nuts to 16-18 ft. lb. (22-24 N•m).
5. Reinstall fuel control arm on yoke and shaft assembly, Figure 3-50. Tighten socket head screw, but do not over tighten.

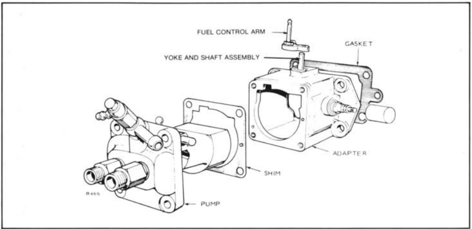


FIGURE 3-50. PUMP AND ADAPTER ASSEMBLY

6. Adjust fuel solenoid plunger so that a 0.010 to 0.030 inch (0.25 to 0.76 mm) clearance exists (see Figure 3-51) between the plunger adjustment screw and the fuel control arm with the solenoid in deenergized position. To adjust the plunger length, hold the plunger, and adjust the screw on the plunger lever pin at the fuel shutoff position. Retighten locknut.

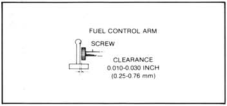


FIGURE 3-51. FUEL SOLENOID ADJUSTMENT

FLOW TIMING - TROUBLESHOOTING ONLY

Flow timing is performed at either injection line to establish or confirm the port closing (PC) point of each fuel injection cycle. The PC point should be about the same for each cylinder, but an allowable difference between cylinders is 2.5 crankshaft degrees of rotation measured on the flywheel rim. Approximately 0.1-inch (2.54 mm) is equivalent to 1-degree rotation. At 1500 and 1800 rpm, PC should occur at 18° BTC ± 4° on MDJE engines.

If piston drop is measured to determine the PC point, the nominal value is 0.115 inch (2.9 mm); the allowable range is 0.171 to 0.070 inch (4.3 to 1.8 mm).

FLOW TIMING PROCEDURE

To determine PC, proceed as follows:

1. Remove one high pressure line (both ends), and the corresponding delivery valve holder, spring, volume reducer, and delivery valve, Figure 3-52. Leave gasket and seat in pump.

Place the spring and volume reducer in a clean container of fuel until re-installed.

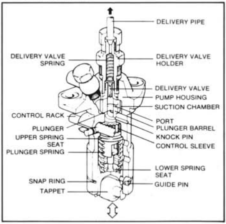


FIGURE 3-52. SINGLE INJECTION PUMP ASSEMBLY

2. Re-install delivery valve holder (without spring and volume reducer).
3. Install high pressure line on delivery valve outlet so that drops of fuel can be easily counted and collected in a receptacle at the open end of the line.
4. Move the fuel control arm toward the front of the engine to full fuel range.

The fuel solenoid must be energized or held (blocked) to keep the plunger out of the way.

5. Manually operate transfer pump lever to provide fuel pressure to injection pump.
6. Rotate flywheel clockwise very slowly by hand until fuel stops flowing from open line even though transfer pump operation is continued.
7. Rotate flywheel counterclockwise until fuel flows freely; then, clockwise very slowly to position where fuel drops can be counted at one drop per second with the transfer pump operating.

This is the PC point; it should be marked on the flywheel opposite the timing pointer.

8. After flow timing is completed, remove high pressure line and delivery valve holder; then reinstall delivery valve, spring, and volume reducer.

CAUTION **Make sure all parts are clean.**

9. Reinstall delivery valve holder and torque Bryce holder to 29-33 ft. lbs. (39-44 N•m). Torque Kiki holder to 44-47 ft. lbs. (60-64 N•m). If fuel leakage occurs, replace the delivery valve gasket.
10. Reinstall high pressure line between pump and nozzle.
11. Using the same procedure, flow timing can be performed on the other cylinder to determine PC or the difference in degrees between cylinders; 2.5 degrees is allowable.

ENGINE PERFORMANCE

Engine performance at 1500 and 1800 rpm varies within acceptable limits when PC occurs between 14° and 22° BTC. Generally, retarded timing results in lower smoke but higher fuel consumption; and vice versa when timing is advanced.

TORQUE INSTRUCTIONS

The following Torque Instructions are for Bryce-Kiki Injection Systems on Onan MDJE Engines, Figure 3-53.

Bryce Pump Model FAOBRO70E0686
Kiki Pump Model NP-PFR2K70/1NP22
and 1NP23.

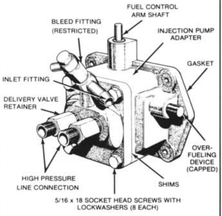


FIGURE 3-53. BRYCE/KIKI PUMP AND ADAPTER ASSEMBLY

- Delivery Valve Retainer
  Bryce: 28.5-32 lb. ft. (39-43 N•m)
  Kiki: 43.5-47 lb. ft. (60-64 N•m).

When using a new delivery valve gasket on Kiki pumps, tighten the valve to full torque value and loosen twice; then, torque retainer a third time to finally seat the gasket.

- Fuel Inlet Stud (both) 15-18 lb. ft. (20-24 N•m).
- Bleed Fitting Retainer (both) 35-52 lb. inch (47-70 N•m).
- All Adapter & Pump Mounting Screws 20-24 lb. ft (27-33 N•m).

FUEL SOLENOID

This solenoid is also referred to as a governor solenoid as it overrides the governor, Figure 3-54. The solenoid is mounted on the cylinder air housing bottom pan and controls the injection pump throttle lever. When energized, the plunger is in the solenoid body. When de-energized, the solenoid spring forces the plunger against the operating arm to shut off fuel. The solenoid has two coils. Both are energized for pulling the plunger in. When the plunger bottoms, it opens a set of contacts, de-energizing the pull-in coil. The other coil holds the plunger in.

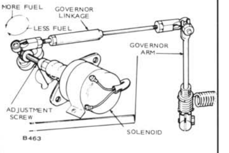


FIGURE 3-54. FUEL SOLENOID

To test the solenoid, check plunger operation and current draw with 12-volt input. Current draw with the plunger up should be about 1 amp. If it is much greater, the contacts did not open.

Refer to the injection installation paragraph, step 6 for information on adjusting the fuel solenoid plunger.

GOVERNOR LINKAGE ADJUSTMENT

With the engine shut off, proceed as follows:

1. Loosen locknuts on governor linkage and then remove link at one ball joint, Figure 3-54.
2. Fully compress solenoid plunger spring and hold.
3. Position governor arm and fuel control arm fully forward (toward front of engine and hold).
4. Adjust governor linkage so that both ball joints fit and snap on without moving governor arm or fuel control lever from their forward positions.
5. Tighten locknuts on governor linkage.
6. Release fuel solenoid plunger allowing fuel shut off with solenoid de-energized.

TROUBLESHOOTING PUMP PROBLEMS

Normally, little goes wrong with the injection pump after it is installed on the engine as long as timing is correct and clean fuel is used continually.

The most common problem is caused by a delivery valve that may be held open by dirt or metal chips that entered the pump or fuel system during assembly and installation. That is the reason protective covers must be used to keep foreign matter out of unassembled fuel system components.

If the pump is suspected of causing misfires or poor operation:

- Check the temperature of each nozzle holder and exhaust port; the coolest cylinder is the faulty one.
- Loosen (crack) the high pressure injection lines, one cylinder at a time (like disconnecting a spark plug wire), to determine the faulty cylinder; the cylinder that looses the least power is misfiring, or not firing.

CAUTION **The Bryce/Kiki fuel injection pumps are precision type units. All testing and calibration should be done in accordance with Onan Specification Sheet 539-0389.**

Pump disassembly by unqualified personnel is not authorized and may void the pump warranty.

Return all faulty pumps to the Onan factory for repairs, or replacement if still under warranty. Otherwise, refer all Service problems to authorized (Bryce/Lucas) and Diesel Kiki service centers.

THROTTLING PINTLE NOZZLE TESTS

The following tests will determine nozzle conditions using a manually operated test stand. Each nozzle must be removed from the engine for testing. Prior to testing, each nozzle must be cleaned, decarboned, and inspected as described for non-throttling pintle type nozzles earlier in this section. New or reconditioned nozzles must be thoroughly cleaned in cleaning solvent or test oil to remove all traces of preservative grease before testing.

The nozzle valve and nozzle body are lap-fitted together and must not be interchanged.

Visual Check: Using Illuminated Magnifier

1. Inspect nozzle valve for damaged or rough seat.
2. Inspect pintle for wear, damage, or out-of-round spray hole.
3. Check nozzle body for damaged or carboned seat.

Slide Test

1. Dip clean nozzle valve in filtered diesel fuel or test oil.
2. Insert valve in nozzle body, Figure 3-55.
3. Holding body almost vertical, pull valve out to one-third of its engaged length; then release valve.
4. The released valve (because of its weight) should slide down to its seat.

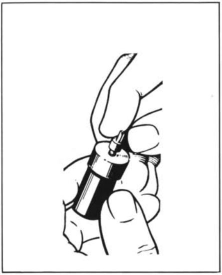


FIGURE 3-55. SLIDE TEST

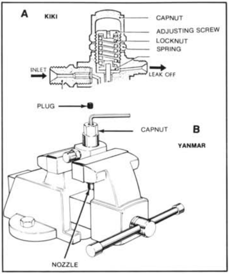


FIGURE 3-56. NOZZLE ADJUSTMENT

Testing Nozzles With Hand Operated Tester

The proper tester can be used to check opening pressure, leak down rate, chatter, and spray pattern. Install cleaned and inspected nozzle in tester and proceed as follows:

1. Place nozzle in holder.
2. Tighten nozzle nut finger tight, then using proper size wrench tighten nut to 45-50 ft. lbs. (61-68 N•m).
3. Connect delivery line between nozzle holder and test stand; be sure that fittings match properly.
4. Test nozzle for jamming:

   a. Bypass pressure gauge.
   b. Press nozzle tester hand lever down quickly so that nozzle opens 6-8 times per second.
   c. Nozzle should chatter with a shrill whistling sound, if valve moves properly.

WARNING The nozzle spray can cut through skin so any test oil or diesel fuel that might enter the blood stream could cause blood poisoning.

KIKI NOZZLE ADJUSTMENT

If the opening pressure is incorrect, connect nozzle to a tester and hold the nozzle in a suitable holder or smooth jaw vise.

1. Remove cap nut, Figure 3-56A.
2. Loosen locknut.
3. Turn adjusting screw to desired opening pressure.
4. Tighten locknut to 45-50 ft. lb. (61-68 N•m).
5. Tighten cap nut to 45-50 ft. lb. (61-68 N•m).
6. Remove nozzle from tester and holder.

YANMAR NOZZLE ADJUSTMENT

If the opening pressure is incorrect, connect nozzle to tester and hold nozzle in a suitable holder or smooth jaw vise.

1. Remove plug from cap nut, Figure 3-56B.
2. Loosen locknut.
3. Turn adjusting screw to desired opening pressure.
4. Tighten cap nut to 45-50 ft. lb. (61-68 N•m).
5. Re-install plug using a thread sealant.
6. Remove nozzle from tester and nozzle.

OPENING PRESSURE

The correct opening pressure should be 2133-2204 PSI (150±5 kg/cm²) (14718-15208 kPa) for new nozzles used on MDJE Spec AB or later. It may be about 200 PSI (14 kg/cm²) (1380 kPa) less after the nozzles have operated a few hundred hours. Open pressure gauge to obtain reading.

Leakage Test:

1. Slowly depress hand lever until nozzle test gauge indicates 285 PSI (1966 kPa) below specified opening pressure.
2. Consider nozzle leak-proof if no fuel (not even one drop) emerges from nozzle tip within 10 seconds.

Chatter Test

1. Operate hand lever downward (1 or 2 nozzle opening cycles per second) until nozzle ejects a stream of fuel with a soft chattering sound.
2. Take pressure readings from gauge.
3. Slightly increase hand lever movements (2 or 3 nozzle opening cycles per second), the stream velocity should increase and create a hissing sound.
4. Accelerate lever movements to 4-6 nozzle opening cycles per second. The nozzle should create a shrill whistling sound and a spray pattern.

SPRAY PATTERN

The spray pattern must be compact and well atomized at full lift to be correct. The pressures between nozzle opening and full lift causes the fuel to emerge in a stream, change to flag-like formations, and finally reach atomized spray pattern at full lift with lever movements producing 4-6 nozzle opening cycles per second. See Figure 3-57.

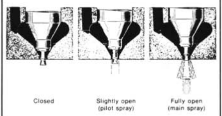


FIGURE 3-57. NOZZLE SPRAY ACTION

ADJUSTMENTS (DIESEL-POWERED UNITS)

There are adjustments that must be checked periodically on a diesel engine to ensure long life, economy, and low service maintenance cost. The importance of making these adjustments according to the time intervals specified in the appropriate operators manual cannot be over emphasized. They are as follows:

- Throttle Stop Screw
- Governor Adjustments
- Valve Clearance Adjustments
- PSU Fuel Injection Pump
- Injector Nozzle
- Injector Pump Timing
- Timing Button Selection

GOVERNOR

The governor controls engine speed. Rated speed and voltage appear on the nameplate. The speed should not vary more than 3 cycles from no-load to full-load operation. Be sure throttle, linkage and governor mechanism operate smoothly.

THROTTLE STOP SCREW

The maximum throttle stop screw shown in Figure 3-58 normally should not be adjusted in the field. This adjustment is set by the manufacturer. If original setting is disturbed, it can be adjusted as follows:

1. Apply a momentary 10% overload to generator. (Example: If set rating is 15 kW, apply 16.5 kW load).
2. Loosen lock nut and adjust stop screw until engine rpm starts to drop off.
3. Tighten lock nut on adjusting screw.

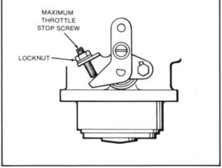


FIGURE 3-58. PSU INJECTION PUMP STOP SCREW

Speed Adjustment: To change the governor speed, change the spring tension by turning the governor speed nut (Figure 3-59). Turn the nut clockwise (more spring tension) to increase governed speed and counterclockwise to reduce governed speed. Hold a tachometer against flywheel cap screw or use frequency meter.

Sensitivity Adjustment: To adjust governor sensitivity (no-load to full-load speed drop), turn the sensitivity adjusting ratchet (Figure 3-59). Counterclockwise gives more sensitivity (less speed drop when full load is applied), clockwise gives less sensitivity (more speed drop). If the governor is too sensitive, a rapid hunting condition occurs (alternate increasing and decreasing speed). Adjust for maximum sensitivity without hunting. After sensitivity adjustment, the speed will require readjustment. After adjusting the governor, secure lock nut.

VALVE CLEARANCE ADJUSTMENTS

Check valve clearance when the engine is at room temperature about 70° F (21° C).

1. Turn the flywheel until the cylinder which is to have its valve adjusted is on its compression stroke. Use a socket wrench on the flywheel retaining screw.

   To determine if the cylinder is in its compression stroke, observe the action of the push rods as the engine is rotated in a clockwise direction. The exhaust valve push rod will be in its lowest position and the intake valve push rod will be moving downward. As the piston reaches top dead center, the flywheel timing mark should be aligned with the timing pointer and the valve push rods stationary.

2. Now turn the flywheel clockwise for an additional 10 to 45 degrees. There is no timing mark for this position so it must be estimated. With the piston located in this position, it will be in its power stroke with both valves completely closed.

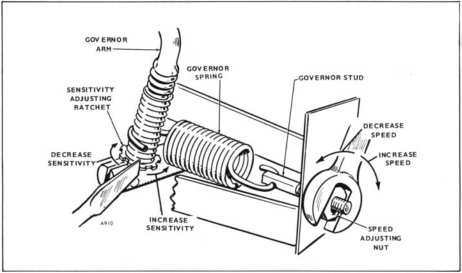
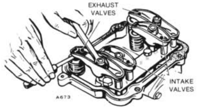


FIGURE 3-59. GOVERNOR ADJUSTMENT

3. To change the setting of valve clearance, adjust the locknut which secures the rocker arm to the cylinder head (see Figure 3-60). Loosen the locknut to increase clearance and tighten it to reduce clearance.
4. Using a feeler gauge, check the clearance between the rocker arm and valve (see Figure 36). Increase or reduce the clearance until the proper gap is established. See table in Figure 3-60 for valve clearances.
5. Always adjust the valve clearances in the firing order (1-2-4-3) sequence. After allowing engine to cool, adjust #1 cylinder. After timing the #1 cylinder, adjust the valve clearance according to Steps 2 and 3.
6. To adjust the valve clearance of #2 cylinder, turn the flywheel in a clockwise direction from the position used when timing #1 cylinder (360° on 2 cylinder MDJB and MDJE units, 180° on 4 cylinder MDJC and MDJF units.
7. After timing #2 cylinder, adjust the valve clearance according to steps 3 and 4.
8. To adjust #4 cylinder valve clearance, turn the flywheel in a clockwise direction 180-degrees (one half revolution). The flywheel should be between 10- and 45-degrees past the TC (top center) flywheel mark.
9. After timing #4 cylinder, adjust the valve clearance according to steps 3 and 4.
10. To adjust the valve clearance for #3 cylinder, turn the flywheel in a clockwise direction 180-degrees (one half revolution).
11. After timing #3 cylinder, adjust the valve clearance according to steps 3 and 4.

VALVE CLEARANCES IN INCHES (mm)

MODEL	INTAKE	EXHAUST
MDJA	.020 (0.51)	.020 (0.51)
MDJB	.015 (0.38)	.013 (0.33)
MDJC	.011 (0.28)	.016 (0.41)
MDJE		
MDJF	.017 (0.43)	.017 (0.43)



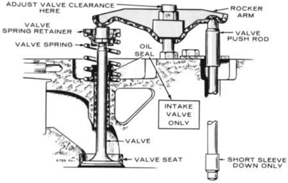


FIGURE 3-60. SETTING VALVE CLEARANCE

STARTING SEQUENCE - Diesel (Figure 3-61)

The following is the sequence of operation for starting of a diesel engine generator set:

1. Operator holds Preheat switch for recommended time interval (see operating instructions).
2. Heater solenoid closes and battery current flows to glow plugs and manifold heater.
3. Operator pushes Start button, or set is started by remote control.
4. Start solenoid closes.
5. Battery current flows to starting motor and governor solenoid (full fuel).
6. Engine cranks and starts
7. Centrifugal switch closes.
8. Start disconnect relay closes—keeps governor solenoid energized.
9. Operator releases Start button.
10. Engine continues running.

STOP SEQUENCE

1. Operator pushes Stop button.
2. Start disconnect relay opens governor solenoid.
3. Engine stops.
4. Operator releases Stop button.

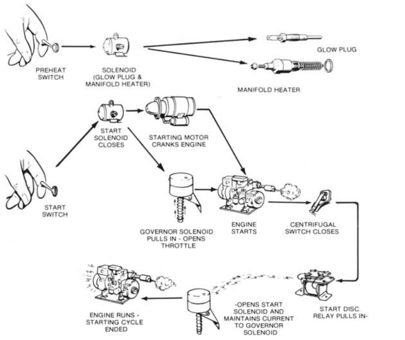


FIGURE 3-61. DIESEL STARTING SEQUENCE

TROUBLESHOOTING GUIDE for DIESEL ENGINES (Water Cooled)

TROUBLE

Hard Starting or Failure to Start	Starter Motor Doesn't Turn	Engine Misfires	Engine Speed Too High	Engine Speed Too Low	Hunting Condition	No Governor Control	Poor Sensitivity	Excessive Oil Consumption	Excessive Fuel Consumption	Low Oil Pressure	High Oil Pressure	Diluted Oil	Engine Overheats	Mechanical Knocks	Coolant Temperature Too High	Loss of Coolant	CAUSE	SYSTEM
													●		●		Insufficient Coolant	COOLING
		●											●		●		Faulty Thermostat	
													●		●	●	Worn Water Pump	
													●		●		Water Passages Restricted	
													●		●	●	Damaged or Defective Water Pump Seals	
		●													●	●	Blown Head Gasket	
								●		●		●		●			Overheating	
													●		●		Water Lines Restricted or Too Long	
●																	Out of Fuel or Shut-off Valve Closed	FUEL
●		●							●					●			Poor Quality Fuel	
●		●							●								Dirty Fuel Filters	
●		●			●				●								Fuel Line Leaks	
●		●			●				●								Air in Fuel System	
									●			●					Fuel Transfer Pump Diaphragm Leaks	
●		●							●				●	●			Incorrect Timing	
								●									Run for Long Periods of Time at No Load	
●		●							●								Restricted Air Intake, Dirty Air Cleaner	
			●	●	●	●	●										Linkage Loose or Disconnected	GOVERNOR
			●	●	●	●	●										Linkage Binding	
					●		●										Excessive Wear in Linkage	
			●	●	●	●	●										Incorrect Governor Adjustment	
					●	●											Spring Sensitivity Too Great	
										●			●	●			Low Oil Supply	LUBRICATION
											●						Defective Gauge	
								●									Excess Oil in Crankcase	
								●									Oil Leaks From Engine Base or Connections	
								●		●			●	●			Crankcase Oil Too Light or Diluted	
●											●						Crankcase Oil Too Heavy	
●	●																Battery Discharged or Defective	STARTING
●		●															Defective Glow Plug or Lead	
●																	Load Connected When Starting	
●	●																Open Solenoid	
●	●																Defective Starter	

ADJUSTMENTS (GASOLINE UNITS)

GENERAL

General adjustments made to the engine to ensure optimum operating performance, efficiency and economy are referred to as Engine Tune-Up Adjustments. Top overhaul includes a thorough examination of the engine without dismantling it. Because of the differences in the ignition system, fuel system, timing and operation, a gasoline engine has more necessary adjustments to keep the engine in peak performance condition. Some of the most important adjustments we cover in this section are:

- Point Setting
- Ignition Timing
- Carburetor Adjustments
- Choke Adjustments and Types
- Governor Adjustments
- Vacuum Speed Booster
- Valve Tappet Adjustments

These adjustments will be covered in the order listed above, because this sequence is the logical sequence to follow when performing an engine tune-up.

POINT SETTING

The first adjustment necessary on a gasoline unit such as the MAJ is the point setting. The magneto supplies ignition current to the spark plug. Remove the flywheel and examine the breaker contact points. Adjust the gap between points for .022 inch (0.56 mm) at full separation. See Figure 3-62. Onan also has a magneto adjusting open flywheel which allows easy adjustment.

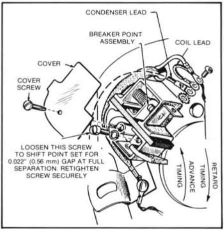


FIGURE 3-62. SETTING POINTS - MAJ

TIMING THE IGNITION

After the point gap is properly adjusted (Figure 3-62), install the flywheel loosely, with its key in place, and turn the flywheel with rotation direction to the position where the mark on the edge of the flywheel is in alignment with the proper degree on the gear cover. The points should just separate at this point. If they do not, remove the flywheel and loosen the magneto backplate mounting screws slightly.

If the points separate too soon, shift the entire backplate assembly clockwise. Tighten the backplate mounting screws and recheck the work for accuracy. When replacing the flywheel, always make sure the key is properly in place on the crankshaft. Ignition timing advance is 19° BTC on MAJ.

The MCCK uses a battery ignition system.

Ignition breaker points, Figure 3-63, must be correctly gapped. Crank engine to fully open breaker points (1/4 turn after top center). Loosen locking screws (A) and turn cam (B) to adjust. Tighten breaker points and recheck gap. Correct point gap is .020 inch (0.51 mm) measured with a flat thickness gauge.

Ignition points should break contact just as the 20° timing mark aligns with the flywheel timing mark. Final timing is corrected by properly shifting the breaker point box on its mounting and using a continuity light.

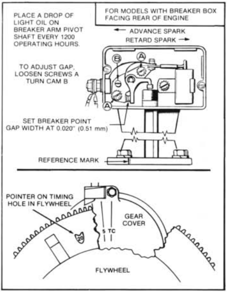


FIGURE 3-63. MCCK IGNITION TIMING

TIMING PROCEDURE - ENGINE RUNNING

WARNING Use extra care when making adjustments with the engine running. Be careful of loose clothing. Do not leave tools laying on the set.

1. To check the ignition timing, use a timing light when the engine is running. Connect the timing light according to its manufacturer's instructions. Either spark plug can be used on the MCCK as they fire simultaneously.
2. Start the engine and check the timing. The mark on the flywheel should line up with the correct timing mark.
3. If timing needs adjustment, use a drift punch on the mounting base of the box and tap in direction required for correct timing.
4. Start engine to be sure mark on flywheel lines up with the correct timing mark.
5. Tighten all screws, replace timing plug (where used).

TIMING PROCEDURE - ENGINE NOT RUNNING

1. Connect a continuity test lamp set across the ignition breaker points. Touch one test prod to the breaker box terminal to which the coil lead is connected and touch the other test prod to a good ground on the engine.
2. Turn crankshaft against rotation (counterclockwise) until the points close. Then slowly turn the crankshaft with rotation (clockwise).
3. The lamp should go out just as the points break which is the time at which ignition occurs (timing marks should align).
4. If timing needs adjustment, loosen the mounting screws on the breaker box and move left to advance or right to retard the timing (when facing rear of engine).

CARBURETOR ADJUSTMENTS

The carburetor is either a side (horizontal) draft type or a downdraft (vertical) type, and has two adjusting needles (Figure 3-64 and 3-65). The correct setting for the main fuel adjustment screw gives the best stability at full rated load operation. The correct setting for the idle screw gives the best stability at no-load operation. Turning the screw inward gives a leaner fuel mixture for that jet.

IMPORTANT: Full-load and no-load operating conditions are necessary when making carburetor adjustments.

Open both needles 1 to 1-1/2 turns off their seats to permit starting. Do not force the needles against their seats. This can bend the needle.

1. Apply a full load to engine.
2. Turn in main fuel adjustment screw (Figure 3-65) until engine speed drops. Then turn out screw until engine speed returns to normal.
3. Remove load from the engine.
4. Turn idle screw out until engine speed drops slightly. Then turn the screw in until speed returns to normal.

CAUTION Forcing the needle against its seat will damage it. The needle does not completely shut off when turned fully in.

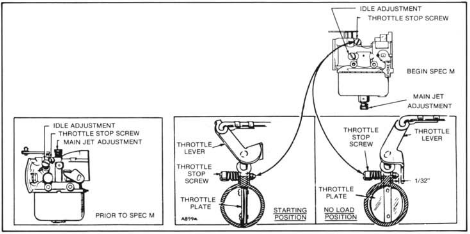


FIGURE 3-64. MAJ CARBURETOR ADJUSTMENTS

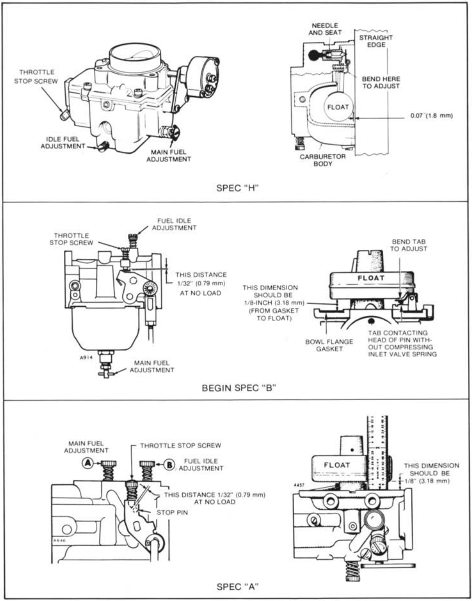


FIGURE 3-65. MCCK CARBURETOR ADJUSTMENTS

AUTOMATIC CHOKES

Automatic chokes are used on engines powering Onan generator sets which are started by remote or automatic control. Automatic chokes operate to close the carburetor choke valve when the set is started cold and to gradually open the choke valve as the set warms up. In this way, the proper gasoline and air mixture is provided for starting "cold" and during the warmup period. See Figures 3-66 and 3-67.

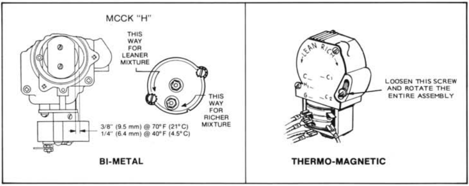


FIGURE 3-66. TYPICAL CHOKES USED WITH ONAN UNITS

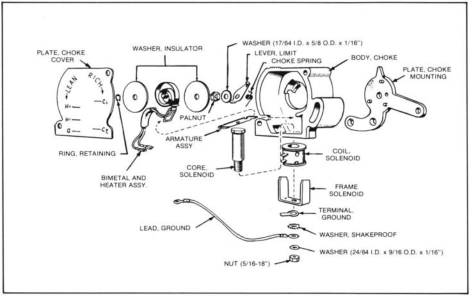


FIGURE 3-67. EXPLODED VIEW OF THERMO-MAGNETIC CHOKE

GOVERNOR SYSTEM ADJUSTMENTS (MAJ)

The governor controls the engine speed. On AC electric sets, engine speed determines generator output voltage and frequency. By increasing engine speed, generator voltage and frequency also increase and by decreasing speed, generator voltage and frequency decrease. Use an accurate voltmeter when adjusting the governor on AC sets. A small speed drop, not noticeable without instruments, will result in an objectionable voltage drop.

When the set stops, tension of the governor spring should hold the carburetor throttle arm at the wide open position, pushed toward the generator end of the set. At wide open position, the lever on the throttle shaft should just touch the carburetor body or clear it by no more than 1/32 inch (0.79 mm). Obtain this setting by increasing or decreasing the length of the connecting linkage as necessary. Be sure to retighten but not bind the linkage to the governor arm. This operation synchronizes governor action with carburetor throttle action.

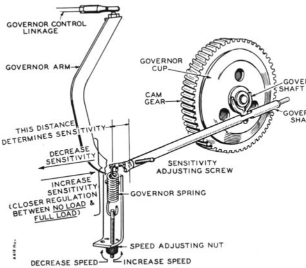


FIGURE 3-68. MAJ GOVERNOR ADJUSTMENTS

GOVERNOR SYSTEM ADJUSTMENTS MCCK

Spec "H"

Preferred speed varies approximately 3 hertz from no load to full load operation. Be sure throttle, linkage, and governor mechanism operate smoothly.

Governor Adjustment: Before making adjustments, run the set about 15 minutes with a light load connected to reach normal operating temperature. (If governor is completely out of adjustment, make a preliminary adjustment at no load to first attain safe voltage operating range.)

Engine speed determines the output voltage and frequency of the generator. By increasing the engine speed, generator voltage and frequency are increased, and by decreasing the engine speed, generator voltage and frequency are decreased. Connect an accurate voltmeter or frequency meter (preferably both) to the generator output in order to correctly adjust the governor. A small speed drop not noticeable without instruments may result in an objectionable voltage drop. Use a tachometer to check engine speed.

A binding in the bearings of the governor shaft, in the ball joint, or in the carburetor throttle assembly causes erratic governor action, or alternate increase and decrease in speed (hunting). A lean carburetor adjustment may also cause hunting. Springs of all kinds have a tendency to lose their calibrated tension after long usage. If all governor and carburetor adjustments are properly made, and the governor action is still erratic, replacing the spring with a new one and resetting the adjustments will usually correct the trouble. See Figure 3-69.

1. Adjust the carburetor main jet for the best fuel mixture while operating the set with a full rated load connected.
2. Adjust the carburetor idle needle with no load connected.
3. Adjust the length of the governor linkage, and check linkage and throttle shaft for binding or excessive looseness.
4. Adjust the governor spring tension for rated speed at no load operation.
5. Adjust the governor sensitivity.
6. Recheck the speed adjustment.
7. Set the carburetor throttle stop screw.

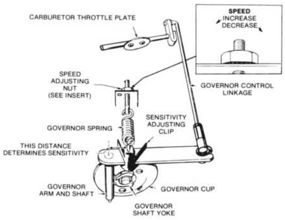


FIGURE 3-69. SPEC "H" GOVERNOR DETAILS

Prior to Spec "H"

Speed Adjustment: With the set running at operating temperature and no load, and with the booster external spring disconnected, adjust the tension of the governing spring. Turn the speed adjusting nut to obtain a voltage and speed reading within the limits shown on page 72.

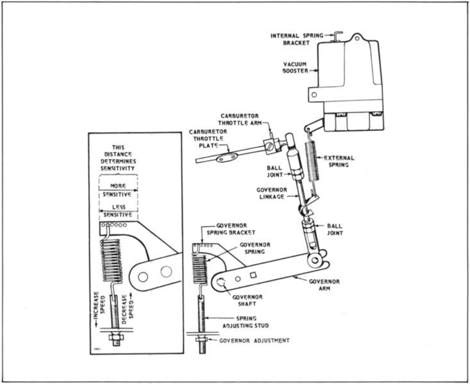


FIGURE 3-70. GOVERNOR DETAILS, PRIOR TO SPEC H

SPEED BOOSTER

Use a fine wire to clean the small hole in the short vacuum tube which fits into the hole in the top of the engine intake manifold. Do not enlarge this hole. If there is tension on the external spring when the unit is operating at no load or light load, it may be due to improper adjustment, a restricted hole in the small vacuum tube, or a leak in the booster diaphragm or gasket (Figure 3-71).

Vacuum-Booster Adjustment: After satisfactory performance under various loads is attained by governor adjustments without the booster, connect the booster. Connect the booster external spring to the bracket on the governor linkage. With the set operating at no load, slide the bracket on the governor linkage to a position where the external spring is just free from the tension, Figure 3-70.

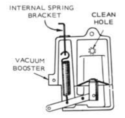


FIGURE 3-71. VACUUM SPEED BOOSTER

Apply a full rated electrical load to the generator. The output voltage should stabilize higher at full load with the vacuum booster operating. If there is a drop in frequency, increase the booster internal spring tension. To increase tension, pull out on the internal bracket and move the pin to a different hole.

With the booster disconnected, a maximum drop of 5 hertz from no load to full load is normal. With the booster in operation, a maximum increase of 2 hertz from no load to 2/3 load is normal. A drop of 1 hertz at 1/4 load is permissible, giving an over-all maximum spread of 3 hertz.

VOLTAGE CHART FOR CHECKING GOVERNOR REGULATION

AC GENERATOR SETS	120 VOLT (1PH, 2W) OR 120/240V (1PH, 3W)	240 VOLT (1PH, 2W) OR 240 VOLT (3PH, 3W)
Maximum No-Load Volts	126	252
Minimum Full-Load Volts (Without Booster)	110	220

NOTE: Output rating is at UNITY power factor load.

SPEED CHART FOR CHECKING GOVERNOR REGULATION

AC GENERATOR SETS	60 HERTZ	50 HERTZ
Maximum No-Load Speed		
RPM	1890	1560
Hertz (Frequency)	63	52
Minimum Full-Load Speed (Without Booster)		
RPM	1770	1490
Hertz (Frequency)	59	49

CLEAN GOVERNOR LINKAGE

The governor linkage on Onan engines employs one of two kinds of ball joints: plastic or steel. Ball joints should be cleaned every 100 hours of operation.

The plastic joint requires cleaning only. Do not lubricate. Clean the steel joint and apply a graphite lubricant.

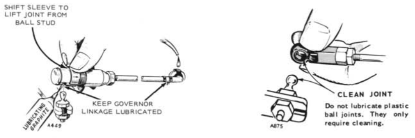


FIGURE 3-72. GOVERNOR LINKAGE

VALVE TAPPET ADJUSTMENT

Most Onan engines are equipped with adjustable tappets. To make a valve adjustment, remove the valve covers. Crank the engine over slowly by hand until the intake valve for that cylinder opens and closes. Continue about 1/4 turn until the correct timing marks align. This should place the piston at the top of its compression stroke, the position it must be in to get proper valve adjustment for each cylinder. Clearances are shown in *Dimensions and Clearances* section of each Operators Manual. For each valve, the gauge should just pass between the valve stem and valve tappet.

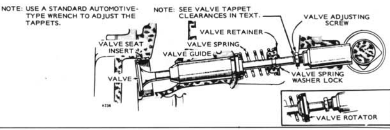


FIGURE 3-73. VALVE SYSTEM

To correct the valve clearance, turn the adjusting screw as needed to obtain the right clearance. The screw is self-locking.

Always adjust the valve clearances in the firing order sequence on engines of 4 or more cylinders.

Use a flat feeler gauge and check the clearance between the valve and the valve rotator. Increase or reduce the clearance until the proper gap is established. See Figure 3-74.

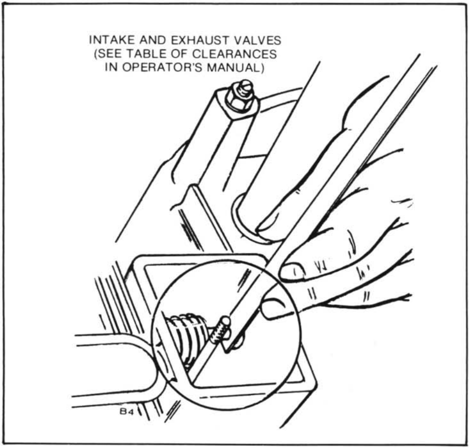


FIGURE 3-74. TAPPET ADJUSTMENT

TROUBLESHOOTING GUIDE for GASOLINE ENGINES (Water Cooled)

Hard Starting or Failure to Start	Starter Motor Doesn't Turn	Engine Misfires	Engine Speed Too High	Engine Speed Too Low	Hunting Condition	No Governor Control	Poor Sensitivity	Excessive Oil Consumption	Excessive Fuel Consumption	Low Oil Pressure	High Oil Pressure	Engine Backfires at Carburetor	Engine Overheats	Mechanical Knocks	Coolant Temperature Too High	Loss of Coolant	Black Smoky Exhaust	Blue Smoky Exhaust	CAUSE	SYSTEM
													●		●				Insufficient Coolant	COOLING
													●		●				Faulty Thermostat	
													●		●	●			Worn Water Pump	
													●		●				Engine Water Passages Restricted	
													●		●	●			Damaged or Defective Water Pump Seals	
●		●											●		●	●			Blown Head Gasket	
								●		●				●			●		Overheating	
													●		●				Water Lines Restricted or Too Long	
●																			Out of Fuel, or Shut-off Valve Closed	FUEL
●		●							●					●					Poor Quality Fuel	
●		●																	Dirty Fuel Filter	
●		●			●				●										Fuel Line Leaks	
●		●							●			●					●		Mixture Too Rich or Choke Stuck	
●		●											●						Mixture Too Lean	
●												●							Engine Flooded	
		●																	Run for Long Periods of Time at No Load	
●		●							●								●		Restricted Air Intake, Dirty Air Cleaner	
						●													Linkage Loose or Disconnected	GOVERNOR
				●	●	●													Linkage Binding	
					●	●	●												Excessive Wear in Linkage	
			●	●			●												Incorrect Governor Adjustment	
			●		●														Spring Sensitivity Too Great	
										●			●	●					Low Oil Supply	LUBRICATION
										●	●								Defective Gauge	
								●		●								●	Excess Oil in Crankcase	
								●											Oil Leaks From Engine Base or Connections	
								●		●			●	●				●	Crankcase Oil Too Light or Diluted	
●											●								Crankcase Oil Too Heavy	
●	●																		Battery Discharged or Defective	STARTING AND IGNITION
●	●																		Loose Battery Connections	
●																			Load Connected When Starting	
●	●																		Open Solenoid	
●	●																		Defective Starter	
●		●																	Wrong Plug or Point Setting	
●		●							●			●	●	●			●		Incorrect Timing	
												●	●						Spark Too Far Advanced	

SUMMARY

Whether we are speaking of a gasoline or diesel powered generator set; the importance of making the correct adjustments at the proper time are the same for each unit. The frequency or time interval for diesel adjustments is usually longer due to the heavier construction, etc. The end result of longer life and lower service cost is the main benefit each owner receives through proper care and maintenance of the unit. There are no short cuts in either case. Maintain the unit and keep it clean and it in turn will pay off with many worry-free hours of dependable safe operation. You can also be proud to display the vessel and its equipment when kept in top operation condition. It could be the difference between going or not going, even a matter of life or death under certain conditions.

Notes

SECTION 4
GENERATOR THEORY AND ADJUSTMENTS

- **Introduction**
- **Generator Theory and Operation**
- **Generator Adjustments**
- **Generator Troubleshooting Guides**
- **Summary**

The operating principles of all generators are basically the same. The key difference is what happens during operation and advantages and/or disadvantages each type of generator has. A service person must thoroughly understand the different principles of operation for each type of generator and know how to check for troubles. They must also know how to make the proper adjustments, replacements or repairs, in a reasonable amount of time. All generators are basically the same in that they must have three main things in order to produce an output voltage, these are:

1. A number of conductors - which is the copper wire coils of the STATOR AND ROTOR.
2. MOTION - which is the rotation in RPM's by use of an engine, either gasoline or diesel.
3. FIELD STRENGTH - which is the initial, residual magnetic field strength and the electro-magnetic field strength during operation.

The generator output voltage is always directly proportional to field strength, speed and number of conductors in the generator stator and rotor windings. In this section the student should learn to understand the principle differences of operation which Onan uses in its marine generators and what adjustments are necessary for proper operation. Troubleshooting guides are included to aid the service personnel in diagnosing field repairs as fast as possible.

GENERATOR THEORY AND OPERATION

All Onan marine generators are either two pole or four pole generators. Some models are inherently regulated and self-excited. Some are statically excited and some of the latest models have brushless excitation. Generator design includes both single and 3-phase, 50 or 60 hertz. The generator rotor connects directly to the engine crankshaft through a tapered shaft and key. The generator is fastened to the engine by the rotor through-stud which passes through the rotor shaft. A centrifugal blower circulates the necessary cooling air for the generator. A ball bearing in the endbell supports the outer end of the rotor shaft. See Table 4-1 for voltage and frequency ranges.

TABLE 4-1. VOLTAGE AND FREQUENCY RANGES

NOMINAL OUTPUT	MAXIMUM VOLTAGE AT NO LOAD	MINIMUM VOLTAGE AT FULL LOAD	PREFERRED DROP NO LOAD TO FULL LOAD	PREFERRED FREQUENCY NO LOAD TO FULL LOAD
120	126	110	122-114	61-59
240	252	228	246-236	61-59
120/240	252	228	246-236	61-59
120/208	218	198	216-200	61-59

GENERATING ELECTRICITY

Basically, the generator is a simple device. A simple generator (Figure 4-1) consists of a coil rotating in a magnetic field. When rotated, voltage is induced into the coil as shown in Figure 4-2. Slip rings connect the coil through brushes to the external circuit. When a load is connected to the generator, a quantity of current will flow depending on generator voltage and load resistance. Each segment of the voltage curve corresponds to a position of the coil in the magnetic field - the highest voltage occurring when the sides of the coil move at right angles to the magnetic flux, the zero voltage when moving parallel to the flux. Voltage reverses twice for each revolution on 1800 rpm units, and once each revolution on 3600 rpm units. This is alternating current (AC) and it has a frequency equal to the number of complete cycles it makes each second.

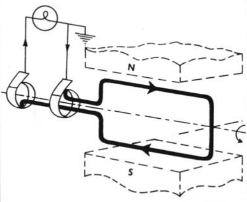


FIGURE 4-1. ALTERNATING CURRENT GENERATOR

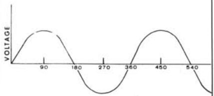


FIGURE 4-2. WAVE FORM OF ALTERNATING CURRENT

It should be noted that the frequency of the alternating current produced depends on the rotating speed of the coil (faster rotation, higher frequency), and the number of poles. The voltage produced depends on the speed of rotation, the number of windings in the coil and the strength of themagnetic field. Changing any one of these changes the output voltage.

With a two-pole revolving armature generator, the rotating coil is the armature, the magnet the field. If two magnets were added (Figure 4-3) the generator would become four-pole, and the AC output frequency would be double that of the two-pole generator operating at the same speed.

Converting the simple AC generator to a direct current generator requires simply adding a commutator to act as a switch. The commutator (Figure 4-4) inverts half of the output voltage by reversing the relationship of the armature and output wires each time the voltage is zero.

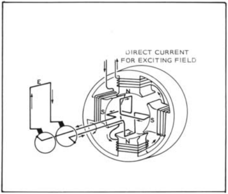


FIGURE 4-3. FOUR POLE AC GENERATOR

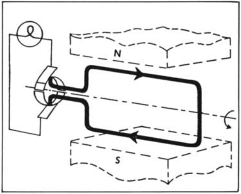


FIGURE 4-4. SIMPLE DIRECT CURRENT GENERATOR

Three types or classes of magnets are natural, permanent and electromagnet. The natural magnet, or lodestone, is a laboratory item that has no use in the electrical generation field.

AC GENERATORS

An AC generator requires direct current for its field by means of an exciter circuit. Means of voltage regulation can vary. The revolving armature generators are inherently regulated by use of field saturation (description following). Revolving field generators are supplied with an exciter which converts AC output to DC and regulates current to the electromagnetic field.

The maximum voltage the generator will produce is determined by field saturation. At this point, further increases in field current will not affect field voltage and will not affect the generator's voltage. This effect is used in all Onan revolving armature generators. The residual magnetism supplies the initial small field of a generator needed to begin voltage buildup during generator starting. Once the generator is turning, a small output voltage is fed back to the field windings to reinforce the field. The reinforced field induces a larger voltage which further reinforces the field. Build-up continues until limited by the generator characteristics.

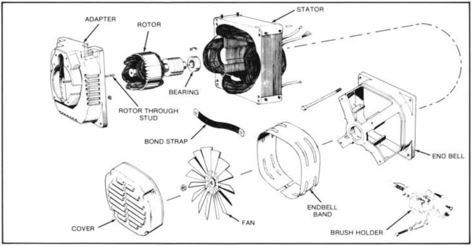


FIGURE 4-5. MCCK SPEC "H", 4 POLE GENERATOR ASSEMBLY

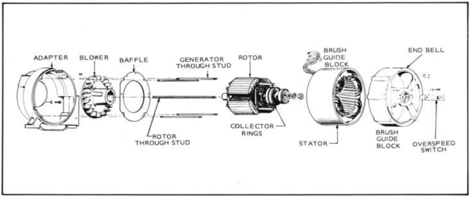


FIGURE 4-6. REVOLVING FIELD GENERATOR ASSEMBLY

REVOLVING FIELD GENERATORS

Suppose instead of turning a coil of wire in the magnetic field, the wire were fixed and the field rotated in the coil. The result is a revolving field generator which produces only alternating current (Figure 4-7). Its revolving field is the rotor and its fixed windings the stator. With this generator, slip rings are not required to transfer power from the stationary armature coils.

The exciter converts AC output to DC and regulates current to the field of the generator. As with the AC revolving armature generator, output frequency depends directly on rotating speed. Voltage output is determined by rotating speed, number of turns in the stator and field strength by controlling field current. See Figure 4-8.

Onan has two basic types of revolving field generators. One is a "Magneciter" generator, which has a static exciter comprised of an AC to DC converter with a magnetic amplifier for voltage regulation. A new brushless "YD" generator has a solid state design. It has a rotating exciter which is mounted directly on the rotor to supply field currents. Automatic field flashing is built into the later models of Onan revolving field generators.

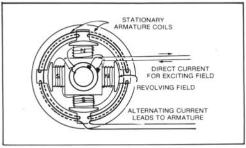


FIGURE 4-7. BRUSH TYPE REVOLVING FIELD GENERATOR

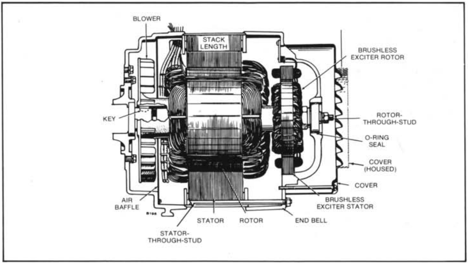


FIGURE 4-8. BRUSHLESS YD GENERATOR - J SERIES (SECTIONAL VIEW)

MAGNECITER GENERATOR THEORY AND OPERATION (J Series Prior to Spec AA)

The Onan magnecitier is an AC to DC converter and voltage regulator combination. It takes current from the revolving field AC generator's output, rectifies it and controls the amount of the resulting DC current allowed to the revolving field.

The circuit in Figure 4-9 is the power supply and produces DC voltage from the generator's AC output. The power supply is a full wave rectifier made up of four rectifiers and supplies DC to the field windings. Some type of control is necessary to regulate the field current. Two gate reactors provide this control (Figure 4-10).

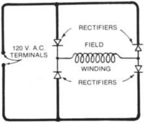


FIGURE 4-9. RECTIFIER POWER SUPPLY

Each gate reactor is a metal, doughnut-shaped core with two windings, an output or gate winding and a control winding. The amount of current the reactor allows to flow in the gate winding depends on the amount of magnetism in the core. With no magnetic flux in the core, the gate reactor allows little current flow. The current flow increases (the gate opens as magnetic flux in the core increases) until the core is saturated. The gate is then all the way open and the reactor does not oppose current flow.

Since the rectifiers allow current in the gate winding to flow in only one direction, this current can act only to magnetize the core. If some means were available to reduce the core's magnetism, this would reduce or control the current flow through the gate winding. That's the purpose of the control windings on each gate reactor. Current flowing in the proper direction in each control winding reduces the total magnetism in the gate reactor core. In this way, the current in the control winding controls the current in the gate winding and therefore, controls the field current and ultimately the generator's output voltage. More demagnetizing current in the control winding means less current in the generator field and a resultant lower output voltage.

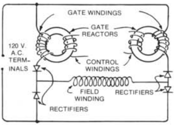


FIGURE 4-10. POWER SUPPLY WITH GATE REACTORS

A voltage regulator has to be used so current in the control winding depends on voltage output of the generator. In order to properly regulate voltage, the regulator should allow little or no current flow in the control windings up to specified output voltage and a large current flow in the control windings above that voltage (circuit shown in Figure 4-11). It draws power from the generators AC output and the rectifiers convert the AC to DC. The control reactor is the voltage sensitive control of the regulator. Below the specified voltage, little current flows through the reactor so little current flows in the the control windings.

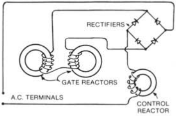


FIGURE 4-11. VOLTAGE REGULATOR CIRCUIT

The gate current is then essentially unchecked. When a voltage high enough to saturate the control reactor core appears in the generator output, the reactor suddenly passes current through the control windings, reducing the current allowed to the field. This reduces the generator's output voltage which in turn reduces the current through the control reactor. The regulator then holds the generator voltage steady at a preset level determined by the control reactor. An adjustable resistor in a voltage-divided circuit with the control reactor allows some adjustment in the output voltage by varying the voltage that appears across the control reactor.

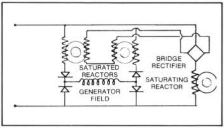


FIGURE 4-12. BASIC MAGNECITER CIRCUIT

This is the basic Magneciter circuit (Figure 4-12). Some minor refinements such as compounding windings (help retain voltage control through load changes) and the control reactor resistor have been added but do not change the basic operating characteristics. Refer to Magneciter Control Service Bulletin #7.

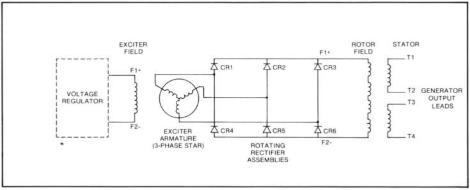


FIGURE 4-13. BRUSHLESS GENERATOR CIRCUIT

YD GENERATORS

The YD generators beginning with Spec AA are four-pole, revolving field, brushless exciter, reconnectible models of drip-proof construction. Generator design includes both single and three-phase, 60 and 50 hertz type generators. The generator rotor connects directly to the engine crankshaft with a tapered shaft and key. The generator is fastened to the engine by the rotor-through-stud which passes through the rotor shaft; it has a nut on the outside of the end bell. A centrifugal blower, on the front end of the rotor shaft, circulates the generator cooling air which is drawn in through the end bell cover and discharged through an outlet at the blower end.

A ball bearing in the end bell supports the outer end of the rotor shaft. The end bell and generator stator housing are attached by four-through-studs which pass through the stator assembly to the engine-generator adapter. The brushless exciter stator mounts in the end bell while the exciter rotor and its rotating rectifier assemblies mount on the generator rotor shaft.

All generators have five wires extending from the stator housing in addition to the AC output leads, Figure 4-14. Lead B2 is from the battery charge winding and connects to terminal 7 of the engine control. Lead F1+ and F2- are from the exciter field winding and are connected to the output terminals of the voltage regulator. Leads 1 and 2 are connected to the stator windings and provide reference voltage and input power to the voltage regulator. These five leads are connected at the factory.

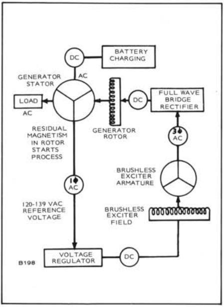


FIGURE 4-15. EXCITATION BLOCK DIAGRAM

Figure 4-14 is a composite illustration showing four output leads for single-phase units, 12 output leads for 3-phase broad range units, and four output leads for code 9X3-phase 347/600 volt generators.

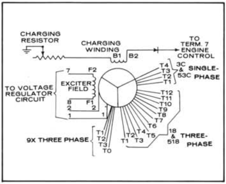


FIGURE 4-14. SINGLE AND THREE PHASE GENERATOR SCHEMATIC (COMPOSITE)

Generator Operation

The basic operation of the generator and voltage regulator involves the stator, voltage regulator, exciter field and armature, a full wave bridge rectifier, and the generator rotor, Figure 4-15. Residual magnetism in the generator rotor and a permanent magnet embedded in one exciter field pole begin the voltage build-up process as the generator set starts running. Single-phase AC voltage, taken from one of the stator windings, is fed to the voltage regulator as a reference voltage for maintaining the generator output voltage. The AC reference voltage is converted to DC by a silicon controlled rectifier bridge on the voltage regulator printed circuit board and fed into the exciter field windings. The exciter armature produces three-phase AC voltage that is converted to DC by the rotating rectifier assembly. The resultant DC voltage excites the generator rotor winding to produce the stator output voltage for the AC load.

The generator rotor also produces AC voltage in the charging winding of the stator which is converted to direct current for battery charging.

GENERATOR ADJUSTMENTS

As a whole there are probably more checks to make in the generator, than there are adjustments in the engine. The spring tension of the brushes should be checked and also the brush block to be sure its tight. A growler can be used to check the armature for shorts. The AC and DC windings of the generator armature can be checked for opens using an ohmmeter. The ohmmeter is also useful for checking both AC and DC grounds. Refer to Onan Generator #9 Service Bulletin for detailed testing procedures using both the ohmmeter or a growler. Sections 2, 3, and 4 of the Onan Master Service Manual (#922-0500) will also aid you in testing all Onan AC generators. An ohmmeter can also be used to check rotor resistance values or shunt field resistance. The lead connections between the brushes themselves and the incoming leads, commonly called pigtails, should also be checked for good contact (Figure 4-16). Continuity tests may be performed without disassembly of the generator.

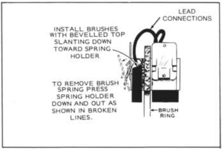


FIGURE 4-16. BRUSH REPLACEMENT

COLLECTOR RINGS

If the collector rings become grooved or out-of-round, or the brush surface becomes pitted or rough so that good brush film cannot be maintained, remove the armature and refinish the collector rings in a lathe. If the commutator appears to be rough or scored, refinish it at the same time. Remove or adequately shield the ball bearing during refinishing. There should be a maximum of .002" run-out of the collector ring when compared to the generator bearing.

COMMUTATOR

The commutator bars wear down with usage so that the mica between them must be undercut. This should be done as soon as the mica on any part of the commutator touches the brushes. A suitable under-cutting tool can be made from a hacksaw blade (Figure 4-17). Avoid damage to the surfaces of the copper bars. Leave no burrs along the edges of the bars. The mica must also be undercut whenever the commutator is refinished.

Any generator repair or adjustment should include a thorough cleaning with air to remove dirt and other fine particles which accumulate over time.

BRUSHES AND SPRINGS

Inspect brushes periodically. Brushes worn to 5/8" should be replaced. Replace springs if damaged or if proper tension is questionable. Rapid brush wear may be caused from high mica between commutator bars, rough commutator or collector rings, or from a deviation from neutral position in the adjustment of the brush rig. Never bend the constant-pressure type spring over the edge of its support.

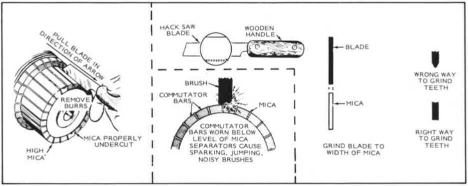
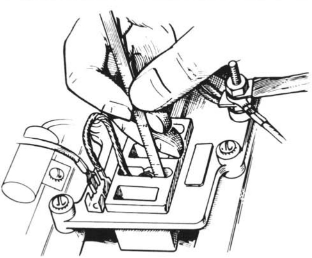


FIGURE 4-17. UNDERCUTTING COMMUTATOR MICA



	DC	AC
NEW	5/8'	11/16"
½ WEAR	13/16"	7/8"
REPLACE	1"	1 1/16"

FIGURE 4-18. CHECKING BRUSH WEAR

TABLE 4-2. DC - EXCITATION VOLTAGES - CLASS "A" MARINE UNITS

MODEL	DC VOLTAGE
2.5MAJ	31
3.5MCCK (Round Gen.)	33
4.0MCCK (Round Gen.)	31.5
6.5MCCK (Round Gen.)	33
4.5MCCK (Square Gen.)	27
6.5MCCK (Square Gen.)	33
4.0 and 6.5 MCCK SPEC "H"	100-110

TROUBLESHOOTING GUIDE
AC REVOLVING ARMATURE GENERATORS

NATURE OF TROUBLE	CAUSE	REMEDY
AC slip rings shorting.	Conducting dirt, dust, grease, or oil shorting out the slip rings.	Clean slip rings with approved solvent.
AC armature short circuit	Insulation or coils broken down.	Rewind or replace.
AC armature open circuit	Rough usage or original short circuit which may have burned a coil or connection.	Test with an ohmmeter and if open replace or rewind the armature.
Incomplete circuit from AC armature to load	Insulating film on slip rings.	Clean slip rings with commutator stone or fine sandpaper and blow out dust. DO NOT USE EMERY CLOTH.
	Slip ring brushes not contacting the slip rings.	Replace brush spring which may have broken or come off or replace brushes which may have become worn down too far to contact the slip rings. Make brushes free to move in holders.
	Brush shunt broken.	Check brush shunts with an ohmmeter and replace open brushes and shunts.
	Loose connections at the slip ring brush terminals.	Check and tighten all slip ring brush terminal connections.
Armature short circuit	(a) Carbon dust or other conducting dust between adjacent bars.	(a) Clean the commutator. The presence of this trouble will be shown by flashing of brushes or heating of one or more coils.
	(b) Insulation or coils broken down.	(b) Replace or rewind if insulation is beyond repair.
Armature open circuit.	Rough usage or original short circuit which may have burned a coil or connection.	Test adjacent commutator bars; replace or rewind the armature.
Incomplete circuit from DC armature to shunt field	(a) Insulating film on commutator.	(a) Clean commutator with fine sandpaper or a commutator stone and blow out dust. DO NOT USE EMERY CLOTH.

TROUBLESHOOTING GUIDE
AC REVOLVING ARMATURE GENERATORS (Continued)

NATURE OF TROUBLE	CAUSE	REMEDY
Incomplete circuit from DC armature to shunt field.	(b) DC commutator brushes not contacting the commutator.	(b) Replace brush spring which may have broken or come off; replace brushes which may have become worn down too far to make contact. Make brushes free to move in holder.
	(c) Brush leads broken due to vibration.	(c) Check brush shunts with an ohmmeter and replace defective brushes and leads.
	(d) Loose connections at the brush terminals.	(d) Check and tighten all brush terminal connections.
	(e) Open circuit in shunt field coil leads.	(e) Check leads with an ohmmeter and repair as needed.
	(f) Open circuit in rheostat or voltage regulator resistance is high.	(f) Check rheostat or regulator with an ohmmeter and repair as needed.
Short circuit in field	Dampness or deteriorated insulation.	Bake if damp, repair or replace if insulation is deteriorated.
Open circuit in field	Rough usage or original short circuit which may have burned a coil or connection.	Examine field connections and test with an ohmmeter. If a coil is open, replace it.
MCCK SPEC "H" (Additional Troubleshooting)		
No generator output or low output.	Defective shunt field bridge rectifier CR1.	Check bridge rectifier with an ohmmeter. Replace if open or shorted. Check for component short to ground in "run ignition" circuit (R1, K3, S3, K4).
	AC components as listed above and preceding page.	See accompanying AC remedies listed above and preceding page.
No battery charger output (1 amp. normal).	Diode CR2 bad.	Check diode with an ohmmeter and replace if open or shorted.
	Open component in charging circuit.	Check fuse F3 (3A), R4 (7.5 Ω), choke heater E5 (40 Ω), resistor R2 (25 Ω).

TROUBLESHOOTING GUIDE
AC REVOLVING FIELD GENERATORS

NATURE OF TROUBLE	CAUSE	REMEDY
Incomplete circuit between exciter and slip rings.	Slip ring brush shunt broken.	Check all slip ring brush shunts with an ohmmeter and replace broken brush shunts.
	Slip ring brushes not contacting the slip rings.	Replace slip ring brush spring which may have come off or broken; or replace brushes which may have become worn down to far to contact the slip rings.
	Insulating film on slip rings.	Clean slip rings with stone or fine sandpaper and blow out dust. DO NOT USE EMERY CLOTH.
	Open circuit in rheostat or voltage regulator resistance is high.	Check rheostat or regulator with ohmmeter and repair or replace.
Revolving field windings shorts.	Insulation or coils broken.	Rewind or replace with new rotor.
Revolving field windings open.	Original short circuit may have burned a coil or connections.	Test with an ohmmeter and if open replace with a new rotor.
AC stator winding shorted.	Insulation or coils broken.	Rewind or replace stator winding.
AC stator winding open.	Original short circuit may have burned a coil or connection.	Test with an ohmmeter and if open rewind or replace with a new stator winding.
Faulty load connections.	Open circuit or short circuit on line.	Check line and load connections and the load.

YD GENERATOR TROUBLESHOOTING

PREPARATION

A few simple checks and a proper troubleshooting procedure can locate the probable source of trouble and cut down troubleshooting time.

1. Check all modifications, repairs, replacements performed since last satisfactory operation of set to be sure that connection of generator leads are correct. A loose wire connection, overlooked when installing a replacement part could cause problems. An incorrect connection, an opened circuit breaker, or a loose plug-in printed circuit board are all potential malfunction areas to be eliminated by a visual check.
2. Unless absolutely sure that panel instruments are accurate, use portable test meters for troubleshooting.
3. Visually inspect components on VR21. Look for dirt, dust, or moisture and cracks in the printed solder conductors. Burned resistors, arcing tracks are all identifiable. Do not mark on printed circuit boards with a pencil. Graphite lines are conductive and can cause short circuits between components.

The question and answer troubleshooting guide which follows, gives a step-by-step procedure for checking the generator components. Refer to Figure 4-19 for an electrical schematic of the generator and voltage regulator connections.

TROUBLESHOOTING PROCEDURES

This troubleshooting information is divided into tables, A, B, C, and D as follows:

A. No build up of AC output voltage.
B. AC output voltage builds up, but is unstable.
C. AC output voltage builds up, but is high or low.
D. AC output voltage builds up, but field breaker trips.

To correct a problem, answer the question of the step either YES or NO. Then refer to the step number in the answer column and proceed to that step next.

Letters A through P in the Test Procedure column refer to detailed procedures in the Adjustments and Tests, pages 94 to 101.

TABLE A. No Build Up of AC Output Voltage	Yes	No	Test Proc.
1. Is Field Breaker CB21 on control panel ON?	2	3	
2. Connect jumper wire across terminals of Field Breaker, CB21. Does AC output voltage build up? If voltage builds up REPLACE FIELD BREAKER.	—	4	
3. Push to reset Field Breaker. Does AC output voltage build up? If voltage builds up but is high, low, unstable, or causes tripping of Field Breaker, refer to Tables B, C, or D.	—	4	
4. Disconnect alternator stator leads 1 & 2 from TB21-1 and TB21-2 on VR22. Is reference voltage across 1 & 2 20 VAC or more?	14	13	

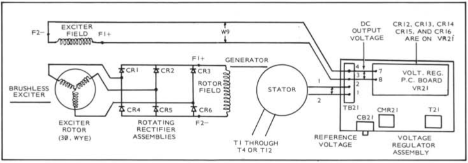


FIGURE 4-19 GENERATOR-REGULATOR ELECTRICAL SCHEMATIC

TABLE A. (continued)	Yes	No	Test Proc.
5. Is exciter field voltage across F1+ and F2− on endbell terminal block 7.0 VDC or more? If not, check wiring harness W9 from end bell to VR22 terminals 3 and 4.	6	—	
6. Is brushless exciter stator (field) winding OK?	7	—	K
7. Are diodes CR1, CR2, CR3, CR4, CR5, CR6 in rotating rectifier assemblies OK? Check all diodes - more than one may be defective.	8	—	F
8. Are brushless exciter rotor windings OK?	9	—	L
9. Is generator rotor field winding OK?	10	—	M
10. Are generator stator windings OK?	11	—	N
11. Is commutating reactor CMR21 OK?	12	—	I
12. Is reference transformer T21 OK?	18	—	J
13. Flash exciter field. Is reference voltage across 1 and 2 now 20 VAC or more?	14	5	E
14. Reconnect generator leads 1 & 2 to TB21-1 and TB21-2 on VR22. Does reference voltage build up?	—	15	
15. Is regulator DC output voltage across VR21-7 and VR21-8 7 VDC or more? See Figure 4-19.	5	16	
16. Are SCR's CR13 and CR16 OK?	17	—	H
17. Are diodes CR12, CR14, and CR15 OK?	18	—	G
18. Replace voltage regulator PC board (VR21)	—	—	P

TABLE B. AC Output Voltage Builds Up, But Is Unstable	Yes	No	Test Proc.
1. Are there any loose or broken wires or connections on voltage regulator assembly VR22?	—	2	
2. Is W9 (exciter field) wiring harness from VR22 to End bell OK?	3	—	
3. Does adjustment of Damping Control R27 potentiometer on VR21 result in stable voltage?	—	4	A
4. Replace PC Board VR21.	—	—	P

CAUTION Do not replace the printed circuit board until the trouble not on the PC board has been located and corrected to avoid damage to new PC board.

TABLE C. AC Output Voltage Builds Up, But is High or Low	Yes	No	Test Proc.
1. Is set running at correct RPM? (See appropriate engine manual to set RPM)	2	—	
2. Does adjustment of Voltage Adjusting knob for R22 on VR22 result in correct output voltage?	—	3	A
3. Does adjustment of potentiometer R26 on VR21 result in correct output voltage?	—	4	A
4. Is correct voltage reference V4 to V1, V2, or V3 on VR21 being used? Refer to Figure 4-33.	5	—	
5. Are generator stator leads properly connected? Refer to Figure 4-33.	6	—	
6. Replace voltage regulator, PC board VR21	—	—	P

CAUTION Do not replace the printed circuit board until the trouble not on the PC board has been located and corrected to avoid damage to new PC board.

TABLE D. AC Output Voltage Builds Up, But Field Breaker Trips	Yes	No	Test Proc.
1. Does AC output voltage build up to 140% or more of rated voltage before Field Breaker trips?	2	7	—
2. Are there any loose or broken wires or connections on VR22?	—	3	
3. Is diode CR15 on VR21 OK?	4	—	G
4. Are T21 windings and connections OK?	5	—	J
5. Are generator stator leads properly connected? Refer to Figure 4-33.	6	—	—
6. Replace VR21.	—	—	P
7. Are diodes CR1, CR2, CR3, CR4, CR5, CR6 in rotating rectifier assemblies OK? Check all diodes - more than one may be defective.	8	—	F
8. Is brushless exciter stator winding OK?	9	—	K
9. Is generator rotor field winding OK?	10	—	M
10. Is brushless exciter rotor OK?	11	—	L
11. Are generator stator windings OK?	6	—	N

ADJUSTMENTS AND TESTS — REFERENCE LIST,

A. VOLTAGE CALIBRATION ADJUSTMENT
B. VOLTAGE STABILITY ADJUSTMENT
C. BATTERY CHARGE RATE ADJUSTMENT
D. VOLTAGE REGULATOR CHECKOUT
E. FLASHING THE FIELD
F. TESTING ROTATING RECTIFIERS
G. TESTING OUTPUT BRIDGE DIODES
H. TESTING SCR'S
I. TESTING REACTOR
J. TESTING REFERENCE TRANSFORMER
K. TESTING EXCITER STATOR
L. TESTING BRUSHLESS EXCITER ROTOR (ARMATURE)
M. TESTING GENERATOR ROTOR
N. TESTING GENERATOR STATOR
O. WIRING HARNESS CHECK
P. VR21 REPLACEMENT

ADJUSTMENTS AND TESTS

GENERAL

The adjustment and test procedures herein are referenced in the generator troubleshooting tables, pages 87 to 89. The following information is needed by servicemen to effectively service or repair J-series generators beginning with Spec AA.

[A]

VOLTAGE CALIBRATION ADJUSTMENT

The calibration adjustment is made using an accurate AC voltmeter to observe generator output voltage and to set the correct no load voltage. If voltage regulator VR^{21} printed circuit board has been replaced, it may be necessary to make a calibration adjustment. To obtain the correct output voltage, proceed as follows:

1. If set has a voltage adjust potentiometer (R^{22}) on the meter panel, set pointer halfway between minimum and maximum positions.
2. With unit running at no load, turn generator voltage potentiometer R^{26} on VR^{21} (Figure 4-20) clockwise to increase output voltage; turn R^{26} counterclockwise to decrease output voltage.

[B]

VOLTAGE STABILITY ADJUSTMENT

Voltage stability is set at the factory, but if printed circuit board VR^{21} has been replaced or if damping potentiometer R^{27} has been unnecessarily adjusted it may be necessary to reset stability. Set stability as follows:

1. With generator set running at no load, turn potentiometer R^{27} (Figure 4-20) to a position where voltage tends to be unstable or hunt.
2. Turn R^{27} clockwise slowly until voltage first stabilizes. This setting will result in stable voltage under all conditions in maximum voltage regulator response time.

[C]

BATTERY CHARGE RATE ADJUSTMENT

One generator winding supplies current for the battery charging circuit. The current flows to diode CR^{11}, ammeter M^{11}, to the battery, and to the ignition-fuel solenoids circuits, Figure 4-14.

1. The slide tap on adjustable resistor R^{21}, located in the generator air outlet, should be set to give about 2 amperes charging rate, Figure 4-34. For applications requiring frequent starts, check battery charge condition (specific gravity) periodically and if necessary, increase charging rate slightly (slide tap nearer ungrounded lead) until it keeps battery charged. Having engine stopped when readjusting avoids accidental shorts. Avoid overcharging.
2. If charge winding AC output is below:
   a. 19 volts on 12 volt battery charge models,
   b. 38 volts on 24 volt battery charge models,
   c. 50 volts on 32 volt battery charge models,

   test the charging circuit for opens or grounds in the leads and charging winding. If leads are defective, replace them. If winding is defective, replace generator stator. The charge winding resistance is 0.11 ohm.
3. If a separate automatic demand control for starting and stopping is used, adjust charge rate for maximum 4.5 amperes. This normally keeps battery charged even if starts occur as often as 15 minutes apart.

[D]

VOLTAGE REGULATOR CHECKOUT

The solid state voltage regulators (VR^{21}) can be checked out on the bench for proper operation or location of faulty components. The following test equipment (one-each) is required for a proper checkout.

REF. DESIGNATION	TEST EQUIPMENT
S	Switch
CMR21	Reactor
F	Fuse, 5 Amps
T1	Transformer, Variable 2 Amp 0-150V
V2	Voltmeter, DC ± 2% of Full Scale 3, Scale 0-50 and 0-150V and 0-10V
V1	Voltmeter, AC ± 2% @ 10VAC, 1% @ 150V
R1	Resistor, 100-Ohm 400 W
T21	Transformer, Input 315-0386

Transformer T^{21} and reactor CMR^{21} are a part of the voltage regulator assembly (VR^{22} or VR^{23}); these are the only parts obtainable with an Onan part number. The big 100-ohm 400 watt resistor (R^{1}) serves as the field during checkout.

Bench Check:

1. Remove voltage regulator from unit according to procedure given for voltage regulator replacement.
2. Referring to Figure 4-20 and Table 4-3 connect test equipment to the printed circuit board VR^{21} terminals as follows:

CONNECT	FROM	TO
Jumper	VR21-V1	VR21-V4
Jumper	VR21-1	VR21-2
Lead	CMR21-1	VR21-10
Lead	CMR21-4	VR21-9
Lead	T21-X1	VR21-6
Lead	T21-X2	VR21-4
AC Voltmeter	Across	T21-H1 & H2
DC Voltmeter	Across	CR21-7 & 8
VARIAC	Across	T21-H1 (fused) and H2

3. Open switch in 120 VAC supply to VARIAC.
4. Plug VARIAC into 120 VAC source.
5. Proceed with checkout according to steps in Table 1.

[E]

FLASHING THE FIELD

The following procedure is used for momentarily flashing the exciter field with a low voltage which restores the residual magnetism in the alternator rotor. Flashing the field is usually necessary when installing a new brushless exciter stator wound assembly, but seldom is necessary under other circumstances. Always check generator residual voltage at terminals 1 and 2 to be certain whether or not flashing the field is necessary. Generator residual voltage should be at least 20 VAC at rated speed. If residual is too low and the output voltage will not build up, flash the field as follows:

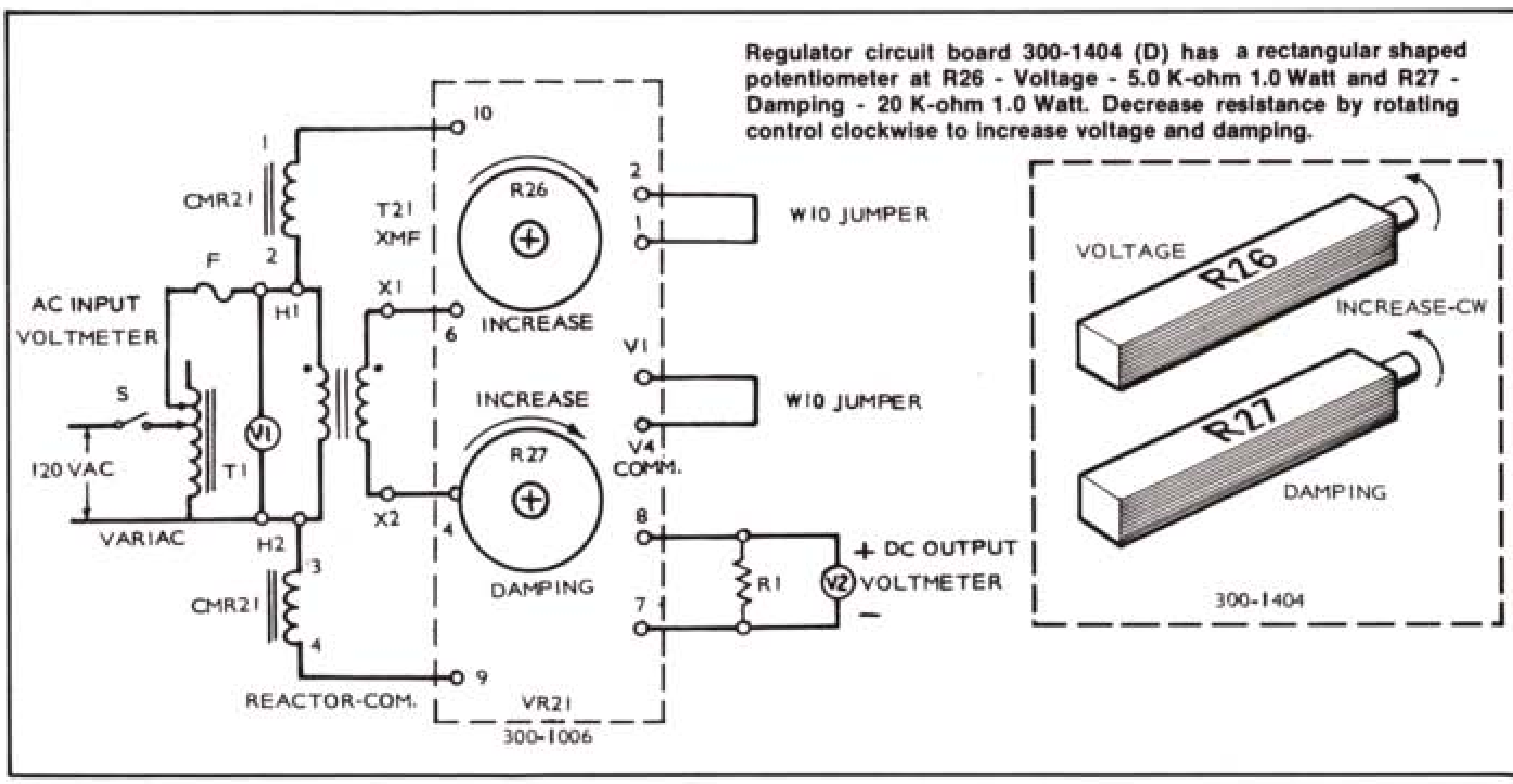
1. Locate terminals 7(–) and 8(+) on voltage

TABLE 4-3. VOLTAGE REGULATOR CHECKOUT

V_1 AC INPUT VOLTAGE
V_2 DC OUTPUT VOLTAGE

(< = LESS THAN) (> = MORE THAN)

STEP NO.	TEST NAME	PROCEDURE	REQUIREMENTS
1	BUILD UP	SET V_1 TO 25 VAC	V_2 SHALL BE $>$ 12 VDC
2	CALIBRATION	SET V_1 TO 120 VAC	SET POT R26 TO HOLD V_2 BETWEEN 50-70 VDC
3	RANGE	A. SET V_1 TO 123 VAC B. SET V_1 TO 125 VAC	V_2 SHALL BE $<$ 30 VDC V_2 SHALL BE $<$ 10 VDC
4	RANGE	A. SET V_1 TO 115 VAC B. SET V_1 TO 117 VAC	V_2 SHALL BE $>$ 85 VDC V_2 SHALL BE $>$ 80 VDC
5	MAX VOLTAGE	SET V_1 TO 140 V	$V_2 <$ 10 VOLTS
6	DAMPING	SET V_1 SO V_2 IS NEAR MAXIMUM RAPIDLY TURN POT R27 FROM FULL COUNTER CLOCKWISE POSITION TO FULL CLOCKWISE POSITION. RETURN R27 TO MIDRANGE POSITION AFTER TEST.	V_2 SHOULD DROP TO $<$ 50 VOLTS THEN RISE TO ORIGINAL VALUE.



Regulator circuit board 300-1404 (D) has a rectangular shaped potentiometer at R26 - Voltage - 5.0 K-ohm 1.0 Watt and R27 - Damping - 20 K-ohm 1.0 Watt. Decrease resistance by rotating control clockwise to increase voltage and damping.

FIGURE 4-20. VOLTAGE REGULATOR CHECKOUT TEST EQUIPMENT CONNECTIONS

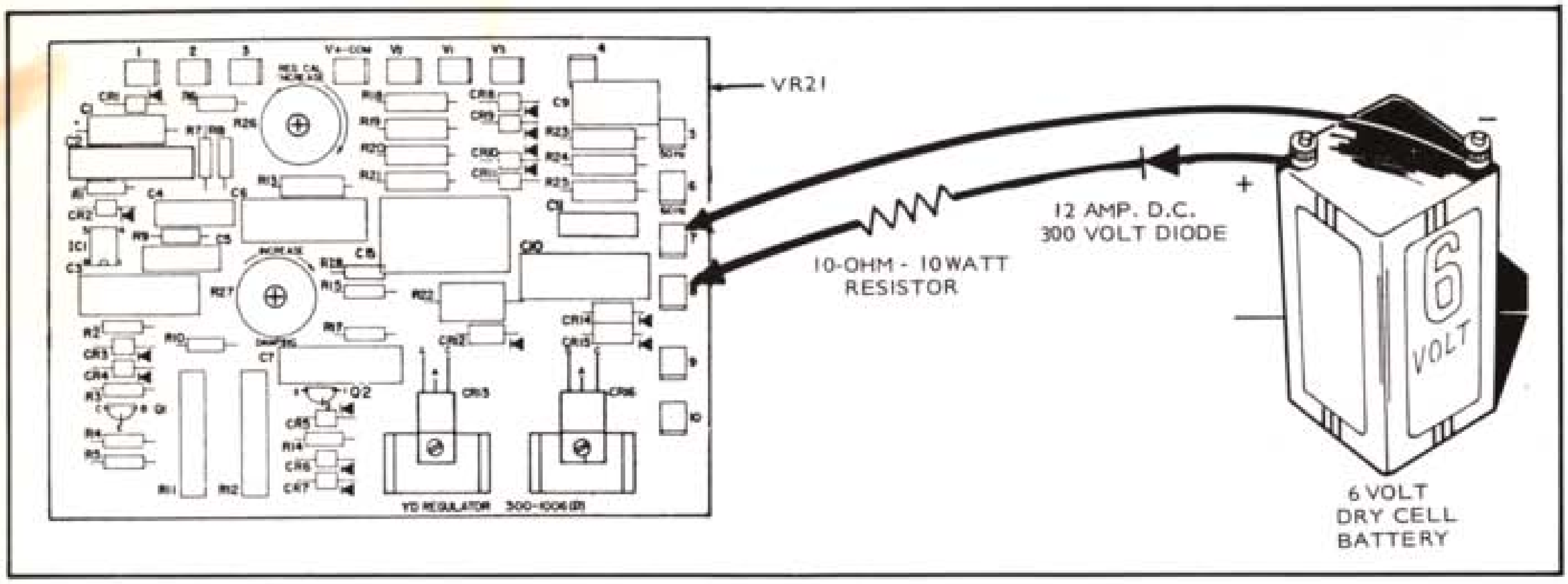


FIGURE 4-21. FLASHING THE FIELD

regulator printed circuit board (VR21).

2. Use a six volt dry cell battery with two clip leads, a 12 amp DC, 300 volt diode, and a 10-ohm resistor as shown in Figure 4-21. If a six volt battery is not available, a 12 volt automotive battery can be used by increasing the 10-ohm resistance to 20-ohms; or a 24 volt automotive battery can be used by increasing the resistance to 40-ohms.

CAUTION **A series resistor MUST be used to protect the meter. Polarity must be observed.**

3. After starting engine, touch positive (+) battery lead to VR21-8 and negative (–) lead to VR21-7, contact terminals just long enough until voltage starts to build up or damage may occur to exciter-regulator system.

WARNING **Be cautious when working on a generator that is running to avoid electrical shocks.**

TEST PROCEDURES

All of the following tests can be performed without disassembly of the generator as shown in the illustrations herein. Use the following test procedures for testing generator components in conjunction with the troubleshooting tables.

[F]

TESTING ROTATING RECTIFIERS

Two different rectifier assemblies make up the rotating rectifier bridge assembly, Figure 4-22. Using an accurate ohmmeter, test CR using negative and positive polarities. Test rectifiers as follows:

1. Disconnect all leads from assembly to be tested.
2. Connect one test lead to F1+ stud and connect other lead to CR1, CR2, and CR3 in turn; record resistance value of each rectifier.
3. Connect one lead to F2– stud and connect other lead to CR3, CR4 and CR5 in turn; record resistance value of each rectifier.
4. Reverse ohmmeter leads from step 2 and record resistance value of each rectifier F1+ to CR1, CR2, and CR3 and F2– to CR4, CR5, and CR6.
5. All three resistance readings should be high in one test and low in the other test. If any reading is high or low in both tests, rectifier assembly is defective.
6. Replace defective rectifier assembly with new, identical part.

Use 24 lbs-in. torque when replacing nuts on F1+ and F2–, CR1, CR2, CR3, CR4, CR5, and CR6.

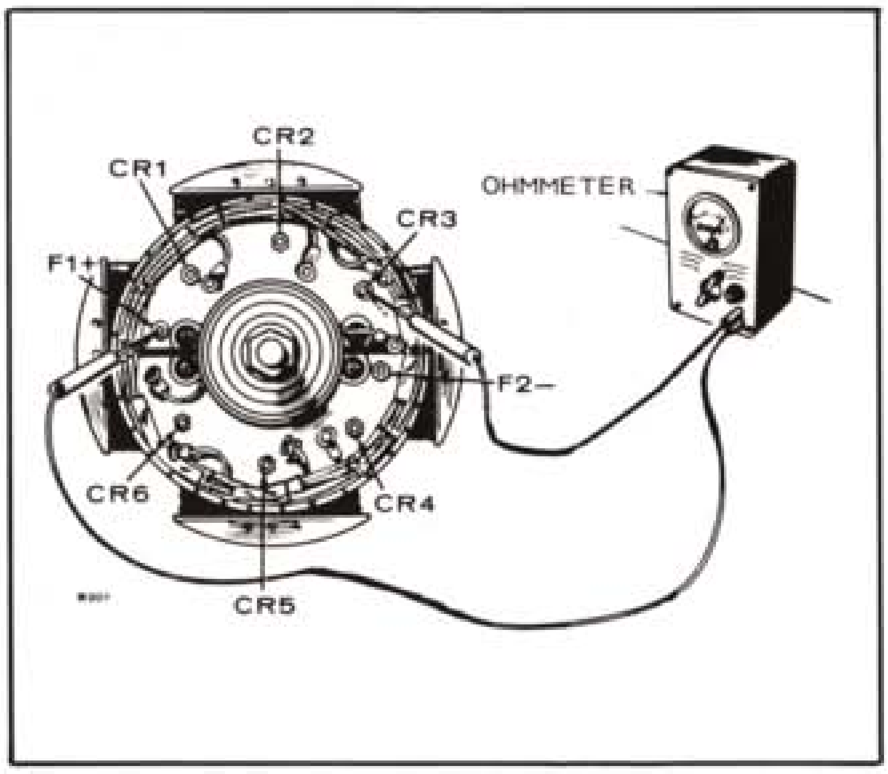


FIGURE 4-22. TESTING ROTATING RECTIFIERS

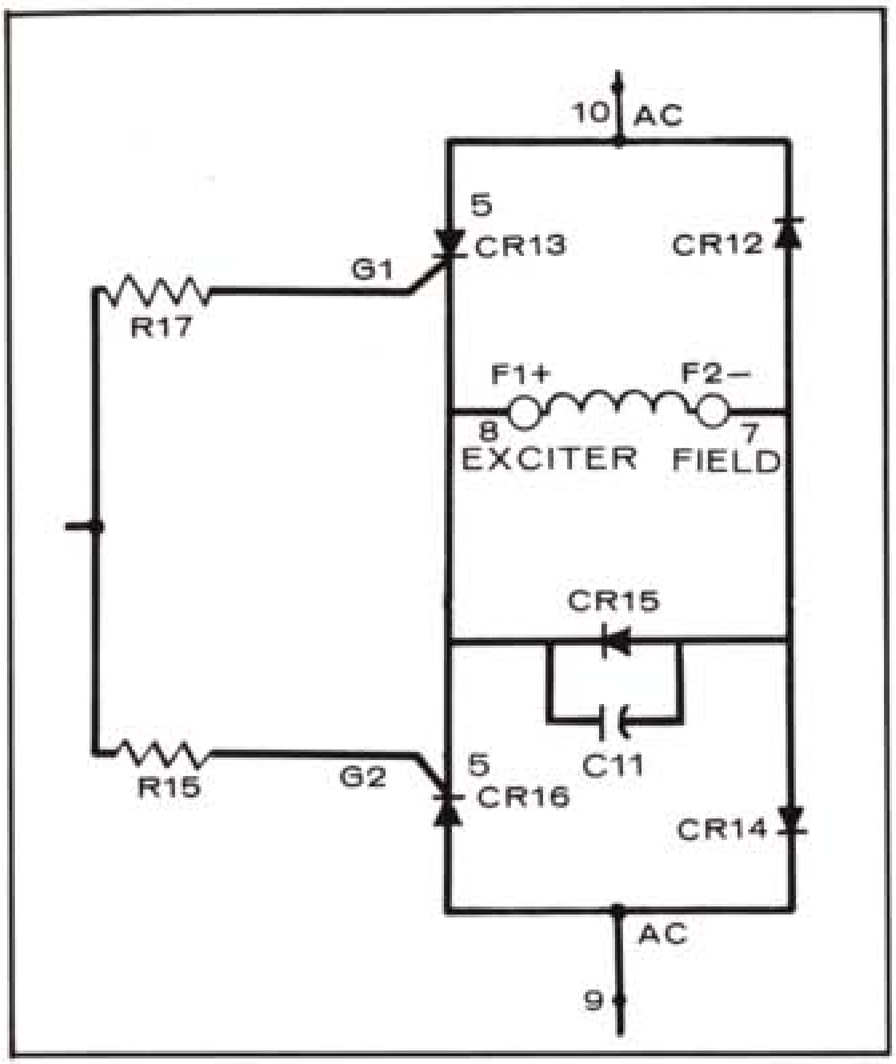


FIGURE 4-23. SILICON CONTROLLED RECTIFIER BRIDGE

[G]

TESTING OUTPUT BRIDGE DIODES

The output bridge rectifier diodes (Figure 4-23), CR^{12}, CR^{14}, and CR^{15}, are located on the voltage regulator printed circuit board. Using an accurate ohmmeter, test diodes CR^{12}, CR^{14}, and CR^{15} as follows:

1. Disconnect at least one lead of diode.
2. Connect one lead to each end of diode and observe resistance reading, Figure 4-24.
3. Reverse ohmmeter leads and again observe resistance readings.

A good diode has a higher reading in one direction than the other. If both readings are high, or low, diode is defective.

4. Replace defective diodes with new, identical parts.

[H]

TESTING SCR'S

Two identical silicon controlled rectifiers (SCR'S), CR^{13} and CR^{16}, control the DC output voltage to the exciter field. These SCR'S are mounted in heat sinks on the voltage regulator and are tested as follows:

1. Unsolder leads from CR^{13} and CR^{16}.
2. Using high scale on ohmmeter, connect ohmmeter leads to anode and cathode of the SCR

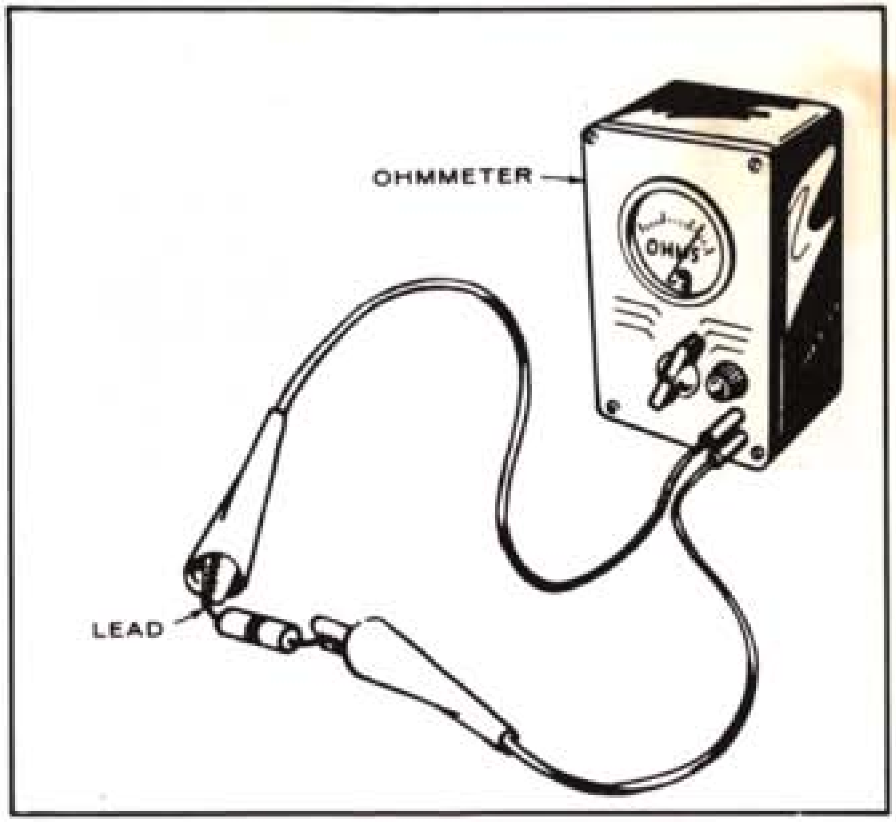


FIGURE 4-25. SCR RESISTANCE TEST

as shown in Figure 4-25. The resistance reading should be one megohm or greater. Reverse ohmmeter leads to anode and cathode; resistance should again be one megohm or greater.

3. Using a 6-volt dry cell battery and a 200-ohm series resistor, observe correct polarity and connect battery leads to anode and cathode as shown in Figure 4-26. Observe polarity and connect a DC voltmeter across the 200 ohm resistor. The voltmeter should now read zero. Jumper anode to gate; voltmeter should now read 6-volts. Remove jumper; voltmeter should still read 6-volts because the SCR remains turned on until voltage is removed from anode to cathode.

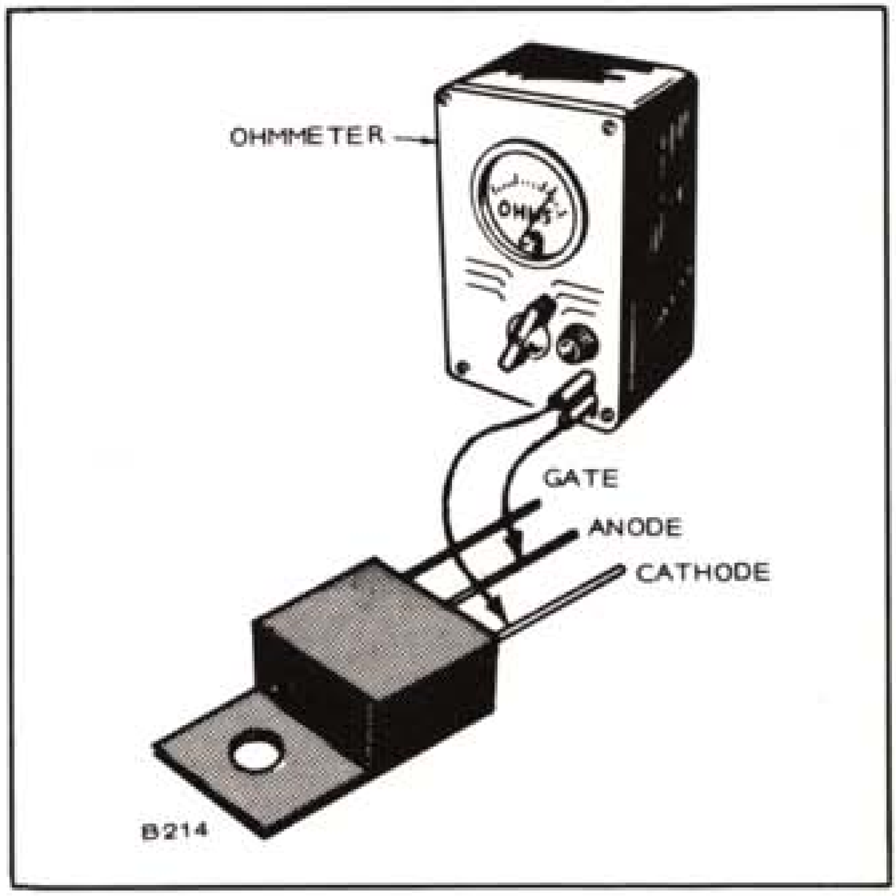


FIGURE 4-24. TESTING DIODES

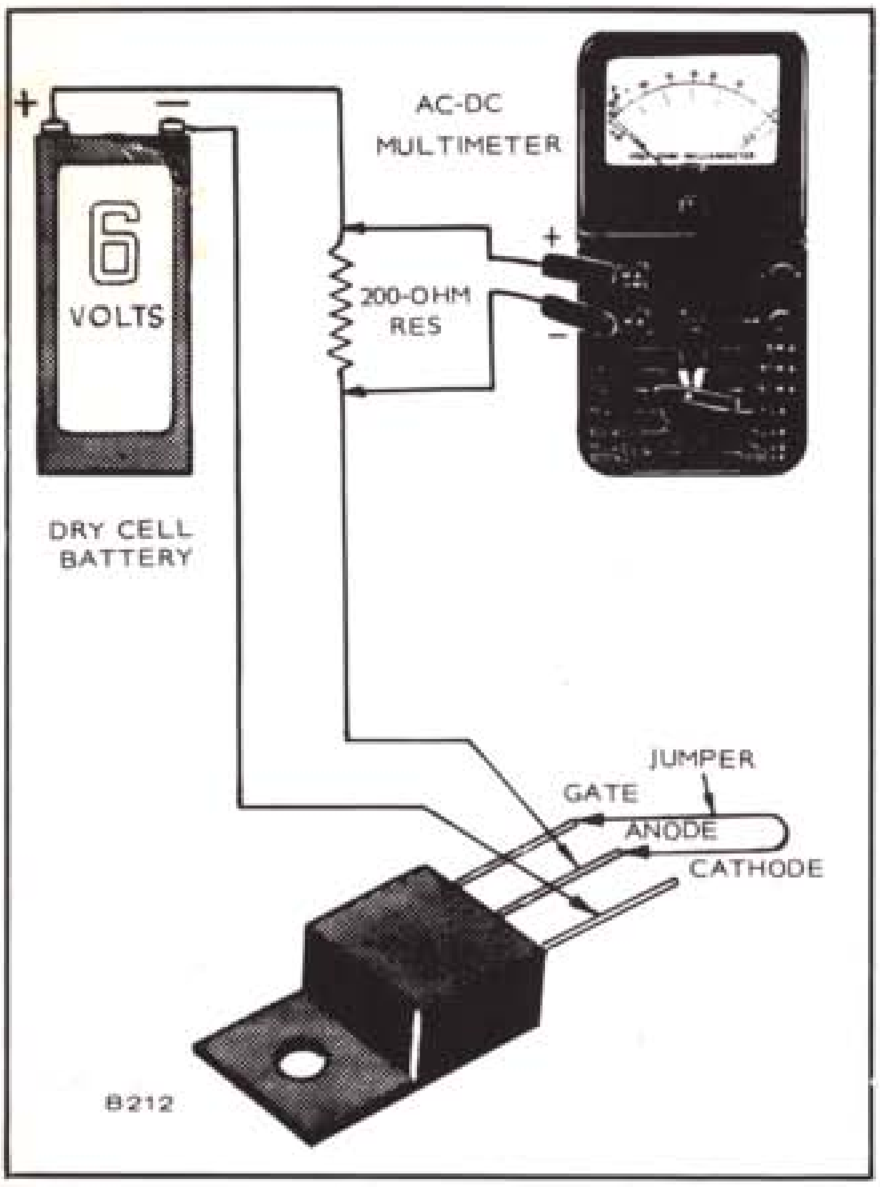


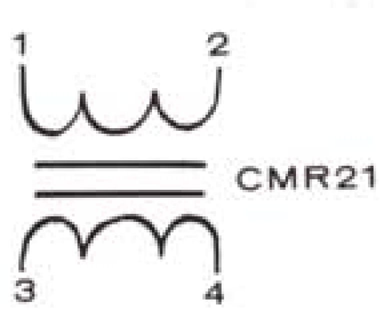
FIGURE 4-26. SCR VOLTAGE TEST

4. If the SCR does not pass either test, it is defective. Replace defective SCR with a new, identical part.

[I]

TESTING REACTOR

The reactor assembly CMR^{21} leads are marked 1, 2, 3 and 4. Wires 1-2 and 3-4 are wound on the same iron core.

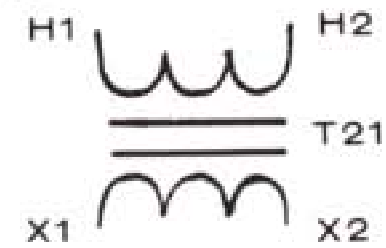


1. Resistance between 1-2 and 3-4 should be about 0.4-ohms.
2. Resistance between 1-3, 2-3, 1-4, or 2-4 should be infinity (∞).
3. Resistance from any terminal to reactor frame should be infinity.
4. If any of the above conditions are not met, install a new reactor.

[J]

TESTING REFERENCE TRANSFORMER

The transformer T^{21} has four leads marked H^1, H^2, X^1, and X^2. H^1-H^2 are the primary leads. X^1-X^2 are the secondary leads.



1. Resistance between H^1-H^2 should be 122 to 150-ohms.
2. Resistance between X^1-X^2 should be 157 to 192-ohms.
3. Resistance between H^1-X^1, H^1-X^2, H^2-X^1 and H^2-X^2 should be infinity.
4. Resistance from any terminal to transformer frame should be infinity.
5. If any of the above conditions are not met, install a new reference transformer.

[K]

TESTING BRUSHLESS EXCITER STATOR

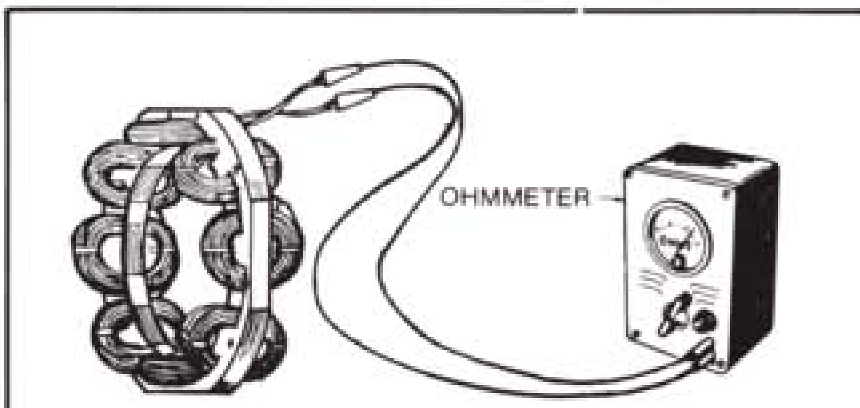
Like the generator, the brushless exciter stator (Figure 4-27) can be tested for open or shorted windings and grounds.

Testing for Open or Shorted Windings:

Disconnect F^1+ and F^2- exciter field leads from terminal block in generator end bell. The resistance between field leads should be 11 to 13.4-ohms at 68° F.(20° C)

Testing for Grounds:

Connect ohmmeter between either field lead and exciter stator laminations. Use ohmmeter set at RX 100 scale. An ohmmeter reading of less than infinity (∞) indicates defective ground insulation.



OHMMETER RESISTANCE BETWEEN F1 AND F2 SHOULD BE 11 to 13.4 OHMS AT 68° F (20° C).

FIGURE 4-27. TESTING EXCITER FIELD

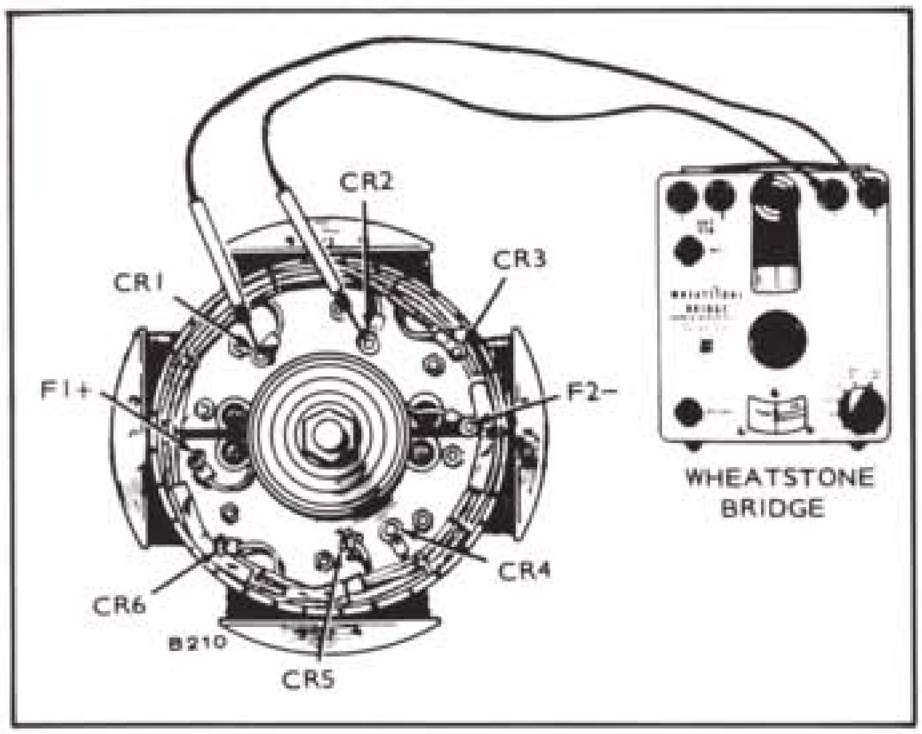


FIGURE 4-28. TESTING EXCITER ARMATURE

[L]

TESTING BRUSHLESS EXCITER ROTOR (ARMATURE)

The brushless exciter rotor (Figure 4-28), can be tested for open or shorted windings or grounds.

Testing for Open or Shorted Windings:

Use a Wheatstone Bridge for this test. Disconnect main rotor field leads which connect to rotating rectifier assemblies at F^1+ and F^2–. Disconnect lead wires from diodes CR^1, CR^2, CR^3, CR^4, CR^5 and CR^6. Test between exciter lead pairs T^1-T^2, T^2-T^3 and T^1-T^3. Resistance should be 0.5 to 0.6 ohms at 68° F (20° C).

Testing for Grounds:

Connect leads of ohmmeter between each CR lead and exciter rotor laminations; use RX 100 scale on ohmmeter. An ohmmeter reading less than infinity (∞) indicates defective ground insulation.

[M]

TESTING GENERATOR ROTOR

For these tests, use an ohmmeter on RX 100 scale.

Testing for Grounds:

On brushless type generators, check for grounds between each rotor lead and the rotor shaft, Figure 4-29. Perform tests as follows:

1. Remove rotor leads F^1+ and F^2– from rotating rectifier assemblies.
2. Connect ohmmeter leads between F^1+ and rotor shaft and between F^2– and rotor shaft. Meter should not register.
3. If meter registers, rotor is grounded.
4. Replace grounded rotor with new, identical part.

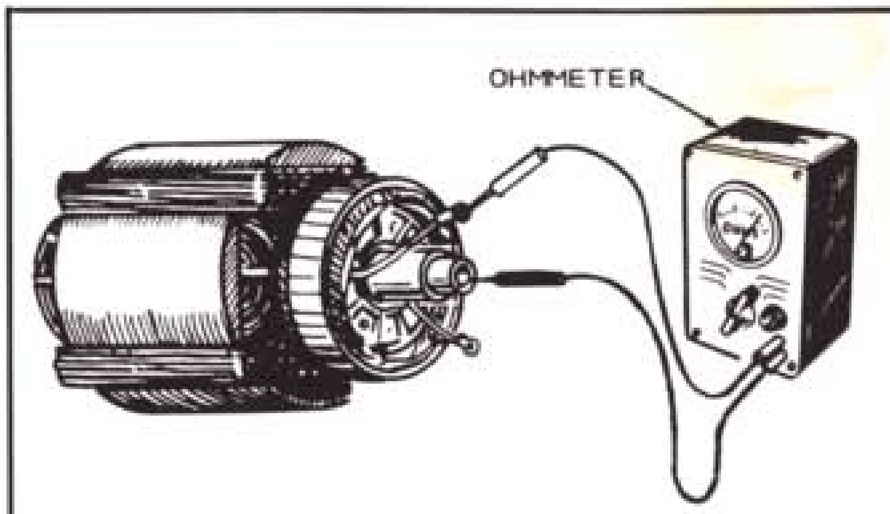


FIGURE 4-29. TESTING ROTOR FOR GROUNDS

Testing for Open or Shorted Winding:

All resistance values should be within ± 10% of values specified in Table 4-4 at 68° F (20° C). Perform tests as follows:

1. Remove rotor leads F^1+ and F^2- from rotating rectifier assemblies.
2. Using ohmmeter, check resistance between F^1 and F^2 leads, Figure 4-30. See Table 4-4 for proper resistance values.

If resistance is low, there are shorted turns. If resistance is high, rotor winding is open. In either case, rotor must be replaced.

3. Replace defective rotor with new, identical part.

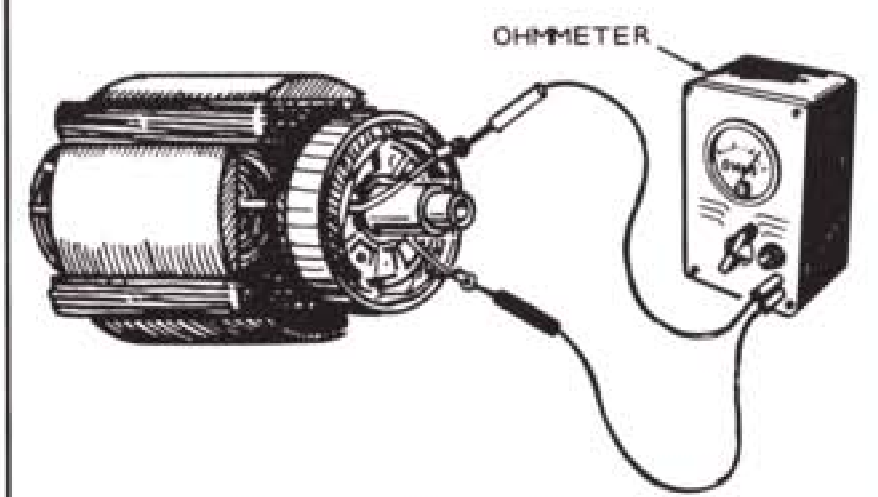


FIGURE 4-30. TESTING ROTOR FOR AN OPEN CIRCUIT

TABLE 4-4. RESISTANCE VALUES FOR ROTORS

KW RATING AND MODEL		RESISTANCE
50 HERTZ	60 HERTZ	OHMS @ 77°F (25°C)
6.0 MDJE	7.5 MDJE	2.76 - 2.82
—	10.0 MJC	2.05 - 2.09
10.0 MDJC	12.0 MDJC	2.30 - 2.35
—	15.0 MJC	2.50 - 2.55
12.0 MDJF	15.0 MDJF	2.50 - 2.55

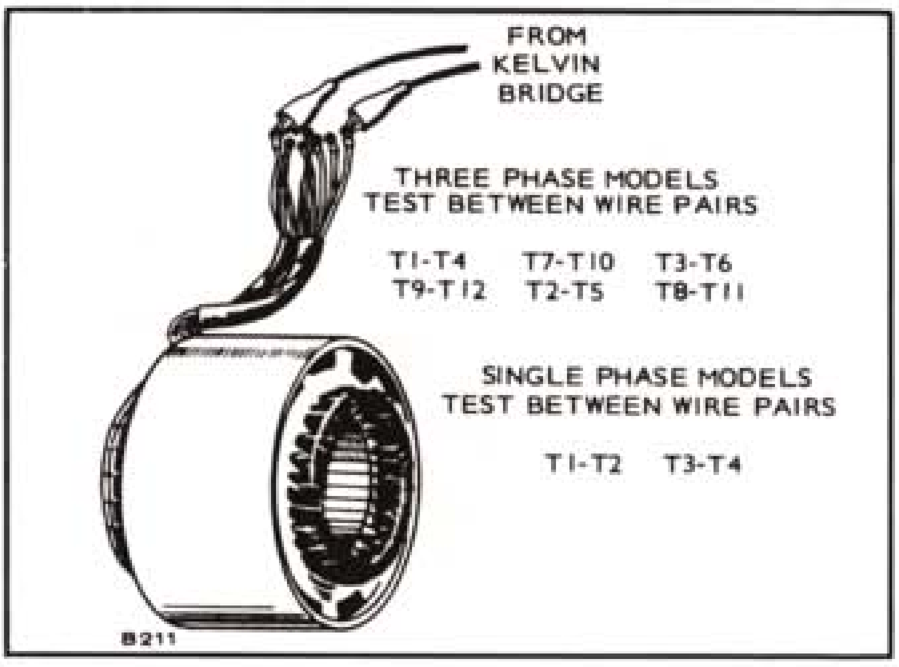


FIGURE 4-31. TESTING STATOR WINDINGS

[N]

TESTING GENERATOR STATOR

Using proper test equipment, check the stator for grounds, opens, and shorts in the windings.

Testing for Grounds:

Some generators have ground connections to the frame. Check wiring diagram.

Using an ohmmeter set on high scale, test each stator winding for shorts to laminations. A reading less than one megohm indicates a ground.

Testing for Open or Shorted Windings:

Test for continuity between coil leads shown in Figure 4-31; all pairs should have equal resistance. Use an accurate instrument for this test such as a Kelvin Bridge. The proper resistance values are given in Table 4-5 according to kW ratings and voltage codes. All resistances should be ± 10% of value shown at 68° F (20° C).

If any windings are shorted, open or grounded, replace the stator assembly. Before replacing the assembly, check the leads for broken wires or insulation.

[O]

WIRING HARNESS CHECK

Carefully check wiring harnesses as follows:

1. Inspect all wires for breaks, loose connections, and reversed connections. Refer to applicable wiring diagram.

TABLE 4-5. RESISTANCE VALUES FOR STATORS

KW RATING AND MODEL		VOLTAGE CODE			
50 Hertz	60 Hertz	18	518	3C	53C
6.0 MDJE	7.5 MDJE	.460	.498	.224	.294
6.0 MDJF	7.5 MDJF	.460	.498	.224	.294
	10.0 MJC	.340	—	.172	—
10.0 MDJC	12.0 MDJC	.303	.260	.120	.153
	15.0 MJC	.220	—	.087	—
12.0 MDJF	15.0 MDJF	.220	.198	.087	.110

2. Remove wires from terminals at each end and using an ohmmeter, check each wire end to end for continuity or opens.
3. Using an ohmmeter, check each wire against each of the other wires for possible shorts or insulation breaks under areas covered by wrapping material.
4. Reconnect or replace wires according to applicable wiring diagram.

[P]

VR21 REPLACEMENT

Use the following procedure for replacing the voltage regulator PC board.

1. Stop engine.
2. Disconnect and if necessary, label the following wires: 3, 4, 5 or 6, 7, 8, 9, and 10.
3. Remove four screws at corners (Figure 4-32).
4. Remove used PC board.
5. Install new PC board; secure with four screws.
6. Reconnect wires removed in step 2 at the proper terminals.
7. Place jumper W10 at proper terminals for your particular voltage code and voltage connection. See Figure 6.
8. Perform voltage calibration and stability adjustment procedures to obtain the correct generator output voltage and stability with new PC board in set.

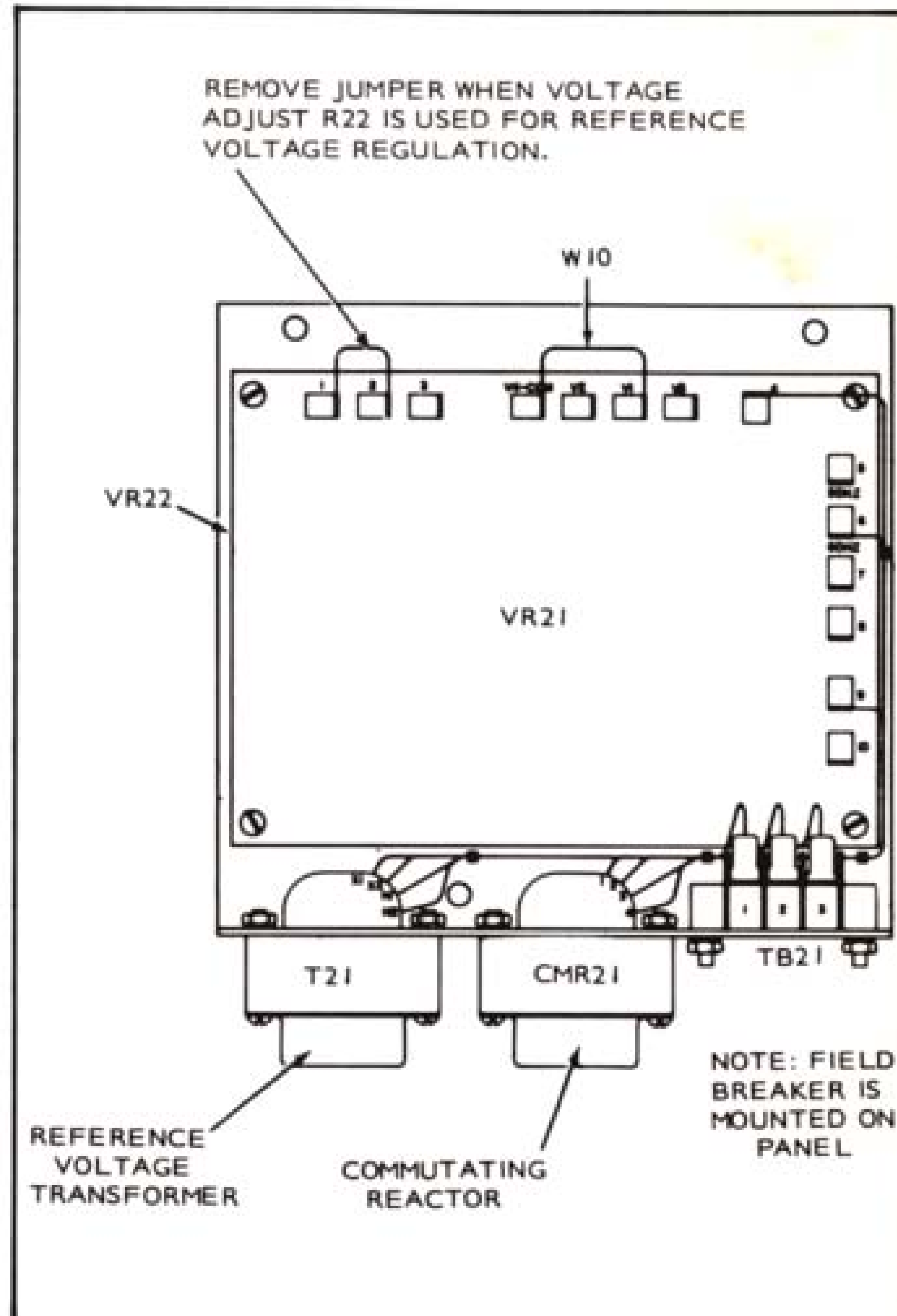


FIGURE 4-32. PC BOARD MOUNTING

NOTE ★: When instructed to connect V4 to V4, either remove V4 jumper or insulate one end and leave unconnected.

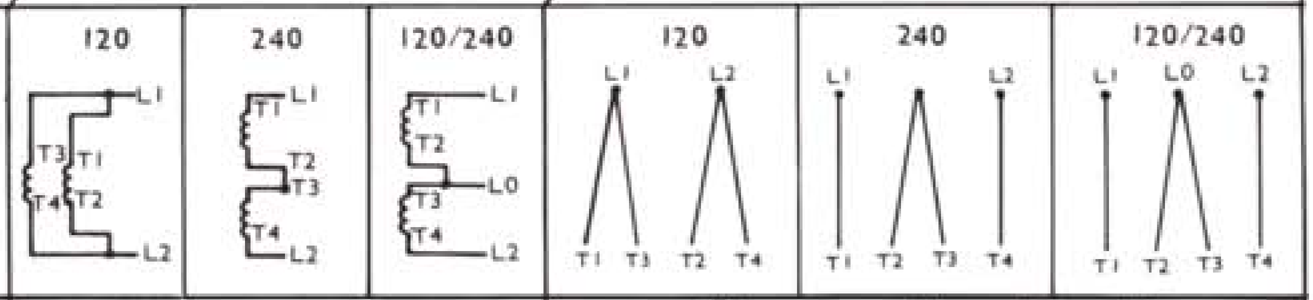
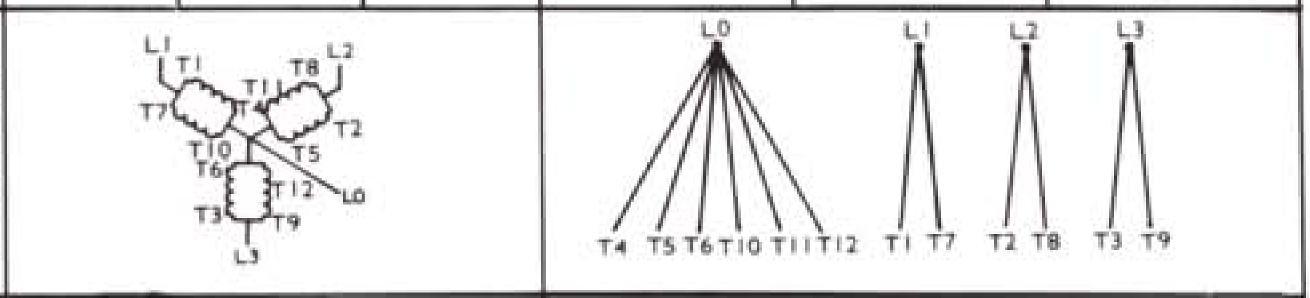
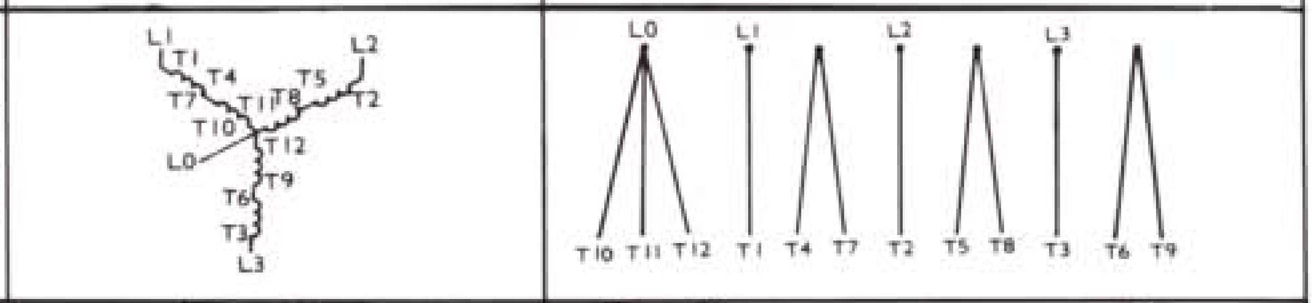
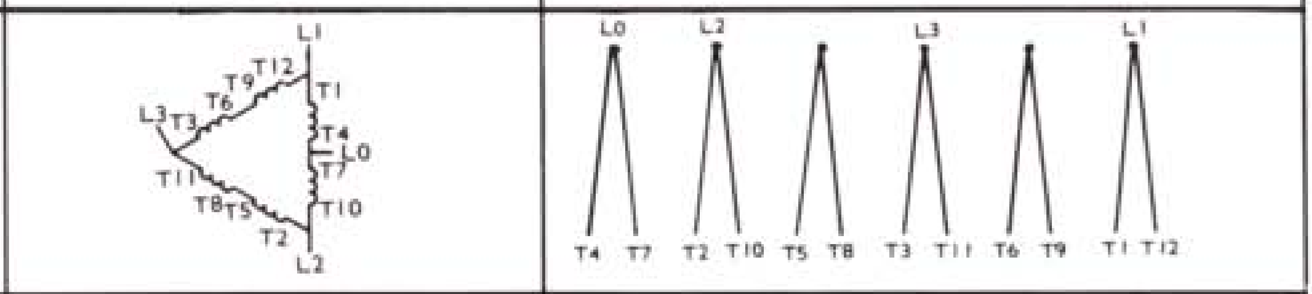
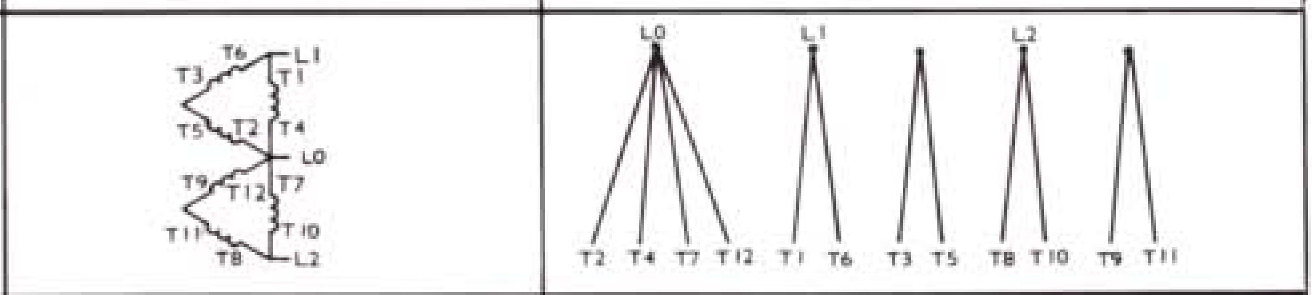
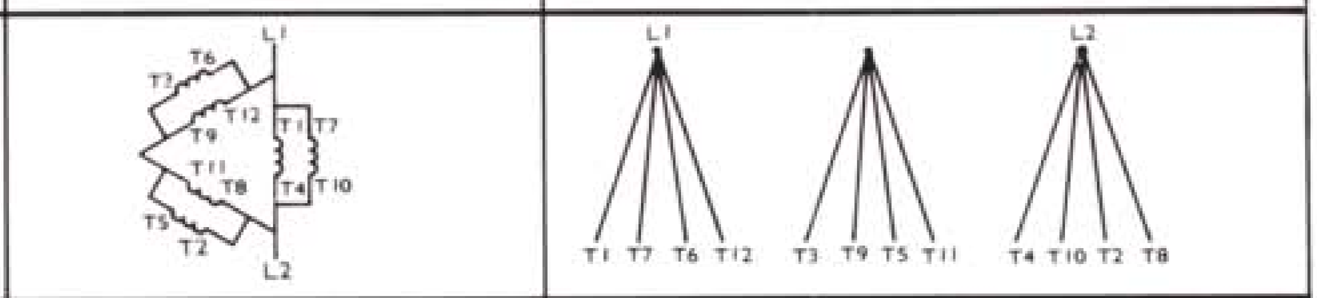
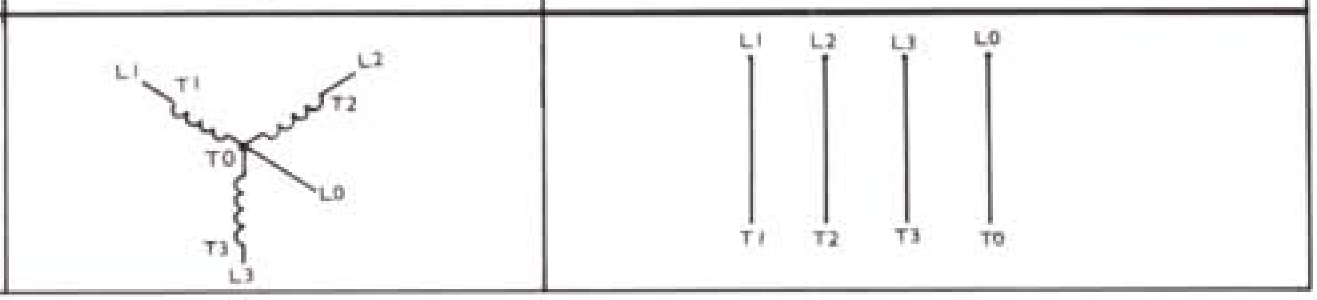
NAMEPLATE VOLTAGE CODE	VOLTAGE	PHASE	FREQUENCY	CONNECT W10 JUMPER WIRE FROM V4 TO:	GENERATOR CONNECTION	GENERATOR CONNECTION SCHEMATIC DIAGRAM / LOAD TO GENERATOR CONNECTION WIRING DIAGRAM (CONNECT X1 TO VR21-5 FOR 50HERTZ: CONNECT X1 TO VR21-6 FOR 60 HERTZ GENERATORS.)
3C	120/240	1	60	V1		
53C	120/240	1	50	V3		
	115/230	1	50	V2		
	110/220	1	50	V1		
18	120/208	3	60	V1	PARALLEL WYE	
	127/220	3	60	V2		
	139/240	3	60	V4 ★		
518	110/190	3	50	V1		
	115/200	3	50	V2		
	120/208	3	50	V3		
	127/220	3	50	V4 ★		
18	240/416	3	60	V1	SERIES WYE	
	254/440	3	60	V2		
	277/480	3	60	V4		
518	220/380	3	50	V1		
	230/400	3	50	V2		
	240/416	3	50	V3		
	254/440	3	50	V4 ★		
18	120/240	3	60	V1	SERIES DELTA	
518	110/220	3	50	V1		
	115/230	3	50	V2		
	120/240	3	50	V3		
18	120/240	1	60	V1	DOUBLE DELTA	
518	110/220	1	50	V1		
	115/230	1	50	V2		
	120/240	1	50	V3		
18	120	1	60	V1	PARALLEL DELTA	
518	110	1	50	V1		
	115	1	50	V2		
	120	1	50	V3		
9X	347/600	3	60	V4 ★	WYE	

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FIGURE 4-33. GENERATOR WIRING AND RECONNECTION DIAGRAMS

GENERATOR DISASSEMBLY

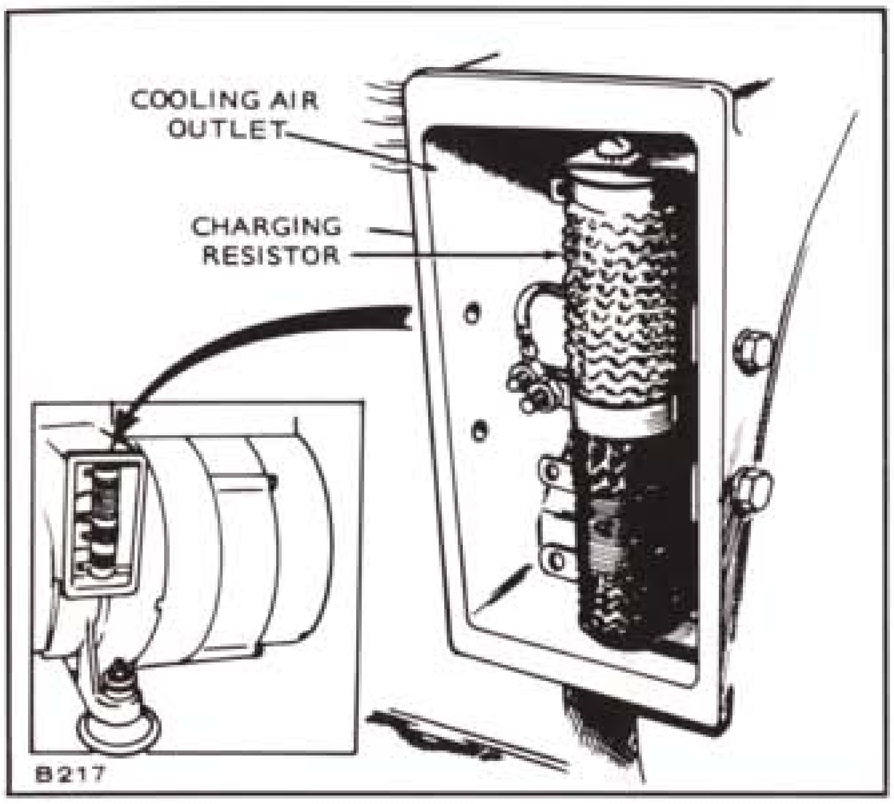


FIGURE 4-34. GENERATOR AIR OUTLET

GENERATOR DISASSEMBLY

1. Disconnect battery to prevent accidental starting of engine.
2. Remove end bell cover to reveal rotor-through-stud nut.
3. Remove B[1] lead from tapped adjustable resistor in generator air outlet opening, Figure 4-34.
4. Remove leads from control box to ignition system, choke, start disconnect switch, etc. on engine.
5. Remove stator-through-stud nuts, end bell, and stator assembly, Figure 4-35. Screwdriver slots in adapter provide a means for prying stator loose. Be careful not to let stator touch or drag on rotor.
6. Remove baffle ring from adapter. Turn rotor-through-stud nut to end of stud. While pulling rotor outward with one hand, strike nut a sharp blow. Support rotor with hoist and sling to avoid bending rotor-through-stud, Figure 4-36. Use a heavy, soft faced hammer to loosen the rotor from its tapered shaft fit. If rotor does not come loose, strike it a sharp downward blow in center of lamination stack. Rotate rotor and repeat until it comes loose. Be careful not to hit bearing or windings.
7. After disassembly, all parts should be wiped clean and visually inspected.

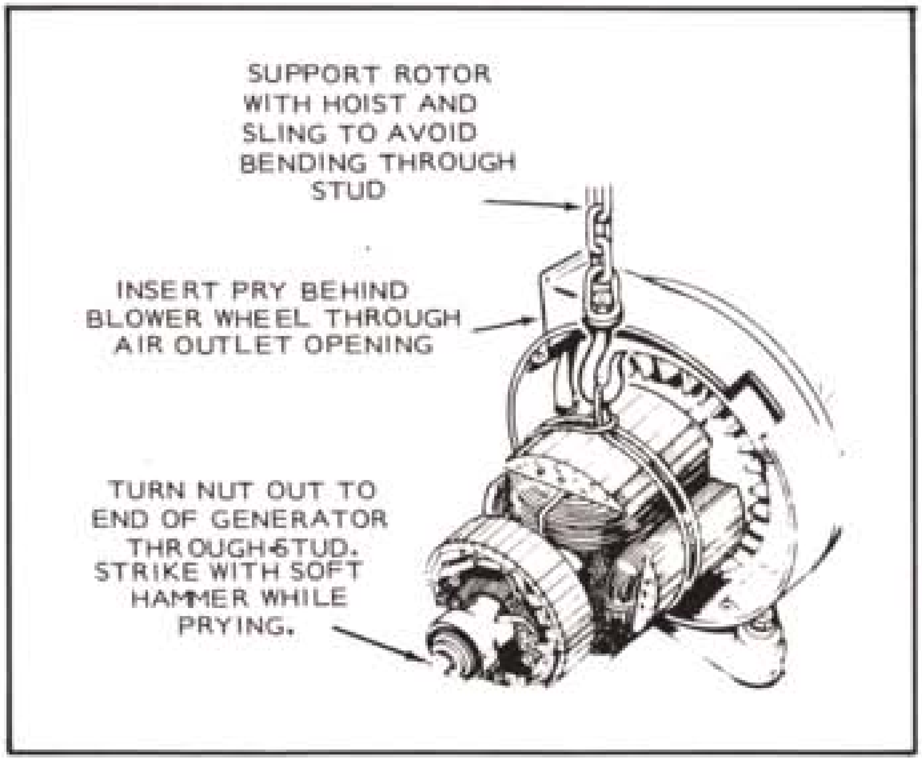


FIGURE 4-36. ROTOR REMOVAL (ENGINE MOUNTED GENERATOR)

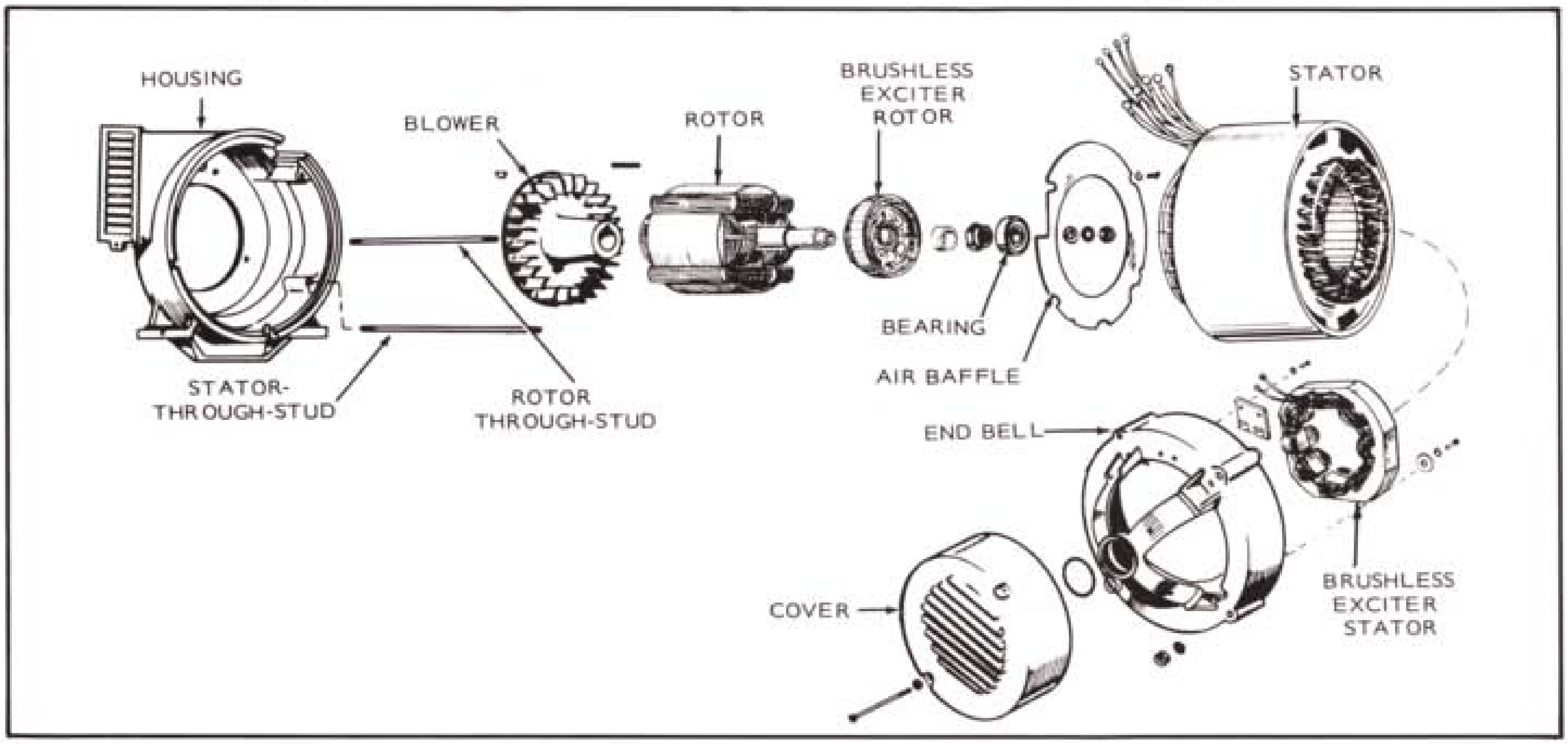


FIGURE 4-35. GENERATOR DISASSEMBLY

GENERATOR ASSEMBLY

1. Clean and inspect all mating surfaces.
2. Coat mating area between generator bearing and end bell bearing hole with a thin film of Molykote or equal.
3. Install rotor-through-stud in engine crankshaft.
4. Install key in the crankshaft.
5. Slide rotor over through-stud and onto crankshaft. Be careful not to let weight of rotor rest on or bend the through-stud.
6. Install baffle ring.
7. Install stator through-studs in adapter.
8. Install stator and end bell. Torque nuts on through-studs to 35 to 38 ft-lbs.

Make certain the B' lead is placed through the grommet in the baffle ring and out the air discharge opening in the adapter.

9. Torque down rotor-through-stud nut (55-60 ft. lb.). The rotor and stator are automatically aligned because stator and bearing support were tightened in step 8.
10. Tap end bell to align at horizontal and vertical plane; use a lead hammer to relieve stresses on components (recheck torque).
11. Reconnect leads to preheater, centrifugal switch and governor solenoid.
12. Install lead B' on adjustable resistor, R^{21}.

CAUTION **Check B' lead to see that it is short and is kept away from the blower. If necessary when installing a new stator or leads, cut B' lead shorter and reinstall the connector.**

13. Install end cover.

SUMMARY

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

There are many special tools available (catalog #900-0019) from Onan to aid you in testing and troubleshooting of generators. The Master Service Manual (sections 2, 3 and 4) gives a detailed explanation including theory, operation and adjustment for all types of Onan generator sets. Cleanliness is also important in order for the generator to maintain its output frequency. Always clean the generator using low pressure compressed air whenever the covers are removed for service.

SECTION 5
CONTROLS

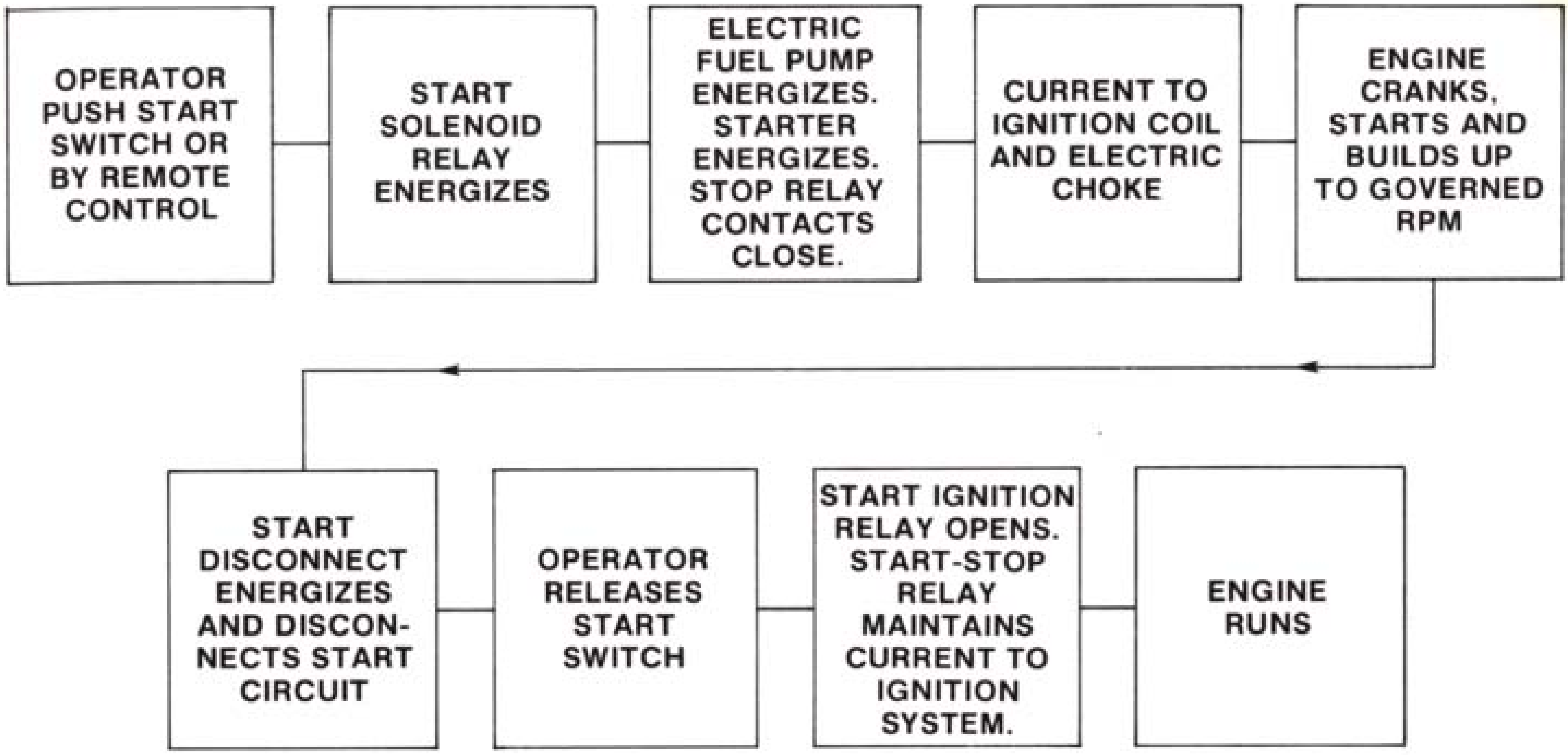
- **Introduction**
- **Starting Methods, Ignition Systems, Types of Controls**
- **Control Theory of Operation and Troubleshooting For:**
  - **611C1145 MCCK SPEC "H" Control**
  - **611C1096 MCCK Solid State Control**
  - **613C0009 MCCK Control-O-Matic Control**
  - **612C2334 Diesel Control, MDJC - MDJF**
  - **"HA" Automatic Load Demand Controls**
  - **Shoreline Controls**
- **Summary**

The marine generator set control system regulates all functions of the generator and engine ignition; it monitors temperature, oil and battery charging functions of the set for both gasoline or diesel engines. Dependable, trouble free operation of the control system is a major concern of every boat owner/operator. Service personnel must understand the theory of operation thoroughly in order to properly adjust or troubleshoot the Control System, and still make repairs or replacements in a reasonable time. The operating cycle includes starting, start disconnect, running, stopping and emergency shutdown functions. In this section the student should become familiar with all types of Onan marine controls, their operation, various component functions in different systems and troubleshooting. He will learn to interpret electrical symbols and read schematic diagrams for current as well as older Onan models.

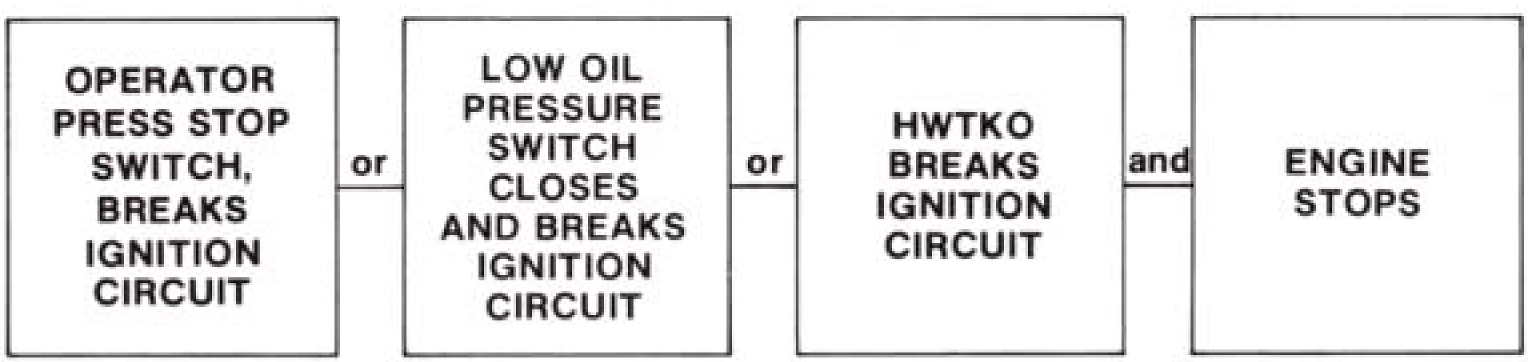
The gasoline and diesel controls are similiar in operation but differ in control components, so each type is described separately. A number of Onan service and technical bulletins are referenced throughout this section to aid the service personnel in detailed operation and troubleshooting of various controls and components.

WARNING **Before commencing any maintenance work on the engine, control panel, or associated equipment, disconnect batteries. Failure to do so could result in damage, serious personal injury in the event of inadvertent starting.**

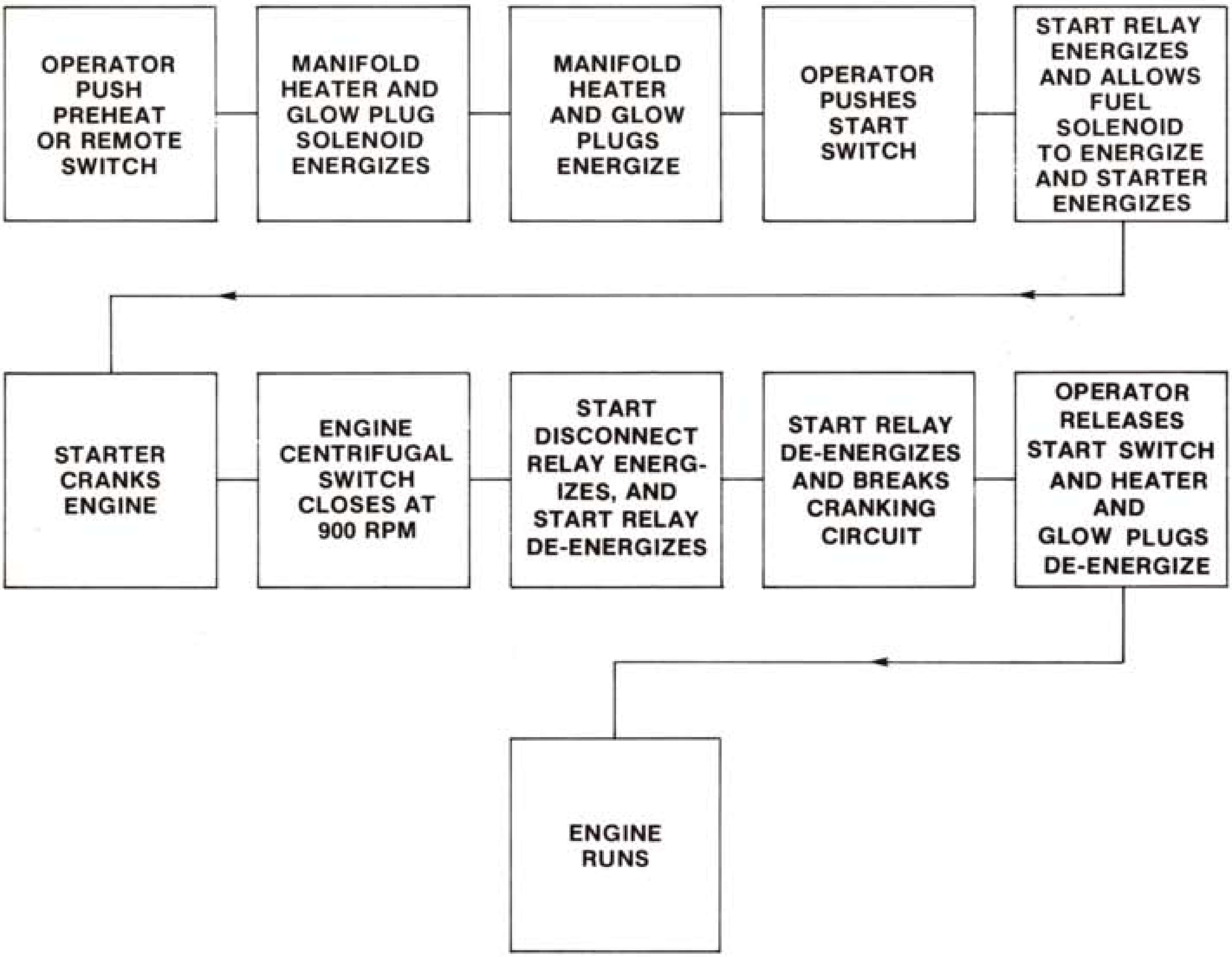
STARTING SEQUENCE-GASOLINE POWERED UNITS



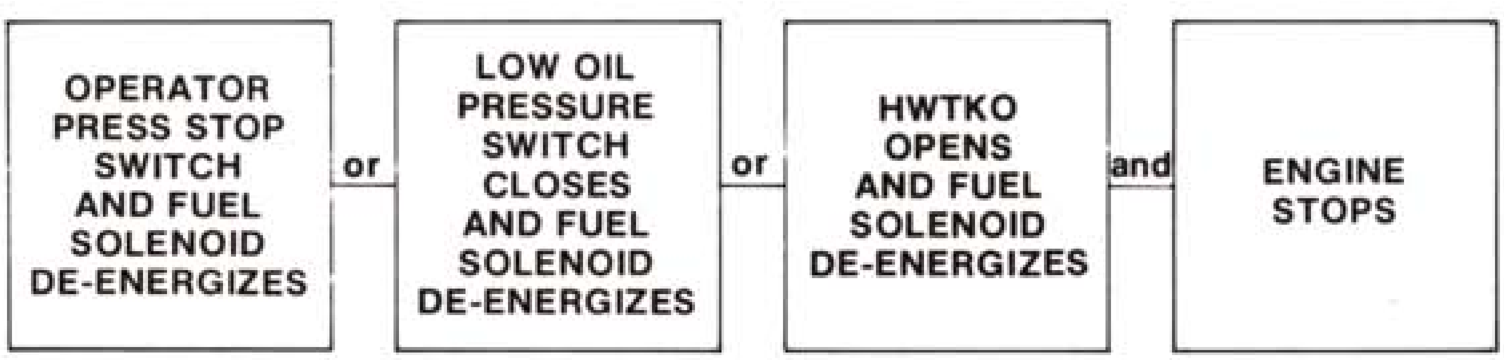
STOPPING SEQUENCE GASOLINE



STARTING SEQUENCE-DIESEL POWERED UNITS



STOPPING SEQUENCE DIESEL



STARTING METHODS

There are two main types of starting methods used on Onan marine units. The first type is *electric start* with all controls at the unit. The other is *remote start* using electric starting, but with starting capability at both the generating set or remote stations anywhere throughout the vessel. The most common method for marine application is electric starting with remote capability. Onan uses three types of starting systems. These are:

Hand cranking used on one cylinder units with flywheel magneto ignition system.

Electric or remote starting with exciter cranking from the generator utilizing a separate battery.

The automotive starter motor using a separate battery with either a Bendix drive starter or the solenoid shift type starter motor.

COMPONENT FUNCTIONS

REVERSE CURRENT PROTECTION

1. Used to prevent engine from cranking through the charge circuit when set is stopped.

2. Disconnects battery from generator when set is stopped.

3. Allows battery charging current to flow only towards battery - and not reverse-flow back into generator.

START-DISCONNECT

Disconnects start circuit when engine starts to run and generator builds up to approximately 1/2 its rated output in DC voltage.

START IGNITION RELAY

Supplies ignition voltage to coil when "start" button (or start circuit) is energized and engine is cranking.

STOP RELAY (IGNITION RELAY)

Removes ignition voltage to coil when "stop" button (or stop circuit) is de-energized.

TWO-STEP VOLTAGE REGULATOR

1. Charges batteries at Hi rate until battery voltage rises to approximately 14.5 volts. Charges at 6 to 8 amps in the Hi rate.

2. When battery voltage reaches approximately 14.5 volts, the regulator charge drops to the low rate and charges at 2 to 3 amps.

START SOLENOID RELAY

Connects battery to generator starting winding for cranking engine (exciter-cranked units) or connects battery to a cranking motor.

CRANKING LIMITER

1. Shuts engine down when unit cranks and fails to start.

2. Will allow cranking time of 45 to 90 seconds before thermal device disconnects the starting circuit.

GENERATOR OUTPUT LEADS

Identified by NEMA markings (i.e. - M^1, M^2, M^3, M^4, T^1, T^2, T^3, T^4 includes 12 - lead reconnectible (except delta wound). If M^0 or T^0 leads are used, this indicates a 3-phase generator with M^0 or T^0 lead always being neutral. Generator output leads marked with an "M" indicate a revolving armature generator. Generator output leads marked with a "T" indicate a revolving field generator.

SUGGESTIONS

A. Service personnel should tag wires to assure proper reconnections.

B. Others take photographs of more complex wiring before disconnecting wires.

C. Most reconnecting/rewiring is best accomplished by using the correct wiring diagram and following the connections shown on the diagram.

D. Also refer to Generator Service Bulletin No. 12.

WARNING **Fire extinguishers should be conveniently located when electrical components are being cleaned and dried. Oil vapors and gases from solvents may be flammable or explosive when mixed with air. Be careful, the gases may be irritating to the eyes, throat, or nose. Observe good safety practices at all times while cleaning, drying, and testing electric equipment.**

611-1145 CONTROL OPERATING SEQUENCE
MCCK SPEC "H" GENERATOR SETS

CRANKING CIRCUIT

The Start/Stop switch is a rocker type switch. In Start position, the ground circuit is completed for start solenoid coil K1 and crank ignition relay coil K2. Battery current flows through fuse F2 (5A), relay coil K2, normally closed contacts of K3 (run ignition, start disconnect relay), relay coil K1 to ground.

Solenoid contacts K1 close and connect the battery to starter motor B1 which cranks the engine. The contacts of relay K2 close and connect battery to the ignition circuit and fuel pump E4.

IGNITION CIRCUIT

During cranking, battery ignition current is connected by relay contacts K2. As engine starts and oil pressure switch S3 closes, relay K3 is energized by current build-up in the generator field. Relay contacts K3 open cranking solenoid K1 (cranking stops), and completes the "run ignition" circuit (K2 contacts open when Start switch is released).

The ignition current flows through resistor R3 (1.72 ohm), high water temperature switch S5, bypass capacitor C1, ignition coil T1 and breaker assembly to ground.

Run ignition start disconnect relay K3 gets its operating current from a tap on the generator shunt field. The circuit is completed by resistor R1 (1000 ohm), oil pressure switch S3 and normally closed contact of stop relay K4.

BATTERY CHARGING AND CHOKE HEATER CIRCUIT

The choke heater E5 is connected in series with the battery charging circuit. Power is taken from the generator 120-volt AC winding M1, M2. The AC current is rectified by diode CR2 and flows through resistor R4 (7.5 ohm), fuse F3 (3A), choke heater E5 (40 ohm), resistor R2 (25 ohm) and fuse F2 (5A). The circuit components limit the charging current to about one ampere.

Fuse F3 protects the battery charging circuit. If blown, the battery will not receive any charging current, and the carburetor choke will not open and result in poor engine performance after warm-up.

STOP CIRCUIT

When the Start/Stop switch is held in the Stop position, current flows from B+ through coil of relay K4 to ground. Relay K4 energizes and opens the circuit to relay K3, which breaks the ignition circuit. With the ignition current cut off, the generator set stops.

BATTERY CHARGING DIODE

Diode CR2 rectifies the AC power from the generator and prevents battery discharge through the generator on shutdown. The diode replaces the reverse current relay used on some earlier models.

SHUNT FIELD BRIDGE RECTIFIER CR1

Diode bridge CR1 is located on the top brush holder of the generator. It rectifies AC power from generator terminals M1 and M2, and supplies DC current for energizing the generator shunt field. At normal operating conditions, field voltage measured between F1 and F2 is 100 to 110-volts DC. If generator output has dropped and the field voltage is low, check CR1 as a possible fault.

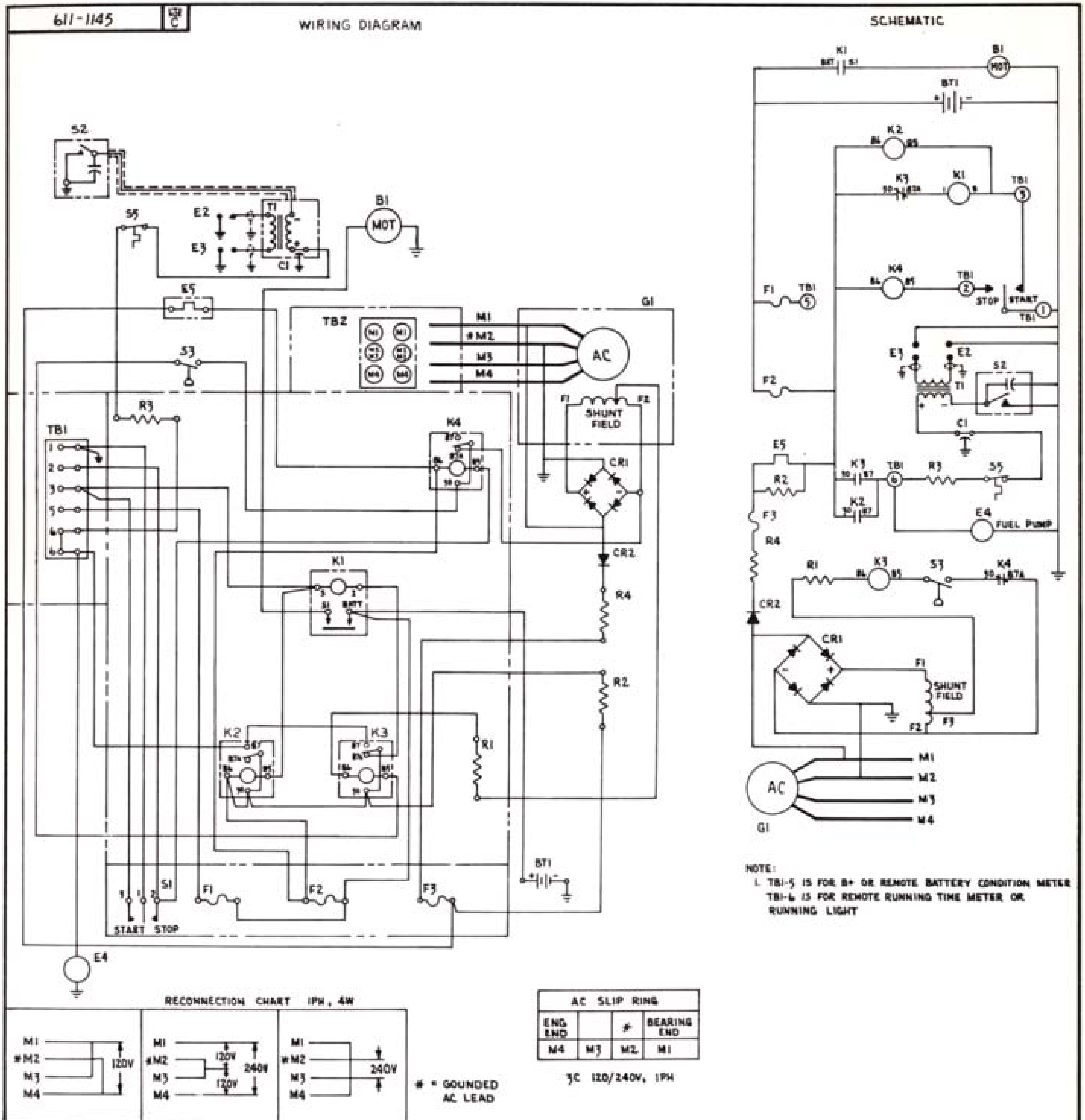


FIGURE 5-1. MCCK SPEC "H" GENERATOR SET CONTROL

611-1096 SOLID STATE CONTROL OPERATING SEQUENCE MCCK (BEGIN SPEC E)

STARTING AND IGNITION:

Switch A1S2 is a rocker type switch. Pressing this to the start position closes it. Battery currents are supplied through the hand crank - electric start switch A1S1, through diode CR1, through switch A1S1 to the primary of the ignition coil T1, to the breaker points to ground and back to the battery. (The ignition coil requires about 4 volts minimum to operate.)

The fuel pump is energized at the same time as the ignition circuit. From a connection point at the coil primary, currents flow to the fuel pump (E1) to ground and back to the battery. (The fuel pump requires 5.5 volts minimum to operate.)

When A1S2 is closed, currents are also supplied from the battery, through the switch, through transistor A1Q2 to the coil of Relay K1 (START SOLENOID) to ground and back to the battery. (Relay K1 requires 4.5 minimum to operate.) K1 energizes and its contacts close connecting the battery to the generator. (Generator required 7.0 volts or more to crank.) If the battery has sufficient capacity the generator acts as a motor and cranks the engine. If coil voltage is correct and fuel available the engine starts and accelerates to governed speed. Relay K1 also energizes the choke coil to close the choke.

START DISCONNECT:

When the engine starts and comes up to speed, generator voltage starts to build up. Generator DC voltage is supplied to charge resistor G1R1 through both sections - 3.8-ohms and 8.3-ohms. When this voltage reaches the same value as battery voltage both sides of A1CR5 are at the same potential. This causes CR5 to stop conducting and it shuts off and also shuts off transistor A1Q2. This de-energizes the start solenoid (K1) and breaks the starting circuit.

At the same time ignition currents are supplied from the generator, through the charge resistor (G1R1) to CR2 diode, to the ignition coil and fuel pump.

BATTERY CHARGING:

There are two steps of battery charging—high and a low rate. The high rate is transistor controlled and the low is a fixed, steady rate—the low charge circuit is from A1 of the generator to G1R1 charge resistor, through the 8.3-ohm side, through CR3 and to the battery. Low charge rate is about 1.56 amps. This supplies ignition current and fuel pump currents.

The high charge rate is through the 3.8-ohm side of the R1 charge resistor, through Q1 transistor, through CR3 diode and to the battery. This circuit supplies about 3.7 amps charge current. The high and low charge rate combined is about 5.26 amps.

Each time the unit is started the high charge circuit is energized. If the battery is close to full charge - indicated by battery voltage - this is de-energized or shut off by transistor Q1 turning off.

HIGH CHARGE CIRCUIT CONTROL:

Q4 and Q5 form a trigger circuit to control Q3 and then Q1. R5 and R8 form a voltage divider and control the trigger point of Q5. Q5 turns off at about 13 volts and on at about 15 volts.

Because of drop in battery voltage, when cranking, the high charge circuit is always turned on. When near normal charge is reached the high charge circuit is shut off. Whenever battery voltage drops below the trip point (13 volts) the high rate circuit is turned back on.

When battery voltage drops to about 13 volts Q5 turns off. This turns Q4 on and it turns Q3 on. Q3 then turns Q1 on and the high charge circuit is re-energized and the battery receives higher charge currents.

When the battery voltage comes up to about 15 volts, Q5 turns on. It then causes Q4 to turn off which turns off Q3. Q3 shuts Q1 off and opens the high charge circuit.

Because of the low power or small size of the transistors Q4 and Q5, transistor Q3 is required to control Q1. Q1 is a high current transistor. Q1 carries the high charge currents. When Q3 is turned off Q1 is turned off and the battery charge drops to the low rate.

STOPPING:

The generator set is stopped by pushing switch A1S2 to the stop position. The battery is prevented from discharging through the generator by CR3 diode.

TROUBLESHOOTING

Disconnect battery before working on solid state control for anything other than voltage checks.

Solid state control can be replaced with relay type control using kit #300-1796.

WARNING **Use caution when troubleshooting a unit in operation! Electrical shock hazard is present.**

SOLID STATE CONTROL VOLTAGES

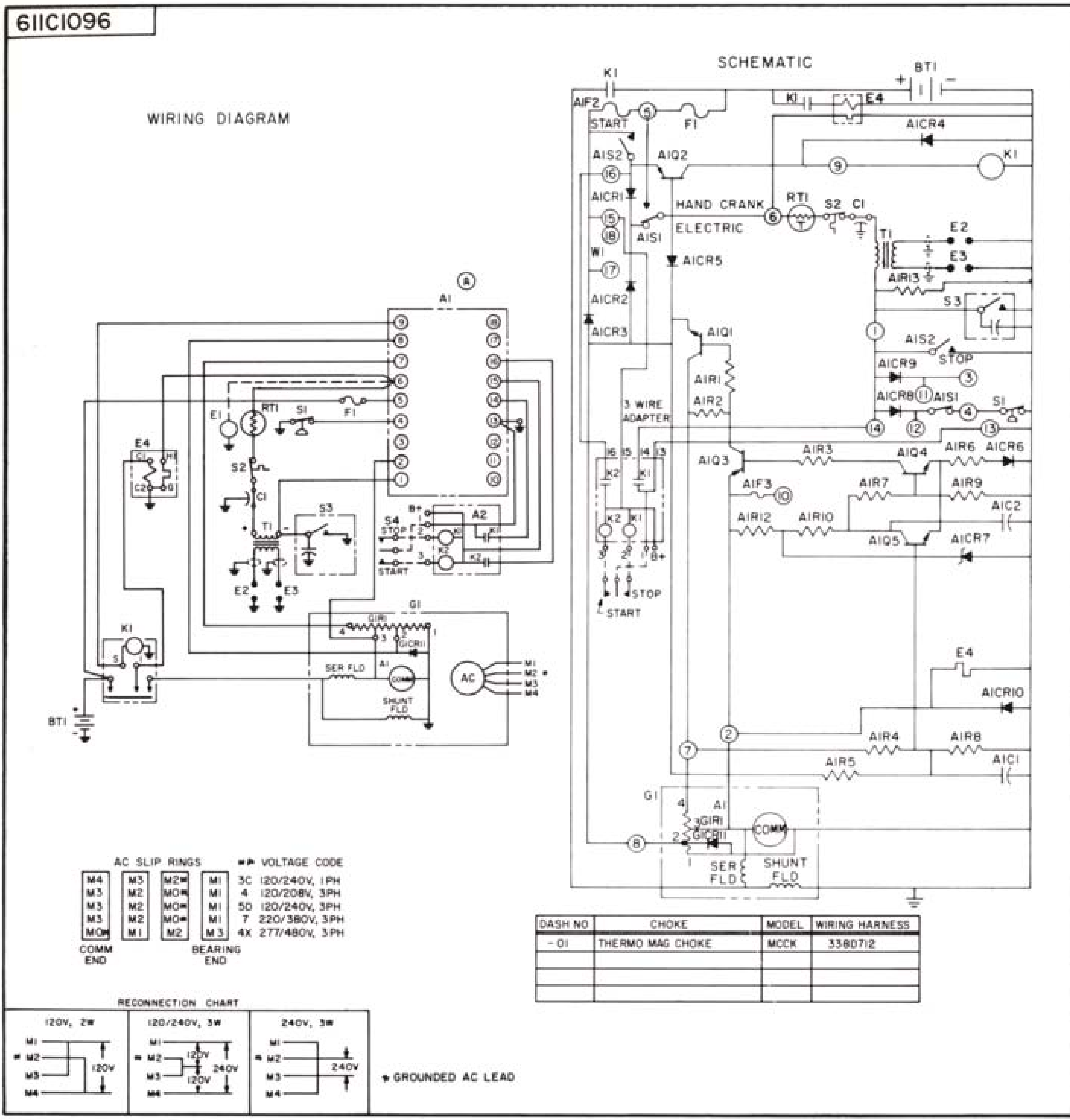
All voltages are DC using ground (terminal 13) as a reference point for measurements with a Simpson 260 VOM (or equivalent).

ENGINE STOPPED

TERMINAL NO.	VOLTAGE
5	12
15	12
17	12
18	12

ENGINE RUNNING

TERMINAL NO.	VOLTAGE
1	10
2	28
3	10
4	10
5	13
6	13
7 Voltage Regulator ON	14
7 Voltage Regulator OFF	28
8	14
9	0
10	28
11	10
12	10
13	0 (GND)
14	10
15	13
16	0
17	13
18	13



DASH NO	CHOKE	MODEL	WIRING HARNESS
-01	THERMO MAG CHOKE	MCCK	338D712

FIGURE 5-2. MCCK SOLID STATE GENERATING SET CONTROL

This troubleshooting section is divided into five parts, A, B, C, D, and E as follows:

A. Engine does not crank.
B. Engine cranks but does not start.
C. Engine starts but stops when start switch is released.
D. Low battery — no high charge rate.
E. Battery loses excess water.

To correct a problem, answer the question of the step either "YES" or "NO". Then refer to the number in the column and proceed to that step next.

Always stop the generating set and disconnect the battery leads before removal of the control cover or control printed circuit board.

A.	ENGINE DOES NOT CRANK	YES	NO
	Perform start tests first from the generating set control. If the generating set starts using the generating set control, the problem lies in the three-wire adapter board or the remote switch. Check relay K2 of the adapter by jumping terminal 3 to ground. If the relay does not operate or its contacts do not close to energize the start circuit, replace the board.		
1.	Check battery. Are battery cables tight?	2	—
2.	Push "HAND CRANK" - "ELECTRIC" (called "ROPE START" or "NONFUNCTIONAL" on some models) switch A1S1. Is battery voltage present between control terminal 6 and ground?	6	3
3.	Remove control cover and jumper terminal 5 to terminal 6. If battery voltage present between terminal 6 and ground?	4	5
4.	Replace switch A1S1.	—	—
5.	Check battery cables for correct polarity. Replace fuse F1 with a 9-ampere, in-line fuse. Push start switch A1S2. Does engine crank?	—	6
6.	With start switch A1S2 depressed, is at least 8 volts present from terminal 9 to ground?	7	11
7.	Jumper solenoid coil terminal S to battery. Does start solenoid K1 operate?	8	9
8.	Is battery voltage present from right-hand terminal of start solenoid to ground when start solenoid is energized?	10	9
9.	Start solenoid is defective and must be replaced.	—	—
10.	Perform generator tests. See Section 4.	—	—
11.	Is voltage present from terminal 15, 17 or 18 to ground?	14	12
12.	With start switch A1S2 depressed, jumper terminal 5 to terminal 15, 17 or 18. Does engine crank and start?	13	14
13.	Remove control P.C. board. Replace A1F2 fuse path with a one-inch length of number 22 wire. Solder in place through holes provided.	—	—
14.	Jumper control terminal 5 to terminal 16. Does engine crank?	15	16
15.	Replace start switch A1S2.	—	—
16.	With start switch A1S2 depressed, jumper control terminals 9 to 16. Does engine crank?	17	—
17.	Check transistor A1Q2. If defective, replace control P.C. board.	—	—

B.	ENGINE CRANKS BUT DOES NOT START	YES	NO
1.	Is battery voltage present between control terminal 6 and ground when start switch A1S2 is depressed?	4	2
2.	Is battery voltage present between control terminal 6 and ground when switch A1S1 is depressed?	3	—
3.	Faulty switch A1S1 or diode A1CR1. Replace control P.C. board.	—	—
4.	Does generating set have an electric fuel pump?	5	6
5.	Check wire lead to fuel pump, check fuel pump and replace if necessary. Does engine crank and run?	—	6
6.	Check oil level. If okay, remove wire lead for low oil pressure switch S1 from control terminal 4 and push start switch A1S2. Does engine crank and run?	7	10
7.	Is wire lead from low oil pressure switch grounded?	8	9
8.	Repair or replace wire lead.	—	—
9.	Check low oil pressure switch S1 and replace if necessary. Does engine crank?	—	10
10.	Check ignition system. See Section 3.	—	—

C.	ENGINE STARTS BUT STOPS WHEN START SWITCH IS RELEASED	YES	NO
1.	Connect voltmeter from control terminal 8 to ground. Crank engine. Is there DC voltage output from generator?	3	2
2.	Check resistor G1R1 and all resistor connections.	—	—
3.	Is voltage present from terminal 6 to ground after engine starts and start switch A1S2 is released?	—	4
4.	Replace control P.C. board.	—	—

D.	LOW BATTERY — NO HIGH CHARGE RATE	YES	NO
1.	Remove wire lead from fuse F1 to control terminal 5. Connect DC ammeter between wire lead and terminal 5. Start generating set. Is high battery charge rate present (over 3 amperes)?	2	3
2.	Measure battery terminal voltage with voltmeter (one percent accuracy or better). Does voltage rise to 14 volts or more?	4	3
3.	Remove control cover and jumper control terminals 7 and 8. Does charge rate increase?	6	5
4.	Check battery and replace if necessary.	—	—
5.	Stop generating set. Check wire leads to charge resistor G1R1. Check resistor and replace if necessary.	—	—
6.	Replace control P.C. board.	—	—

E.	BATTERY LOSES EXCESS WATER	YES	NO
1.	Connect a voltmeter (one percent accuracy or better) to battery terminals, start and run generating set for 30 minutes. Does battery terminal voltage exceed: a. 14 volts at 100°F (38° C) or above; or b. 15 volts at 50 to 100° F (10-38° C) or, c. 16 volts at 50° F (10° C) or below?	2	—
2.	Replace control P.C. board.	—	—

613-0009 MCCK CONTROL-O-MATIC

GENERAL DESCRIPTION

The MCCK Control-O-Matic is an engine control, automatic-demand control and bilge-blower control, all combined into one top-mounted control box.

The front panel, facing the generator end of the unit, holds the charge ammeter, emergency relay and toggle switch. A unique hinge arrangement holds the front panel, cover and chassis together and opens in a very limited space to expose all the relays for servicing.

HOW CONTROL-O-MATIC WORKS

A three-position switch on the front panel selects RUN, OFF or AUTOMATIC OPERATION.

When the three-position toggle switch is moved to the RUN position, the Bilge-Blower Control delays cranking while it closes a 12-volt, 5-ampere circuit to operate the bilge blower. After the time delay for bilge blower operation, the electric generating set cranks and runs.

When the toggle switch is moved to AUTOMATIC position, the Control-O-Matic will monitor the AC load circuit to:

a. Sense a load on the AC line.
b. Close the bilge blower circuit (when used).
c. Open the bilge blower circuit.
d. Assume the electrical load.
e. Sense when all load is removed.
f. Stop the electric generating set.

OPERATION OF CONTROL-O-MATIC

The Control-O-Matic operation explanation on the following pages refers to schematic drawing with current flow shown in bolt lines. Figure 5-11 shows a pictorial wiring diagram of the Control-O-Matic. Throughout the text are references to various components, terminal positions and current flow. When reading the text, follow current flow on the schematics and locate relative positions of electrical devices and terminal positions on the respective wiring diagram. The following description of Control-O-Matic operation is for Spec D units.

CAUTION **The Control-O-Matic must operate with a negative ground only. Connect the battery with correct polarity.**

For operating the bilge blower from a separate battery or power source, or connecting a bilge blower to the Control-O-Matic, see page 128.

Switch S^1 is a three-position switch with a center OFF position. In the RUN position, the switch bypasses relay A^2K^1 contact (2-3) to energize the bilge blower control which goes through its control cycle before the electric generating set cranks and runs. In the AUTO position, the Control-O-Matic starts the unit which runs as long as a load demand prevails. The load must be at least a 50-watt incandescent lamp for reliable automatic operation.

LOAD DEMAND

When the generating set is in AUTOMATIC and a 50-watt lamp (or larger) is turned on, a load demand exists. Battery current flows through Switch S^1, Relay A^1K^1 (A-B), Fuse A^1F^1, K^3 contacts, load terminal A, the load, ground. Terminal M^2 and back to the battery to energize Relay A^1K^1.

TRANSISTOR ON AND TIME DELAY

Relay A^1K^1 contacts (2-3) close the circuit from B+ through the heater of relay A^2K^1 to the 6¼-ampere fuse, to ground and back to the battery. The heater on the five-minute time delay begins its cycle. Simultaneously, as current flows through the heater on Time Delay A^2K^1, it also flows through the closed A^2K^1 contacts (1-2) through Resistor A^2R^1 to the base of the transistor, through Resistor A^2R^2, and through the fuse to ground. This switches on Transistor A^2Q^1.

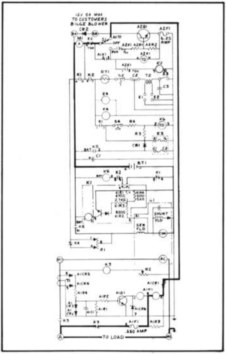


FIGURE 5-3. LOAD DEMAND (SPEC D)

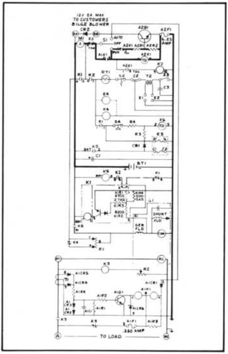


FIGURE 5-4. TRANSISTOR ON AND TIME DELAY (SPEC D)

BILGE BLOWER ON

When Transistor A^2Q^1 turns on, current flows from the B+ Terminal through the bilge blower, to Terminal BB through the transistor and fuse to ground. The bilge blower operates for five minutes to evacuate explosive vapors from the vessel bilge. At the end of the five-minute period, Time Delay A^2K^1 operates to close contacts (1-3) and open contacts (1-2). Transistor A^2Q^1 turns off to interrupt the power to the bilge blower.

Diode (CR^2) between B+ and BB is a discharge diode to protect other components in the control from inductive voltage when the bilge blower is turned off.

ENGINE CRANK

When Time Delay A^2K^1 contacts (1-3) close, current flows to energize the Start-Stop Relay (K^2). The K^2 contacts close the circuit through K^2 contacts (8-6) to energize Start Solenoid Relay K^5. The K^5 main contact ($BAT\text{-}S^1$) closes to supply battery power to the cranking windings on the generator.

CHOKE

The Start Solenoid K^5 auxiliary contact (BAT-I) closes the circuit to the Solenoid (C^1-C^2) on the thermo-magnetic choke mounted on the carburetor.

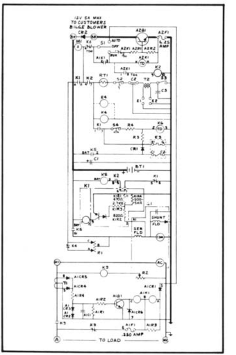


FIGURE 5-5 BILGE BLOWER ON (SPEC D)

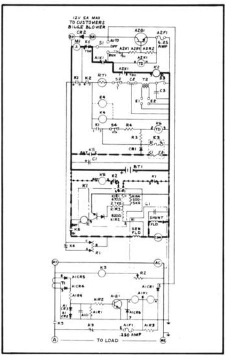


FIGURE 5-6. ENGINE CRANK CIRCUIT (SPEC D)

CRANKING LIMITER

When Starting Solenoid Relay K^5 picks up, contact 1 closes the circuit through Diode CR^1, Resistor R^3 to the heater on the Time Delay Relay K^6 (320-0104 emergency relay). If the electric generating set does not start within approximately 45 seconds, this relay opens its contacts to the control circuit and shuts the unit down.

Diode CR^1 serves as a blocking diode to prevent current flow to the choke control during a low oil-pressure condition.

IGNITION

When Relay K^2 energizes, its contacts close the circuit to Relay K^4 and the ignition circuit. Current flows through the Ignition Resistor (RT^1), the High-Water-Temperature Switch (S^2), the primary of the ignition coil and through the breaker points (S^3) to ground. This supplies ignition power to spark plugs E^1 and E^2.

START DISCONNECT, CHOKE HEATER

When the electric generating set starts and voltage builds up, Start Disconnect Relay K^1 is energized by a transistor and Zener diode. K^1 contacts (5-4) open the Start Relay K^5 coil circuit. Relay K^5 de-energizes opening its contacts to disconnect the cranking circuit and choke solenoid circuit.

Relay K^1 contacts (1-3) close the circuit to the Bi-metal Heater (H^1-G) of the thermo-magnetic choke. The Bi-metal heats to open the choke for normal running as the engine warms up.

Relay K^1 contacts (1-3) also close the circuit to Time Delay Relay K^6 through Low Oil Pressure Switch S^4 and Resistor R^4. If oil pressure switch S^4 does not open, Time Delay Relay K^6 operates to open the normally-closed contact K^6 (1-4) to shut down the unit. Wait one minute, then push to reset.

BATTERY CHARGE

When the generator comes up to speed, it supplies battery charge current through S^1 to Start Solenoid Relay K^5, and Terminal S^1 to Resistor R^1 (charge resistor). The resistor is divided with the upper Terminal C and the lower Terminal A connected to the contact on the Voltage Regulator K^4. The closed

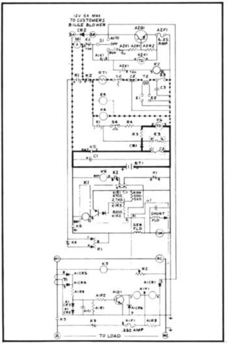


FIGURE 5-7. CRANKING LIMITER AND IGNITION (SPEC D)

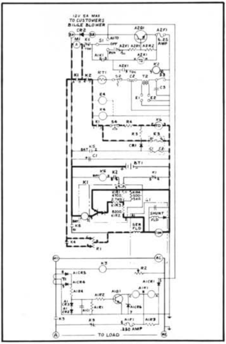


FIGURE 5-8. START DISCONNECT, CHOKE HEATER AND BATTERY CHARGE (SPEC D)

contact reduces the resistance to supply the high charge rate for fast battery charging.

Current flows from Reverse Current Diode (CR^1), through the ammeter back to the battery for charging. When the battery reaches a preset charge level, the coil on Relay K^5 is energized, opening the contacts and dropping the charge to a low rate. The terminal of Relay K^4 through closed K^1 contacts (6-8), through the ammeter back to the battery for charging. When the battery reaches a preset charge level, Relay K^4 is energized, opening the contacts and dropping the charge to a low rate.

Resistor R^1 is set at the factory for correct two rate charging.

GENERATOR SUPPLYING POWER

When the generator AC voltage reaches approximately 105 volts on 120-volt units or 210 volts on 240-volt units, Line Contactor K^3 energizes to open the auxiliary contacts and close the main contacts.

Load current through Transformer T^1 produces current to Load Sensor Amplifier A^1. Transistor A^1Q^1 switches on and passes current through both coils of Relay A^1K^1 keeping it energized. This relay remains energized as long as a minimum 50-watt incandescent lighting load is across the output terminals of Relay K^3.

STOP

When the load is removed, the flow of current through the transformer T^1 drops to zero. This switches the transistor off to de-energize Relay A^1K^1. The contacts open to break the ignition circuit and stop the engine.

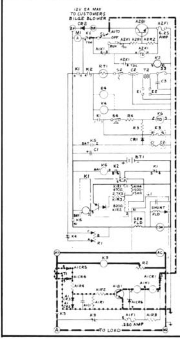


FIGURE 5-9. OFF POSITION (SPEC D)

TROUBLESHOOTING (SPEC D ONLY)

120-Volt, Single-Phase, 12-Volt DC Control-O-Matic

A 20,000 ohm/volt VOM is needed for some of the following tests. The symptoms are listed by number and followed by test procedures.

1. Control switch is in RUN position, but electric generating set does not crank after the usual 5-minute delay period.

a. Check battery connections and battery voltage.

b. If necessary to test engine cranking circuit, temporarily bypass bilge-blower control relay A^2K^1 by moving lead at terminal 1 on A^2K^1 to terminal 3, Figure 5-11. This lead comes from A1-3 (single lug). If unit cranks with the bilge-blower control disabled, the problem is in the bilge-blower control circuit. Refer to Figure 5-5.

WARNING **The bilge-blower is a safety device that removes explosive vapors from the bilge area for five minutes prior to starting the generator set. Failure to reconnect this lead wire from A1-3 back to A^2K^1 terminal 1 upon completion of the above test could be disastrous.**

c. Check to see if the Start Solenoid K^5 picks up. If it doesn't, check for a faulty solenoid by connecting a jumper from the S terminal to ground. This bypasses contact K^1 and K^2. The start solenoid should pick up. If it picks up, check for proper operation of relay K^1 and K^2.

2. Electric generating set will not start on load demand.

a. Move the toggle switch to RUN position. Unit should crank after approximately a five-minute delay.

b. Apply some load (at least 100 watts) to load the circuit. Move toggle switch to AUTO position. Unit should continue running.

c. If unit stops with 100 watt load, move toggle switch to OFF position. Remove cover from A^1K^1 printed circuit board. Connect a jumper wire from terminal C of Relay A^1K^1 to the ground terminal in the Control-O-Matic. Move toggle switch to AUTO. Unit should start and run. If it does not, remove relay to check continuity of relay coil terminals A, B and C of 307-1087. Resistance A-C equals approximately 34 ohms. See Figure 5-3.

Apply 6 to 12 volts to terminals A-C to see if relay operates. When relay operates, contacts should close.

d. If relay is good, check voltages as follows. The voltage measured from the chassis-ground terminal to:

- the B+ terminal on the Start Solenoid should equal battery voltage.
- terminal A of relay socket should equal battery voltage less 0.5 to 0.7 volts.
- terminal B of Start-Run relay should be near zero if K^3 is closed properly and sufficient load is connected to the load circuit.

e. Check voltages of load sensor amplifier with set running under a minimum load of 100 watts. Start electric generating set in AUTO position for this test by jumpering the outside terminals of Switch S^1.

- Measure AC output voltage of Transformer T^1 at terminals on load sensor amplifier. The voltage should read 2 to 3 VAC.

  Use a 20,000 ohm voltmeter to minimize error.
- Voltage from ground to the transistor side of Resistor A^1R^2 should measure 0.6 to 0.7 VDC.
- Voltage across A^1K^1 coil A-C should read 5 to 14 VDC.
- Remove jumper from Switch S^1.

3. Control-O-Matic starts generating set automatically under load, but slows down or stops as soon as contact picks up.

a. Recheck size and type of load. Minimum requirements are a 50-watt incandescent lamp load or a 425-watt heater load.

b. Recheck adjustment of contactor Pick-Up Resistor R^2.

- Apply a load and help contactor pick up and hold in as the set starts. If this corrects the problem, reduce the resistance of R^2.
- Apply a load and hold the contactor to delay pickup. If this helps, increase the resistance setting of Resistor R^2.

c. Move toggle switch to the OFF position. Connect a jumper from Terminal C of Relay A^1K^1 to ground terminal. Move toggle switch to the AUTO position. The unit should start and run.

d. Apply a load such as a 100-watt lamp; then remove the jumper while the unit is running with the switch in the AUTO position. If it stops, place the toggle switch to OFF, jumper the two outside terminals of the toggle switch. Place in AUTO position to restart. While the unit is running with a 100-watt minimum load, measure the voltage on the load sensor amplifier as follows:

- AC output voltage of Transformer T^1 measured at terminals on load sensor amplifier should be 2 to 3 VAC.
- Voltage from ground to the transistor side of Resistor A^1R^2 should measure 0.6 to 0.7 VDC.
- Voltage across A^1CR^6 should read less than 5 VDC.
- Voltage across Relay A^1K^1 coil A-C should read 5 to 14 VDC.

4. Generating set won't stop with load removed.

a. Move the toggle switch to the OFF position to stop the set. If the set does not stop, remove the battery lead and check for a faulty Start Solenoid. The contacts may have stuck closed.

b. Remove the load from the load side of the contactor in the Control-O-Matic and reconnect battery.

c. Put toggle switch in AUTO position.

- If the unit does not crank, place the toggle switch in the RUN position to start the unit. Put the switch in AUTO position; the generating set should stop. If the unit stops with the load lead removed from the load side of the contactor, it indicates that there was sufficient load on the AC line to keep the Control-O-Matic energized. Recheck the load circuit.
- If the generating set cranks with the toggle switch in the AUTO position and the load lead disconnected, the Start-Run relay or Load Amplifier are malfunctioning. Remove the ground lead from battery.

d. Take out the printed circuit board and remove the cover from the Start-Run relay A^1K^1 (marked "K^1" on board). See Figure 5-10 for references during tests.

- With the VOM set at x10, measure resistance between A and B — should be approximately 34 ohms. Resistance between A and C or B and C should be approximately 650 ohms (x100 scale). As shown in Figure 5-10, the top K^1 contact should be closed, the bottom contact open. There should be continuity between the top contact and point D.
- Check Zener Diode A^1CR^6 ("CR^6" on printed circuit board). Resistance should be 600 ohms in one direction, infinity in the other direction. Check resistance of transistor A^1Q^1 (marked "Q^1" on p.c. board) leads in one direction, then reversing leads and checking resistance in that direction. B to C - 750 ohms, infinity; B to E - 750 ohms, 11,000 ohms; C to E - 700 ohms, infinity.

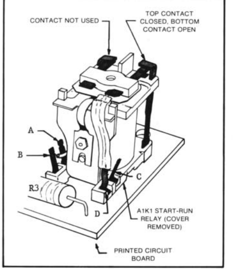


FIGURE 5-10. START-RUN RELAY A1K1 (SPEC D)

5. Bilge Blower Control circuit does not function at all.

a. Check the 6¼-ampere fuse A^2F^1.

6. Blower circuit is energized continuously and electric generating set won't crank.

a. Check heater element of thermal relay for an open circuit or a poor connection which may prevent relay from heating up enough to switch.

7. Blower circuit is not energized but generating set starts after a 2- to 6-minute delay.

a. Check blower operation by placing a jumper from Terminal BB to ground. Switch S^1 must be in RUN position for these checks. Measure voltage from BB to ground — should be 2 volts or less.

b. Measure voltage from Terminal 2 of A^2K^1 to ground. Voltage should equal battery voltage. Check voltage across Resistor A^2R^2. Voltage should be 0.7 to 1.5 volts. If these tests are satisfactory, the transistor is defective. Replace it.

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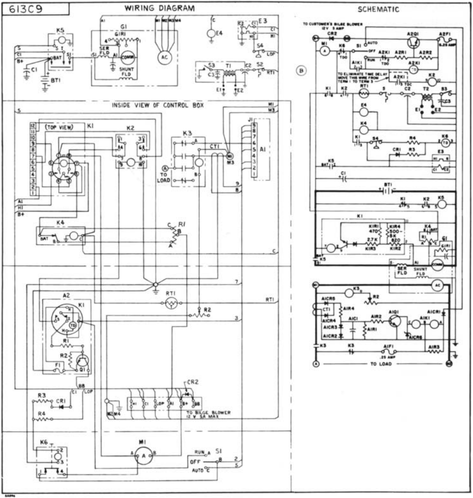


FIGURE 5-11. CONTROL-O-MATIC CONTROL MCCK GENERATING SET (SPEC D)

120-Volt, Single-Phase, 12-Volt DC Control-O-Matic

A 20,000 ohm/volt VOM is needed for some of the following tests. The symptoms are listed by number and followed by test procedures.

1. **Control switch is in RUN position, but electric generating set does not crank after the usual 5-minute delay period.**
   a. Check battery connections and battery voltage.
   b. If necessary to test engine cranking circuit, temporarily bypass bilge-blower control relay A^2K^1 by moving lead at terminal 1 on A^2K^1 to terminal 3, Figure 5-11A. This lead comes from S^1 run terminal. If unit cranks with the bilge-blower control disabled, the problem is in the bilge-blower control circuit.

WARNING **The bilge-blower is a safety device that removes explosive vapors from the bilge area five minutes prior to starting the generator set. Failure to reconnect this lead wire from S^1 back to A^2K^1 terminal 1 on completion of the above test could be disastrous.**

   c. Check to see if the Start Solenoid K^6 picks up. If it doesn't, check for a faulty solenoid by connecting a jumper from the S terminal to ground. This bypasses contact K^1 and K^2. The start solenoid should pick up. If it picks up, check for proper operation of relay K^1 and K^2.

2. **Electric generating set will not start on load demand.**
   a. Move the toggle switch to RUN position. Unit should crank after approximately a five-minute delay.
   b. Apply some load (at least 100 watts) to load the circuit. Move toggle switch to AUTO position. Unit should continue running.
   c. If set stops with 100-watt load, move toggle switch to OFF position. Connect a jumper wire from terminal 8 of Relay K^4 to the ground terminal in the Control-O-Matic. Move toggle switch to AUTO. Generating set should start and run. If it does not, remove relay to check continuity of relay coil terminals 2-3 and 8 of 307-0062. Resistance 2-3 equals approximately 100 ohms; 2-8 equals approximately 1000 ohms.

      Apply 6 to 12 volts to terminals 2-8 to see if relay operates. When relay operates, contacts 4-6 open and contacts 6-7 close.
   d. If relay is good, check voltages as follows. The voltage measured from the chassis-ground terminal to:
      - the B+ terminal on the Start Solenoid should equal battery voltage.
      - terminal 2 of relay socket should equal battery voltage.
      - terminal 3 of Start-Run relay should be near zero if K^3 contact is closed properly and sufficient load is connected to the load circuit.
   e. Check voltages of load sensor amplifier with set running under a minimum load of 100 watts. Start electric generating set in AUTO position for this test by jumpering the outside terminals of Switch S^1.
      - Measure AC output voltage of Transformer T^1 at terminals on load sensor amplifier. The voltage should read 2 to 3 VAC.

        Use a 20,000-ohm voltmeter to minimize error.
      - Voltage from ground to the transistor side of Resistor A^1R^2 should measure 0.6 to 0.7 VDC.
      - Voltage across A^1CR^1 should read 5 to 14 VDC.
      - Remove jumper from Switch S^1.

3. **Control-O-Matic starts unit automatically under load but slows down or stops as soon as contactor picks up.**
   a. Recheck size and type of load. Minimum requirements are a 50-watt incandescent lamp load or a 425-watt heater load.
   b. Recheck adjustment of contactor Pick-Up Resistor R^2.
      - Apply a load and help contactor pick up and hold in as the set starts. If this corrects the problem, reduce the resistance of R^2.
      - Apply a load and hold the contactor to delay pickup. If this helps, increase the resistance setting of Resistor R^2.
   c. Move toggle switch to the OFF position. Connect a jumper from Terminal 8 of Relay K^4 to ground terminal. Move toggle switch to the AUTO position. The generating set should start and run.
   d. Apply a load, such as a 100-watt lamp; then remove the jumper while the set is running with the switch in the AUTO position. If the unit stops, place the toggle switch to OFF, jumper the two outside terminals of the toggle switch, and place in AUTO position to restart. While

the unit is running with a 100-watt minimum load, measure the voltage on the load sensor amplifier as follows:

- AC output voltage of Transformer T^1, measured to terminals on load sensor amplifier should be 2 to 3 VAC.
- Voltage from ground to the transistor side of Resistor A^2R^2 should measure 0.6 to 0.7 VDC.
- Voltage across A^1CR^6 should read less than 5 VDC.
- Voltage across Diode A^1CR^1 should read 5 to 14 VDC.

4. Generating set won't stop with load removed.

a. Move the toggle switch to the OFF position to stop the unit. If the generating set does not stop, remove the battery lead and check for a faulty start solenoid. The contacts may have stuck closed.

b. Remove the load from the load side of the contactor in the Control-O-Matic and reconnect battery.

c. Put toggle switch in AUTO position.

- If the generating set does not crank, place the toggle switch in the RUN position to start the unit. Put the switch in AUTO position; it should stop. If it stops with the load lead removed from the load side of the contactor, it indicates that there was sufficient load on the AC line to keep the Control-O-Matic energized. Recheck the load circuit.
- If the generating set cranks with the toggle switch in the AUTO position and the load lead disconnected, the Start-Run relay or Load Amplifier are malfunctioning.

  Remove the ground lead from battery. Remove the Start-Run relay. Check continuity from Terminal 6 to 7 of Relay 307 62. This circuit should be open. Check continuity with 1-1/2 volts or less from tube socket Pin 8 to ground. The circuit should show a high resistance (approximately 20,000 ohms), with positive on Pin 8 and will show a low resistance (approximately 20 ohms) with negative to Pin 8.

  If this check indicates continuity in both directions, unsolder one end of Zener Diode A^1CR^6 and repeat same test. If resistance increases to the expected values, the zener diode has shorted. To verify this, check continuity in both directions on the zener diode itself.

  If resistance does not increase with the diode disconnected, check the transistor for a short from the collector to the emitter.

5. Bilge Blower Control Circuit does not function at all.

a. Check the 6¼-ampere fuse A^2F^1.

6. Blower circuit is energized continuously and electric generating set won't crank.

a. Check heater element of thermal relay for an open circuit or a poor connection which may prevent relay from heating up enough to switch.

7. Blower circuit is not energized but generating set starts after a 2- to 6-minute delay.

a. Check blower operation by placing a jumper from Terminal BB to ground. Switch S^1 must be in RUN position for these checks. Measure voltage from BB to ground — should be 2 volts or less.

Measure voltage from Terminal 2 of A^2K^1 to ground. This voltage should equal battery voltage. Check voltage across Resistor A^2R^2. Voltage should be 0.7 to 1.5 volts. If these tests are satisfactory, the transistor A^2Q^1 is defective. Replace it.

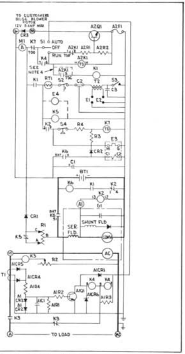


FIGURE 5-11A. MCCK CONTROL-O-MATIC SCHEMATIC (SPEC C)

Connecting Auxiliary Relay To Control-O-Matic

This circuit allows a separate battery or power source to operate the bilge blower. It also permits use of larger blowers with running currents in excess of 5 amperes. The auxiliary relay should have a 12VDC coil and contacts heavy enough to carry the current required by the bilge blower.

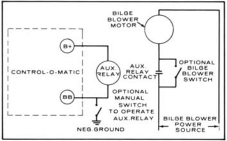


FIGURE 5-12. AUXILIARY RELAY CONNECTIONS

Connecting Bilge Blower To Control-OMatic

The bilge blower operates on power from the electric set cranking battery. The optional switch will run the bilge blower as long as the switch is closed. The bilge blower running current must not exceed 5 amperes.

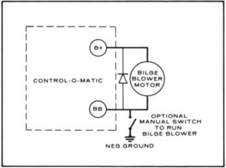


FIGURE 5-13. BILGE BLOWER CONNECTIONS

612-2334 CONTROL OPERATING SEQUENCE MARINE DIESEL GENERATING SETS

STARTING

The common practice for Onan controls is to ground the center of the switch portion of all start-stop switches. The operation of the control is accomplished through grounding certain components.

Moving the handle of the manifold heater switch to the heat position energizes the manifold solenoid which then supplies battery power through the main contact of that relay to the glow plugs and the manifold heater. This switch should be held in this position normally for 30 seconds. If extreme cold weather conditions are encountered, hold switch for one minute.

After a sufficient pre-heat time has been allowed, placing the start-stop switch to the start position causes a current flow from the B+ terminal of start solenoid, to the coil, to the start disconnect and fuel solenoid relay. Then from this point through the normally closed contacts of that relay, to the start side of the start-stop switch to terminal 1 on the terminal connection block to ground. This energizes the start solenoid and supplies battery power to the solenoid shift on the cranking motor and then to the starter, cranking the engine.

Battery voltage is picked up at the ammeter and this causes a current flow to the coil of the start relay through the coil to the normally closed contacts on the relay to the start switch and to ground. This causes the start relay to energize. From the battery a current flows through the ammeter, through it to the start relay contacts, which are now closed, through the contacts on the emergency relay. (This is a low oil pressure relay and its heater is energized when the unit starts and if the low oil pressure switch fails to open). Through these contacts to the terminal 4 on the terminal block to the high temperature cutout switch to the fuel solenoid. This energizes the fuel solenoid and allows the governor to position the metering sleeve in the injection pump to full fuel.

With the manifold heater switch released and the start switch still closed, the starter solenoid and the manifold heater solenoid remain energized. Battery power is supplied to the glow plugs and manifold heater and to the cranking motor.

START DISCONNECT

The cranking motor continues to turn the engine until it starts and accelerates. The centrifugal switch has been set to operate at 900 rpm. The centrifugal switch is driven by a gear from the camshaft gear. As centrifugal force is high enough the weights fly out allowing the cam to drop in and the centrifugal disconnect closes. When the centrifugal switch closes, battery power is supplied through this switch to the 15 ohm, 10 watt resistor, to the coil of the start disconnect and fuel solenoid relay and to ground. This energizes that relay causing the normally closed contacts to open and break the start solenoid circuit. This also de-energizes the coil on the start relay. The contact in the start relay opens just after the contacts in the start disconnect and fuel solenoid close. This supplies power to the fuel solenoid and keeps it energized so that it does not release and cause the injection pump control metering sleeve to go to minimum fuel and stop the engine.

The engine governor maintains the engine speed at rated value for that particular unit. In this case it is 1800 rpm.

BATTERY CHARGE

When the engine has come up to speed the residual magnetism in the rotor poles produce a small voltage in the battery winding of the generator. A consequent voltage buildup is produced. When voltage has built up to normal then the battery charge winding in the stator has a voltage produced in it which is directed through the charge rectifier to the charge ammeter to the battery terminal on the manifold heater solenoid and to the battery, recharging it. The charge resistor is adjustable for the most satisfactory charge rate. It is factory set at approximately 5 amperes. The charge rectifier replaces the reverse current relay. It is a battery charge diode and this unit has only the one step of battery charging.

LOPKO

The 1 ohm, 10 watt resistor is to limit the current through the heater on the emergency relay. This heater gets current only after the generator has come up to a certain speed and centrifugal switch has closed. Should low oil pressure remain for 45 seconds the heater will allow the rachet to release and contacts will open breaking the circuit to the fuel solenoid causing a shutdown.

STOP

Placing the start-stop switch to the stop position shorts out the power supply to the start disconnect and fuel solenoid relay and breaks the circuit to the fuel solenoid. The solenoid shaft applies force to the injection pump control arm causing positioning of the metering sleeve to "no fuel" position. The engine stops due to no fuel to injectors.

FAST TROUBLESHOOTING

The ammeter indicating "O" usually means the generator has not built up voltage. This generator has an automatic field flash circuit which receives power from the S terminal of the start solenoid. When the start solenoid is energized, power is applied to the static exciter and to the revolving field for faster voltage build up. The 12-volt battery used does not cause damage to the exciter nor to the revolving field due to the high cranking currents causing a substantial voltage drop across the battery and reducing this voltage to approximately 8 volts.

Should the high water temperature cutoff switch operate due to excessive engine temperature it opens the circuit to the fuel solenoid, de-energizing it and shutting the unit down. Temporarily place a jumper across the switch terminals to determine if shutdown was due to high water temperature.

Should the centrifugal switch fail to close or make contact, the start disconnect and the fuel solenoid relay will not energize and as soon as the start switch is released, the unit will shutdown. This can be readily checked by taking the cover off the switch and holding contacts closed manually. It also can be checked by taking the cover off the control box and holding the start disconnect and fuel solenoid relay armature closed by hand. Should a centrifugal switch fail to open on shutdown it will cause a battery discharge and also operation of the emergency relay.

CENTRIFUGAL BREAKER POINTS

Centrifugal breaker points act as mechanical start disconnect switch for diesel ignition circuit. The centrifugal switch is wide open when engine is stopped. Loosen and move stationary contact to correct gap.

Rotate engine crankshaft a few degrees counterclockwise before adjusting points. To release any torsional forces created by the water pump impeller, use a socket wrench on the flywheel retaining screw.

Replace burned or faulty points. If only slightly burned, dress smooth with file or fine stone. Measure gap with thickness gauge (Figure 5-14).

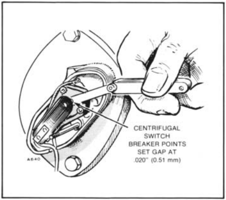


FIGURE 5-14. CENTRIFUGAL SWITCH

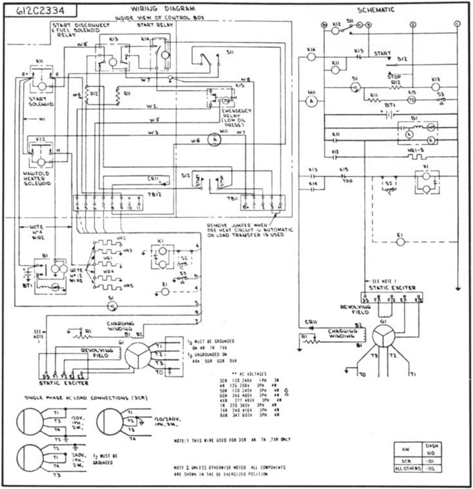


FIGURE 5-15. DIESEL GENERATING SET CONTROL

TROUBLESHOOTING "J" SERIES — BEGIN SPEC AA

ENGINE CONTROLS

This troubleshooting information is divided into four tables, A, B, C, and D as follows:

A. Engine does not crank.
B. Engine cranks but does not start.
C. Engine starts but stops when start switch is released.
D. Battery loses excess water.

Preparation: In the event a troubleshooting procedure has to be initiated, it is possible that a few simple checks could expose the probable problem source or at least cut down on troubleshooting time.

1. Check all modifications, repairs, replacements performed since last satisfactory operation of set. A loose wire connection, overlooked when installing a replacement part could cause problems. An incorrect connection, an opened switch or circuit breaker, or a loose plug-in are all potential malfunction areas to be eliminated by a visual check.
2. Unless absolutely sure that panel instruments are accurate, use portable test meters for troubleshooting.

The troubleshooting guide on the following pages gives a step-by-step procedure for checking the Control System.

Voltage Check Points: The voltages listed below indicate normal conditions. Check all terminal block terminals for correct voltages between terminal and ground using a DC voltmeter on 12V battery system.

TB11-B+	12 VDC
TB11-1	GROUND
TB11-2	12 VDC
TB11-3	12 VDC
TB11-H	12 VDC
TB12-4	12 VDC RUNNING
TB12-5	12 VDC RUNNING
TB12-6	(O-VDC STOPPED, 12 VDC RUNNING
TB12-7	19 to 21 VAC
TB21-1 to 2	120 to 139 VAC
K11-B+	12 VDC
K11-S	12 VDC ON STARTING
K13-H	12 VDC ON PREHEAT

To correct a problem, answer the question of the step either YES or NO. Then refer to the step number in the answer column and proceed to that step next. Refer to typical wiring diagram #612-2334 for locating control component leads, terminals, and other check points.

TABLE A. Engine Does Not Crank	Yes	No
1. Check 12 VDC to ground at battery BT1 and at starter motor B1. Check B+ present at TB11, K11, K13, S1, and M11.	—	—
2. Check battery cables for polarity and tightness at battery and starter motor.	—	—
3. Is battery dead? Check if centrifugal switch S1 is open to ground. If S1 remains closed when set is shutdown, R11 and K14 will discharge through S4 to ground. Remove switch cover and check operation manually.	4	
4. Replace S4. Replace or charge battery.	—	—
5. Jumper battery cable connection to ground at starter. Does engine crank?	7	6
6. Check starter motor. Repair or replace.		
7. With S11 at START, is at least 7 volts present between terminal S on K11 and ground. Does K11 energize?	8	
8. Does manual operation of K11 crank engine?	9	
9. Jumper K11 from B+ to S terminal. Does engine crank?	10	
10. Start relay K11 is defective; replace.		
11. With S11 at START, jumper K11 contacts to starter solenoid. Does engine crank?	11A	12
11A. Replace K11.		
12. With S11 at START, jumper normally closed contacts of K12. Does engine crank and start?	13	
13. Replace K12.		

TABLE B. Engine Cranks But Does Not Start	Yes	No
1. Is 12 VDC present between start terminal on S11 and ground (TB11-1) with S11 at START?		2
2. Is 12 VDC present between M11- B+ and ground TB11-1 with S11 at START? Check Wire W3 & W8.	3	4
3. Replace faulty switch S11.	—	—
4. Does engine operate on gasoline? Is fuel primer solenoid K3 energized when S11 is at START?	—	6
5. Does engine operate on diesel fuel? Did glow plugs and manifold heater warm engine on pre-heat attempt with S12.		6
6. Does fuel pump and fuel solenoid operate when S11 is at START?		7
7. Fuel solenoid and pump must operate during cranking and running. Remove fuel line from carburetor or injector pump and press S11. Does fuel pulsate from fuel line?		8

TABLE B. (continued)	Yes	No
8. Remove fuel solenoid from fuel line and press S11. Does fuel pulsate from line?		9
9. Check lead from TB12-4 to fuel pump; check fuel pump and replace if necessary.	—	—
10. Check engine oil level. If okay, remove LOP switch S4 lead at TB12-4. Does engine crank and run when S11 is pressed?		11
11. Is lead 6 from TB12-6 to LOP switch S4 grounded?		12
12. Repair or replace lead 6 to S4.		
13. Check switch S4; replace if necessary.		

TABLE C. Engine Starts But Stops When Start Switch is Released	Yes	No
1. Connect voltmeter from TB12-7 to ground. Is K12 energized with S11 at START?	2	
2. Is charge winding producing DC voltage? If AC voltage is present, replace CR11.	3	
3. Jumper contacts of K12 for gasoline ignition circuit check. Does engine start and run?		5
4. Jumper contacts of K12 for diesel fuel solenoid relay K1 circuit. Does engine start and run?		5
5. Replace K12.	—	—
6. Check charge resistor R21 and charging circuit connections.		

TABLE C. (continued)	Yes	No
7. Is charging ignition-fuel solenoid voltage present from TB12-7 to ground after engine starts and S11 is released?		

TABLE D. Battery Loses Excess Water	Yes	No
1. Connect a voltmeter (one percent accuracy or better) to battery terminals, start and run generator set for 30 minutes. Does battery terminal voltage exceed: a. 14 volts at 100°F (38° C) or above; or b. 15 volts at 50° to 100°F (10-38° C) or; c. 16 volts at 50°F (10° C) below?		

OPERATING SEQUENCE FOR DIESEL GENERATING SET CONTROL #612-4792

STARTING CIRCUIT

The common practice for placing "Onan" Class "A" controls into operating condition is by grounding certain components. The switch is used to place this ground on the affected components.

Moving the handle of the manifold heater switch S12 to the preheat position causes a current flow from B+, through the coil of manifold heater solenoid K13 to ground and back to battery negative terminal. This causes manifold heater relay K13 to energize and closes its contacts to supply power to the manifold intake heater and glow plugs. If the preheat circuit is controlled by a load transfer control, this relay is energized by the grounding of terminal "H." The length of preheat can be selected through the use of a relay or through manually holding heater switch S12 on.

After the preheat period has passed, the load transfer control will cause terminal 3 to be grounded energizing the starting circuit. The starting circuit can also be energized by placing start-stop switch S11 in the start position. This allows battery current to flow from the B+ through start solenoid relay coil K11, through the closed contacts of the start-disconnect and fuel solenoid relay K12, through the start switch S11, to the center terminal to ground and to the battery causing start solenoid K11 to energize. K11 start solenoid energizes and causes its main contacts to close, connecting the battery through the cranking motor. At the same time the main contacts of K11 are closed, an auxiliary circuit is also completed from start solenoid K11 through the contacts of the emergency time delay relay K14, to the fuel solenoid K1, and to the battery. The fuel solenoid K1 is a two coil unit with a pickup coil and a holding coil. This relay energizes to take pressure off the control arm of the fuel injection pump and allows the metering sleeve to be positioned so fuel is supplied to the injectors so the engine can fire, start and run.

When the engine has started and accelerated to approximately 900 RPM, the centrifugal disconnect switch S1 closes. When switch S1 closes, battery current flows through its contacts, through resistor R11, through the coil of the start-disconnect and fuel solenoid relay K12 to the battery. This causes the K12 relay to energize and breaks the circuit to the start solenoid relay K11 causing the start solenoid K11 to de-energize and remove the cranking motor from the battery. At the same time, another set of K12 contacts close supplying power from the charging circuit or the battery through the normally closed contacts of emergency relay K14 to the fuel solenoid K1. This keeps relay K1 (fuel solenoid) energized and allows the governor to control the fuel injection pump.

The engine governor will maintain engine speed at approximately 1860 RPM (62 hertz) or a fairly constant speed with load added.

A permanent magnet is imbedded in the exciter field assembly. This is installed at the time the lamination stack is assembled. This permanent magnet aids in the voltage build-up in the exciter. The residual magnetism of the pole pieces plus the permanent magnet in the one pole, causes a higher residual voltage to be produced. This produces, in the three phase exciter rotor, a voltage which is rectified by a network of three positive and three negative diodes to the generator rotor for field excitation. The voltage produced in the stator is supplied to the voltage regulator which controls the turn on point of the SCR's and in turn controlling field current. When the generator's voltage reaches the control point, the voltage regulator maintains field current to hold essentially constant output voltage.

BATTERY CHARGING CIRCUIT

A separate battery charge winding is placed in the generator stator and has a voltage produced in it dependent upon the field strength of the main generator. The charging current is controlled by resistor R21. This charging circuit is essentially a 5 ampere circuit. Battery charging current is supplied through diode CR11 to the ammeter and to the battery back to ground and to the charging winding. This charges the battery and prepares it for supplying power for the next start. The charge winding also supplies power to maintain the fuel solenoid K1, energized.

LOW OIL PRESSURE CUT-OUT (LOPKO)

The low oil pressure cutout circuit is from the battery side of the ammeter through the centrifugal disconnect switch S1 to resistor R12, through the heater of the emergency time delay relay K14 and through the low oil pressure switch S4 to ground. Resistor R12 sets the timing interval of emergency relay K14. Should there be a loss of oil pressure or an excessive drop in level, switch S4 will close and the emergency time delay relay K14 will operate in approximately 15 seconds. When time delay relay K14 operates due to low oil pressure, its normally closed contacts open and break the circuit to the fuel solenoid K1. The fuel solenoid de-energizes and its plunger drops down on the control arm of the fuel injection pump and shuts down the engine.

UNIT STOPPING

To stop the engine it is necessary to ground terminal #2 through the load transfer control or to place start-stop switch S11 in the stop position. Grounding terminal #2 or placing start-stop switch S11 in the stop position causes a ground to be placed on the supply side of the start-disconnect and fuel solenoid relay K12. Relay K12 de-energizes, its contacts open and break the circuit to the fuel solenoid K1 causing engine shutdown. Resistor R11 is placed in the circuit so a short circuit or direct ground is not placed on the battery charging circuit.

FAST TROUBLESHOOTING

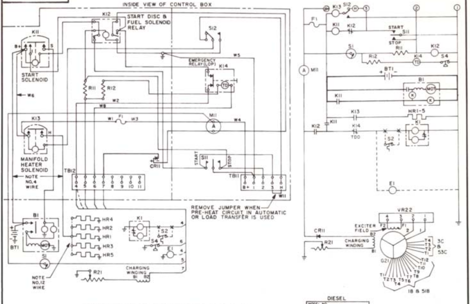
If the ammeter does not indicate a charge, it usually means the generator has not built up voltage. This generator does not have an automatic field flash circuit; and consequently, it is necessary to make a field voltage measurement. This can be done across terminals 3 and 4 at the end bell of the generator or at terminal 7 or 8 of the voltage regulator assembly. Terminal 8 is positive and terminal 7 is negative. Should no voltage be measured at these points, refer to the "YD" Generator Service Manual (900-0184).

The water-cooled units have a high water temperature cutoff switch S2 in series with the fuel solenoid K1. This switch can be checked by placing a jumper across the terminals of the switch and closing the start switch S11 to see if the solenoid energizes.

If there has been a low oil pressure cutout condition, the red button on the emergency relay K14 will be sticking out. One minute of "cool down" is required before resetting (pushing in the button) the relay to place it back in operation. A shorter time may result in the solder pot not fusing correctly and permitting the button to be pushed out by the spring when the unit vibrates.

Should the centrifugal switch S1 fail to close or make contact, the start-disconnect and fuel solenoid relay K12 will de-energize as soon as the start switch S11 is released and then the unit will shut down. This causes a cycling condition on the generator set. The centrifugal switch S1 can be checked by removing the cover and holding the contacts closed manually after the unit has started. Set the centrifugal disconnect switch gap at approximately .020 inches (0.51 mm) for proper wipe and contact pressure. Should the centrifugal switch S1 fail to open on shutdown, it will cause a battery discharge and burn out of the emergency time delay relay (K14).

612-4792



MODEL	VR22 4 CYL.	VR23 4 CYL	VR22 MARINE	VR23 MARINE	VR27 2 CYL.	VR23 2 CYL.
3CR & 53CR	-01	-03	-05	-07	-09	11
18R & 518R	-02	-04	-06	-08	-10	-12

DIESEL

MODEL NO	
	4.5 & 9.0KW-53CR/96AA
	4.5 & 9.0KW-518R/96AA
	6.0 & 12.0KW-3CR/96AA
	6.0 & 12.0KW-18R/96AA
MARINE	6.0,10.0 & 12.0KW-53CR/1AA
MARINE	6.0,10.0 & 12.0KW-518R/1AA
MARINE	7.5,12.0 & 15.0KW-3CR/1AA
MARINE	7.5,12.0 & 15.0KW-18R/1AA

STANDARD DIESEL CONTROL 612-4792

FIGURE 5-16. DIESEL GENERATING SET CONTROL

"HA" AUTOMATIC LOAD DEMAND CONTROLS (SPEC D MODELS)

The HA automatic demand control provides automatic starting of a generator set when a load (lighting, motor, or other electrical device) is switched on. When the electrical load is removed, it automatically stops the generator set. It is designed to operate an Onan generator set as the only power source, not as a standby unit during commercial power outages. Therefore, if an AC load demand is intermittent, the generator set does not need to run continuously.

WARNING **The HA automatic control is not certified for use in a gasoline fueled environment and must be separated by a bulkhead or deck.**

BASIC PRINCIPLES OF OPERATION

When the generator set is not running, the DC starting battery is connected across the line (in place of AC voltage). When a load is connected across the line (when a light is turned on for example), the small amount of current flowing through the 120-volt bulb (from the battery) operates a sensitive relay to the generator set start circuit. When the generator set starts and reaches full speed, another relay disconnects the battery from the line and connects the 120-volt output of the generator set to the line (load).

The generator set will continue to run if engine AC current flows through the load from the generator set. In general, a 40-watt load keeps a 120-volt generator set running (100 watts for a 240-volt generator set).

The HA automatic demand control requires little attention, but if difficulties arise, use the operation description, service information, and troubleshooting chart to diagnose and locate the trouble.

CONTROL COMPONENTS

AUTO-MANUAL SWITCH

For normal operation, keep the auto-manual switch in the "AUTO" position. Whenever you do not want automatic starting or you want to service the generator set, set the switch at "MANUAL". In the "MANUAL" position, the generator set will start only from its start-stop switch or by hand cranking.

LINE CONTACTOR

The line contactor connects the generator AC output to the load after generator voltage builds up. It has auxiliary contacts to disconnect the pilot and cranking circuits after the generator set starts. Both the contacts and coil of the contactor are replaceable.

Contacts on the contactor may require cleaning if operated in extremely dusty or dirty environments. If so, remove the plastic cover (Figure 5-17). Pull a medium grade and weight paper (if a burnishing tool isn't available) between the closed contacts.

Silver contacts will discolor with use but still operate efficiently.

If the contact points become badly burned or pitted, replace them as follows:

1. Remove plastic hood.
2. Remove spring and washer from each contact guide post.
3. Lift contacts from guide post. Curved silver contact surfaces face inward when replacing.
4. Take out stationary contacts by removing screws holding them to the plastic body.

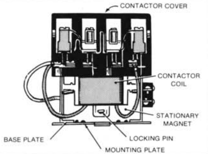


FIGURE 5-17. HA LINE CONTACTOR

CURRENT TRANSFORMER

The current transformer senses AC load current flow. Load current through the transformer produces a small AC output to the load sensor.

If the transformer is believed defective, check continuity between all three leads. Replace the coil if continuity does not exist between all windings.

CRANKING LIMITER

The cranking limiter is a safety device to control the maximum cranking time. If the engine will not start after 45 to 90 seconds cranking, the breaker opens removing battery voltage from the pilot circuit and start-run relay.

The limiter can be tested by checking continuity of the heater and checking for heating during a starting cycle. To test circuit breaking, disconnect the generator set remote start lead (terminal 3, remote) and apply a load. The start-run relay should operate immediately. After any start time delay and bilge blower time delay (begin Spec D only), the cranking limiter should heat. After 45 to 90 seconds, the limiter should open.

TIME DELAY RELAY

The time delay is a thermostatic relay with a delay between heater energization and contact pull-in. Energized by the pilot circuit, it starts preheat immediately by grounding remote terminal H. After the prescribed delay, the relay contacts close starting the cranking cycle.

To test this relay, apply a load to the control and watch contact operation. One contact should bend to close the circuit with the time delay. If the contacts do not close, check voltage at the heater terminals of the relay socket and check continuity of the heater.

BILGE BLOWER TIME DELAY (SPEC D)

This solid state time delay relay is an in-line type and delays starting of the generator set for about five minutes while the bilge blower operates. It is energized by completion of a ground circuit through the start-run relay contacts. After the time delay period, it opens the bilge blower circuit by deenergizing a transistor, and it closes a circuit for a start time delay (if used) or for beginning of engine cranking.

Before testing the timer, always check the 6.25-ampere fuse to see if it has blown. If the fuse is okay, connect a DC voltmeter between B+ and time delay terminal 3 on the terminal block. At the end of the time delay, the voltmeter should indicate battery voltage. The DC voltmeter connected between B+ and time delay terminal 2 should now read zero volts.

LOAD SENSOR

The load sensor amplifier rectifies and regulates the AC voltage from the current transformer. Rectifiers on the printed circuit board convert the AC voltage into DC. The capacitors and resistors filter and regulate the voltage.

If the load sensor is believed to be the source of a control malfunction, use the troubleshooting procedures for checking components.

LINE CONTACTOR PULL-IN VOLTAGE ADJUSTMENT

An adjustable resistor in series with the line contractor coil adjusts the contractor pull-in voltage (Figure 5-18). This is factory adjusted to pull in when the generator voltage reaches 102 to 108 volts (204 to 216 volts on 240-volt models). Do not adjust this resistor unless the line contactor will not pull in when the generator set starts or if it pulls in at too low a voltage causing the generator set to start and stop repeatedly.

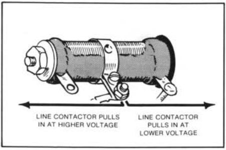


FIGURE 5-18. LINE CONTACTOR ADJUSTMENT

CIRCUIT DESCRIPTION

PILOT CIRCUIT

The pilot circuit initiates generator crank and start when there is a demand for electric power (Figure 5-19). If an AC load is connected to the generator set, DC current from the B+ terminal flows through safety breaker contacts K3, auto-manual switch S1 (in AUTO position) rectifier A1CR1, one-half the relay coil A1K1, fuse A1F1, contact K2, and the AC load to common ground and battery to energize the start-stop relay A1K1.

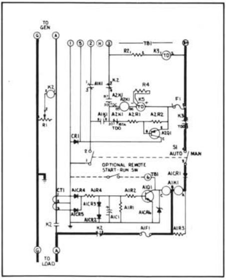


FIGURE 5-19. PILOT CIRCUIT

BILGE BLOWER

When start-stop relay A1K1 energizes to close its normally-open contacts A1K1 (3-2), it completes a circuit from transistor A2Q1, resistor A2R1, normally-closed contacts A2K1 through the A1K1 contacts, auto-manual switch S1 to ground. Transistor A2Q1 turns on to conduct B+ through F1, A2Q1 to terminal 5 for operation of the bilge blower (Figure 5-20).

Contacts A1K1 (3-2) also connect a ground to the bilge blower control relay A2K1 and relay K5. Relay K5 begins a five-minute delay while the bilge blower operates to evacuate explosive vapors from the bilge.

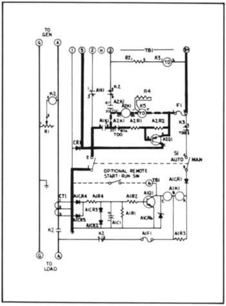


FIGURE 5-20. ENERGIZATION OF BILGE BLOWER CIRCUIT

CRANKING CIRCUIT

At the end of the five-minute delay, bilge blower relay A2K1 opens its normally-closed A2K1 contacts (30-87A) to remove battery ground from transistor A2Q1. Transistor A2Q1 turns off removing B+ from terminal 5 for the bilge blower operation. Relay A2K1 also closes its normally open contacts A2K1 (30-87) to connect battery ground through K2 contacts (5-4) to terminal 3. Terminal 3 connects to the generator set start circuit.

DC current from B+ terminal flows through cranking limiter K3, resistor R2, normally-closed K2 contacts, A2K1 contacts (30-87), A1K1 contacts (3-2) and auto-manual switch S1 to ground (Figure 5-21). If the generator set does not start within 45 to 90 seconds, the heat produced by the element in the cranking limiter causes relay K3 contacts (2-3) to open the circuit to start-stop relay A1K1. Relay A1K1 is de-energized to open its normally-open contacts which removes battery ground from start terminal 3. Wait at least one minute before resetting the breaker. This time allows the material in the breaker to solidify and hold the contacts closed so cranking can resume.

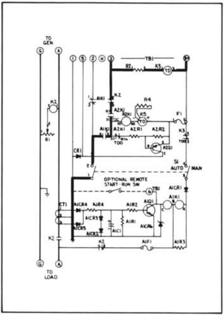


FIGURE 5-21. CRANKING LIMITER

GENERATOR RUN CIRCUIT

When the engine starts and the generator AC voltage builds up to approximately 210 volts on 240-volt units, line contactor K2 is energized (Figure 5-22). Resistor R1 adjusts the line contactor pick-up voltage.

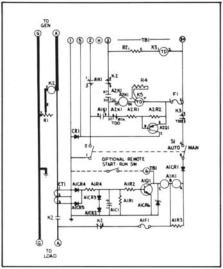


FIGURE 5-22. GENERATOR RUN CIRCUIT

POWER CIRCUIT

When the contactor K2 energizes, the pilot circuit interlock contacts open just before the power contacts close (Figure 5-23). The closed K2 contacts open to break the grounding circuit from control terminal 3. The circuit to the coil of A1K1 opens and prevents application of generator voltage to the low voltage control circuit.

Load current passes through the primary of the current transformer CT1 to induce a voltage in the transformer secondary. Current and voltage from the CT1 secondary turn on transistor A1Q1. Current flows from B+ through normally-closed K3 contacts, auto-manual switch S1, rectifier A1CR1, both coils of start-stop relay and the transistor to ground. The relay A1K1 remains energized as long as a load is connected keeping normally-closed A1K1 contacts open to prevent generator set shutdown.

STOP CIRCUIT

When the AC load is removed, there is no current flow through transformer CT1 and transistor A1Q1 switches off. The start-stop relay A1K1 is de-energized and its contacts return to their original positions. Normally-open A1K1 contacts open and normally-closed A1K1 contacts close to connect terminal 2 through the auto-manual switch S1 to ground (Figure 5-24). Terminal 2 is an extension of the generator set stopping circuit. The control grounds the ignition to stop the generator set. When the generator set shuts down, the K2 contacts return to their original positions.

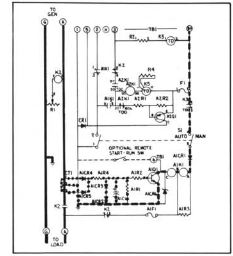


FIGURE 5-23. POWER CIRCUIT

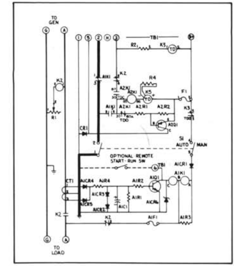


FIGURE 5-24. STOP CIRCUIT

TROUBLESHOOTING CHART (Spec D Only)

TROUBLE	REMEDY
Bilge blower does not operate when load is connected	1. Check switch positions. Auto-manual switch should be at "AUTO", elec-start switch at "ELEC START." 2. Battery terminals may be incorrect. Should have negative ground only. 3. Check 6.25-ampere fuse. If open, check for short circuit. Remedy and replace fuse. 4. Check fuse on load sensor printed circuit board and replace if open. Make sure incoming wires from generator aren't connected to the load side of the contactor. 5. With a hydrometer, check battery specific gravity. Check battery voltage at control B+ terminal. 6. Check load circuits. Disconnect load wires from control and substitute another load (such as a 100-watt lamp.) If generator set starts with this load, check for problem in load circuits. 7. Jumper a wire from terminal TB1-B+ to terminal TB1-5. If bilge blower does not operate, problem is in bilge blower or its circuitry. **Bilge blower operates:** Check for battery voltage between B+ and relay A2K1 terminal 30. If battery voltage is absent, see *Printed Circuit Boards Tests (Spec C and D)*. 8. For 120/240-volt HA controls, jumper K1 terminals 6 and 7. For other HA controls, jumper relay A1K1 terminal 2 to 3. If bilge blower operates, replace K1 or A1K1 relay, whichever applies. Remove jumper wire. 9. Jumper terminal 87A of relay A2K1 to a good ground. If the bilge blower operates, check relay A2K1 and replace if necessary. 10. Check power transistor A2Q1 and replace if necessary (see Figure 5-25). a. Unsolder the wire and resistor connections to A2Q1. Do not take so much time to unsolder that you damage A2Q1 with heat. b. With an ohmmeter or multitester, check the resistance readings between B, C, and E. Use the metal bracket or A2Q1 mounting hardware for C connection during the tests. B is the top transistor pin, and E is the bottom pin. c. Between B and C: infinity in one direction, about 11 ohms with the ohmmeter leads reversed. d. Between B and E: infinity in one direction about 11 ohms when you reverse the ohmmeter leads. e. Between C and E: infinity in both directions. **If A2Q1 is defective, check CR1 before replacing A2Q1 or before starting operation again. With the ohmmeter leads on TB1 terminals 1 and 5, you should get a low resistance reading in in one direction, infinity when reversing the ohmmeter leads.**

TROUBLESHOOTING CHART (Cont.)

TROUBLE	REMEDY
Automatic demand control will not start generator set with load	1. Check switch positions. Auto-manual switch should be set at "AUTO," elec-start switch at "ELEC START." 2. Check battery terminals. Must be connected negative ground. 3. Check cranking limiter. If tripped, push reset button after waiting one minute. Before restarting, check for cause. 4. Check 6.25-ampere fuse. If open, check for short circuit. circuit. Remedy and replace fuse. 5. Check fuse on load sensor printed circuit board and replace if open. Before restarting, make sure incoming wires from generator aren't connected to the load side of the contactor. 6. With a hydrometer, check battery specific gravity. Check battery voltage at control B+ terminal. 7. Check load circuits. Disconnect load wires from control and substitute another load (such as a 100-watt lamp). If generator set starts with this load, check for problem in load circuits. 8. Check if bilge blower is operating. If it is, wait until the end of the bilge blower operation to see if unit start. **If bilge blower does not operate when a load is connected to the generator set, see** *Bilge Blower Does Not Operate When Load is Connected.* 9. Check generator set operation without automatic demand control. Disconnect demand control from generator set. Start generator set with start-stop switch on set controls. If set doesn't operate properly, reconnect demand control and refer to the generator set operator's manual or service manual. 10. Jumper A2K1 terminal 30 to TB1-3, then remove jumper. Remove quickly if unit starts. **WARNING** **Before performing this test, make sure the bilge blower has operated. Otherwise, any gas accumulations could ignite resulting in fire and explosion.** 11. If HA has a start time delay relay, note if the contact has bent to close the circuit with the time delay. If you are not sure, repeat Step 10 again and note the start time delay contact. Replace if necessary. 12. Remove the load, stop the generator set, and disconnect battery ground cable. With an ohmmeter, check for continuity across contactor K2 contacts C-NC for the 120/240 volt HA controls, across contactor K2 contacts 4-5 for the other HA controls. 13. Replace the bilge blower time delay A2K1.

TROUBLESHOOTING CHART (Cont.)

TROUBLE	REMEDY
Generator set starts but does not assume load	1. Check generator output voltage. See generator set operator's manual. 2. Check the automatic control contactor coil. If malfunctioning, see *Line Contactor Pull-in Adjustment* under CONTROL COMPONENTS. 3. Check pull-in voltage and change setting (if necessary) of adjustable resistor for contactor pull-in. See *Line Contactor Pull-in Adjustment* under control components.
Generator set starts but stops when line contactor pulls in	1. Move auto-manual switch to "MANUAL" position. Connect a jumper from terminal 6 to terminal 1. Move auto-manual switch to "AUTO" position. Generator set should start and run. 2. Apply a load and remove jumper while generator set is running with switch at "AUTO". If generator set stops, remove printed circuit board from control. 3. See *Printed Circuit Board Tests.*
Generator set will not stop when load is removed	1. Pull auto-manual switch in "MANUAL" position and stop generator set with start-stop switch on engine control. 2. Remove the lead from the load side of the contactor in the demand control. 3. Move the auto-manual switch to "AUTO." 4. If engine cranks, proceed to Step 5. If engine doesn't crank, put auto-manual switch to "MANUAL" position. Start engine with engine start-stop switch. Move auto-manual switch to "AUTO" position and generator set should stop. This indicates there was sufficient load to keep the control energized. Check load circuit for loads. 5. See *Printed Circuit Board Tests.*

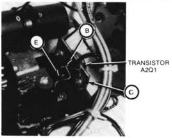


FIGURE 5-25. LOCATION OF TRANSISTOR A2Q1

300-0740 AND 300-0743 Printed Circuit Boards

Remove the printed circuit board from the control. Check components with an ohmmeter set at R X 100 scale except where noted. Always recheck zero setting when changing scale settings.

CAUTION **The volt-ohm-milliameter used must have batteries of 3 volts or less or diodes on the printed circuit board can be damaged during the tests.**

With the printed circuit board positioned as shown in Figure 5-26, start the tests on the left. All readings given are approximate.

1. Condenser C1 and resistor R1 have a resistance of approximately 10,000 ohms in one direction and 1100 ohms in the other direction.
2. Rectifiers CR2 and CR3 normally have resistance of 15,000 ohms in one direction and 750 ohms in the other direction.
3. Check transistor Q1 (three-lead component) like a rectifier. Check resistance in one direction, reverse leads and check resistance in that direction. B to C - 750 ohms, infinity; B to E - 750 ohms, 11,000 ohms; C to E - 700 ohms, infinity.
4. Resistors R2 and R4 should have resistances of 200 ohms and 47 ohms respectively. Use R X 1 scale for R4.
5. Rectifiers CR4 and CR5 should have a resistance of 600 ohms in one direction, infinity in the other direction.
6. Resistance of Zener diode CR6 should be 700 ohms in one direction, infinity in the other direction.
7. Rectifier CR1 normally has 600 ohms in one direction, infinity in the other direction.
8. Using the R X 1 scale, check resistor R3. Resistance should be 33 ohms.
9. *300-0743 Board Only:* Resistance of resistor R5 (by start-run relay) and R6 (below fuse) should be approximately 1500 and 160 ohms respectively.

300-0741 Printed Circuit Board

Remove the printed circuit board from the control. Check components with an ohmmeter set at R X 100 scale except where noted. Always recheck zero setting when changing scale settings.

CAUTION **The volt-ohm-milliameter used must have batteries of 3 volts or less or diodes on the printed circuit board can be damaged during the tests.**

With the printed circuit board positioned as shown in Figure 5-27, start the tests on the left. All readings given are approximate.

1. Condenser C1 and resistor R1 have a resistance of approximately 2100 ohms in one direction and 900 ohms in the other direction.
2. Rectifiers CR2 and CR3 normally have resistance of 3700 ohms in one direction and 650 ohms in the other direction.
3. Check transistor Q1 (three-lead component) like a rectifier. Check resistance in one direction, reverse leads and check resistance in that direction. B to C - 700 ohms, infinity; B to E - 750 ohms, 2100 ohms; C to E - 700 ohms, infinity.
4. Resistors R2 and R4 should have resistances of 200 ohms and 47 ohms respectively. Use R X 1 scale for R4.
5. Rectifiers CR4 and CR5 should have a resistance of 600 ohms in one direction, infinity in the other direction.

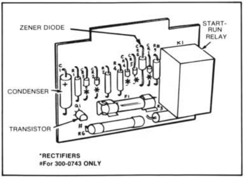


FIGURE 5-26. 300-0740 AND 300-0743 PRINTED CIRCUIT BOARDS

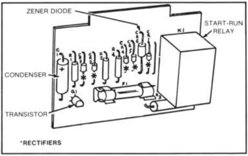


FIGURE 5-27. PRINTED CIRCUIT BOARD

6. Resistance of Zener diode CR6 should be 700 ohms in one direction, infinity in the other.
7. Rectifier CR1 normally has 600 ohms in one direction, infinity in the other direction.
8. Using the R X 1 scale, check resistor R3. Resistance should be 55 ohms.

300-0747 Printed Circuit Board

Remove the printed circuit board from the control. Check components with an ohmmeter set at R X 100 scale except where noted. Always recheck zero setting when changing scale settings.

CAUTION **The volt-ohm-milliameter used must have batteries of 3 volts or less or diodes on the printed circuit board can be damaged during the tests.**

With the printed circuit board positioned as shown in Figure 5-28, start the tests on the left. All readings given are approximate.

1. Condenser C1 and resistor R1 have a resistance of approximately 2100 ohms in one direction and 900 ohms in the other direction.
2. Rectifiers CR2 and CR3 normally have resistance of 3700 ohms in one direction and 600 ohms in the other direction.
3. Check transistor Q1 (three-lead component) like a rectifier. Check resistance in one direction, reverse leads and check resistance in that direction. B to C - 700 ohms, infinity; B to E - 700 ohms, 2300 ohms; C to E - 900 ohms, infinity.
4. Resistors R2 and R4 should have resistances of 200 ohms and 47 ohms respectively. Use R X 1 scale for R4.
5. Rectifiers CR4 and CR5 should have a resistance of 600 ohms in one direction, infinity in the other direction.
6. Resistance of Zener diode CR6 should be 600 ohms in one direction, infinity in the other.
7. Resistance of resistors R6, R5, and R3 should be 200, 100, and 200 ohms respectively.
8. Rectifier CR1 normally has 600 ohms in one direction, infinity in the other direction.

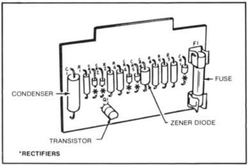
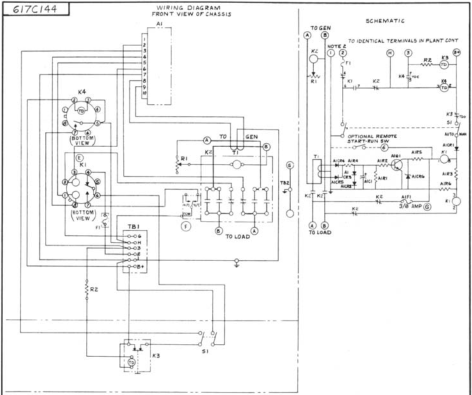


FIGURE 5-28. 300-0747 PRINTED CIRCUIT BOARD



NOTES:

1. OPERATE WITH NEGATIVE GROUND ONLY.
2. IT IS NOT NECESSARY TO CONNECT TERMINAL 1 TO GEN BECAUSE GEN & CONTROL ARE CONNECTED THRU AC GROUND LEAD.

FIGURE 5-29. AUTOMATIC LOAD DEMAND CONTROL SYSTEM

SHORELINE CONTROLS

Onan LT series line transfer controls are designed to be used with remote starting electric generatng sets installed for standby service. In standby service, generating sets operate when the primary source of electric power fails or when it is desired for any other reason to have the generating set carry the load. The primary power source may be either a commercial power line or another generating set.

The line transfer control, standby set, and primary source should all have the same electrical characteristics - voltage, frequency, phase, and number of wires.

Listed on the nameplate is the maximum electrical load the line transfer can safely carry. Be sure the maximum current requirements of the electrical circuit never exceed the nameplate rating of the line transfer control, even if a set with a smaller capacity is used.

In operation, the line transfer control connects the electrical load lines to the primary source of power. When primary power fails or drops off excessively, the line transfer control automatically disconnects primary power, starts the standby set, and connects the standby set to the load lines. When primary power is restored, the line transfer control automatically disconnects and stops the standby set and reconnects primary power to the load lines.

For simplicity, the line contactor contacts shall be called line contacts, and the generator contactor contacts shall be called generator contacts.

This explanation is comprised of two sections covering controls with electrically held contactors and controls with mechanically held contactors.

LT controls rated at 30amps (also LT60-21) and less have electrically held contactors. During operation on primary power, the line contacts are held closed by the contactor coil. They remain closed as long as the coil is energized.

LT controls rated at 60amps (except LT60-21) and greater have mechanically held contactors. During operation on primary power, the line contacts are held closed by a mechanical latch. The contactor coil is de-energized after the contacts close.

Refer to control Service Bulletin #9 and #18 and T-011 Technical Bulletin.

All LT type controls have an electrical interlock between the two contactors to prevent both of them from closing at the same time.

AUTOMATIC TRANSFER SWITCH

These are single coil transfer switches enclosed in NEMA #1 cabinets and provide automatic switching of AC electrical loads from the vessel's electric generating set to the shoreline utility power. The transfer switch's magnetic reversing action automatically switches the vessel's electrical load to SHORELINE, utility power when you connect the vessel's shore power electric line into a shoreline receptacle. If shoreline power is disconnected or disrupted in any way, the transfer switch normally closed on shoreline power, automatically reconnects the load to the vessel's electric generating set. If generating set is equipped with either a Control-O-Matic or an HA automatic control, it will start up automatically if load exists. Other sets must be started by start switch manually. Under no condition can power be supplied at the same time from both sources.

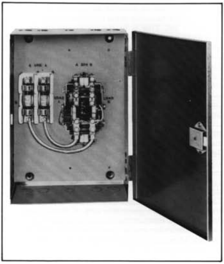


FIGURE 5-30. TYPICAL AUTOMATIC SHORELINE TRANSFER SWITCH

MANUAL ROTORY SWITCH

OPERATION — This manual transfer switch is intended for switching from line voltage (shore power) to generator set voltage (generating set). With this switch it is possible to change from line voltage to generator voltage with only a small power interruption. Push in on switch handle to go from "OFF" to Onan Power or Shore Power. It is recommended that the generator is started and allowed to warm-up a few minutes before switching to generator voltage. The generator may be allowed to run with the switch set for line voltage (shorepower). In either OFF position, the load system has no power applied unless from another source.

These switches are manually operated, with four positions, (2 "OFF") and are rated at 60 amperes. They are intended for use as a transfer switch from commercial line power (shore power) to generating set power.

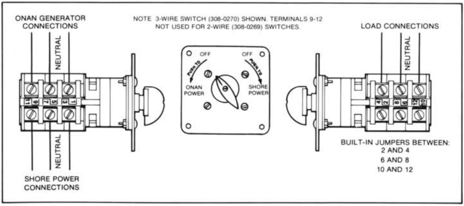


FIGURE 5-31. TYPICAL LOAD TRANSFER SWITCH DIAGRAM

SUMMARY

The control systems for the various marine units serve as sort of a nerve center for controlling and synchronizing all the individual operations and functions of the marine generating set. Depending on the particular unit involved; its installation, and the demand placed upon the set by the vessels load; the control functions to see that all systems and circuits work together to perform the common objective of the generator set. This is to supply power on demand whenever and where ever its needed. The starting, ignition, running, stopping and emergency shutdown functions of the unit are all controlled by the sets control system. The automatic demand and load transfer systems work together with the generator set control to make the overall system more completely automatic from start to stop. In this respect the control system might be called the brain of the generator set. With the aid of the information contained in this section; the service personnel should be able to thoroughly troubleshoot and repair any Onan marine control system quickly and efficiently. Remember too that Onan has many other manuals and special tools available to aid the service personnel in troubleshooting a specific section of the overall generating set. The Onan Master Service Manual (#922-0500) and many other Service and Technical Bulletins deal specifically with individual areas of all Onan generator sets in detail. When in doubt always consult the regular Operator's Manual for the particular model being repaired. Remember too that when consulting the factory for assistance in Troubleshooting of any Onan unit, always give the complete *model number, serial number and specification letter* of the unit being repaired. This is also important when ordering any parts.

When the electric generating set is correctly serviced and maintained, it provides many hours of safe and efficient operation. Service and maintenance includes following the proper adjustment and testing procedures and as a routine part of the schedule every time when preparing to leave the pier.

- Check the marine generating set for a safe and proper installation.
- Be sure all connections are clean and tight.
- Check service items such as:
  - Oil in crankcase
  - Clean flame arrestor/air cleaner
  - Battery properly connected
  - Fuel lines tight
  - Rated voltage being produced
  - Water pump operation
  - Governor set for correct RPM
  - All spilled gasoline or oily rags removed
  - Bilge blower working properly
  - Check fuel supply
  - Inspect exhaust system
  - Have an approved, fully charged fire extinguisher located close by.

With a minimum of preventive maintenance your Onan unit will provide its owner with many happy hours of trouble free cruising and safe happy boating. Remember Onan builds power afloat for any size vessel. Power on Demand for the *Good* Things in Life. Performance certified.

REFERENCE PUBLICATIONS

The Onan Technical Publications listed on this page are available at nominal cost from the Onan Office Services Department. The information contained in these various manuals and bulletins will serve to supplement the various sections of the training manual in more detail for each subject and section of the manual. The listing is grouped into five main catagories.

TECHNICAL BULLETINS	TITLE
T-011	Load Transfer Controls
T-021	Onan Marine Generator Set Installation

SERVICE BULLETINS	TITLE
Eng. 21	Onan Gasoline Engine Maintenance Chart
Eng. 22	Onan Diesel Engine Service Chart
Eng. 24	Crankcase Oil Recommendations for Onan Built Engines
Eng. 32	Air Cleaner Maintenance
Eng. 34	Timing Button Selection J-Series Diesel
Eng. 45	Storage of Marine Generator Sets
Eng. 56	Out of Service Protection Gasoline Engine
Eng. 57	Out of Service Protection Diesel Engines
Gen. 18	Reconditioning Water Damaged Electric Generator Sets
Misc. 2	Care of Batteries

OPERATOR MANUALS	TITLE
927-0121	MCCK Operator Manual
968-0123	MDJA Operator Manual
968-0122	MDJC Operator Manual
968-0120	MDJE Operator Manual
968-0121	MDJF Operator Manual

PARTS CATALOG	TITLE
927-0221	MCCK Parts Catalog
968-0223	MDJA Parts Catalog
968-0222	MDJC Parts Catalog
968-0220	MDJE Parts Catalog
968-0221	MDJF Parts Catalog

OTHER ONAN BOOKS	TITLE
922-0500	Onan Master Service Manual
900-0184	YD Generator Service Manual
900-0019	Onan Tool Catalog

Onan Corporation • 1400 73rd Avenue Northeast • Minneapolis Minnesota 55432

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