SERVICE MANUAL
UV GENERATORS AND CONTROLS
300 kW to 600 kW

TABLE OF CONTENTS

ONAN RECOMMENDS THAT ALL SERVICE, INCLUDING INSTALLATION OF REPLACEMENT PARTS, BE PERFORMED BY QUALIFIED PERSONNEL.

SAFETY PRECAUTIONS

The following symbols in this manual highlight potentially dangerous conditions to the operator or equipment. Read this manual carefully. Know when these conditions can exist. Then, take necessary steps to protect personnel as well as equipment.

WARNING **Onan uses this symbol throughout this manual to warn of possible personal injury.**

CAUTION **This symbol refers to possible equipment damage.**

GUARD AGAINST ELECTRIC SHOCK

Disconnect electric power before removing protective shields or touching electrical equipment. Use rubber insulative mats placed on dry wood platforms over floors that are metal or concrete when around electrical equipment. Do not wear damp clothing (particularly wet shoes) or allow skin surfaces to be damp when handling electrical equipment.

Disconnect batteries to prevent accidental engine start. Jewelry is a good conductor of electricity and should be removed before working on electrical equipment.

Use extreme caution when working on electrical components. High voltages cause injury or death.

Follow all state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician.

PROTECT AGAINST MOVING PARTS

Avoid moving parts of the unit. Loose jackets, shirts or sleeves should not be worn because of the danger of becoming caught in moving parts.

Make sure all nuts and bolts are secure. Keep power shields and guards in position.

If adjustments are made while the unit is running, use extreme caution around hot manifolds, moving parts, etc.

Do not work on this equipment when mentally or physically fatigued.

INTRODUCTION

FOREWORD

This manual provides troubleshooting and repair information for ONAN series UV generators. It is intended to provide the maintenance technician, serviceman or Onan distributor with a logical procedure to enable him to systematically locate and repair malfunctions in the generator and control systems. This information is not applicable to the prime mover; refer to the engine manufacturer's manual.

Repair information is not extensive because solid-state printed circuit modules lend themselves more to replacement than repair. ONAN does not recommend repair of the printed circuit module, except at the factory and has initiated a return/exchange service obtainable through distributors, whereby faulty modules can be returned and exchanged for good units. For more information, contact your distributor or the ONAN service department.

CAUTION **Application of meters or high heat soldering irons to modules by other than qualified personnel can result in unnecessary and expensive damage.**

This manual is divided into two sections as follows:

1. **GENERATOR**—Consists of general specifications on the UV generator, troubleshooting guides, and procedures for testing and repairing the systems.
2. **CONTROLS**—Troubleshooting guides, procedures for testing and repairing the system are contained in this section. A description of components and an analysis of module circuitry are included.

TEST EQUIPMENT

Most of the tests outlined in this manual can be performed with an AC-DC multimeter such as a Simpson 260 or 262 VOM.

A Wheatstone or Kelvin bridge meter is also required.

CAUTION **Exercise care when purchasing a foreign made VOM. Some units deliver +9VDC, others, +22VDC to the circuit under test on R x 1 scale. Maximum recommended voltage is +1.5VDC. Damage to solid state devices can result from excessive voltage application.**

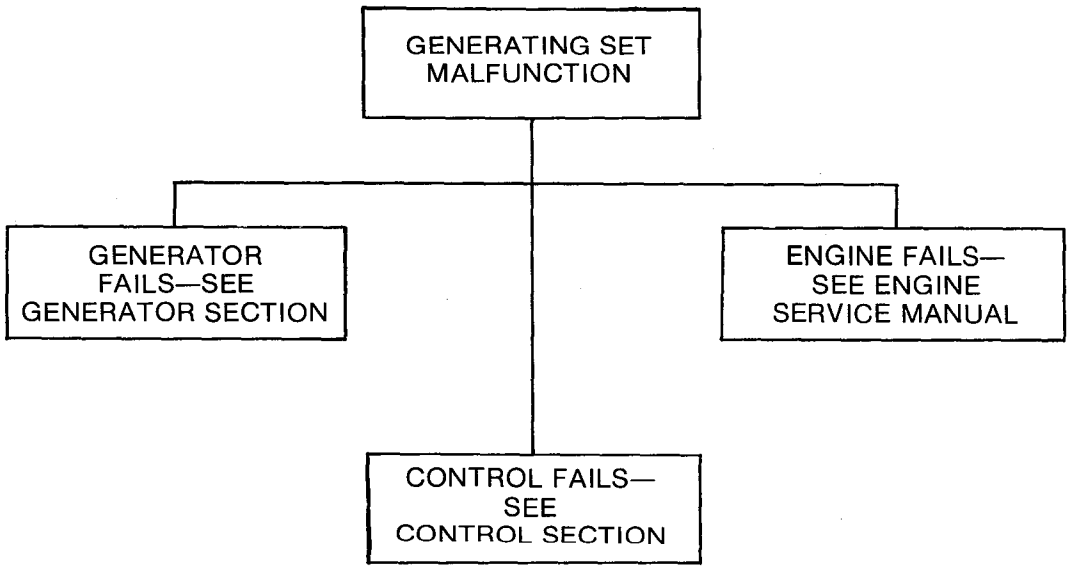


TABLE 1. UV GENERATOR AMPERE RATINGS

KILOWATTS/ MODEL	kVA	PH.	AMPERE RATING						
			4 120/208 60 Hz	5D* 120/240 60 Hz	7X 240/416 60 Hz	6D* 240/480 60 Hz	4X 277/480 60 Hz	9X 347/600 60 Hz	57 220/380 50 Hz
300.0 DFT	375.0	3	1041	902	520	451	451	361	475
350.0 DFU	437.5	3	1214	1052	607	526	526	421	551
350.0 WF	437.5	3	1214	1052	607	526	526	421	551
400.0 DFV	500.0	3	1388	1203	694	601	601	481	627
400.0 WK	500.0	3	1388	1203	694	601	601	481	627
450.0 DFW	562.5	3	1561	1353	781	677	677	541	731
500.0 DFY	625.5	3	1736	1505	868	752	752	602	843
600.0 DWV	750.0	3	2082	1804	1041	902	902	722	973
700.0	875.0	3	2429	2105	1214	1052	1052	842	

* - Delta wound.

RATING 0.8PF

COOLING AIR (1800 rpm) 3120 CFM (89 m^3/min)
(1500 rpm) 2600 CFM (74 m^3/min)

GENERATOR—SECTION I

GENERAL

The ONAN series UV generator is a revolving field, brushless, 4-wire 3-phase unit. Stator coils are brought out and connected to a bus-bar assembly to produce series wye, parallel wye or delta windings in the current/voltage options of Table 1. These options are factory connected to customer requirements. Loads are connected to the bus-bar assembly through a load transfer switch. Phase rotation is counter-clockwise (ACB).

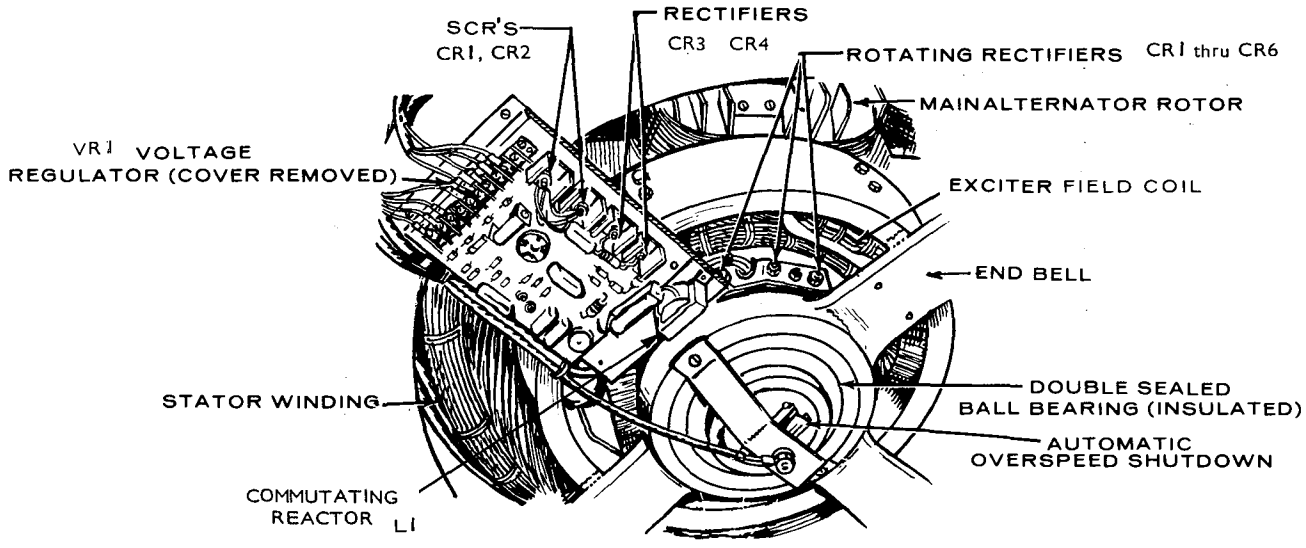


FIGURE 1. GENERATOR END VIEW (FRONT GRILLE REMOVED)

EXCITATION AND REGULATION

Excitation and voltage regulation is achieved as follows:

1. A voltage reference transformer connected across generator stator leads T1 and T2 supplies 120 VAC single phase through regulator terminals 6 and 8 into a bridge rectifier, from where it is fed into an amplifier.
2. A second bridge rectifier connected across generator stator leads T0 and T3 supplies a pulsating DC voltage to an oscillator which applies a voltage through the primary windings of transformer T1. This is compared with the amplified voltage of item 1 and induces a current flow in a secondary winding of T1 to apply a DC supply to the exciter field winding. The operative T1 secondary coil depends on the half-cycle output of the generator.
3. The DC supplied to the exciter field induces a 3-phase AC voltage in the exciter rotor.
4. This AC is applied to a rotating full-wave bridge rectifier assembly, where it is converted into DC.
5. The generator rotor receives this DC as field excitation current, which induces a voltage in the stator windings. This voltage is applied to the load.

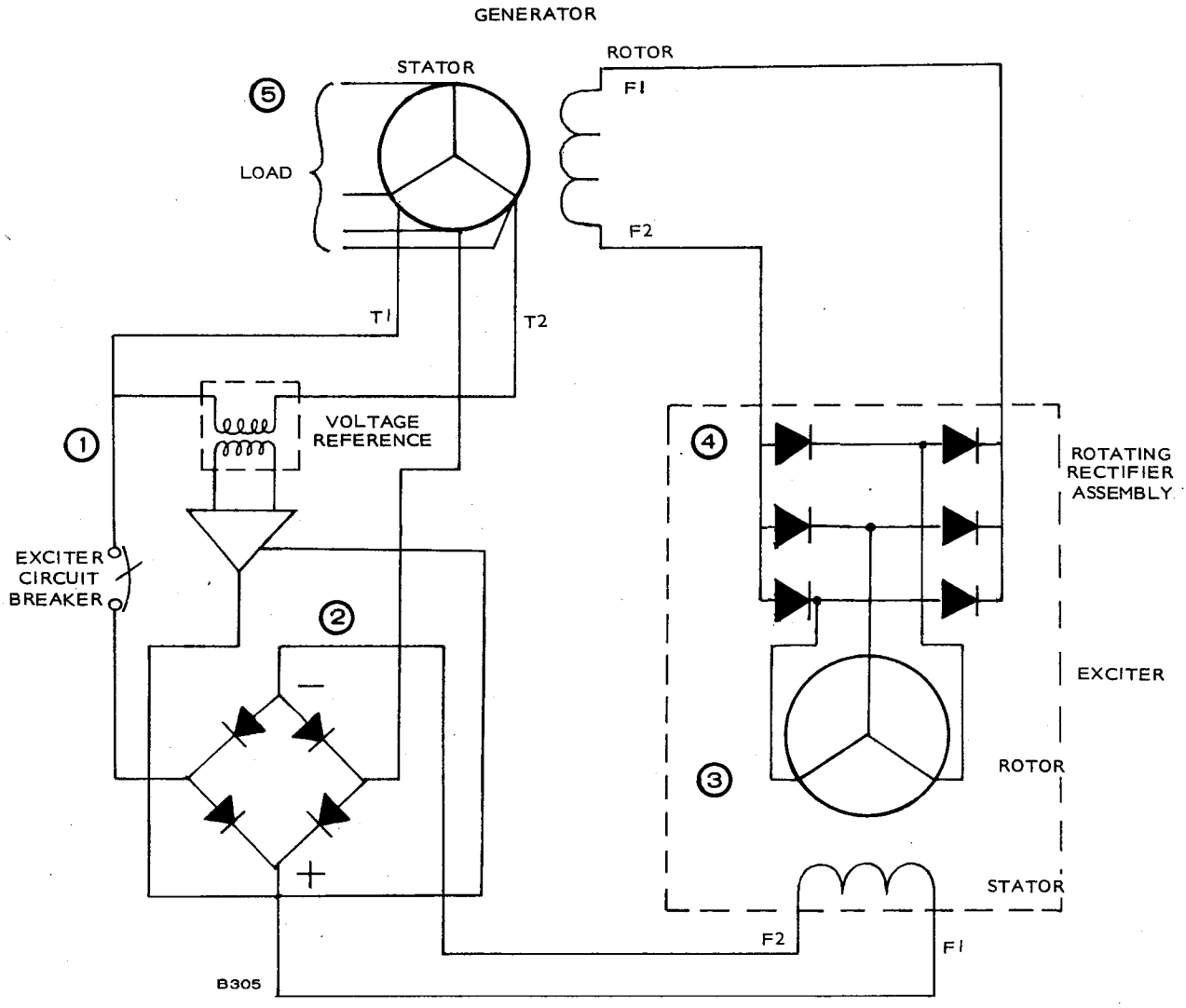


FIGURE 2. EXCITATION SCHEMATIC

GENERATOR TROUBLESHOOTING

TROUBLESHOOTING GUIDES

A. **CONDITION:** NO GENERATOR OUTPUT
ENGINE RUNNING RATED RPM

B. **CONDITION:** GENERATOR OUTPUT TOO HIGH OR TOO LOW
ENGINE RUNNING STEADY RPM

C. **CONDITION:** GENERATOR VOLTAGE BUILDS UP, CIRCUIT BREAKER TRIPS.
ENGINE RUNNING STEADY RATED RPM.

D. **CONDITION:** UNSTABLE OUTPUT.
ENGINE RPM NOT FLUCTUATING

PREPARATION

A few simple checks could expose the probable source of trouble 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 circuit breaker, a relay not secure 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 printed circuit boards. Burned resistors, arcing tracks are all identifiable. Do not mark on printed circuit board 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, etc.

To use this guide, answer the question either "yes" or "no" then proceed to the step given in the column containing your answer. When a letter appears in the Method column, refer to that letter in the Procedure section for the recommended method for testing or repairing.

QUESTION AND ANSWER TROUBLESHOOTING GUIDE

To correct a problem, answer the question "Yes" or "No", then proceed to the next step given in whichever column the question was answered.

A. CONDITION: NO GENERATOR OUTPUT
ENGINE RUNNING RATED RPM

Item		Yes	No	Meth	R-S-R-
1	Is panel meter selection switch positioned correctly for a voltage/current reading?	2	—		Run
2	Is panel circuit breaker (CB1) in the ON position?	4	3		
3	Switch CB1 to ON. Does generator output build up? a. Is output high or low? (See Guide B) b. Is output unstable? (See Guide C) c. Does CB1 trip? (See Guide D)	—	4		
4	Shut down engine. Apply temporary jumper across TB1-66 and TB1-65 inside control cabinet. Restart engine. Does voltage build up? Remove jumper.	5	6		Run
5	Shutdown engine. Check wiring between TB1-65, TB1-66 and CB1. If wiring is good, replace CB1.	—	—		Stop
6	Check wiring between voltage regulator (VR1) and control panel terminal board. Refer to applicable wiring diagram.	7	—		
7	Check wiring between VR1 and bus-bar assembly.	8	—		
8	Restart engine. Measure VAC across VR1 terminals 4 and 5 (residual voltage). Does voltmeter read 20- to 24-VAC?	10	9		Run
9	With engine running, place CB1 to OFF. Using method described under A in procedure section, flash exciter field to restore residual magnetism. Place CB1 to ON. Does the AC voltage buildup?	—	10	A	
10	Measure VDC across VR1 terminals 2 and 3 (positive lead on 3) with engine running. Does voltmeter read 10- to 90-VDC?	15	11		
11	Shut down engine. Check continuity of fuse F1 on VR1 circuit board. Is continuity obtained?	12	—		Stop
12	Check silicon controlled rectifiers CR1 and CR2. Are SCRs CR1 and CR2 OK?	13	—	B	
13	Check diodes CR3 and CR4. Are diodes CR3 and CR4 OK?	14	—	C	

Item	A. NO GENERATOR OUTPUT (Continued)	Yes	No	Meth	R-S-R-
14	Check L1 commutating reactor for continuity. Is L1 good? **Note: Reactor L1 is connected across VR1-1 and 5.** See Figure 1 for location.	15	—	D	
15	Disconnect exciter stator leads F1 and F2 at VR1 terminals 2 and 3. Measure continuity between F1 and F2. Is continuity obtained?	16	—	E	
16	Are rotating diodes CR1 thru CR6 on exciter rotor OK?	17	—	C	Stop
17	Replace voltage regulator VR1. Restart engine. Does generator voltage build up?	—	18	J	Run
18	Is exciter rotor winding OK?	19	—	F	
19	Are generator stator windings OK?	20	—	G	
20	Are generator rotor windings OK?	—	—	H	

B. CONDITION: GENERATOR OUTPUT TOO HIGH OR TOO LOW ENGINE RUNNING STEADY RPM

Item		Yes	No	Meth	R-S-R-
1	Rotate voltmeter/ammeter phase selector switch. Is discrepancy identifiable on all switch positions?	4	2		Run
2	Can condition be corrected by adjustment of voltage control rheostat R1 on panel?	—	3		
3	If output too low, is unit overloaded?	9	5		
4	Connect portable voltmeter across panel voltmeter terminals, rotate selector switch. Do portable meter and panel meter readings agree?	5	8		
5	Measure VAC across VR1-6 and 8. Does voltmeter read 120VAC?	6	7		
6	Replace voltage regulator VR1.	—	—	J	
7	Replace voltage reference transformer in control cabinet.	—	—		
8	Replace voltmeter.	—	—		
9	If all phases overloaded, remove non-essential loads until low voltage condition is corrected. If over-loaded on one or two phases, rearrange single phase loads until phases are balanced. **Single phase load capacity is 2/3 that of total rated 3-phase capacity of unit. i.e., total 3-phase capacity 450 kW, 1-phase capacity 300 kW.**				

C. CONDITION: GENERATOR VOLTAGE BUILDS UP, CIRCUIT BREAKER TRIPS ENGINE RUNNING STEADY RATED RPM					
Item		**Yes**	**No**	**Meth**	**R-S-R-**
1	Does generator voltage build up excessively before circuit breaker CB1 trips?	2	5		Run
2	Are all wires and connections at voltage regulator VR1 in good condition?	3	—		Stop
3	Are diodes CR19 CR1 thru CR4 on VR1 good?	6	—	B, C	
4	Check rotating diodes CR1 thru CR6. Are diodes good?	5	—		
5	Replace circuit breaker CB1.	—	—	C	
6	Replace voltage regulator VR1.	—	—		

D. CONDITION: UNSTABLE OUTPUT. ENGINE RPM NOT FLUCTUATING.					
Item		**Yes**	**No**	**Meth**	**R-S-R-**
1	Check connections at VR1; TB1 in control cabinet. Was repair required?	—	2		Stop
2	Can condition be corrected by adjustment of damping potentiometer R19 on VR1?	—	3		Run
3	Replace voltage regulator VR1.	—	—		Stop

PROCEDURES

[A]

FLASHING FIELD

If output voltage does not build up, it may be necessary to restore residual magnetism of the poles by flashing the field. Assemble a six-volt supply, resistor and diode as shown in Figure 3. If a six-volt supply is not available 12-volts can be used, however, a 20-ohm resistor must be substituted for the 10-ohm.

Remove frontal grille to gain access to voltage regulator. Disconnect lead F1 at VR1-3. Start unit. Touch positive lead of supply to F1 and negative to VR1-2. Hold leads on terminals just long enough for voltage to start building up. Shut down unit and reconnect wires.

WARNING **If generator output builds up, high voltage will be present on voltage regulator terminals. Use caution.**

CAUTION **Do not keep field flashing circuitry connected longer than 5-seconds or damage may occur to exciter and regulator.**

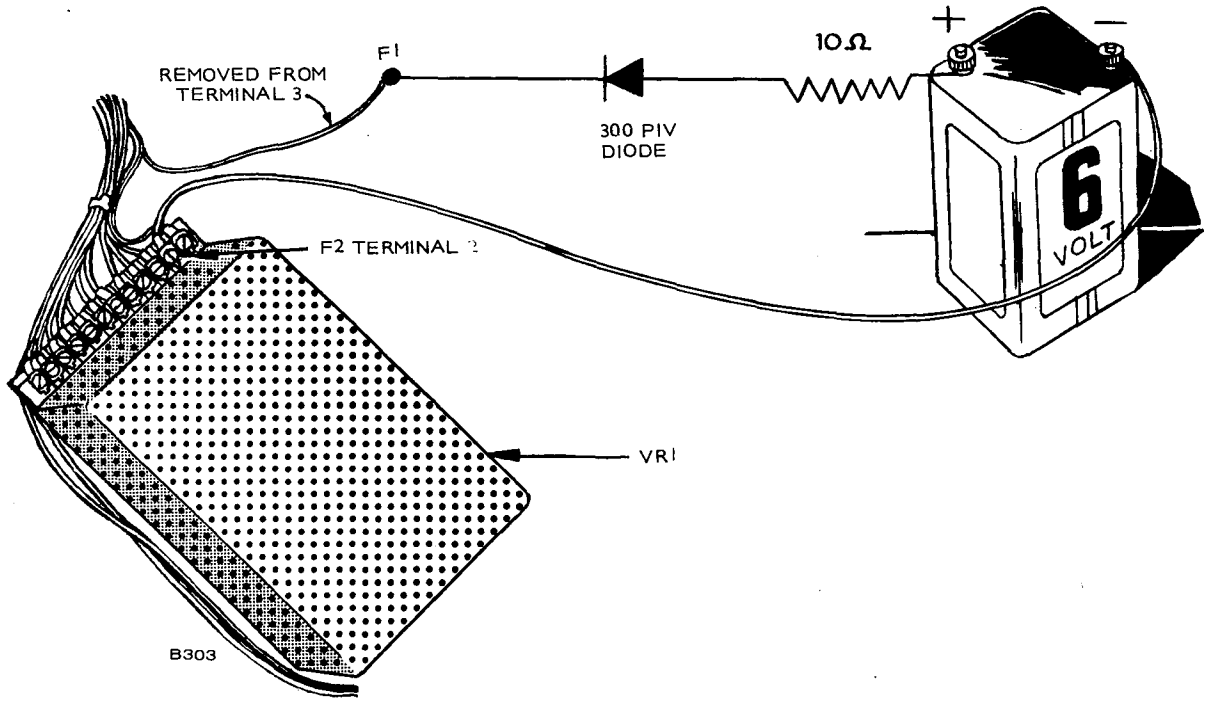


FIGURE 3. FIELD FLASHING CIRCUIT

[B]

TESTING SCRs

To check silicon controlled rectifiers (gated diodes), proceed as follows:

1. Remove voltage regulator VR1 cover to gain access to SCRs.
2. SCRs on VR1 are identified CR1 and CR2, and are positioned closest to the terminal board. See Figure 15.

   It is important to know correct polarity of the ohmmeter leads. Red and black, or + and - on the meter are not necessarily an indication of the battery output polarity of the meter on OHMS range.

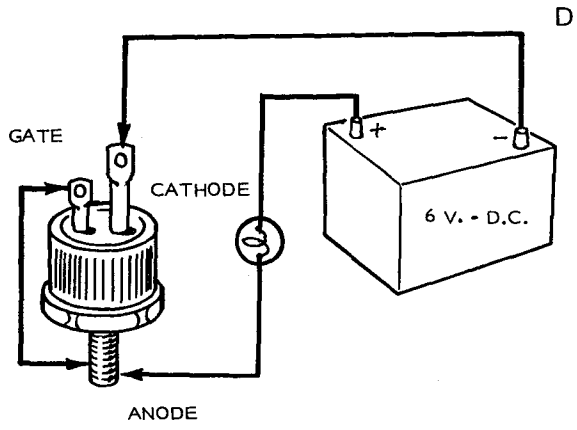
3. Remove gate and cathode wires from SCR.
4. With ohmmeter set on R x 10K scale, measure resistance across anode and cathode. Meter should read 1 megohm or greater (Figure 4A).
5. Reverse leads as shown in Figure 4B. Reading should again be 1 megohm or greater.
6. With leads connected as in step 5 (meter or R x 1 scale), short gate to anode as shown in Figure 4C. The resistance should drop to 25-ohms or less.
7. Remove the short between gate and anode; the resistance should remain unchanged.
8. Results not in accord with those given above indicate a bad SCR. Replace.

Alternate method

If an ohmmeter is not available, or if output voltage of ohmmeter is excessive, assemble test circuitry as in Figure 4D, using a 6 volt dry cell and a current-limiting bulb.

Perform test per items 4 and 5; bulb should not light. With leads connected as in Figure 4D, apply jumper from anode to gate, bulb should light, and remain ON when jumper is removed.

Results different from those given above indicate a bad SCR. Replace



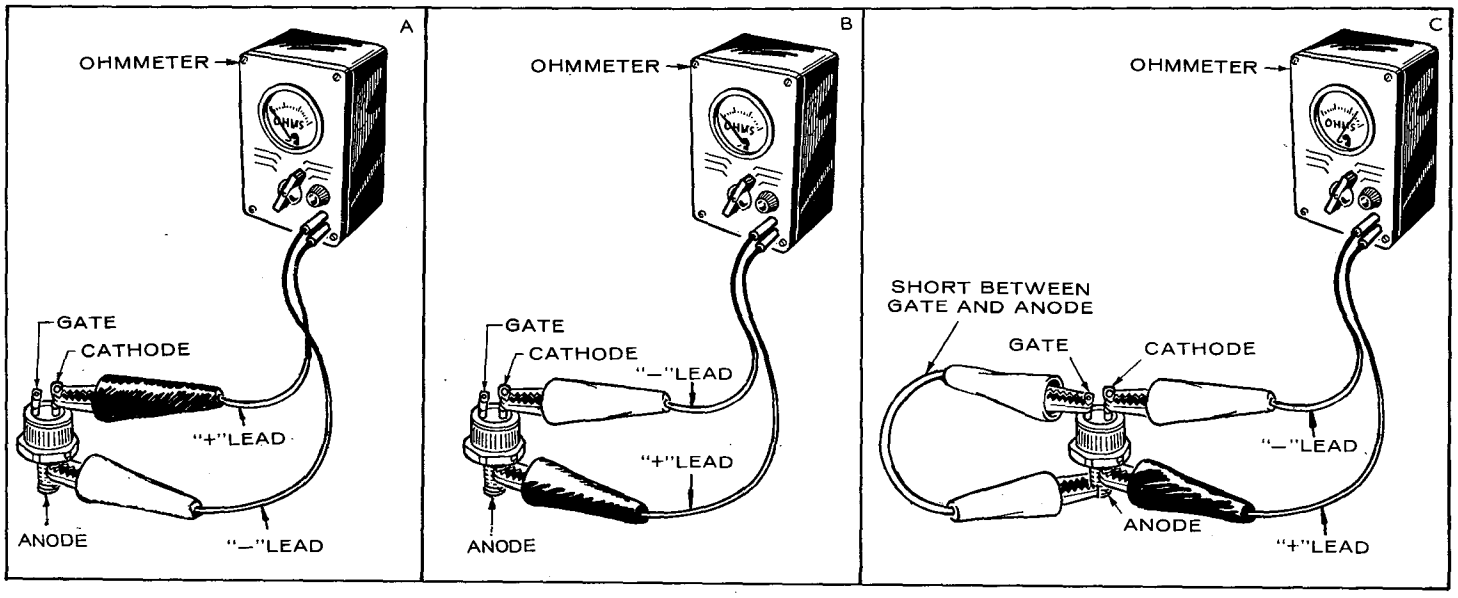


FIGURE 4. TESTING SCRs (GATED DIODES)

[C]

TESTING DIODES

Six diodes labeled CR1 thru CR6 are mounted on the rotating exciter assembly as shown in Figure 5, and 2 labeled CR3 and CR4, on VR1. Test diodes as follows:

1. Remove one diode at a time from heat sink. Test that diode and reinstall on heat sink before proceeding to the next one.
2. Check the resistance of the diode with an ohmmeter. Connect one lead to the top of the diode and other lead to the diode stud. Observe reading. See Figure 6.
3. Now reverse leads and again observe reading. A good diode should have a higher reading in one direction than the other. If both readings are high, or if both readings are low, diode is defective and must be replaced with a new, identical part.

CAUTION **Excessive dust or dirt on diodes and other components will cause overheating and eventual failure. Keep these assemblies clean!**

REPLACING SCRs and CRs

1. Unsolder leadwires from terminals.
2. Use proper size wrenches to hold the body while removing the nut.
3. Push the rectifier free of its mounting hole in the heat sink.
4. Insert new rectifier into its mounting hole in the heat sink. Using nut and washer provided, secure rectifier to heat sink.
5. Torque diodes on rotating exciter assembly to 15-lb.-in. (1.7 N•m).
6. Solder leadwires to new rectifiers.

CAUTION **Use a 40 watt soldering iron. Hold a needlenose pliers between rectifier and soldering point to prevent destructive heating. Excessive heat on these components will destroy them.**

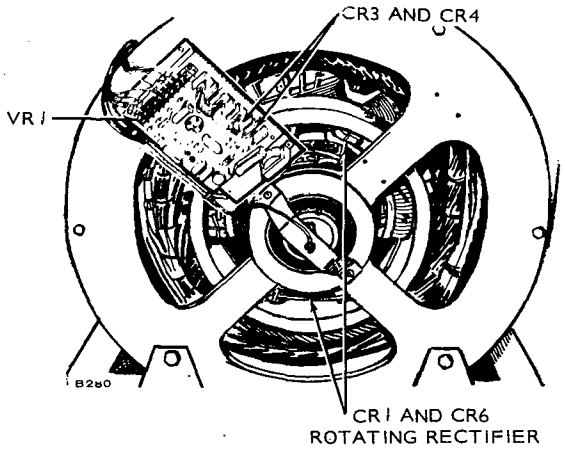
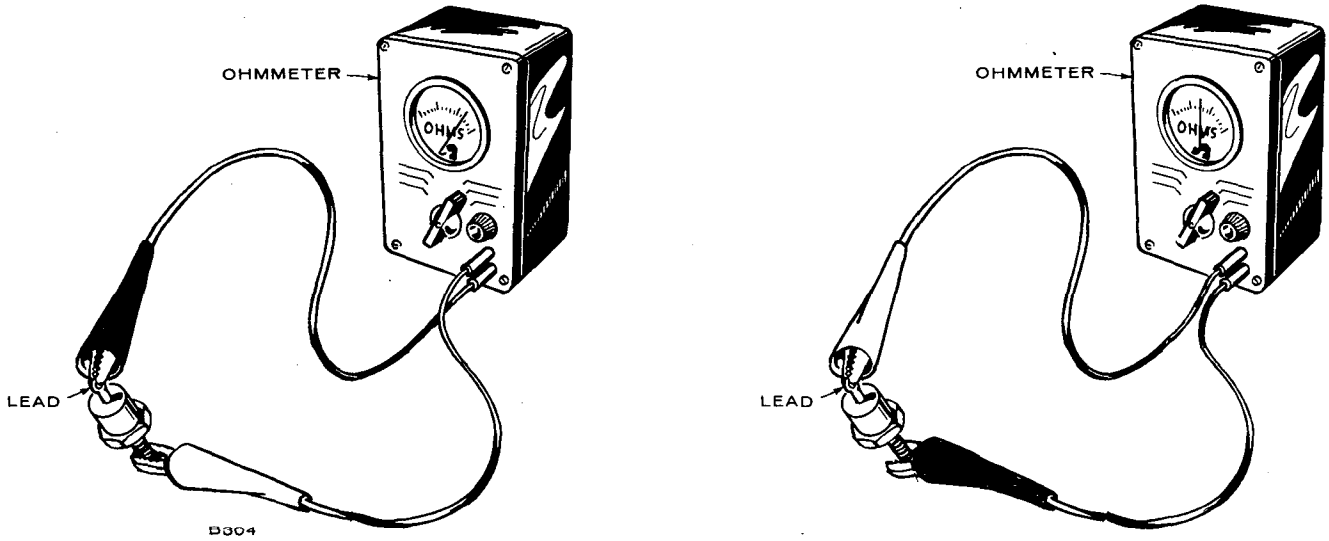


FIGURE 5. ROTATING RECTIFIER ASSEMBLY



GOOD DIODE WILL HAVE HIGH RESISTANCE READING IN ONE DIRECTION AND LOW READING WHEN OHMMETER LEADS ARE REVERSED.

FIGURE 6. TESTING DIODES

[D]

CHECKING REACTORS

To measure resistance of the L1 commutating reactor (315-0301) use a Wheatstone bridge ohmmeter; use a Simpson 260 ohmmeter for measuring coil resistance on L2 reactor (315-0300), and insulation resistance on both L1 and L2.

L1 and L2 are mounted on voltage regulator VR1.

Resistance measurement of L1 is taken across coil terminals, see Figure 7. Reading should be 0.0693- to 0.0847-ohms at 20° C. Set ohmmeter scale to R x 10K, measure between either coil terminal and frame. A reading less than infinity indicates low insulation resistance in the coil winding. Replace reactor.

Resistance measurement of L2 is taken across coil terminals 1 and 4, see Figure 8. Reading should be 308.8- to 377.4-ohms at 20° C, meter on R x 1 scale. With meter on R x 10K scale, a reading of less than infinity between any coil terminal and frame indicates low insulation resistance, replace reactor.

Measure continuity between either terminal 1 or 4 and terminals 2 and 3 to verify taps are not broken.

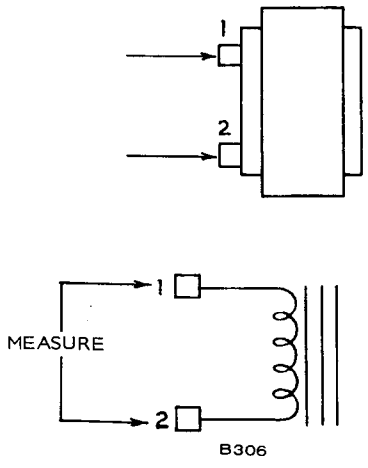


FIGURE 7. L1 (315-0301)

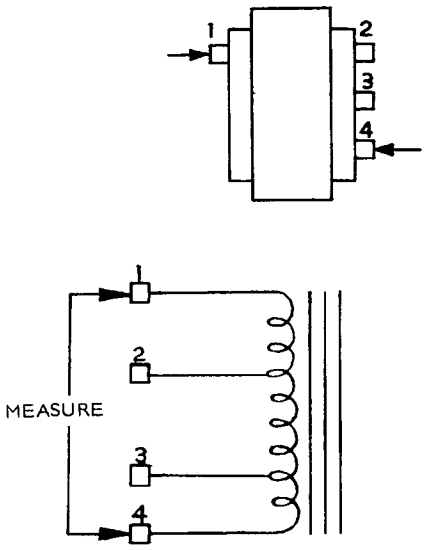


FIGURE 8. L2 (315-0300)

[E]

TESTING EXCITER STATOR

Testing for grounds: Using an ohmmeter (R x 10K scale), measure the insulation resistance between either lead F1 or F2 and the generator frame. A reading of less than infinity indicates a ground.

Exciter stator leads F1 and F2 are connected across voltage regulator VR1 terminals 2 and 3.

Testing winding resistance: Measure coil resistance between leads F1 and F2 with an ohmmeter (scale R x 1). Resistance should be 14.85- to 18.15-ohms at 20° C (68° F). See Figure 9.

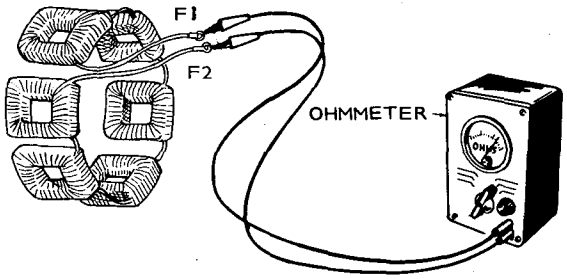


FIGURE 9. MEASURING FIELD RESISTANCE

[F]

EXCITER ROTOR

Use a Kelvin bridge instrument for this test. Remove rotating diodes CR1, CR2, CR3, Figure 10, from heat sinks. Measure resistance of rotor windings as shown in Figure 11. Resistance should be within 0.1463- to 0.1788-ohms at 20° C (68° F).

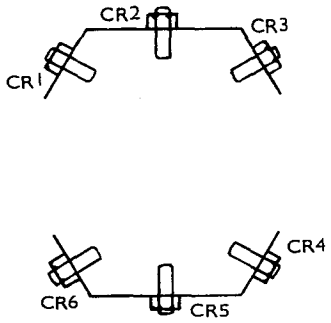


FIGURE 10. ROTATING DIODE ASSEMBLY

Test from—

CR1 to CR2
CR1 to CR3
CR4 to CR5
CR4 to CR6

Replace rotating diodes on heat sinks. Hold body of diode with proper size wrench while torquing, to prevent wire from twisting. Torque to 15 lb-in. (1.7 N•m). Using an ohmmeter on R x 10K scale, measure between any rotating diode lead and generator frame. A reading of less than infinity indicates low insulation resistance of the exciter windings.

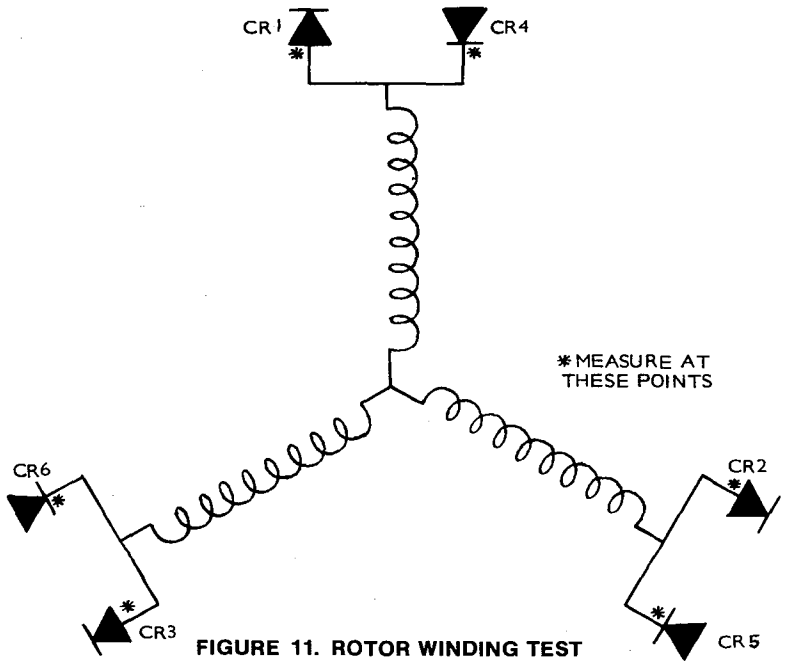


FIGURE 11. ROTOR WINDING TEST

[G]

TESTING GENERATOR STATOR

Testing for Grounds: Disconnect stator leads from bus bar assembly; observe wire identification. Connect all stator output leads (T1-T12) together. Use an ohmmeter set on the R x 10K scale and measure the insulation resistance between these windings and the stator frame. A reading of less than infinity indicates a ground. See Figure 12.

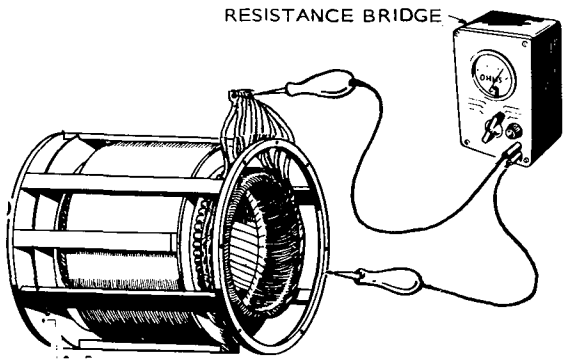


FIGURE 12. TESTING STATOR WINDINGS

Testing for Shorts: Connect an ohmmeter (R x 10K scale) between each individual winding and the other windings connected together. Repeat until all six coils have been tested. A reading of less than infinity indicates a short. See Figure 12A.

Measure resistance of windings using a Wheatstone or Kelvin bridge meter. Readings should be between 0.00322- and 0.00394-ohms at 20° C (68° F). If any windings are shorted, open or grounded, replace the stator assembly. Before replacing the assembly, check the leads for broken wires or damaged insulation.

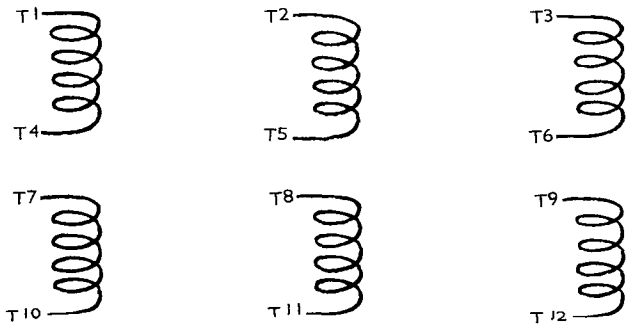
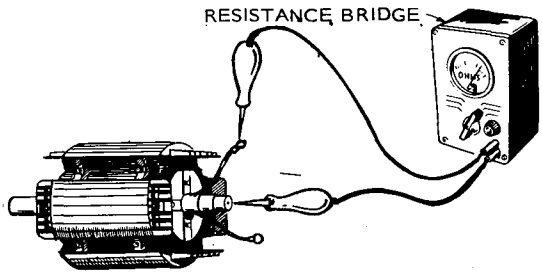


FIGURE 12A. STATOR COILS (SCHEMATIC)

[H]

TESTING GENERATOR ROTOR

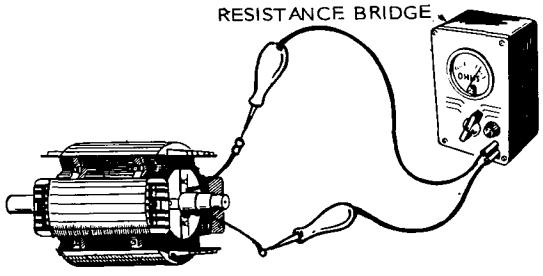
Testing for grounds: Remove F+ and F- rotor leads from diode heat sink assemblies. Connect an ohmmeter (R x 10K scale) between either rotor lead and the rotor shaft. A reading of less than infinity indicates a ground. See Figure 13.



CONTACT ONE PROD TO EACH OF THE FIELD LEADS AND THE OTHER PROD TO THE ROTOR SHAFT.

FIGURE 13. TESTING ROTOR FOR GROUNDS

Testing winding resistances: Use a Wheatstone or Kelvin bridge for this test. Remove F+ and F- rotor leads from diode heat sink assembly. Connect meter leads between F+ and F-. Resistances should be within 1.646- to 2.695-ohms at 20° C (68° F). See Figure 14.



CONTACT ONE PROD TO ONE FIELD LEAD AND THE SECOND PROD TO THE OTHER FIELD LEAD.

FIGURE 14. MEASURING ROTOR WINDING RESISTANCE

[J]

VOLTAGE REGULATOR (Except 600.0 DWV)

Voltage adjustment of generators with voltage regulators VR1 mounted on the end bell is accomplished by turning Voltage Regulator rheostat on control panel. If voltage is unstable or tends to hunt adjust R18 potentiometer on the regulator board to eliminate output instability. Refer to Figures 15 and 16.

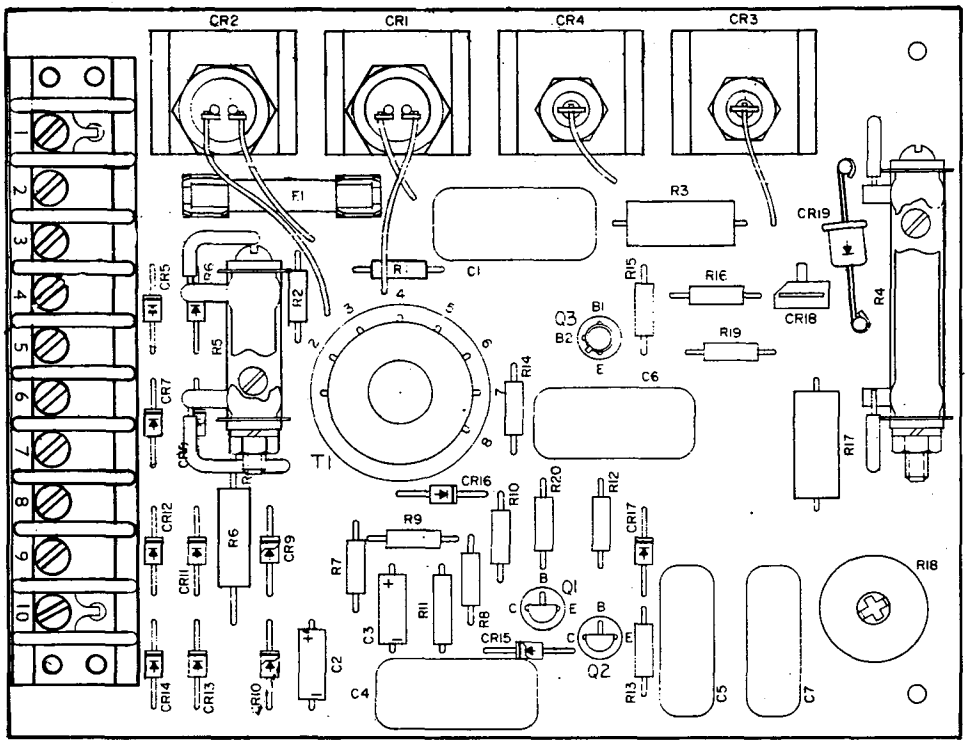


FIGURE 15. VOLTAGE REGULATOR PRINTED CIRCUIT BOARD (TYPICAL)

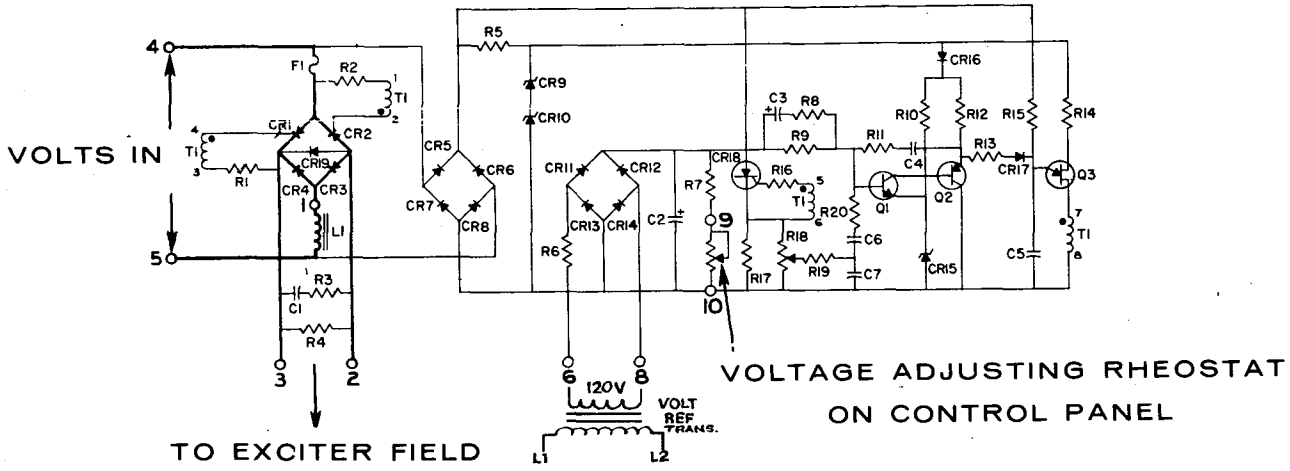


FIGURE 16. VOLTAGE REGULATOR SCHEMATIC (TYPICAL)

[K]

GENERATOR DISASSEMBLY

If testing determines that generator needs repair, disassemble and remove according to Figure 17 and the following instructions:

1. Disconnect and remove load wires.
2. Disconnect batteries.
3. Disconnect lead wires from control box. Check wire markings for legibility to ease assembly. Reidentify if necessary. Arrange leads so that they can be withdrawn easily from control box.
4. Disconnect engine control wires and voltage regulator wires and pull back into cabinet.
5. Remove ten-3/8-inch bolts (1) and lift control cabinet assembly (2) clear of set.
6. Remove two-3/8-inch bolts (3) and cooling fan grille (4).
7. Remove six-3/8-inch bolts (5) and remove upper and lower sheet metal covers (6).
8. Remove four-10-32 screws (7) and voltage regulator.
9. Support generator on wooden blocks placed across skid base.
10. Remove two-5/8 bolts (8), two-5/8 studs (9), four-3/4-inch bolts (10) from generator support bracket. Remove shims from between support bracket and skid base; identify shims with placement reference; save for reinstallation. Remove generator support bracket (11).
11. Remove six-3/8-inch bolts (12) and endbell (13).
12. Attach overhead hoist and sling to stator assembly. Tension hoist sufficiently to take weight of stator. Remove support blocks.
13. Remove sixteen-1/2-inch bolts securing stator, and slide stator assembly clear of rotor.

    CAUTION **Exercise care when sliding stator over rotor. Collision with coils can cause damage.**

14. Attach sling and hoist to rotor. Tension hoist to take weight of rotor.
15. Remove six-5/8-inch bolts and slide rotor clear from flywheel.
16. Lower rotor and place on a support cradle where coils cannot receive damage.

    CAUTION **When removing drive disk from flywheel, do not bend disk.**

GENERATOR ASSEMBLY

Pre-assembly Procedure.

1. Inspect bearing; replace if necessary. Torque bearing locknut 150- to 200-lb-ft (203- to 271 N•m).
2. Inspect bearing rubber holding ring. Replace if necessary. Apply Molykote to ring before installing.
3. Inspect all mounting bolts. Replace any bolts that show signs of being stretched.

ASSEMBLY

1. Hang rotor in place; rotate to align; insert six-5/8-inch bolts with lock washers. Torque bolts 120- to 125-lb-ft (162- to 170- N•m).
2. Using hoist and sling, slide stator assembly in place.

   CAUTION **Use care to ensure that damage does not occur to rotor or stator windings while stator is being positioned.**

   Align stator, insert sixteen-1/2-inch bolts and lockwashers. Pull up bolts evenly, then torque 65- to 70-lb-ft (88- to 95- N•m).
3. Install end bell assembly. Ensure rubber holding ring is not distorted while end bell is being positioned on rotor bearing. Rock gently into place and pull up evenly with six-3/8-inch bolts and washers. Torque bolts 30- to 35-lb-ft (40- to 48- N•m).
4. Attach generator support bracket; insert two-5/8-inch bolts with washers. Torque bolts 195- to 200-lb-ft (264- to 272- N•m).
5. Insert two-5/8-inch studs with nuts and lockwashers. Torque 195- to 200-lb-ft (264- to 272- N•m).
6. Install shims in same position from which they were removed.
7. Insert support bracket-to-skid base bolts and tighten.
8. Reinstall voltage regulator, upper and lower generator, fan air band, and control cabinet assemblies.
9. Refer to parts catalog for replaceable parts and assemblies. Refer to wiring diagrams for reconnection.

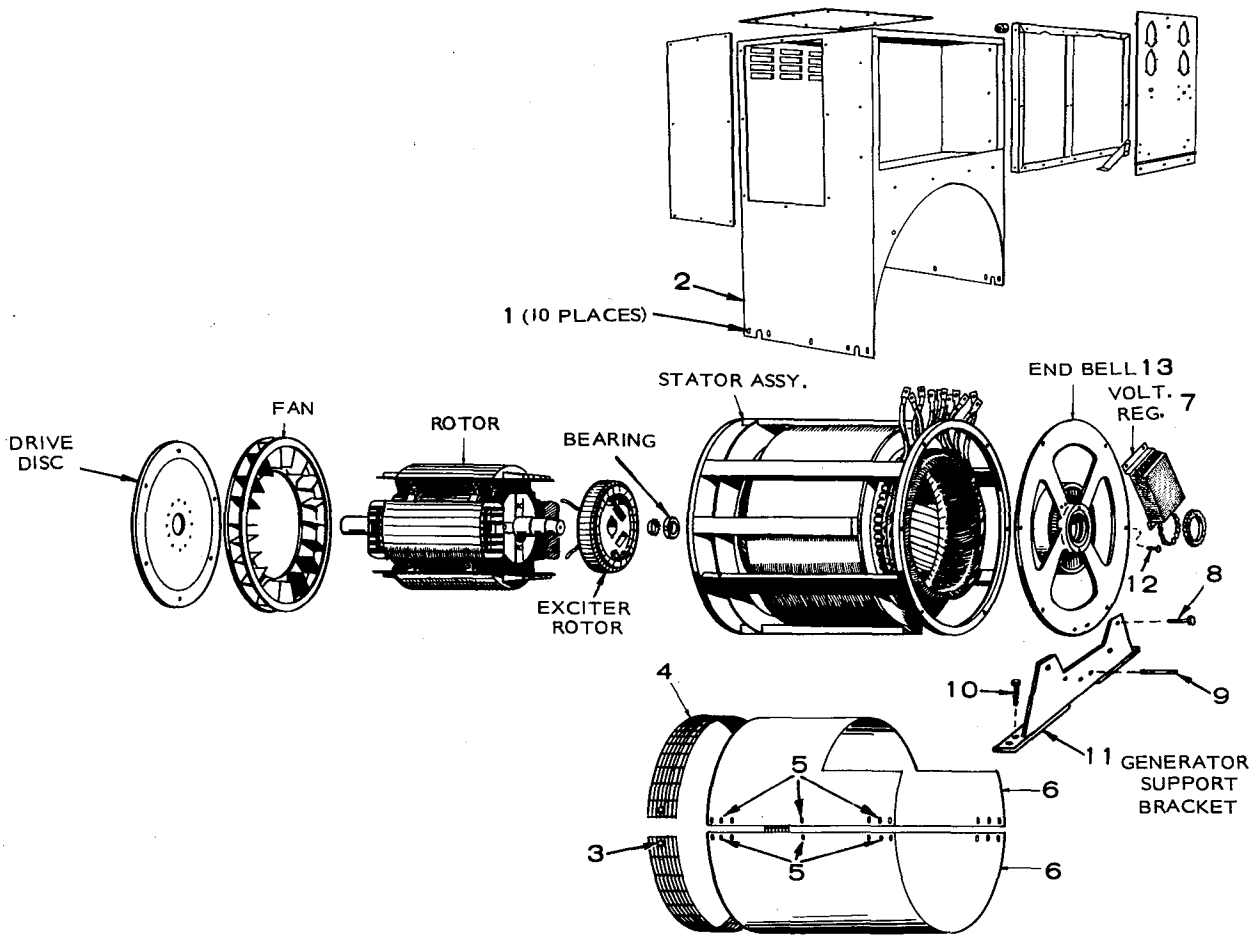


FIGURE 17. GENERATOR DISASSEMBLY

GENERATOR—SECTION II

GENERAL

Voltage regulators for Onan series DWV generators are located in the control panel cabinet.

The regulator system consists of voltage regulator VR21 (332-1704), SCR bridge CR21 (305-0524), commutating reactor L21 (315-0384) and reference transformer T21 (315-0342). Voltage regulator VR21 is a printed circuit board with voltage and damping control potentiometers.

Three diodes and two SCRs originally located on regulator VR1 have been repackaged and are now encapsulated in an hermetically sealed box. If a diode or SCR fails, the entire box has to be replaced. Do not attempt to repair it. Principles of operation and method of excitation remain unchanged. See Figure 19 for location of units.

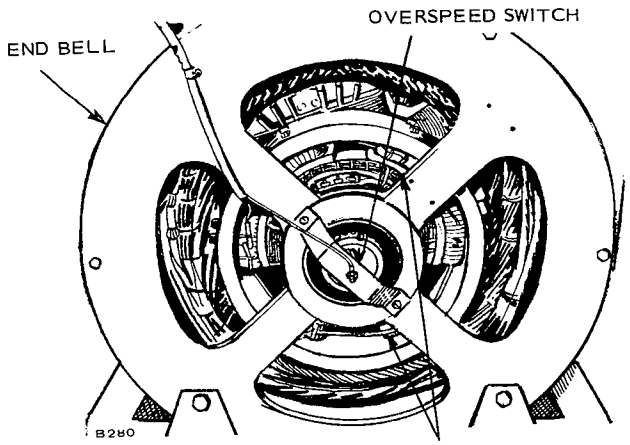


FIGURE 18. ROTATING RECTIFIER ASSEMBLY

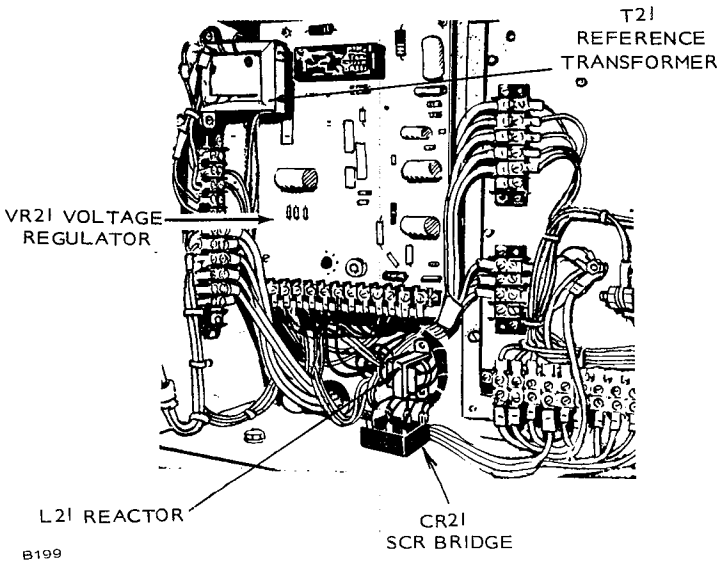


FIGURE 19. SCR BRIDGE AND REACTOR LOCATION

GENERATOR TROUBLESHOOTING

TROUBLESHOOTING GUIDES

E. **CONDITION:** NO AC OUTPUT VOLTAGE
ENGINE RUNNING RATED RPM

F. **CONDITION:** UNSTABLE OUTPUT—ENGINE RUNNING AT
1800 RPM WITH NO FLUCTUATION

G. **CONDITION:** OUTPUT VOLTAGE TOO HIGH OR LOW

H. **CONDITION:** EXCITER CIRCUIT BREAKER TRIPS

I. **CONDITION:** UNBALANCED GENERATOR OUTPUT VOLTAGE

TROUBLESHOOTING

The question and answer troubleshooting guides which follow give a step-by-step procedure for checking the generator. To use the guides, answer the questions either "yes" or "no" then proceed to the next step given in whichever column is indicated.

QUESTION AND ANSWER TROUBLESHOOTING GUIDES

ITEM	E. CONDITION: NO AC OUTPUT VOLTAGE — ENGINE RUNNING RATED RPM	YES	NO	METHOD
1.	Is the Exciter Circuit Breaker (CB21) on the meter panel in the "ON" position?	3	2	
2.	Switch CB21 to the "ON" position. Does the AC voltage build up? **NOTE:** If voltage builds up but is high, low or unstable, or causes CB21 to trip, refer to section G or H of the troubleshooting guide.	—	3	
3.	Is the AC voltage measured at terminals 1 and 2 on voltage regulator (VR21) printed circuit board 5 to 10 volts?	6	4	
4.	Is the AC voltage measured at terminals 11 and 12 on VR21 5 to 10 volts?	5	7	
5.	Replace reactor assembly (L21).	—	—	
6.	Is the DC voltage measured at terminals + and - on Rectifier Bridge (CR21) 5 to 10 volts?	15	11	
7.	Shut down generator set. Check continuity between terminal 2 on VR21 and T8 on generator, between terminal 1 on VR21 and T7 on generator. Is there continuity between these connections? VR21-2 to T8 VR21-1 to T7	 14 14	 10 8	
8.	If no continuity exists between VR21-1 and T7 (CB21-ON) apply a shorting jumper across CB21. Is continuity obtained?	9	10	
9.	Replace circuit breaker CB21.	—	—	
10.	Check for loose or broken wires on VR21, CR21, reference voltage transformer (T21), generator bus-bars and terminal board (TB21) in control box. Secure or repair where necessary. If repairs have been made, restart engine. Does AC voltage now build up?	—	14	
11.	Are diodes CR1, CR2 and CR3 on CR21 assembly good? (See method O in procedure section for checking diodes.) If faulty diode located, replace CR21.	12	—	O
12.	Are SCRs 4 and 5 in CR21 good? (See method O in procedure section for checking diodes.) If faulty SCR's located, replace CR21.	13	—	O

ITEM	E. CONDITION: NO AC OUTPUT VOLTAGE — ENGINE RUNNING RATED RPM (Continued)	YES	NO	METHOD
13.	Fault probably lies with a defective component on VR21. Replace voltage regulator VR21.	—	—	
14.	Start engine. Place CB21 in "OFF" position. Using method prescribed under "M" in procedure section flash the exciter field to restore residual magnetism. Place CB21 ON. Does the AC output voltage build up?	—	15	M
15.	Shut off engine. Is the exciter field winding OK?	16	—	E
16.	Are the rotating diodes CR1, through CR6 on the exciter rotor OK?	17	—	C
17.	Is the main generator field winding OK?	18	—	H
18.	Is the exciter rotor winding OK?	19	—	F
19.	Are the generator stator windings OK?	13	—	G

ITEM	F. CONDITION: UNSTABLE OUTPUT—ENGINE RUNNING AT 1800 RPM WITH NO FLUCTUATION	YES	NO	METHOD
1.	Are there any loose or broken wires or connections at voltage regulator VR21 terminals?	—	2	
2.	Does adjustment of R26 (damping control potentiometer) on VR21 stabilize generator voltage?	—	3	L
3.	Replace VR21 voltage regulator.	—	—	

ITEM	G. CONDITION: OUTPUT VOLTAGE TOO HIGH OR LOW	YES	NO	METHOD
1.	Does adjustment of R21 "voltage adjust knob" on the meter panel correct voltage level?	—	2	
2.	Does adjustment of R18 potentiometer on VR21 correct voltage level?	—	3	L
3.	Are rotating diode heat sink mounting screw insulators OK?	4	—	
4.	Are the reconnections correct and secure?	5	—	
5.	Replace voltage regulator VR21.	—	—	

ITEM	H. CONDITION: EXCITER CIRCUIT BREAKER TRIPS	YES	NO	METHOD
1.	Does AC output build up to 150% or more of rated voltage before CB21 trips?	2	7	
2.	Are there loose or broken terminals or connections at voltage regulator VR21?	—	3	
3.	Is CR21 rectifier assembly OK?	4	—	O
4.	Are the reference voltage transformer (T21) windings and connections OK?	5	—	
5.	Replace voltage regulator VR21.	—	—	
6.	Does AC output build up to rated value before tripping CB21?	7	—	
7.	Are the rotating diodes CR1 through CR6 on the exciter rotor OK?	8	—	C
8.	Is the exciter stator winding OK?	9	—	E
9.	Is the generator main field winding OK?	10	—	H
10.	Is the exciter rotor winding OK?	—	—	F

ITEM	I. CONDITION: UNBALANCED GENERATOR OUTPUT VOLTAGE	YES	NO	METHOD
1.	Remove load from generator terminals. Is output still unbalanced?	2	4	
2.	Are generator leads properly connected or grounded?	3	—	
3.	Is generator stator winding continuous?	4	—	G
4.	Is grounding procedure of generator and load correct?	5	—	
5.	Check for ground faults on load.	—	—	

[L]

VOLTAGE ADJUSTMENT

After replacement, voltage regulator (VR21) adjustment is performed as follows (see Figure 20):

1. Center the voltage adjust knob so pointer is in a vertical position.
2. Open meter panel doors. Start unit.
3. Using a screwdriver, turn R18 potentiometer on printed circuit board VR21. Observe voltmeter on meter panel while making adjustment. Set voltage with no load connected to generator. (Example: For a 120/240 volt connection, set at no-load voltage or approximately 246 volts.)

If voltage is unstable or tends to hunt, turn R26 potentiometer on VR21 in the direction shown on printed circuit board to increase voltage dampening (i.e., decrease sensitivity).

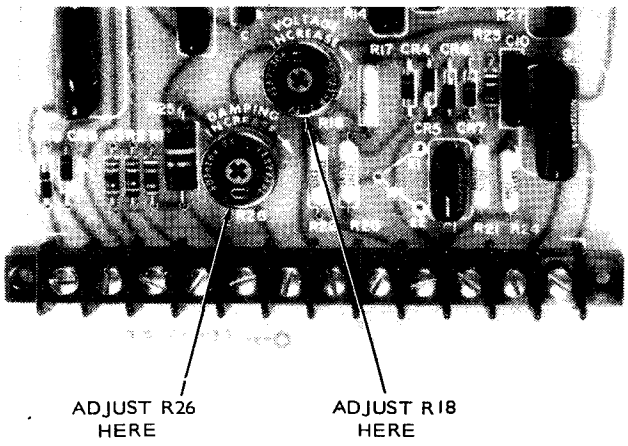


FIGURE 20. ADJUSTING VOLTAGE ON VR21

[M]

FLASHING THE FIELD

If output voltage does not build up it may be necessary to restore the residual magnetism of the poles by flashing the field. Assemble a six volt supply, resistor and diode as shown in Figure 21. If a six volt supply is not available a 12-volt can be used, however a 20-ohm resistor must be substituted for the 10-ohm. Start the generator set, touch positive lead to + on rectifier bridge, and negative lead to the - terminal. Hold leads on terminals just long enough for voltage to build up.

CAUTION **Do not keep excitation circuitry connected longer than 5-seconds, or damage may occur to the exciter regulator.**

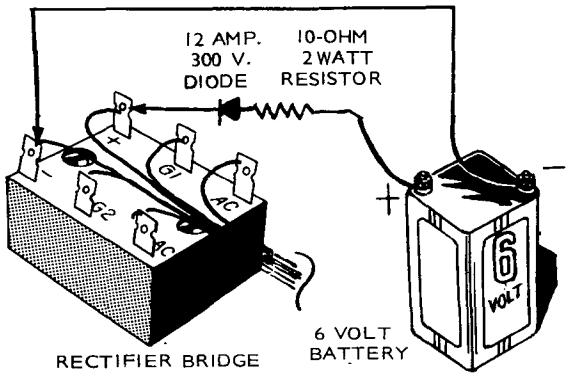


FIGURE 21. FIELD FLASHING CIRCUIT

[N]

TESTING L21 REACTOR

The L21 commutating reactor mounts inside the control box, below the VR21 Voltage Regulator.

The coils 1-2 and 3-4 are wound on the same core. Resistance between 1-2 and 3-4 should be equal. Resistance between coils (e.g., 1-4) or from any terminal to frame of the reactor should be infinity (Figure 22).

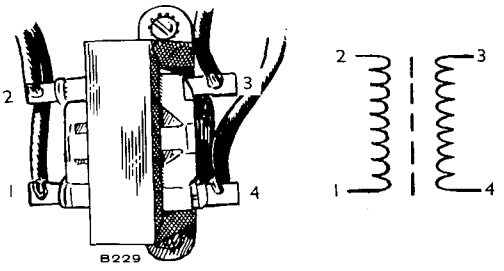


FIGURE 22. L21 REACTOR

[O]

TESTING RECTIFIER BRIDGE ASSEMBLY (CR21)

The rectifier bridge located within the control cabinet, below the voltage regulator, contains 3 diodes, CR1, CR2, and CR3, and two silicon controlled rectifiers, CR4 and CR5. These diodes and SCRs are encapsulated within an hermetically sealed box, therefore failure of any diode or SCR means the entire unit has to be replaced. See Figure 23.

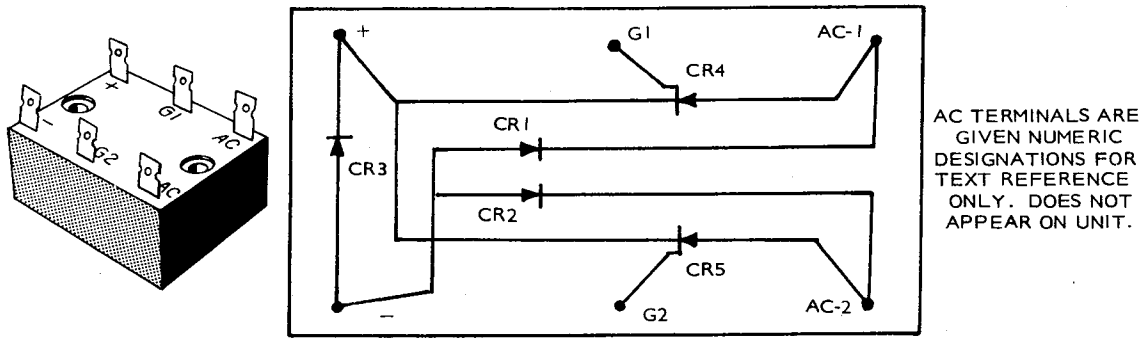


FIGURE 23. RECTIFIER ASSEMBLY

Disconnect wires from rectifier unit prior to testing. Test unit in order shown in Table 2. Refer to Figure 24 for CR4 and CR5 test circuit. When test is complete and satisfactory, reconnect unit observing correct wiring hook-up.

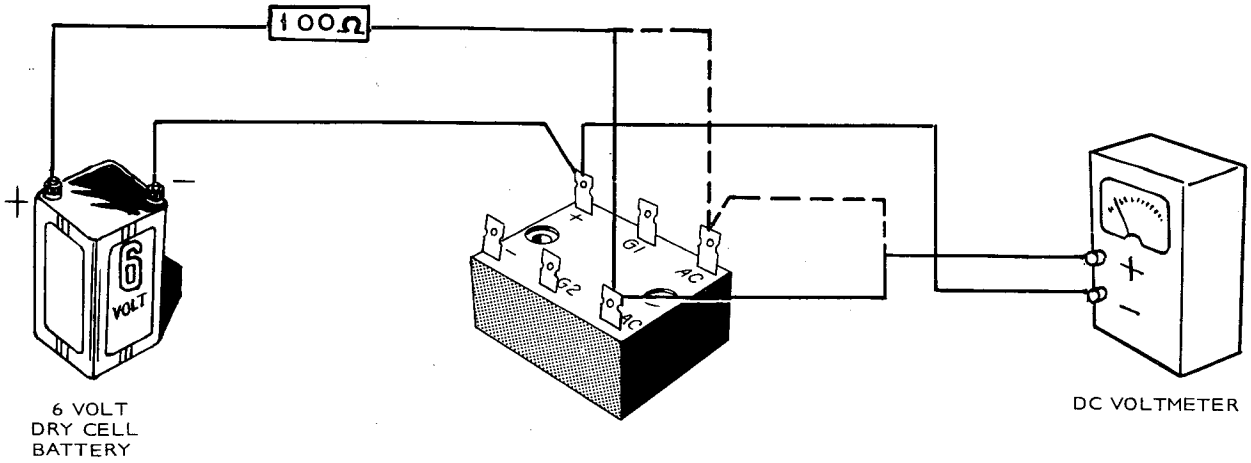


FIGURE 24. TESTING SCR

TABLE 2. TESTING SCR ASSEMBLY CR21

TEST	OHMMETER LEAD +	OHMMETER LEAD -	RECTIFIER TERMINALS	TESTING CR	TESTING SCR	REMARKS	METER SCALE
1	X		+	CR3		Infinity	RX10K
		X	-				
2	X		-	CR3		6- to 50-Ohms	R X 1
		X	+				
3	X		+		CR4	Infinity	RX10K
		X	AC1				
4	X		AC1			Infinity	RX10K
		X	-				
5	X		-	CR1		6- to 50-Ohms	RX1
		X	AC1				
6	X		+		CR5	Infinity	RX10K
		X	AC2				
7	X		AC2			Infinity	RX10K
		X	-	CR2			
8	X		-	CR2		6- to 50-Ohms	R X 1
		X	AC2				
	6 V Battery with Resistor +	**6 V Battery with Resistor** -				**DC Voltmeter lead** +	**DC Voltmeter lead** -	**DC Voltmeter Reading** less than
9*	AC1	+			CR4	AC1	+	3 Volts
10**	AC2	+			CR5	AC2	+	3 Volts

* Apply temporary jumper from AC1 to G1 to test CR4. Remove jumper, read voltmeter. See Figure 24.

** Apply temporary jumper from AC2 to G2 to test CR4. Remove jumper, read voltmeter. See Figure 24.

CONTROLS

TABLE OF CONTENTS

ABBREVIATIONS

To avoid repetitious use of terms or designations, abbreviations have been used as follows:

R-S-R	Run-Stop-Remote
N.C.	Normally closed
N.O.	Normally open
VDC	Volts Direct Current
VAC	Volts Alternating Current
LOP	Low Oil Pressure
HET	High Engine Temperature
K	Relay
Q	Transistor
R	Resistance/Rheostat
C	Capacitor
O/S	Overspeed
O/C	Overcrank
LET	Low Engine Temp
CR	Crystal Rectifier (diodes)
VR	Voltage Regulator
CB	Circuit Breaker
L	Reactor
T	Transformer
T.D.	Time Delay

CONTROLS—SECTION I

GENERAL

Early UV series generator sets used relays exclusively, for engine controls. As the state-of-the-art has improved, ONAN has been able to change concepts to improve quality and reliability of its product.

The Controls portion of this manual is divided into two sections. The first, provides a description of the relay control, relay function and system troubleshooting. The second section provides similar information on solid-state controls. Refer to Table 3. Locate the specification letter of a particular unit, the table will tell you which section of the manual to locate the required information.

TABLE 3. CONTROLS LOCATION

RELAYS		SOLID STATE	
Model	**Spec**	**Model**	**Beginning Spec**
DFT	A, B	DFT	C, D only*
DFU	A, B, C	DFU	D only*
DFV	A, B, C, D	DFV	E
DFW	A	DFW	B
WF	A	DFY	A
WK	A	WF	B only*
		WK	B
		DWV	A

* - DFT spec E, DFU spec E, and WF spec C controls information is located in the YB series major service manual, ONAN No. 900-0181.

RELAY—CONTROLS OPERATION

The following operational description is applicable only to relay-operated engine controls. See Figures 25 and 26.

K11. OIL PRESSURE TIME-DELAY RELAY (One and four fault lamp systems)

Energized after engine has started, by output from AUX terminal of battery charging alternator. Relay contacts close 15-seconds after 24VDC is applied to coil. This delay allows engine to start and oil pressure to build-up while the Low Oil Pressure switch is still closed. When K11 relay actuates, N.O. contacts close and complete circuit between K15 and LOPCO switch.

K12. CRANKING LIMITER TIME-DELAY RELAY (One and four fault lamp controls)

Energized when R-S-R- switch is placed in Run position and K14 actuates. Relay energizes at initial current application and contacts OPEN 45- to 90-seconds later. This delay limits the period of time the engine starter will crank. If the engine does not start within this time period, N.O. contacts will open and allow K14 relay to drop out. On four light installations N.C. contacts will close and light the PLANT FAILED TO START fault light.

If the engine starts, N.C. contacts K13, 1-4 will open and remove 24VDC from K12 coil, thus preventing any further time-out action.

In addition, on four lamp systems only, two extra N.O. contacts close when relay actuates. One set lights "Plant Failed to Start" lamp, the other applies 24VDC to an external alarm circuit.

Cranking limiter is not used when a cycle cranker is installed at a remote station.

K13. START DISCONNECT RELAY (One and four fault lamp controls)

Two pole, double throw relay, standard octal base plug-in. In the de-energized position N.C. contacts 1-4 connect to K1 starter solenoid and K12 cranking limiter. The relay is energized when output from the battery charging alternator reaches coil pull-in value. N.C. contacts 1-4 open and remove 24VDC from K1 and K12, preventing further operation. N.O. contacts 1-3 close and apply 24VDC to K11 which energizes, to arm the LOPCO circuit. Contacts 1-3 hold 24VDC on the water solenoid for engine cooling.

K14. FUEL RELAY (One and four lamp systems)

Same type of relay as K13.

Energized when R-S-R- switch is placed in Run position. N.O. contacts 6-8 close to apply 24VDC to battery charging alternator for field excitation.

N.O. contacts 1-3 close to apply 24VDC to the following—

a. Oil pressure gauge (M11)
b. Water temperature gauge (M13)
c. K2 fuel solenoid valve
d. K1 starter solenoid (thru K13 N.C. contacts)
e. K12 cranking limiter relay (thru K13 N.C. contacts)

after K13 relay has actuated—N.O. contacts close—

f. K11 time delay relay; oil pressure
g. K3 water solenoid valve

K15. EMERGENCY SHUTDOWN RELAY (Single light control only)

Normally a de-energized relay, operates only with Low Oil Pressure, High Water Temperature, or Overspeed malfunction. LOPCO and HETCO circuits are "armed" when K11 operates. Closure of either of these two cut-off switches applies a ground (through K11 contacts) to the coil of K15, causing it to energize with the following result—

a. N.C. contacts open to de-energize K14 for engine shutdown and de-energize K15 coil.
b. N.O. contacts close to light DS12 fault lamp.
c. N.O. contacts close to apply 24VDC to common alarm circuit.

If the relay has been energized, it is reset by manually pressing the latch button. Overspeed switch is a centrifugal unit which closes at 2000- to 2200-rpm and applies a ground to K15 to perform the functions previously described. Overspeed shutdown is not "armed" by K11 relay, therefore is not affected by its operation.

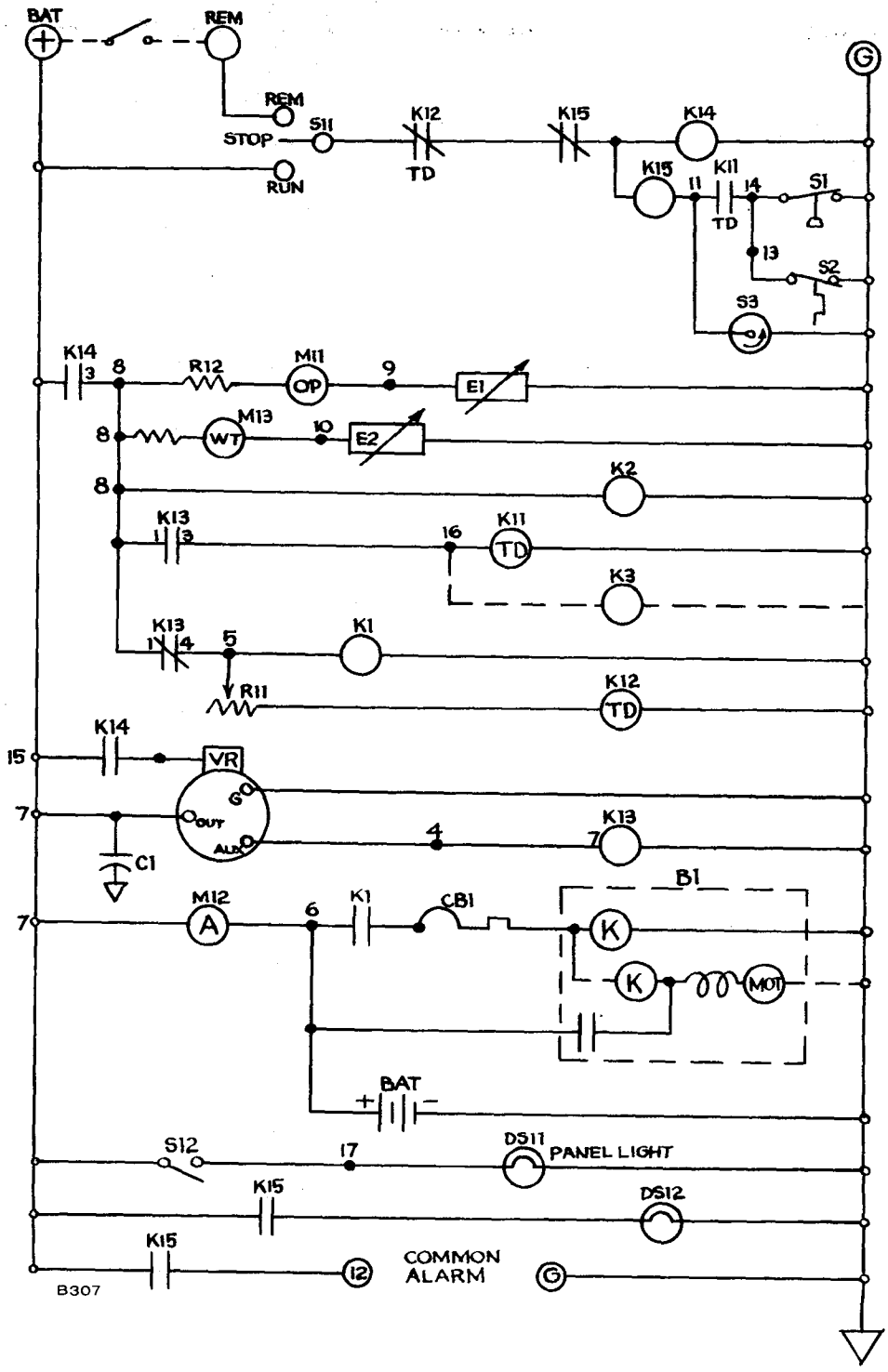


FIGURE 25. SCHEMATIC, SINGLE LIGHT

K15. LOW OIL PRESSURE SHUTDOWN (Four fault lamp controls)

With a four fault light panel, K15 relay has only one function, Low oil Pressure shutdown and fault lamp indication. Armed by K11 as previously noted, closure of LOP switch (S1) will apply a ground to K15 coil and cause it to actuate, with the following switching action—

a. N.C. contacts open, K14 drops out to shutdown engine, K15 coil is de-energized.
b. N.O. contacts close to light DS13 LOP fault lamp.
c. N.O. contacts close to apply 24VDC to alarm.

The following relays are used with four fault lamp control panels. See Figure 26.

K16. HIGH WATER TEMPERATURE SHUTDOWN (HETCO)

Placing R-S-R- switch to Run applies 24VDC to K16 coil. The relay is then in a ready condition and when the high water temp switch (S2) closes at 102° C (approx) a ground is applied to the other side of K16 coil.

The relay will actuate and perform the following switching action—

a. N.C. contacts open, K14 drops out to shut down engine.
b. N.O. contacts close to light DS14 High Water Temperature Fault light.
c. N.O. contacts close to apply 24VDC to alarm.

K17. OVERSPEED SHUTDOWN

Placing R-S-R- switch to Run applies 24VDC to K17 coil. Relay is then in a ready condition. An engine Overspeed condition in excess of 2000 rpm will cause a centrifugal switch mounted on the generator shaft, to close and complete the relay ground circuit.

The relay will actuate and perform the following switching action—

a. N.C. contacts open, K14 drops out to shut down engine.
b. N.O. contacts close to light DS15, Overspeed fault lamp.
c. N.O. contacts close to apply 24VDC to alarm.

The preceding operational description refers to R-S-R- switch in Run position. This is for purposes of brevity only. Identical functions will result with R-S-R- switch in Remote, when remote station circuits are complete.

OPTIONAL RELAYS

K12. ALARM RELAY (Specs 9560A; 6925A; 5504A)

Energized by signal from remote station, which also lights "Failed to Start" fault lamp. N.O. contacts close, apply 24VDC to TB11-12 for external alarm.

K18. REMOTE START TIME—DELAY RELAY (Spec 9560A)

Used only with remote start. The three-second delay between energize and actuate prevents unit-engine start when a sudden drop in utility company voltage indicates a power-out, unless the voltage dip exceeds 3-seconds.

Actuation of the relay closed N.O. contacts to complete circuit between TB12-Remote and R-S-R- switch in Remote position.

ENGINE CONTROL OPERATION, Spec 9730A

This system has engine shutdown for Overcrank and Overspeed only, all other malfunctions operate alarms. Operation of K12 Cranking Limiter, K13 Start Disconnect, K14 Fuel Relay and K15 Overspeed Shutdown are as previously described.

The following relays—

K16 Low Oil Pressure alarm,
K17 High Water Temperature alarm,
K18 Low Engine Temperature alarm,
K19 High oil Temperature alarm,

—are double pole, single throw units. Each has one set of N.O. contacts which close to apply 24VDC to TB13, then to a remote annunciator panel. See Figure 27 for schematic diagram.

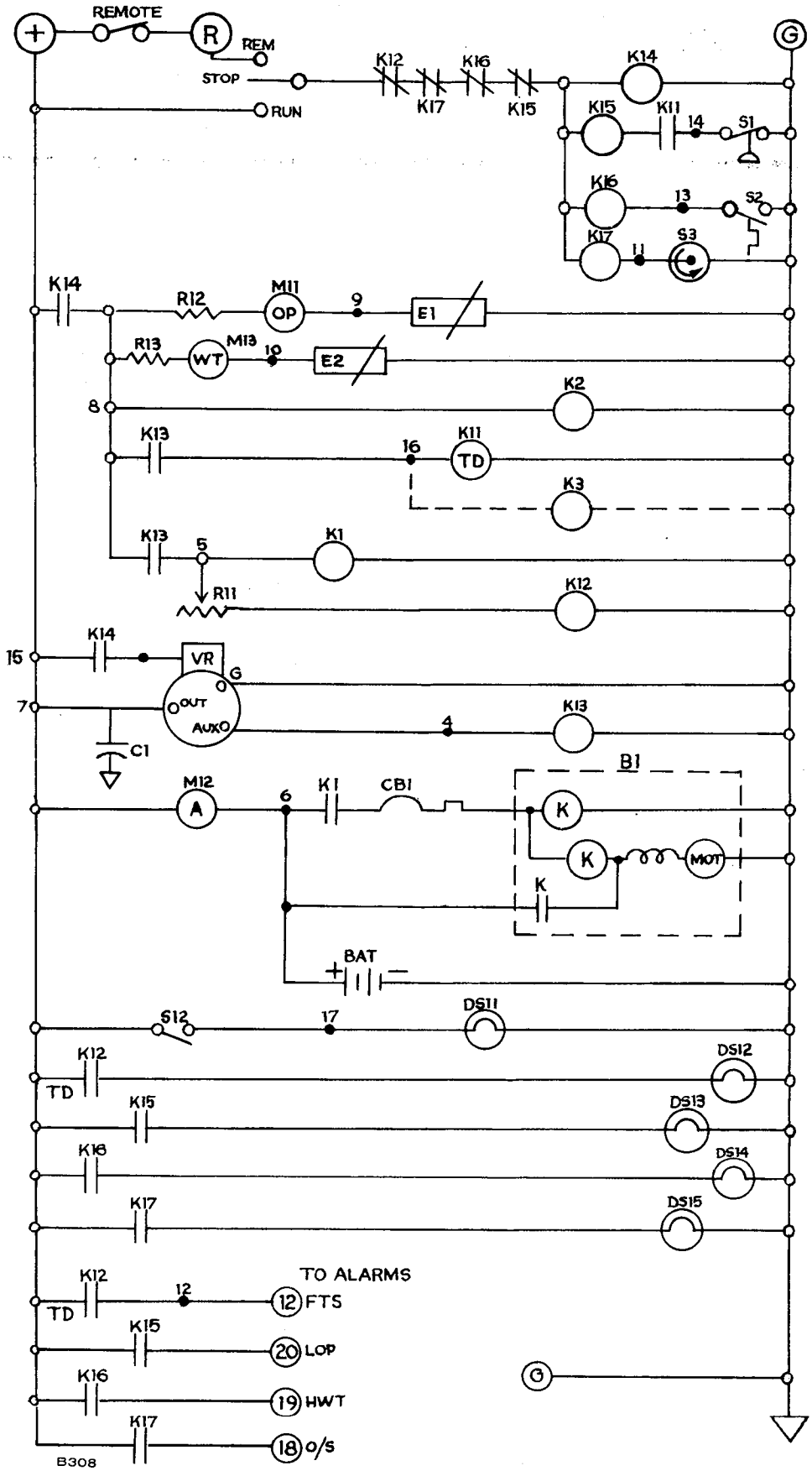


FIGURE 26. SCHEMATIC, FOUR LIGHT

TYPE 3 CYCLE CRANKER 625-0821 (Specs 5504A; 6925A; 9560A)

This optional unit combines cranking limit time and a number of crank/rest cycles within this time. Referring to Figure 27 it will be seen that relays K1, K2 and K3 are adjustable time-delay units. K1 and K3 delay between energize and actuate, K2 delays between de-energize and de-actuate.

Placing R-S-R- switch in Run position applies 24VDC through cycle cranker relay contacts K4 and K1 to control panel relay K14 which pulls-in and starts the engine cranking cycle. This same 24VDC is applied to cycle cranker relay K3 which control the cranking limiter time period. Relay K2 actuates and closes contacts to apply 24VDC to K1. When K1 actuates, power is removed from the engine starter circuit, and from K2, which de-actuates 10-seconds later and allows K1 to dropout. K2 will again pull in, K1 will energize and then actuate, and the crank/rest time will continue until K3 actuates, N.O. contacts close and cause K4 to pull-in, open N.C. contacts and shut down the engine cranker circuit.

If the engine starts within the K3 energize/actuate time limit, output from the battery charging alternator will actuate relay K13 which will switch and apply 24VDC to cycle cranking relay K5. This relay will pull in and keep the cranking circuit de-energized.

Relay K4 is a mechanical-latch type. In the event of non-start, K4 will drop out and disable the cranking circuit, which will remain disabled until K4 is manually reset by depressing the latch button.

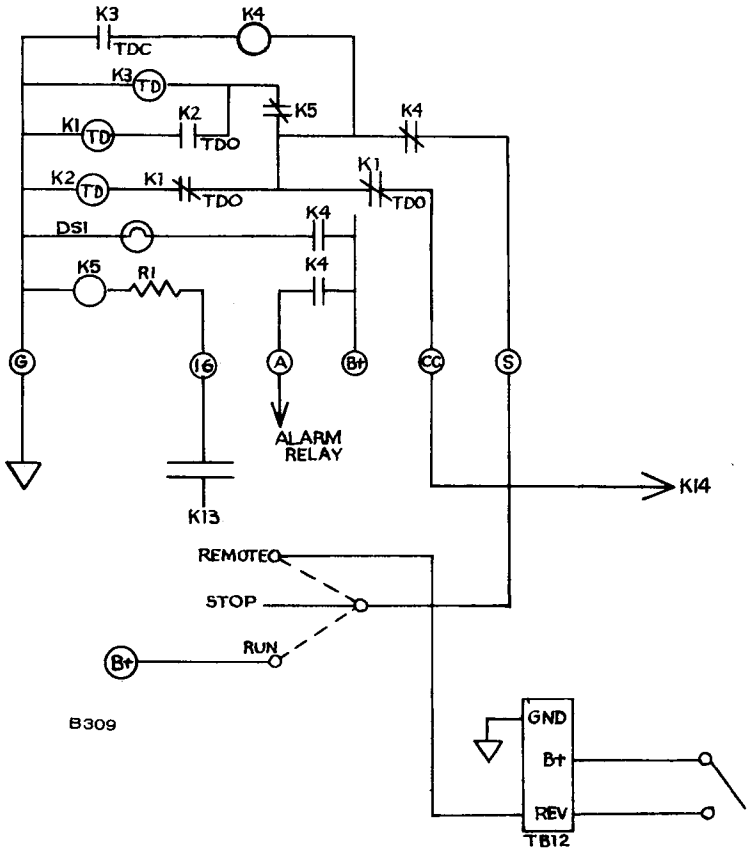


FIGURE 27. TYPE III CYCLE CRANKER (625-0821)

CONTROLS TROUBLESHOOTING

GENERAL

Before you start the troubleshooting procedure, visually inspect all wiring and connections. Check relay plug-in receptacles for cold solder joints. Look at the engine control and wiring. Check that no broken or shorted wires and no loose terminals exist.

This troubleshooting guide assumes that your knowledge of the electric generating set will allow you to consider the nature of the fault before proceeding.

For example, your set cranks without starting; you will check fuel, fuel lines, ignition carburetion, etc. If it does not crank—

Check Batteries

- Connected properly?
- Connections secure?
- Fully charged?

Starter Connections secure?

Remote Station start switch in correct position?

A few minutes spent logically analyzing a malfunction can save hours and expense on an inoperative generating set. This manual will help you with your electrical control problems. Consult your engine operator's manual for engine troubleshooting information.

To use this guide, answer the question either "yes" or "no" then proceed to the step given in the column containing your answer.

QUESTION AND ANSWER TROUBLESHOOTING GUIDE

To correct a problem, answer the question "Yes" or "No", then proceed to the next step given in whichever column the question was answered.

Preparation for troubleshooting. Check batteries for state of charge. Check wiring and connections for correct connection and security.

DFT, DFU, DFV, DFW. Specs R8/1A; R8/50A, R8/8554A, R8/9730A.
WF. WK. R8/1A.

Single Fault Lamp Control

CONDITION: A. ENGINE WILL NOT CRANK R-S-R- SWITCH IN RUN POSITION				
Item		**Yes**	**No**	**R-S-R-**
1	Is Fault lamp lit?	2	4	Run
2	Reset relay K15 latch button. a. Does fault lamp go OFF. Does engine crank? b. Does fault lamp stay ON? c. Does fault lamp go OFF, then ON?	 — 3 5	 — — —	
3	Replace K15 relay.	—	—	
4	Reset relay K12. Does engine crank?	 —	 5	
5	Unplug K14 relay. Measure resistance from TB11-11 to ground. Is resistance reading Infinity?	 —	 6	Stop
6	Disconnect wire to Overspeed switch. Measure resistance of lead to ground. Is resistance reading Infinity?	 8	 7	
7	Replace or readjust Overspeed switch.	—	—	
8	Measure resistance from TB11-11 (O/S switch still disconnected) to ground. Is resistance reading Infinity?	 —	 9	
9	Replace K11, Oil Pressure Cut-off relay.	10	—	
10	Reconnect wires disconnected at TB11-11. Plug-in K14 relay.	 11	 —	
11	Measure voltage at starter. Does coil wire read 24 VDC? Does motor input read 24 VDC?	 12 12	 13 —	Run
12	Replace starter.	—	—	
13	Measure voltage at TB11-6. Does voltmeter read 24 VDC?	 14	 17	
14	Measure voltage at starter circuit breaker where wire connects from relay K1. Does voltmeter read 24 VDC?	 15	 18	

Item	A. ENGINE WILL NOT CRANK (Continued)	Yes	No	R-S-R-
15	Place temporary jumper across circuit breaker terminals. Does engine crank?	16	17	
16	Replace circuit breaker.	—	—	Stop
17	Check wiring and connections between battery and terminal board. Repair, replace, secure where necessary.	—	—	
18	Measure voltage at TB11-5. Does voltmeter read 24 VDC?	19	23	Run
19	Measure voltage at coil input terminal on starter solenoid K1. Does voltmeter read 24 VDC?	20	22	
20	Measure resistance from K1 coil return connection to ground. Is continuity obtained?	21	22	Stop
21	Replace starter solenoid K1.	—	—	
22	Check all wiring and connections to K1. Replace, repair, secure as necessary.	—	—	
23	Unplug relay K13. Measure voltage at receptacle pin 1. Does voltmeter read 24 VDC? Reinsert K13 relay.	24	26	Run
24	Check wiring and connections between K13-4 and TB11-5. Replace, repair, secure as necessary. Was repair required?	—	25	Stop
25	Replace K13 Relay.	—	—	
26	Toggle R-S-R- switch between Run and Stop positions; watch relay K14 during this operation. Does K14 relay actuate?	—	27	
27	Unplug relay K14. Measure voltage at receptacle pin 7. Does voltmeter read 24 VDC? Reinstall Relay K14.	31	28	Run
28	Recheck latching of K12 and K15 relays. Check wiring and connections (refer to schematic). Replace, repair, secure where necessary. Was repair required?	—	29	
29	Measure continuity between K14 and pin 2 and ground. Is continuity obtained?	32	30	Stop
30	Check wiring and connections between K14-7 and TB12-Ground. Repair, replace, secure where necessary.	—	—	
31	Replace relay K14.	—	—	

Item	A. ENGINE WILL NOT CRANK (Continued)	Yes	No	R-S-R-
32	Measure voltage at armature of R-S-R- switch. Does voltmeter read 24 VDC?	—	33	Run
33	Check wiring and connections at R-S-R- switch. Repair, replace, secure where necessary. Was repair required?	—	34	Stop
34	Replace R-S-R- switch.			

CONDITION: B. ENGINE WILL NOT CRANK R-S-R- SWITCH IN REMOTE POSITION				
Item		Yes	No	R-S-R-
1	Switch R-S-R- switch to Run position. Does engine crank?	2	A1	
2	Return R-S-R- switch to Remote. Apply temporary jumper across TB12-B+ and Remote terminals. Does engine crank?	3	5	
3	Apply temporary jumper across Start switch at remote station. Does engine crank?	4	6	
4	Replace remote station start switch.	—	—	
5	Check wiring between TB12-Remote and R-S-R- switch. Repair, replace, secure where necessary.	—	—	—
6	Measure continuity between TB12 and Remote station. Repair, replace, secure where necessary.	—	—	—

CONDITION: C. ENGINE MALFUNCTION SHUTDOWN			
Item		**Yes**	**No**
1	Did engine shut down immediately after start (i.e., within 3-seconds)?	5	2
2	Did engine shut down 10- to 20-seconds after start?	6	3
3	Did engine shut down 45- to 90- seconds after start?	14	4
4	Did engine shut down after running, crank for 45- to 90-seconds, then shut down without cranking? Fault light ON after cranking cycle complete? WF and WK sets only.	— 14 16	— — —
5	Check throttle linkage for freedom of movement. Check governor setting. Check overspeed switch. Readjust or replace as necessary.	—	—
6	Check engine crankcase oil. Does oil need replenishing?	—	7
7	Disconnect switch wire at TB11-14. Restart engine. Watch oil pressure gauge. Does Engine run satisfactorily? Does oil pressure build up to normal?	9 —	 8
8	Refer to engine manufacturer's manual for oil system troubleshooting guides.	—	—
9	Disconnect oil pressure switch. Measure resistance between wire and ground, Ohmmeter scale R x 10K. Is reading less than infinity?	10	11
10	Repair or replace wire.	—	—
11	Connect ohmmeter (R x 1 scale) between oil pressure switch and ground. Start engine, observing ohmmeter. Does ohmmeter reading go to infinity when engine starts?	13	12
12	Replace oil pressure switch.	—	—
13	Shut down engine. Visually check oil pressure time-delay relay contacts. Manually operate armature and make sure contacts make-and-break properly. If contacts hang up or are stuck, replace relay.	—	—
14	Check fuel. Are tanks (day tank and main fuel tanks) full?	15	—
15	Check fuel system; lines, pump, etc.	—	—
16	Check fuel lines; gas pressure, etc.	—	17
17	Check ignition system. Refer to Waukesha manual for troubleshooting fuel and ignition systems.	—	—

Preparation for troubleshooting. Check batteries for state of charge. Check wiring and connections for correct connection and security.

Four Fault Lamp Control

CONDITION D. ENGINE WILL NOT CRANK R-S-R- SWITCH IN RUN POSITION				
Item		**Yes**	**No**	**R-S-R-**
1	Is one of the following fault lamps ON?	—	2	Run
	a. Plant Failed to Start? Refer to guide—	E	—	
	b. Low oil pressure? Refer to guide—	F	—	
	c. High Water Temperature? Refer to guide—	G	—	
	d. Overspeed? Refer to guide—	H	—	
2	Toggle R-S-R- switch between Stop and Run; watch K14 relay. Does K14 operate?	8	3	
3	Unplug K14 relay. Measure continuity between K14-7 and R-S-R- switch armature. Is continuity obtained?	5	4	Stop
4	Refer to Figure 26, Schematic Diagram. Progressively measure continuity from R-S-R- switch through K12, K17, K16, K15, to K14-7. Repair, replace or secure wiring or connections where necessary.	—	—	
5	Measure continuity between K14-2 and TB12-Ground. Is continuity obtained?	6	7	
6	Replace K14 Relay.	—	—	
7	Check wiring and connections between K14-2 and TB12-Ground. Replace, repair, secure where necessary. Reinsert relay.	—	—	
8	Toggle R-S-R- switch between Stop and Run; hold K1 Starter solenoid. Does K1 operate?	13	9	
9	Measure voltage at TB11-5. Does voltmeter read 24VDC?	10	18	Run
10	Measure voltage at coil terminal of K1. Does voltmeter read 24VDC?	11	—	
11	Measure continuity from ground side of K1 coil terminal to ground. Is continuity obtained?	12	—	Stop
12	Replace K1 Starter solenoid.	—	—	
13	Measure voltage at starter motor relay coil terminal. Does voltmeter read 24 VDC?	16	14	Run
14	Apply temporary jumper across circuit breaker CB1. Does starter crank?	15	—	

Item	D. ENGINE WILL NOT CRANK R-S-R- SWITCH IN RUN POSITION (Continued)	Yes	No	R-S-R-
15	Replace starter circuit breaker.	—	—	Stop
16	Are starter-to-battery cable connections secure?	17	—	
17	Replace starter motor.	—	—	
18	Unplug relay K13. Measure continuity across relay pins 1 and 4. Is continuity obtained?	20	19	
19	Replace relay K13.	—	—	
20	Check wiring and connections between TB11 and K13 and K14 relays. Repair, replace, secure where necessary.	—	—	

Four Fault Lamp Control

CONDITION: E. ENGINE MALFUNCTION SHUTDOWN PLANT FAILED TO START			
Item		**Yes**	**No**
1	Reset latch button on relay K12. Does engine crank? Does engine start?	— —	C2 2
2	Refer to engine manufacturer's manual for engine non-start troubleshooting guides.	—	—

CONDITION: F. ENGINE MALFUNCTION SHUTDOWN LOW OIL PRESSURE SHUTDOWN			
Item		**Yes**	**No**
1	Check engine crankcase oil quantity. Is oil required?	—	2
2	Reset latch button on K15 oil pressure relay. Start engine; watch oil pressure gauge. Does oil pressure build up to normal, then engine shut down? Does engine shut down before pressure build up?	3 7	— —
3	Disconnect lead from low oil pressure switch (S1). Measure continuity between lead and ground. Is continuity obtained?	4	5
4	Repair or replace lead.	—	—
5	Connect ohmmeter between S1 and ground. Reset relay K15. Restart engine; watch ohmmeter. Does switch open when oil pressure builds up?	—	6
6	Replace oil pressure switch.	—	—
7	Refer to engine manufacturer's manual for low oil pressure troubleshooting guide.		

CONDITION: G. ENGINE MALFUNCTION SHUTDOWN HIGH WATER TEMPERATURE SHUTDOWN			
Item		**Yes**	**No**
1	Check coolant. **WARNING: If engine has been running and coolant is hot, bleed off pressure BEFORE attempting to open system. Severe burns could result from contact with hot coolant.**	—	—
2	Check fan belts.	—	—
3	Check coolant pump drive belts.	—	—
4	Check radiator (if appropriate) and remove any obstructions to air flow.	—	—
5	Reset latch button on relay K16. Restart engine. If city water cooled system, adjust water flow to keep engine within normal operating temperatures.	—	—
6	Check load on generator. Reduce load if excessive.	—	—

Preparation for troubleshooting. Loss of governor control is the only thing that will cause an engine to overspeed. This can be caused by either a faulty governor (which is unlikely), uncoupled, sticky or binding throttle linkage to the governor.

When an engine has shut down because of an Overspeed condition, check the following before continuing with the troubleshooting guide.

a. Throttle linkage for freedom of movement.
b. Both banks of cylinders are connected to governor throttle linkage.

Four Fault Lamp Control

CONDITION: H. ENGINE MALFUNCTION SHUTDOWN OVERSPEED CONDITION			
Item		**Yes**	**No**
1	Disconnect Overspeed switch lead from TB11-11. Measure continuity between disconnected lead and ground. Is continuity obtained?	2	—
2	Leaving ohmmeter connected, disconnect lead from Overspeed switch on generator shaft. Is continuity still maintained?	3	4
3	Repair or replace wire between TB11-11 and Overspeed switch.	—	—
4	Adjust or replace Overspeed switch.	—	—

Single or Four Fault Lamp Controls

CONDITION: I. ENGINE RUNNING. STARTER RE-ENGAGES.				
Item		**Yes**	**No**	**R-S-R-**
1	Unplug K13 Start-disconnect relay. Measure continuity from AUX terminal on battery charging alternator to pin 7 of relay receptacle. Is continuity obtained?	2	5	
2	Measure continuity from relay receptacle pin 2 to TB11-Ground. Is continuity obtained?	3	5	
3	Remove cover from battery charging alternator voltage regulator. Measure continuity from relay K14 receptacle, pin 6 to input of battery charging alternator voltage regulator (yellow wire). Is continuity obtained?	4	5	
4	Measure continuity from K13 receptacle pin 4 to coil input terminal of starter relay K1. Is continuity obtained?	6	5	
5	Check all wiring and connections in the previously mentioned circuits. Repair, replace, secure where necessary.	—	—	
6	Replug K13 relay. Do not close panel door. Restart engine; remove K13 relay as soon as engine has started. **WARNING: Proceed with care! High voltages are present within the control cabinet, which could cause shock or serious injury.** Measure voltage at AUX terminal of battery charging alternator. Does voltmeter read 24 VDC?	7	8	Run
7	Replace K13 relay with new unit.	—	—	
8	Measure voltage at excitation input terminal of battery charging alternator (yellow wire). Does voltmeter read 24 VDC?	9	—	
9	Replace battery charging alternator.	—	—	

CONDITION: J. ENGINE WILL NOT START, BUT CONTINUES TO CRANK IN EXCESS OF 90-SECONDS CRANKING LIMITER TIME				
Item		**Yes**	**No**	**R-S-R-**
1	Disconnect one wire from resistor R11 (cranking limiter). Measure resistance from slider to disconnected terminal. Is resistance approximately 7.5 ohms?	3	2	
2	If resistor indicates either open (infinity) or shorted, replace resistor.	—	—	
3	Measure voltage at coil input terminal of K12 relay. Does voltmeter read 24 VDC? (after 90-seconds)	4	—	Run
4	Replace K12 relay.	—	—	

CONTROLS—SECTION II

SOLID-STATE

SOLID STATE ENGINE CONTROLS

This section of engine controls is applicable only to the following sets—

TABLE 4

Model	Starting Spec
DFT	*C and D only. Not spec E
DFU	*D only. Not spec E
DFV	E
DFW	B
DFY	A
WF	*B only. Not spec C
WK	B
DWV	A

Engine controls on these units have been mostly replaced by solid state devices on plug-in printed circuit boards.

* DFT spec E, DFU spec E and WF spec C controls information is located in YB series major service manual, Onan number 900-0181, and Generator Section 9, of Master Service Manual, 922-0500.

DESCRIPTION

The shock-mounted control cabinet has two doors, opening from the top. For purposes of identifying location, left and right is considered, in this manual, when facing the control panel.

The left hand door is designated the AC panel and contains the following equipment as a standard installation. See Figure 29.

1. **AC voltmeter.** Scales 50 to 300 volts or 100 to 600 volts DC.
2. **AC ammeter.** Range of meter depends upon size of generator.
3. **Voltmeter-ammeter phase selector switch.** Selects the phases of the generator output to be measured by the AC voltmeter and AC ammeter, i.e., line-to-line, line-to-neutral, single phase or three phase.
4. **Frequency meter.** Reed type meter indicates generator output frequency in Hertz.
5. **Running time meter.** Registers total number of hours, to one-tenth hour, unit has run. Recorded time is accumulative; the meter cannot be reset to zero time.
6. **Voltage regulator.** Rheostat (R1) provides an adjustment of plus or minus 5 percent of generator output voltage.
7. **Exciter Circuit Breaker (CB1).** Provides generator exciter and regulator protection from overheating in the event of certain failure modes of the generator exciter and voltage regulator.

OPTIONAL EQUIPMENT INSTALLED ON THE AC PANEL

Governor Control

Woodward PSG Governor. Single-pole, double-throw, center-off, momentary contact switch, operates split-field series motor situated on top of the engine governor to position the governor and adjust engine speed.

Barber-Colman Governor. Ten-turn potentiometer connected into governor control box provides vernier positioning of governor.

The right hand door, designated the DC panel, contains the following equipment. See Figure 29.

1. **Oil pressure gauge.** Connected to a resistance type sender on the engine, this instrument indicates engine circulating oil pressure.
2. **Water temperature gauge.** Connected to a resistance type sender on the engine, this instrument indicates engine coolant temperature.
3. **Ammeter.** Indicates the output current of the battery charging alternator.
4. **Run-Stop-Remote switch.** Starts and stops the unit locally or from a remote location.
5. **Warning light.** Indicates "Fault in engine operation."
6. **Panel light and switch.**

Optional equipment installed on the DC panel

7. **Warning lights.** See Table 5. Eliminates the one "Fault" light and substitutes five indicator lights to give warning of:
   1. Overcrank
   2. Overspeed
   3. Low Oil Pressure
   4. High Engine Temperature
   5. Low Engine Temperature
8. **Reset switch.** Manual reset for engine monitor after shut-down, Run-Stop-Remote switch in "Stop" position.
9. **Lamp test.** Depress to test warning lamp bulbs. Operate only while engine is running.

TABLE 5. FAULT LAMP OPTIONS

SYSTEM	FAULT	FAULT LAMP	STOP ENGINE	EXTERNAL ALARM	PRE-ALARM
PENN STATE SINGLE LIGHT	Overcrank	x	x	x	
	Overspeed	x	x	x	
	Low Oil Pressure	x		x	
	High Engine Temperature	x		x	
STANDARD SINGLE LIGHT	Overcrank	x	x	x	
	Overspeed	x	x	x	
	Low Oil Pressure	x	x	x	
	High Engine Temperature	x	x	x	
5 LIGHT	Overcrank	x	x	x	
	Overspeed	x	x	x	
	Low Oil Pressure	x	x	x	
	High Engine Temperature	x	x	x	
	Low Engine Temperature	x			
5 LIGHT PRE-ALARM	Overcrank	x	x	x	
	Overspeed	x	x	x	
	Low Oil Pressure	x	x	x	*
	High Engine Temperature	x	x	x	*
	Low Engine Temperature	x			
PENN STATE FIVE LIGHT	Overcrank	x	x	x	
	Overspeed	x	x	x	
	Low Oil Pressure	x		x	
	High Engine Temperature	x		x	
	Low Engine Temperature	x		x	

* - With additional optional sensors.

CONTROL OPERATION

GENERAL

In emergency situations a serviceman can be faced with the problem of returning an inoperative generator set to service to restore vital electrical power in the minimum time (e.g., life support equipment in hospitals). The more information he has on the system the shorter is the down-time period.

This section of the manual is intended to instruct the serviceman on the operation of the relays and printed circuit modules which comprise the UV control system. Used in conjunction with the schematic diagrams at the back of the manual this information should provide the serviceman with greater understanding of the function of the system.

Refer to Figure 28 for location of solid state equipment within the control panel cabinet.

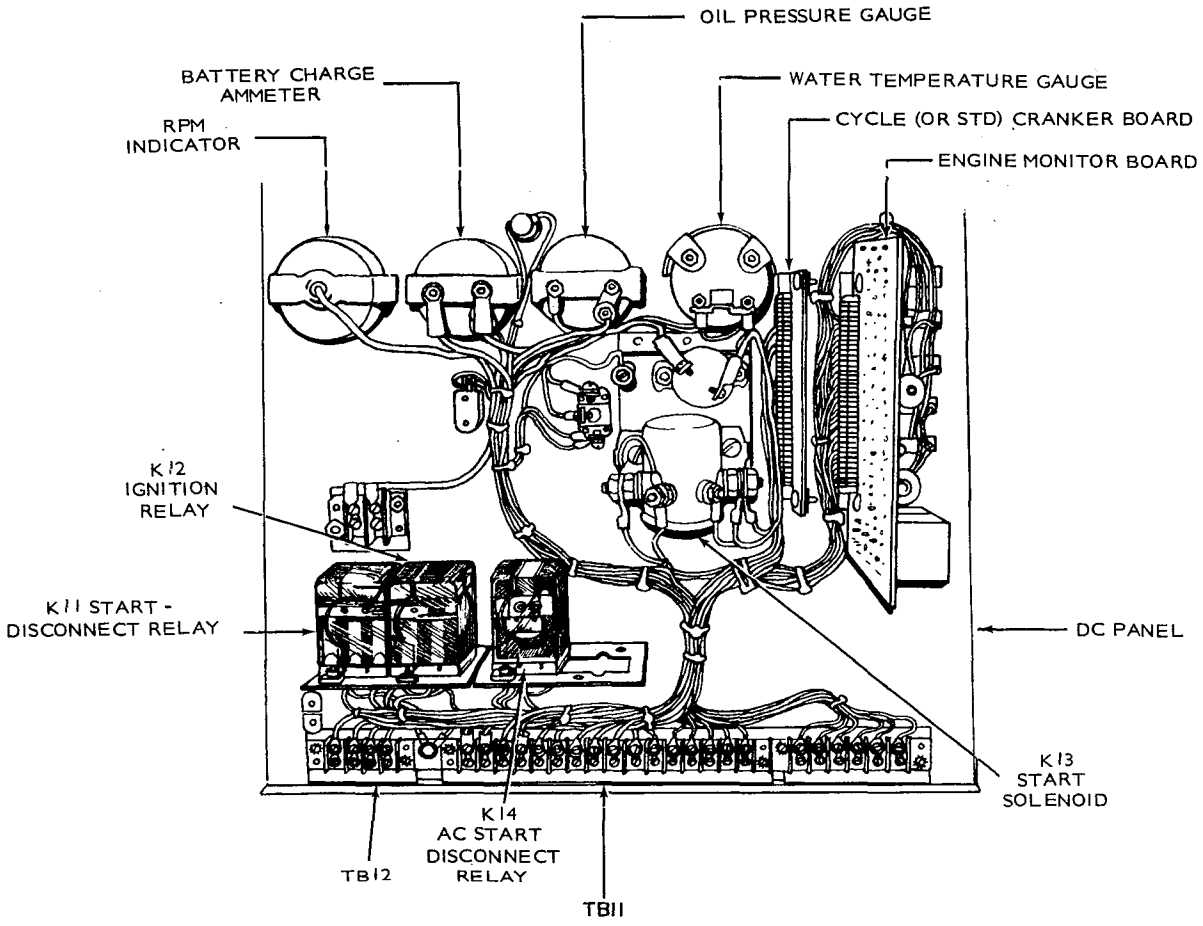


FIGURE 28. LOCATION OF DC CONTROL COMPONENTS

STANDARD, SINGLE LIGHT SYSTEM

A single fault lamp is standard equipment on UV generator sets. This means that the lamp will indicate a fault for any engine malfunction. Refer to appropriate troubleshooting guide for single lamp fault-location. See Figure 29 for panel layout.

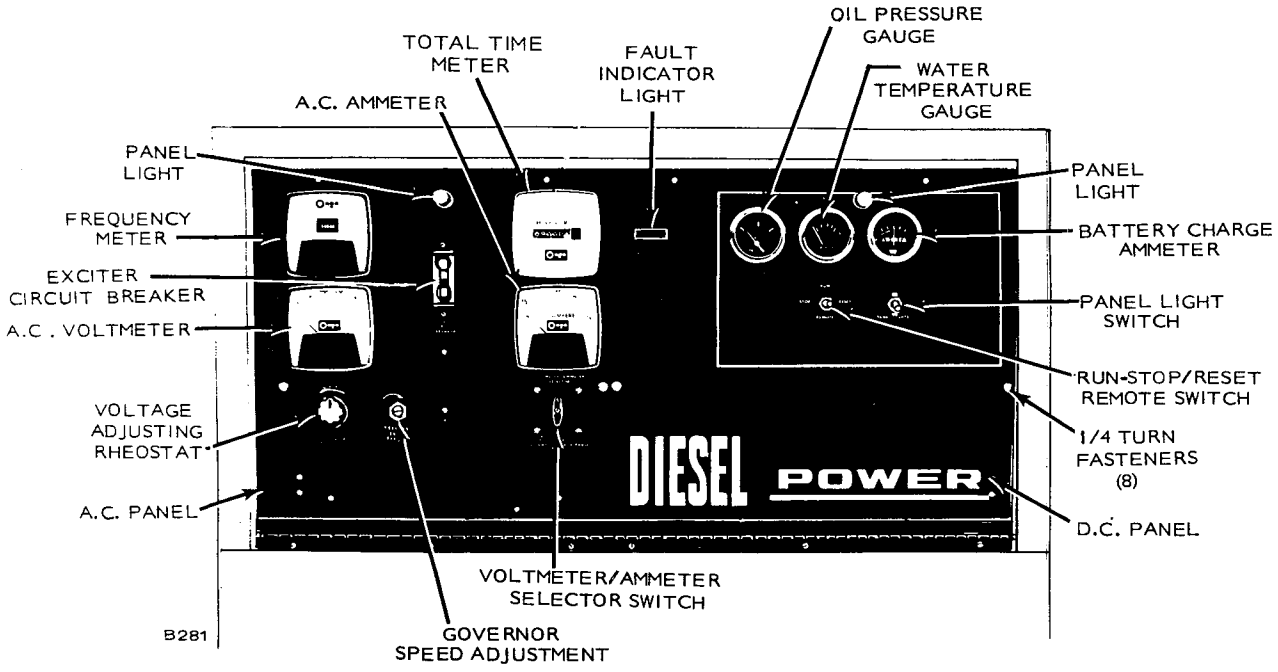


FIGURE 29. CONTROL PANEL, SINGLE FAULT LAMP (TYPICAL)

ENGINE MONITOR MODULE A11.

OVERSPEED

Switch closure between 200 and 2200 rpm applies a ground to A11-14 to turn ON transistor A11-Q7. This applies a bias to the gate of A11-CR6 which provides a ground to light the fault lamp and pull-in relay A11-K1. The following switching action takes place:

1. N.C. contacts open and break 24VDC to A11-7 to drop-out K12 and shut down engine.
2. N.C. contacts open and remove power from the Overspeed and LOP/HET circuits. A11-K1 will remain pulled in.
3. N.O. contacts close and apply 24VDC to A11-8 for the external alarm.

K1 Relay contacts are not numbered.

OVERCRANK

Allows a maximum crank time of 70- to 80-seconds (nominal 75). Placing R-S-R switch to Run starts engine cranking function and applies 24VDC to the Overcrank circuit. Time delay is determined by charge rate of capacitor A11-C3 which is adjustable by rheostat A11-R4 (screwdriver adjustment).

If engine starts within 75-second time limit, output from battery charging alternator AUX terminal will pull-in relay K11. N.O. contacts K11-6-9 close and short capacitor A11-C3, thus terminating engine overcrank shutdown function.

If engine does not start within the time limit, A11-C3 will become fully charged and turn OFF transistor A11-Q3. This will turn ON A11-Q2 and A11-Q1 which causes A11-CR6 to conduct and provide a ground to light the fault lamp and pull in A11-K1. See Overspeed description for A11-K1 function.

HIGH ENGINE TEMPERATURE AND LOW OIL PRESSURE

Operation of either of these malfunction condition switches applies a ground to A11-13, therefore they will be considered together.

Application of a ground to A11-13 will turn ON transistors A11-Q8 and A11-Q6; capacitor A11-C4 will begin to charge. This insert a 10- to 15- (nominal 12.5) second time delay in the shutdown function. When A11-C4 is charged, A11-Q8 and A11-Q6 will turn OFF, transistors A11-Q5 and A11-Q4 will bias the gate of A11-CR6 which will conduct and provide a ground to light the fault lamp and pull-in A11-K1.

The Low Oil Pressure switch is normally closed, therefore, to allow the engine to start when the oil pressure shutdown circuit is presented with a malfunction indication, N.O. contacts of relay K11-5-8 are connected in series with the Low Oil Pressure switch. These contacts close when K11 is pulled in, and connect the LOP switch into the circuit.

RESET

Relay A11-K1 will remain actuated as long as the R-S-R switch is in position to supply 24VDC to A11-9. To reset K1 relay, place R-S-R switch to Stop/Reset, then to the required operating position.

SINGLE LIGHT. PENNSYLVANIA STATE

Overspeed

Ground at A11-14 causes A11-Q4 to turn ON, applying bias to A11-CR7 which conducts to provide a ground for fault lamp and relay K1.

Relay K1 switches to perform the following switching action—

1. N.O. contacts close, apply 24VDC to A11-8 for external alarm.
2. N.C. contacts open, remove power from solid state devices on board.
3. N.C. contacts open, break circuit to A11-7 which drops out K12 ignition relay for engine shutdown.

Overcrank

Operation same as single light standard.

Low Oil Pressure and High Engine Temperature.

Either switch closing will complete ground circuit to A11-K2. Relay pulls in, N.O. contacts close and apply 24VDC to A11-8 for external alarm.

N.O. contacts 5-8 of K11 remain open until battery charging alternator output builds up, to allow engine start without alarm. There is no engine shutdown or fault lamp indication with either Low Oil Pressure or High Engine Temperature condition.

FIVE LIGHT ENGINE CONTROLS

Available as an option, the five fault light installation performs the functions as designated in Table 2. See Figure 30 for panel layout. Refer to the appropriate troubleshooting guide for fault location.

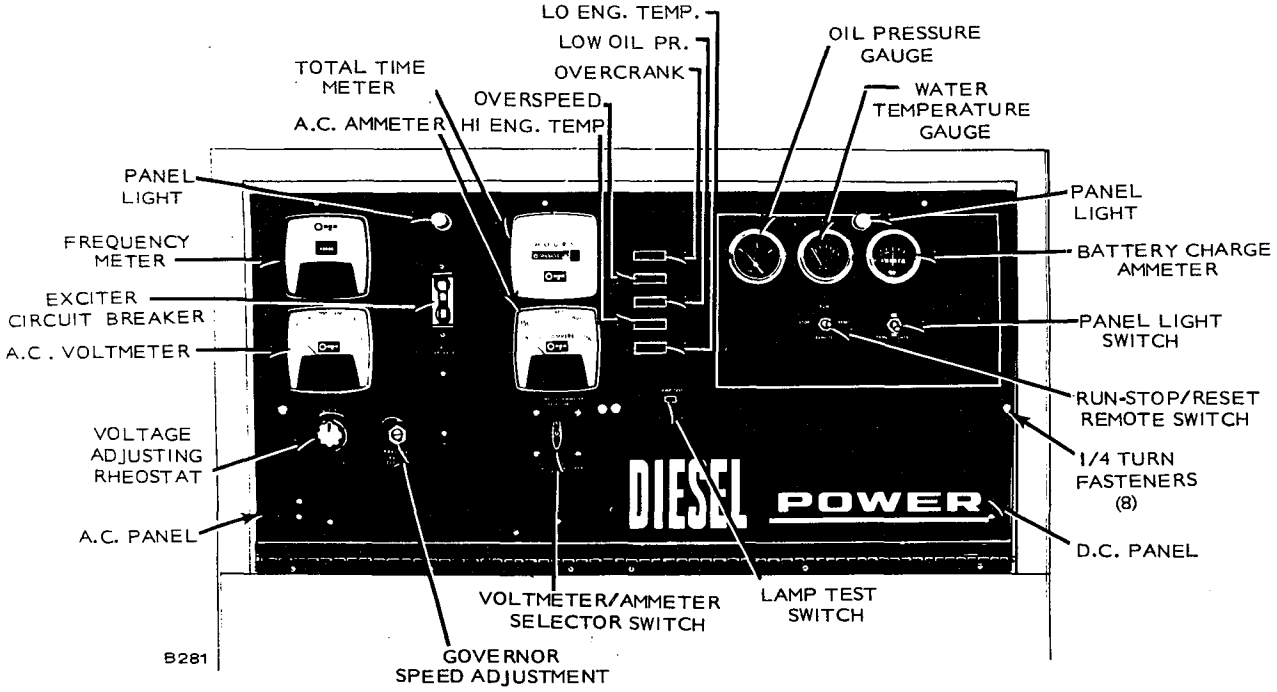


FIGURE 30. CONTROL PANEL, FIVE FAULT LAMP (TYPICAL)

LOW ENGINE TEMPERATURE

The Low Engine Temperature fault lamp is lit at any time the engine temperature is below a nominal 65° F (18.3° C). After engine start, the light will remain ON until engine temperature reaches 80° F to 90° F (26.7° C to 32.2° C). There is no alarm or shutdown with this indication.

At a nominal 85° F (29.4° C) the LET switch will open and the fault light will go out. At the same time, transistor A11-Q14 will turn OFF and 24VDC signal to A13 Alarm Control Relay module will be removed.

HIGH ENGINE TEMPERATURE

This fault indication system operates in two steps. A Pre-alarm and a HET shutdown switch.

Pre-Alarm: When engine temperature reaches 200° F to 210° F (93.3° C to 98.9° C), HET pre-alarm switch will close and apply a ground to A11-9. Transistor A11-Q10 will conduct and apply a bias to the gate of A11-CR18 which will turn ON and provide a ground to light HET fault lamp and pull-in A11-K2. At the same time A11-Q11 will conduct and supply 24VDC to A11-7 for A13 Alarm control module. Actuation of A11-K2 closes N.O. contacts to supply 24VDC to A11-20 for external alarm system and arms A11-K1 coil circuit (K1 does not pull-in).

High Engine Temperature Switch. Closes when engine temperature reaches 210° F to 220° F (98.9° C to 104.4° C), applies ground to A11-21 which energizes A11-K1 and removes 24VDC from K12 relay, to shutdown engine.

LOW OIL PRESSURE

Pre-alarm Switch closes at 18 psi to 22 psi (124- to 152 kPa) and applies ground to A11-8 through N.O. contacts K11-5-8. (Relay held in by 24VDC from battery charging alternator.) Current flow through resistor A11-R23 turns ON transistor A11-Q6. After a time delay of 10- to 15-seconds (12.5 sec nominal), A11-Q8 will fire, causing A11-Q7 and A11-Q9 to fire to bias the gate of A11-CR17. This completes ground circuit to light Low Oil Pressure fault lamp, energize A11-K2 then turn ON A11-Q5 which applies 24VDC to Alarm relay control module.

Activation of A11-K2 applies 24VDC to A11-20 for external alarm and closes ground circuit between A11-K1 and Low Oil Pressure cut-off switch.

Low Oil Pressure Cut-Off (LOPKO) switch closes at 12 psi to 16 psi (83- to 110 kPa), applies ground to A11-21 to complete circuit to energize A11-K1. Relay actuation removes 24VDC from A11-19 which allows K12 relay to drop-out and shut down the engine.

The LOP pre-alarm switch being a normally closed unit, would prevent the engine from starting because as soon as the R-S-R switch was placed in the Run position there would be a shutdown after 12.5-seconds. To allow engine start, N.O. contacts of K11-5-8 remain open thus disconnecting the LOP pre-alarm circuit, until the battery charging alternator output has built-up enough to pull-in K11 relay, close the contacts and place the circuit in readiness for a malfunction shutdown.

OVERCRANK

Allows maximum engine crank time of 70- to 80- (nominal 75-) seconds. Placing R-S-R switch to Run position starts engine cranking and applies 24VDC to A11-Q1 to initiate the time function. Cranking time is determined by the charge time of capacitor A11-C1 which is limited by adjustment of rheostat A11-R2 (screwdriver adjust). If engine starts within 75-seconds, output from battery charging alternator (AUX terminal) pulls in K11 relay, which closes a set of contacts (K11-6-9) to apply a ground to A11-16 and discharge A11-C1 to stop the Overcrank shutdown procedure.

If the engine does not start within the limit period, capacitor A11-C1 will charge and cause transistor A11-Q1 to fire which will turn ON A11-Q2 and A11-Q3 to bias the gate of A11-CR10. This gated diode will conduct to complete the ground circuit to light the Overcrank fault lamp and pull-in relay A11-K1. Transistor A11-Q4 will turn on and apply 24VDC to A11-14 for the A13 Alarm relay control module. Actuation of A11-K1 will close one pair of contacts to apply 24VDC to the external alarm system; open one set to drop out K12 relay and open another set to remove 24VDC from the solid state devices on the board.

Should the engine shutdown through loss of fuel, relay K11 will drop out, the engine will go through the 70- to 80-second crank cycle, then shutdown with an Overcrank indication. Therefore, the first things to check with an Overcrank shutdown are loss of fuel or, if applicable, ignition failure.

OVERSPEED

A centrifugal type switch located on the generator end-bell closes between 2000 and 2200 (nominal 2100) rpm and applies a ground to A11-4. This will cause transistor A11-Q13 to conduct and apply a bias to turn ON A11-CR20, which completes the ground circuit to light Overspeed fault lamp and pull-in A11-K1. Transistor A11-Q12 will turn ON and supply 24VDC to A11-6 for the A13 Alarm relay control module. Actuation of relay A11-K1 will remove power from K12 relay to shutdown the engine, apply 24VDC to the external alarm terminal (A11-20) and disconnect the solid state devices on the board.

LAMP TEST

Push type switch mounted on engine monitor board, protruding through panel face, applies 24VDC and ground to fault lamps for test. This switch does not check out the module, and should be depressed ONLY WHEN ENGINE IS RUNNING.

RUN-STOP/RESET-REMOTE SWITCH

Single-pole, double-throw, center-off toggle switch. In **Run Position:** applies 24VDC through A11-18 to engine monitor board.

Stop/Reset Position: stops engine and allows relay(s) on engine monitor board to drop out.

Remote Position: allow engine to be started from a remote station. Closure of the remote station switch applies 24VDC to A11-18 through R-S-R- switch.

FIVE LIGHT SYSTEM. PENNSYLVANIA STATE

Essentially the same as the standard five light system previously described, but with the following exceptions—

1. No pre-alarm switches.
2. High engine temperature, alarm and light only. No engine shutdown.
3. Low Oil Pressure, alarm and light only. No engine shutdown.
4. Low Engine Temperature, light only.
5. Engine shutdown on Overcrank or Overspeed only.

Use standard five light troubleshooting guides.

CONTROL SYSTEM FUNCTION

STANDARD CRANKER MODULE A12

Plug-in type printed circuit board. Provides for continuous engine starter cranking within the time limit restraints of the engine monitor module.

CYCLE CRANKER A12

Optional equipment. Provides 3 cranking cycles of 15-seconds each, with a 10-second rest time between. Total time (crank-rest-crank, etc.) is again limited to the 75-seconds set up by the engine monitor module.

Placing the R-S-R switch to Run applies 24VDC through A11-board to energize relay K12 and to A12-3. Transistor A12-Q2 conducts causing A12-Q3, A12-Q4 and A12-Q5 to conduct in turn to apply 24VDC to K13 start solenoid.

Connected to the base of A12-Q2 is capacitor A12-C1. Charge time of this capacitor is adjusted by rheostat A12-R4. When A12-C1 is charged, A12-Q2 ceases to conduct, A12-Q1 turns ON, thereby causing transistors A12-Q3, Q4 and Q5 to turn OFF and remove 24VDC from K13 start solenoid. Discharge time of A12-C1 is adjusted by rheostat A12-R1. When this capacitor is discharged, A12-Q1 turns off, A12-Q2 turns ON and the crank cycle is again initiated. At engine shut down, relay K12 is de-energized, contacts K12-9-3 close and discharge A12-C1 ready for the next starting requirement.

ALARM RELAY CONTROL MODULE A13

This board is available as an option and contains five relays, A13-K1 through A13-K5. Relays are energized by signals from A11 as follows:

A11-14 to A13-53, Overcrank
A11-12 to A13-54, Low Oil Pressure
A11-7 to A13-55, High Engine Temperature
A11-2 to A13-56, Low Engine Temperature
A11-6 to A13-57, Overspeed

Closure of the relay contacts allow alarms to be used independently of the common alarm system from A11-20.

Description of these relays is not the same as that given under 'Relay Control' in Section I.

START DISCONNECT RELAY K11

In the de-energized position, contacts K11-1-7 are closed and in series with a set of N.C. contacts from K14, thus completing the input circuit to A12-3, for engine start.

When the engine has started, output from the AUX terminal of the battery charging alternator pulls-in K11 with the following switching action:

1. N.C. contacts 1-7 open to disconnect starter solenoid.
2. N.O. contacts 5-8 close to arm Low Oil Pressure alarm circuit at A11-8.
3. N.O. contacts 6-9 close to discharge A11-C1 and prevent an Overcrank shutdown.

IGNITION RELAY K12

When de-energized, N.C. contacts 3-9 connected across A12-8-9 keep capacitor A12-C1 discharged.

Relay K12 is energized when R-S-R switch is placed in Run position, 24VDC is applied to K12 coil through A11 module. Switching is as follows:

1. N.C. contacts 3-9 open and allow cranking cycle to be initiated.

   These contacts perform no function with a standard cranker module.

2. N.O. contacts 5-8 close to apply 24VDC for battery charging alternator excitation.
3. N.O. contacts 4-7 close to apply 24VDC to TB11-26 for the following functions:
   a. Oil pressure gauge.
   b. Water temperature gauge.
   c. Energize K1 solenoid.
   d. Energize K2 coolant solenoid.
   e. Energize E3 fuel pump.
   f. Energize A12 module for engine start.

STARTER SOLENOID K13

Single-pole solenold, energized through A12 cranking module.

Performs following function:

1. N.O. contacts close and apply 24VDC to 'K' on engine starter and solenoid assembly. 'K' solenoid pulls in to apply 24VDC to cranking motor.

STARTER PROTECTION RELAY K14

In de-energized position,N.C. contacts 1-7 are in series with a set of contacts of K11, thus completing the input circuit to A12-3 for engine starting. Relay K14 is an AC coil relay, actuated from the output of the UV generator, and is a back-up for contacts 1-7 of relay K11.

When energized, switching action is as follows:

1. N.C. contacts 1-7 open, thus preventing engine starter re-engagement should battery charging alternator fail and allow relay K11 to drop out.
2. N.O. contacts 6-9 close to light a lamp on remote panel to indicate UV generator set is ON (on five light only).

K15, STOP RELAY (WF and WK sets only)

Actuated by closure of relay contacts K12-4-7. In the de-energized condition, relay contacts are as follows:

1. N.C. contacts 1-7 and 3-9 apply ground to magneto (magnetron) input to primary coil.

When energized, contacts perform the following switching action:

1. N.C. contacts 1-7 and 3-9 open to remove ground from magneto primary coils.
2. N.O. contacts 4-7 close to apply 24VDC to fuel solenoid K1.

CONTROLS TROUBLESHOOTING

TROUBLESHOOTING SOLID STATE CONTROLS

The purpose of the following troubleshooting guides is to help the technician restore an inoperative set to service and eliminate valuable down-time. Before proceding to a trouble call, make sure you have spare printed circuit boards and spare relays which will fit the set you are going to repair. A set of batteries (fully charged) can be jumpered across the set's batteries for starting and removed later if necessary.

The most important thing to remember is to put the set back on the line in the minimum amount of time.

PREPARATION FOR TROUBLESHOOTING

CONDITION: A. Starter will not crank. R-S-R- switch in Remote position, see Figure 31.

Possible fault location;
Fault in Remote station or circuit to station.
Starter relay not pulling in because—

a. Starter relay K13 faulty.
b. A12 printed circuit board faulty.
c. All printed circuit board faulty.
d. Relay K12 faulty.
e. Overspeed switch stuck closed.
f. Short to ground on overspeed switch wire.

Starter faulty.

1. Switch R-S-R- switch to Run. If starter cranks, problem is in Remote circuitry. Refer to troubleshooting guide condition B for this malfunction.
2. If starter does not crank with R-S-R- switch in Run, switch to Stop and check the following—
   a. Batteries for condition. Connections for security.
   b. Wiring to starter, and starter solenoid. Secure, clean, etc.
3. Open control cabinet.
   Check wiring to K13 starter solenoid; K12 Ignition relay; A11 Engine Monitor; A12 cranking control boards.
4. Toggle R-S-R- switch between Run and Stop positions. Action of K12 relay can be observed if it is operating, K13 can be felt. Both relays can be heard.

Relays K11 and K12 are interchangeable. If K12 does not operate remove it and plug K11 in its place. If the 'now' K12 relay operates then obviously the old one is defective. Install new relay.

5. If fault lamp lights as soon as R-S-R- switch is placed in Run, the fault is in the Overspeed circuit. Check the Overspeed switch to see if it has stuck closed or if there is some foreign matter shorting it out. Check the wire from TB-29 to the Overspeed; measure continuity to ground, change or repair wire if continuity is obtained.
6. Proceed to Troubleshooting guide.

LOW OIL PRESSURE SHUTDOWN

This type of malfunction is caused by one of the following—

1. Low oil quantity resulting in low oil pressure.
2. Engine oil system malfunction.
3. Ground between TB11-30 and LOP switch.
4. Permanently closed LOP switch.
5. Faulty engine monitor board.

If the generator set has LOP pre-alarm, then the most possible reason for shutdown is either low oil quantity or an engine oil system malfunction. If the latter, refer to the engine manufacturer's manual for oil system troubleshooting guide. A grounded wire or permanently closed switch are unlikely because the pre-alarm switch has to operate to arm the shutdown system. However, a double fault is possible and should never be discounted. When all other troubleshooting possibilities have been tried, the double fault should be considered.

This could be either—

1. Grounded wire between TB11-30 and LOP switch.
2. Grounded wire between TB11-34 and LOP pre-alarm switch.
3. Permanently closed LOP switch.
4. Permanently closed LOP pre-alarm switch.
5. Faulty engine monitor board.

Initial troubleshooting should start with checking oil quantity, then a check of the electrical system, followed by an examination of the engine oil system. This procedure is detailed in the following troubleshooting guide.

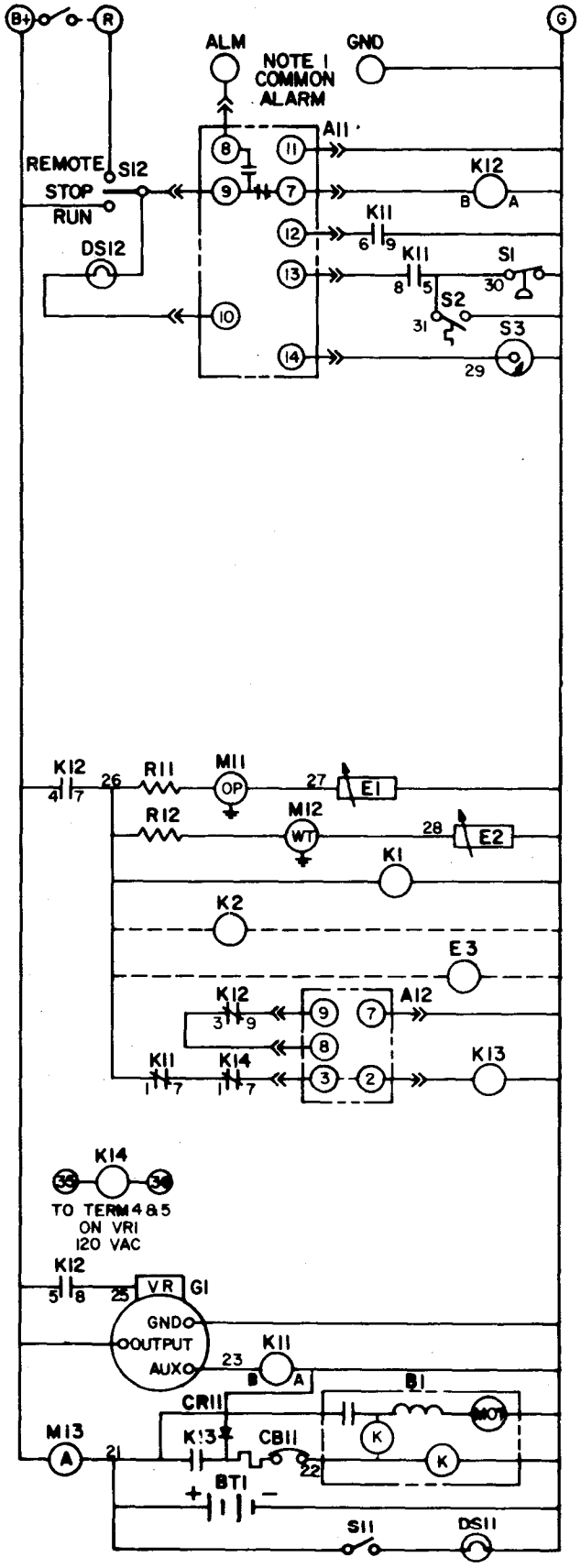

B+
R
G
ALM
NOTE 1
COMMON
ALARM
GND
A11
REMOTE
STOP
RUN
S12
DS12
K12
K11
S1
S2
S3
K11
K12
R11
M11
OP
E1
R12
M12
WT
E2
K1
K2
E3
A12
K11
K14
K13
K14
TO TERM 4 & 5
ON VR1
120 VAC
K12
VR
G1
GND
OUTPUT
AUX
K11
B1
CR11
M13
K13
CB11
BT1
S11
DS11

FIGURE 31.

QUESTION AND ANSWER TROUBLESHOOTING GUIDE

To correct a problem, answer the question "Yes" or "No", then proceed to the next step given in whichever column the question was answered.

CONDITION: A. ENGINE FAILS TO CRANK R-S-R- SWITCH IN RUN POSITION				
Item		**Yes**	**No**	**R-S-R-**
1	Does fault lamp light?	2	7	Run
2	Position R-S-R- switch to Stop/Reset, then back to Run. Does fault lamp light? Does engine crank?	 3 —	 — 7	Run
3	Open control cabinet. Disconnect wire at TB11-29. Position R-S-R- switch to Stop/Reset, then back to Run. Does fault lamp light? Does engine crank?	 4 —	 5 —	Run
4	Replace engine monitor board.	—	—	Stop
5	Measure resistance between Overspeed switch wire at TB11-29 and ground. Should be infinity. Is reading correct?	 6	 —	Stop
6	Repair or replace wire as necessary.	—	—	Stop
7	Hold starter solenoid K13 and observe K12 ignition relay. Toggle R-S-R- switch between Stop and Run several times. Does K12 relay operate? Does K13 starter solenoid operate?	 — 14	 8 10	Stop
8	Unplug K12 Relay. Measure voltage at K12 receptacle, pin B. Is 24VDC obtained?	 9	 13	Run
9	Check that wire from K12 receptacle, pin A to ground is connected. If ground circuit is satisfactory, replace K12 Relay.	—	—	
10	Apply jumper from TB11-26 to input side of K13 Starter solenoid coil. Does relay operate?	 12	 11	
11	Check wire and connections between output side of K13 coil and ground. Repair, replace secure as necessary. If wire is good, replace K13 starter solenoid.	 —	 —	
12	Replace A12 Cranker board.	—	—	
13	Check that wire and connection between A11-7 and K12-B is good. If so, replace A11 Engine monitor board.	—	—	

Item	A. ENGINE FAILS TO CRANK (Continued)	Yes	No
14	Measure voltage at starter motor connections, with K13 Relay energized. Does voltmeter read 24VDC at coil? Does voltmeter read 24VDC at motor lead?	 15 15	 17 16
15	Replace starter.	—	—
16	Secure starter to battery connection. Recheck. If starter still does not crank, replace it.		
17	Measure voltage at both sides of contact terminals of K13 starter solenoid (solenoid energized). Does voltmeter read 24VDC?	 18	 19
18	Check wiring and connections between K13 and starter. Repair, replace, secure as necessary.	—	—
19	If checks made in item 18 are satisfactory, replace K13 solenoid.	—	—

CONDITION: B. ENGINE FAILS TO CRANK R-S-R- SWITCH IN REMOTE POSITION			
Item		**Yes**	**No**
1	Position R-S-R- switch to Run. Does engine crank?	 2	See Guide A Item 1
2	Return R-S-R- switch to Remote. Apply jumper across TB12-Remote and TB12-B+. Does engine crank? Remove jumper.	 3	 5
3	At remote station, apply jumper across Start terminals on start switch (refer to applicable wiring diagrams). Does engine crank?	 4	 7
4	Replace remote station Start switch.	—	—
5	Measure continuity between Remote terminal of R-S-R- switch and TB12-RMT. Is continuity obtained?	 —	 6
6	Check wire between R-S-R- switch and TB12-RMT. Repair, replace, secure as necessary. Was repair required?	 —	 8
7	Refer to applicable wiring diagrams.	—	—
8	Measure continuity between TB12-RMT, TB12-B+ and Remote Station. Repair, replace or secure open circuit wires where necessary.	—	—

CONDITION: C. ENGINE MALFUNCTION SHUTDOWN

Item		Yes	No	R-S-R-
1	Did engine shut down immediately after start (i.e., within 3-seconds)?	6	2	
2	Did engine shut down 10- to 20- seconds after start?	10	3	
3	Did engine crank for 75-seconds then shut down without starting?	17	4	
4	Did engine shut down after running, crank for 75-seconds then stop without further cranking action? Fault light ON after cranking cycle complete?	18	5	
5	If none of the above are applicable, refer to High Water Temperature shut down.	19	—	
6	Check throttle and governor linkage for freedom of movement. If set has switch-operated governor control (Woodward) or rheostat control (Barber-Colman), make sure that control is not at "High RPM" position. After completing above checks has malfunction been located?	—	7	
7	Check position of Overspeed switch. Is adjustment required?	—	8	
8	Disconnect wire at TB11-29. Measure continuity to ground. Is continuity obtained?	9	—	
9	Check wire from TB11-29 to Overspeed switch for bad condition. Repair, replace as necessary.	—	—	
10	Low Oil Pressure Shutdown. Check crankcase oil quantity. Is oil at "Full" mark on dipstick?	11	—	
11	Disconnect wire at TB11-30 and from oil pressure switch. Measure resistance to ground. Should be infinity. Is correct reading obtained?	12	13	
12	Locate ground in wire. Repair or replace as necessary.	—	—	
13	Connect ohmmeter from oil pressure switch to ground. Start engine. Observe oil pressure gauge and Ohmmeter. a. Did oil pressure build up to normal? b. Did oil pressure switch open? c. Did engine shut down?	— 16	15 —	
14	Refer to engine manufacturer's manual for oil system troubleshooting guide.	—	—	

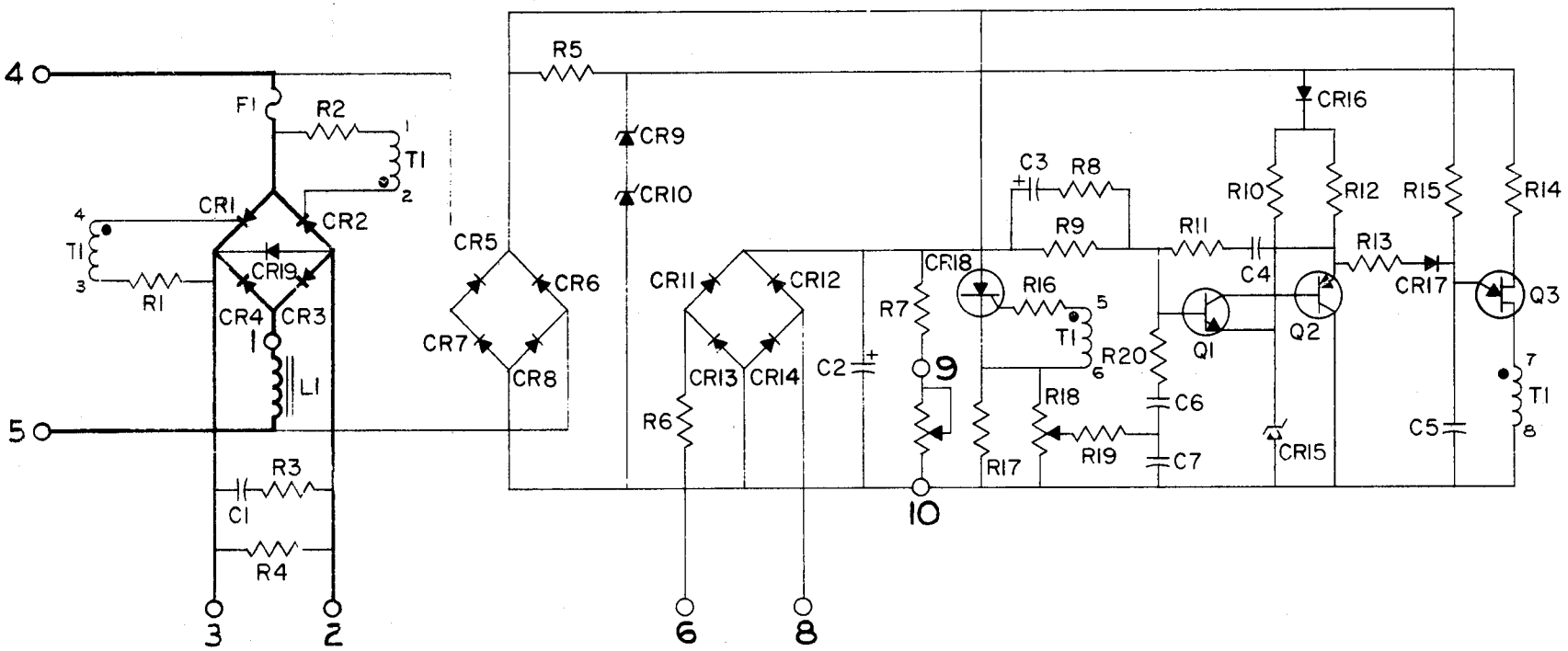
Item	C. ENGINE MALFUNCTION SHUTDOWN (Continued)	Yes	No
15	Replace oil pressure switch.	—	—
16	Replace A11 engine monitor board.	—	—
17	Overcrank Shutdown. Refer to engine manufacturer's manual for non-starting troubleshooting techniques.	18	—
18	Check fuel system. Verify adequate fuel supply and flow to injector pump or carburetor. WF and WK only. Check ignition.	—	—
19	High Water Temperature Shutdown. Check coolant quantity. Does coolant need replenishing?	—	20
20	City Water cooled sets. Are solenoid valves open?	21	—
21	Is flow valve open?	22	—
22	Radiator cooled sets. Are fan belts tight?	23	—
23	Is radiator air flow unrestricted?	24	—
24	Disconnect High Water Temperature switch. Measure resistance from terminal to ground. Should be infinity. Is correct reading obtained?	25	26
25	Replace High Water Temperature switch.	—	—
26	Disconnect wire at TB11-31. Measure resistance of wire to ground. Should be infinity. Is correct reading obtained?	27	28
27	Repair or replace wire from TB11-31 to High Water Temperature switch.	—	—
28	Restart engine. Check voltmeter and ammeter readings. Is unit overloaded?	29	—
29	Remove non-essential loads.	—	—

Five Fault Lamp System.

CONDITION: D. ENGINE MALFUNCTION SHUTDOWN OVERCRANK LIGHT ON				
Item		**Yes**	**No**	**R-S-R-**
1	Did engine fail to start?	7	2	
2	Did engine shut down after running?	3	—	
3	Check fuel supply; quantity and quality. Is day tank supply adequate? Is main tank supply adequate?	 — 7	 4 —	
4	Is float operated pump system functioning correctly?	5	—	
5	Check lines from tank to injector. Are lines blocked?	 —	 7	
6	WF and WK sets only. Check ignition system. Has K15 relay opened? Is magneto system functioning?	 8 —	 9 7	
7	Refer to engine manufacturer's manual for engine non-start troubleshooting guide.	—	—	
8	Check K1 fuel solenoid valve. Does K1 operate?	 —	 9	
9	Check wiring (refer to appropriate schematic) to K15 relay, and K1 solenoid valve. Repair, replace, secure where necessary.	—	10	
10	Replace non-functioning item, i.e., stop relay K15 or fuel solenoid valve K1.	—	—	

CONDITION: E. ENGINE MALFUNCTION SHUTDOWN LOW OIL PRESSURE LIGHT ON			
Item		**Yes**	**No**
1	Does control have pre-alarm?	3	2
2	Did unit shut down within 16-seconds of start?	4	3
3	Check oil quantity. Does oil need replenishing?	—	4
4	Disconnect wire at TB11-30. Restart engine. Does engine run satisfactorily? Is oil pressure at normal value?	5 5	6 6
5	With engine still running, measure continuity between LOP switch and ground. Is continuity obtained? **WARNING: When the set is running, high voltages present within the control cabinet, could cause injury or death. Use extreme caution.**	7	10
6	Refer to engine manufacturer's manual for oil system troubleshooting guide.	—	—
7	Shut down engine. Disconnect wire from LOP switch. Measure resistance from disconnected wire to ground (should be infinity). Is correct resistance obtained?	9	8
8	Replace LOP switch.	—	—
9	Repair or replace wire.	—	—
10	Replace A11 Engine Monitor board.	—	—

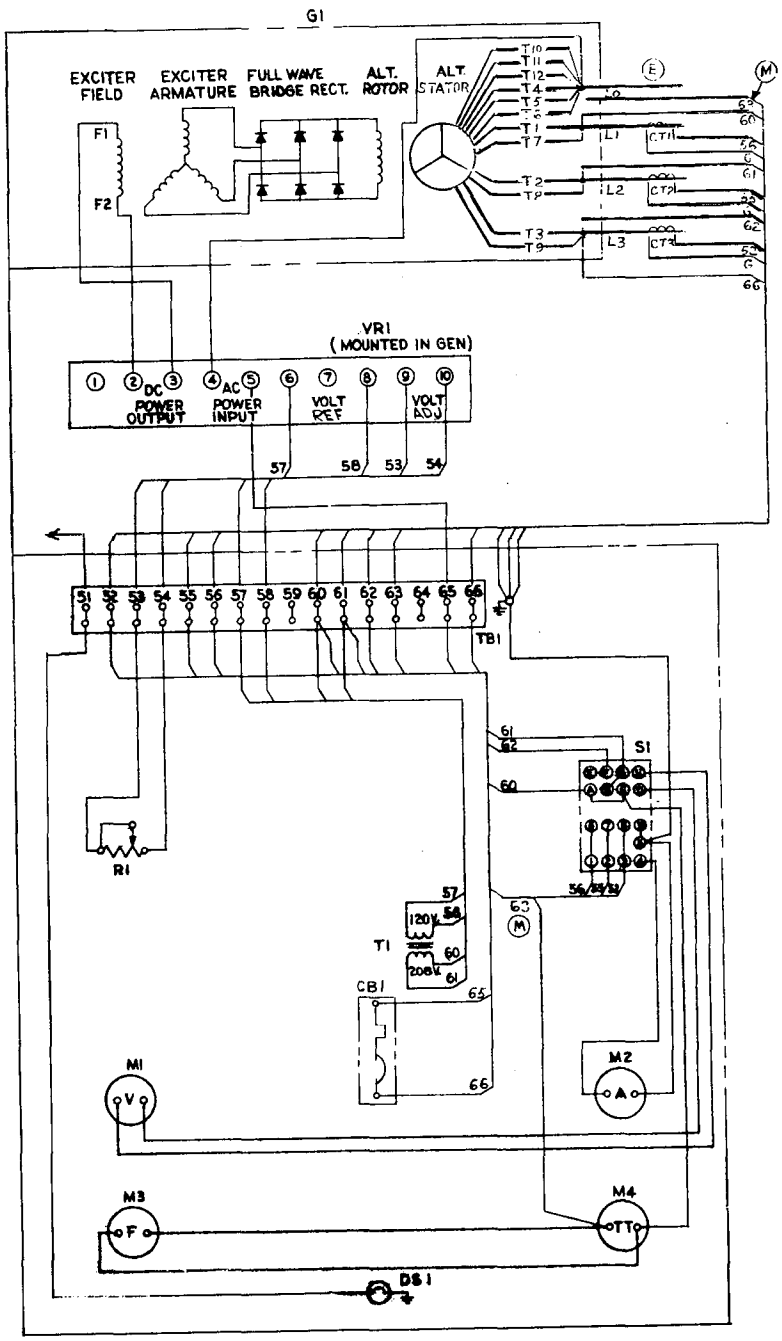
WIRING DIAGRAM INDEX



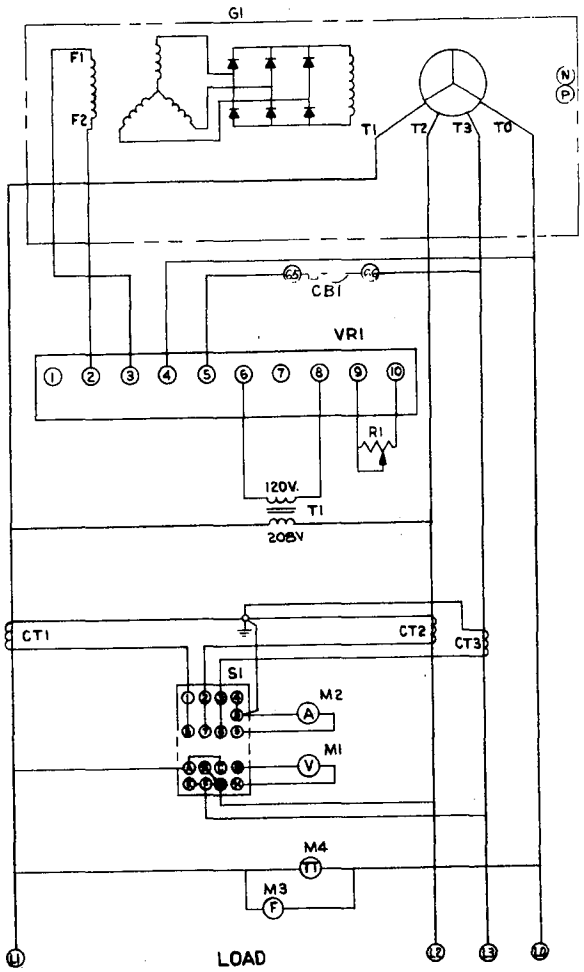
VOLTAGE REGULATOR VR1
300-500 kW

305-0455

WIRING DIAGRAM



SCHEMATIC DIAGRAM

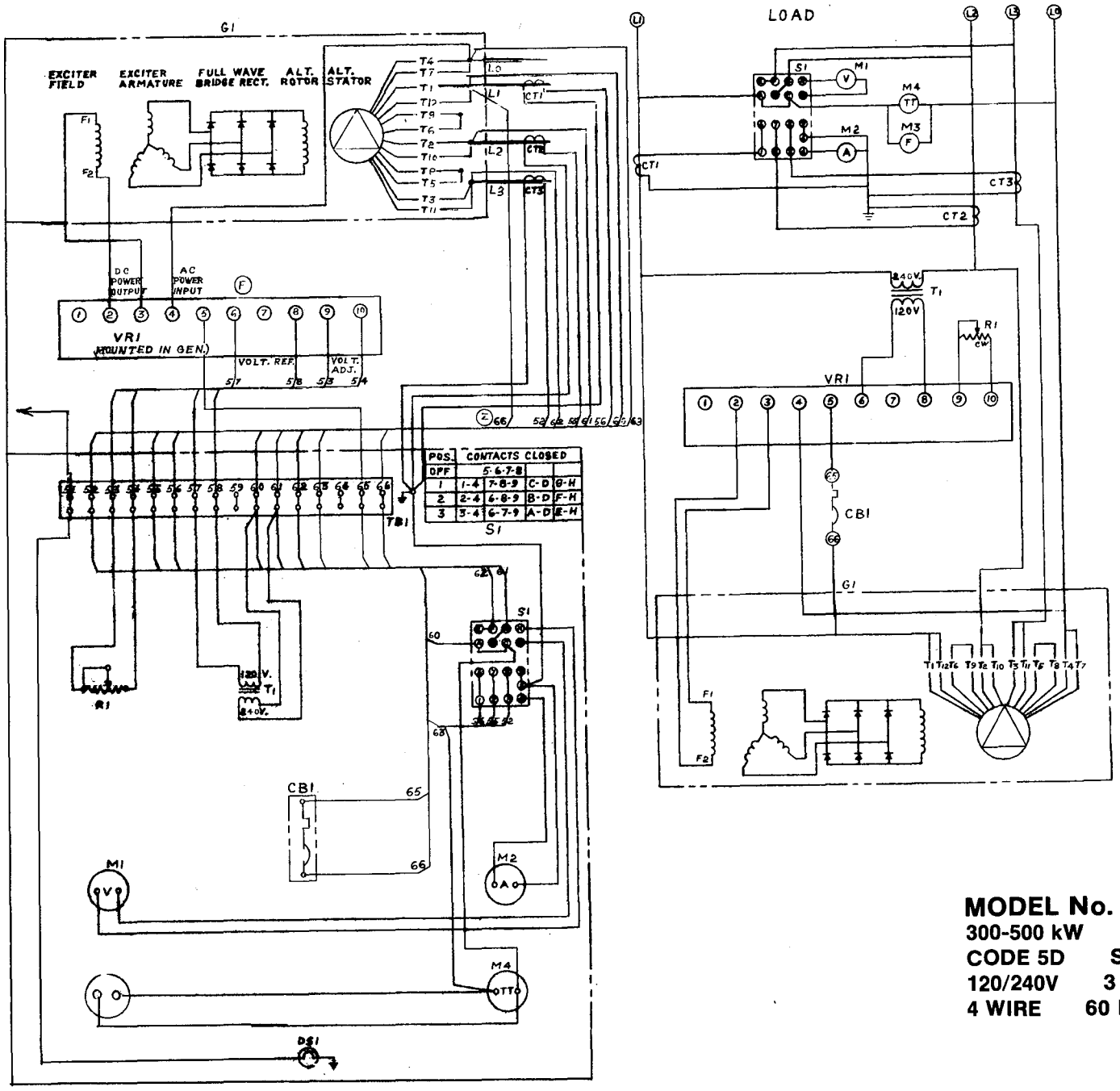


MODEL No.
300-500 kW
CODE 4 SPEC 1A
120/208V 3 PH
4 WIRE 60 Hz

612-3187

WIRING DIAGRAM

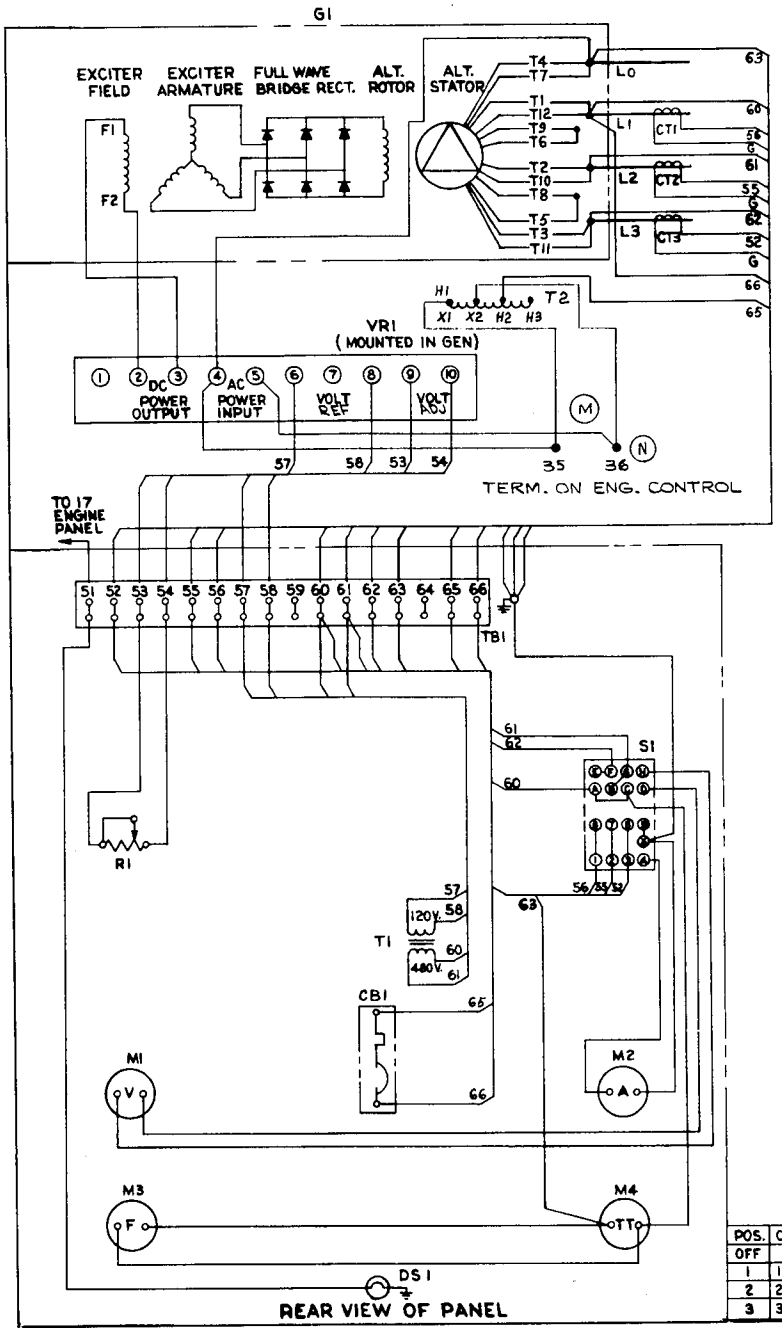
SCHEMATIC DIAGRAM



MODEL No.
300-500 kW
CODE 5D SPEC 1A
120/240V 3 PH
4 WIRE 60 Hz

612-3269

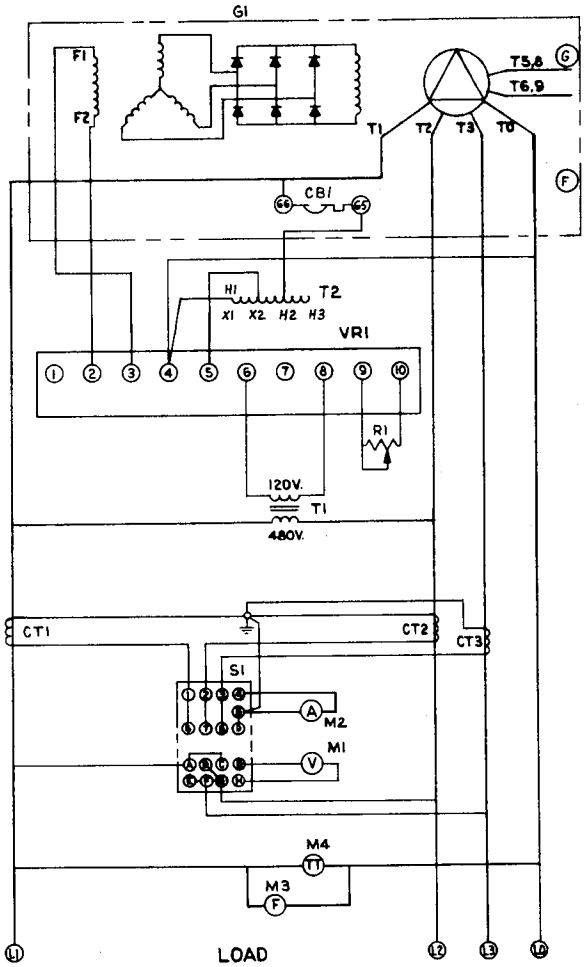
WIRING DIAGRAM



S1

POS.	CONTACTS CLOSED			
OFF	5,6,7,8			
1	1-4	7-8-9	C-D	G-H
2	2-4	6-8-9	B-D	F-H
3	3-4	6-7-9	A-D	E-H

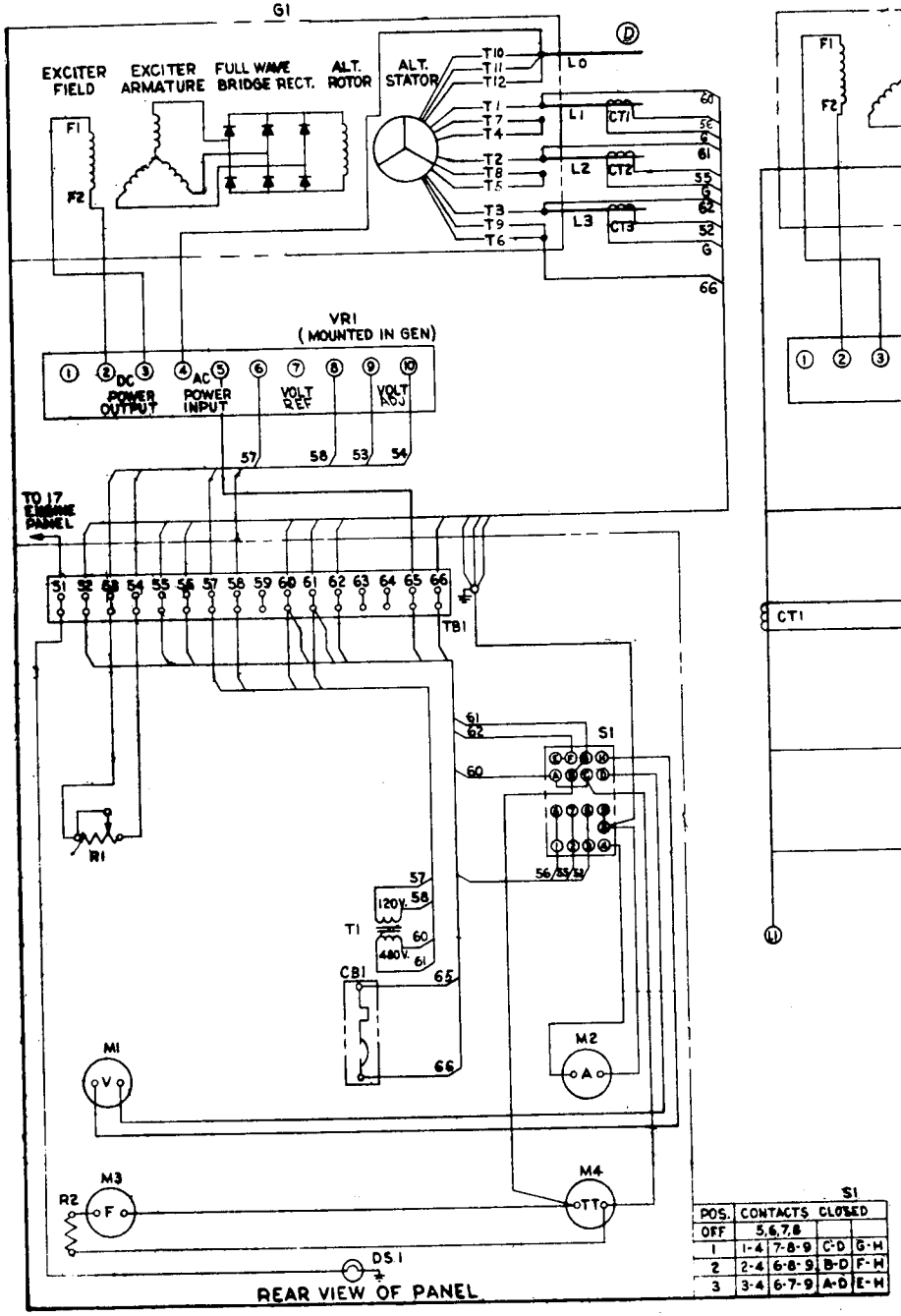
SCHEMATIC DIAGRAM



MODEL No.
300-500 kW
CODE 6D SPEC 1A
240/480V 3 PH
4 WIRE 60 Hz

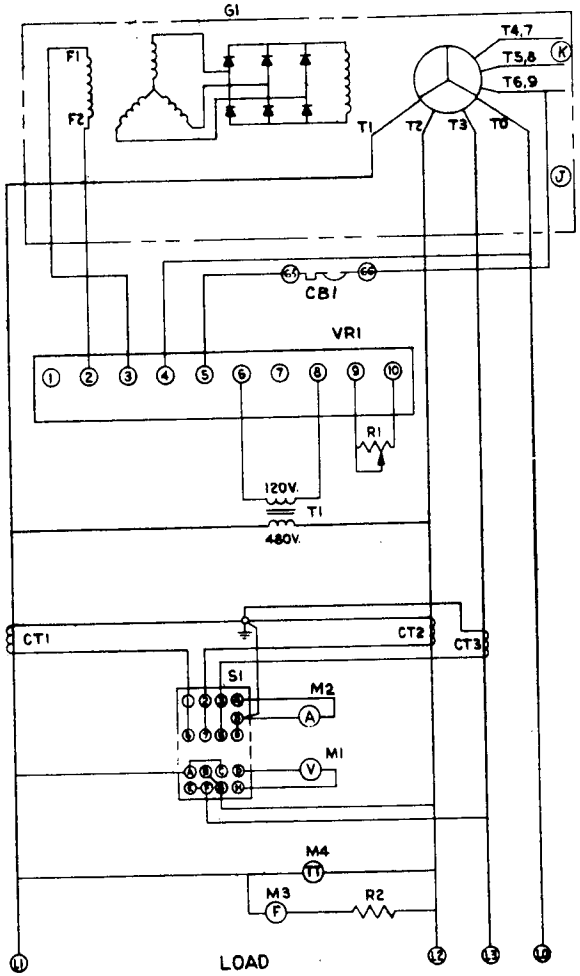
612-4290

WIRING DIAGRAM



S1				
POS.	CONTACTS CLOSED			
OFF	5,6,7,8			
1	1-4	7-8-9	C-D	G-H
2	2-4	6-8-9	B-D	F-H
3	3-4	6-7-9	A-D	E-H

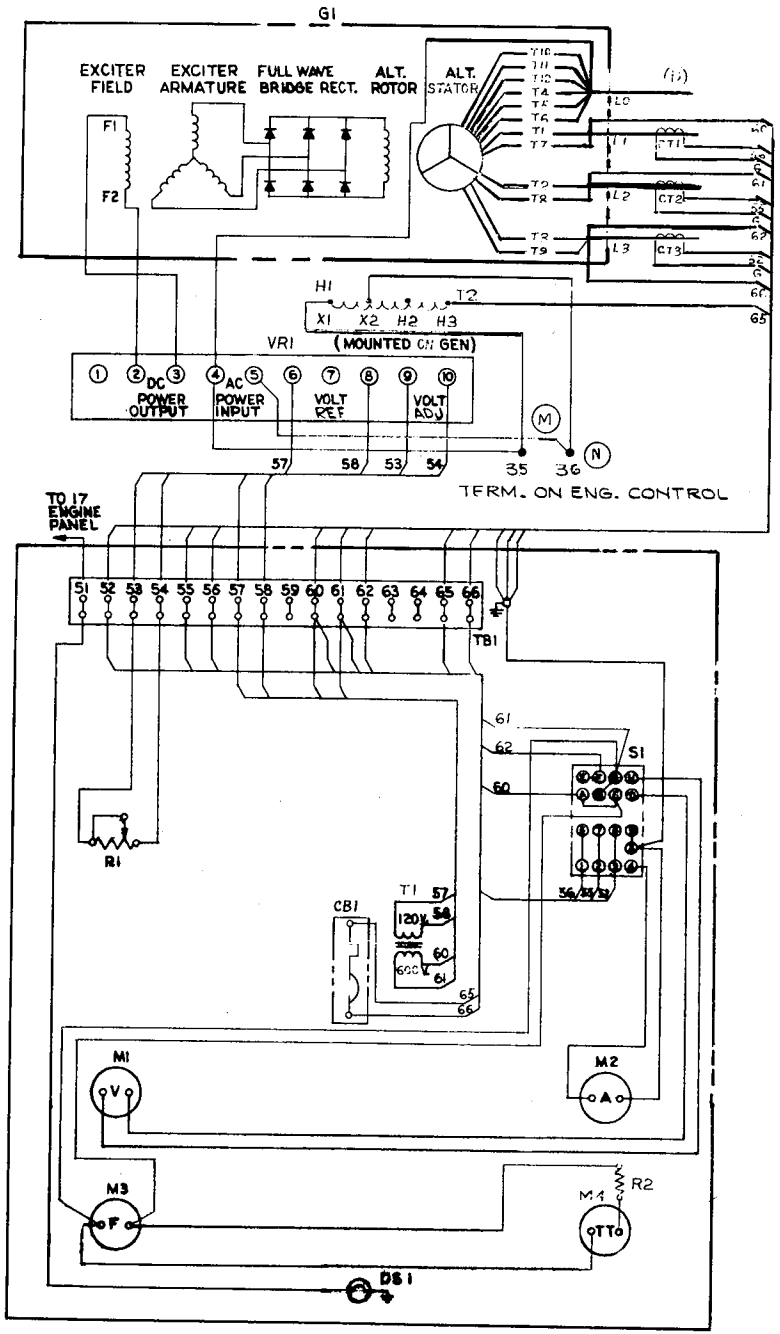
SCHEMATIC DIAGRAM



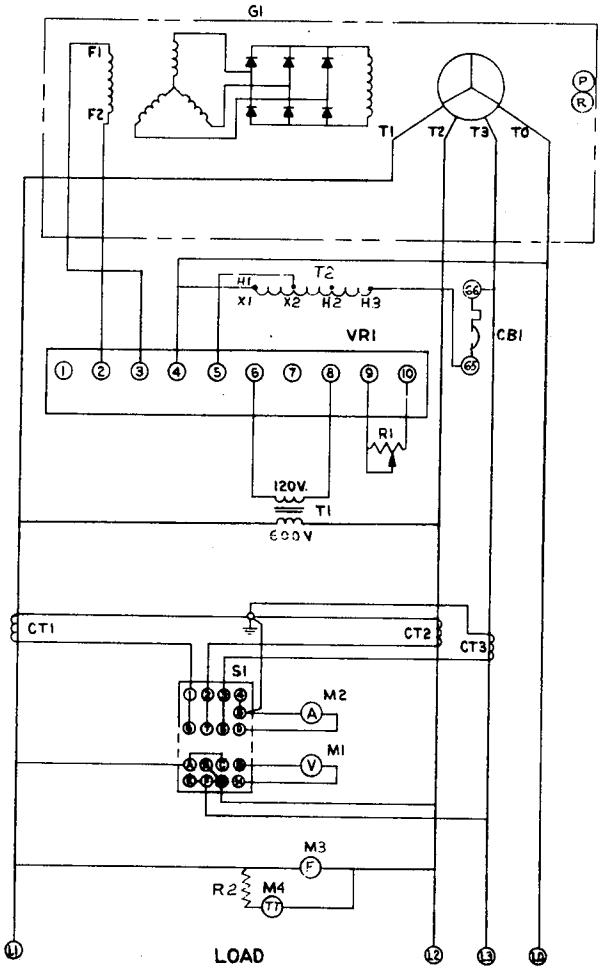
MODELNo.
300-500 kW
CODE 4X SPEC 1A
277/480V 3 PH
4 WIRE 60 Hz

612-3188

WIRING DIAGRAM

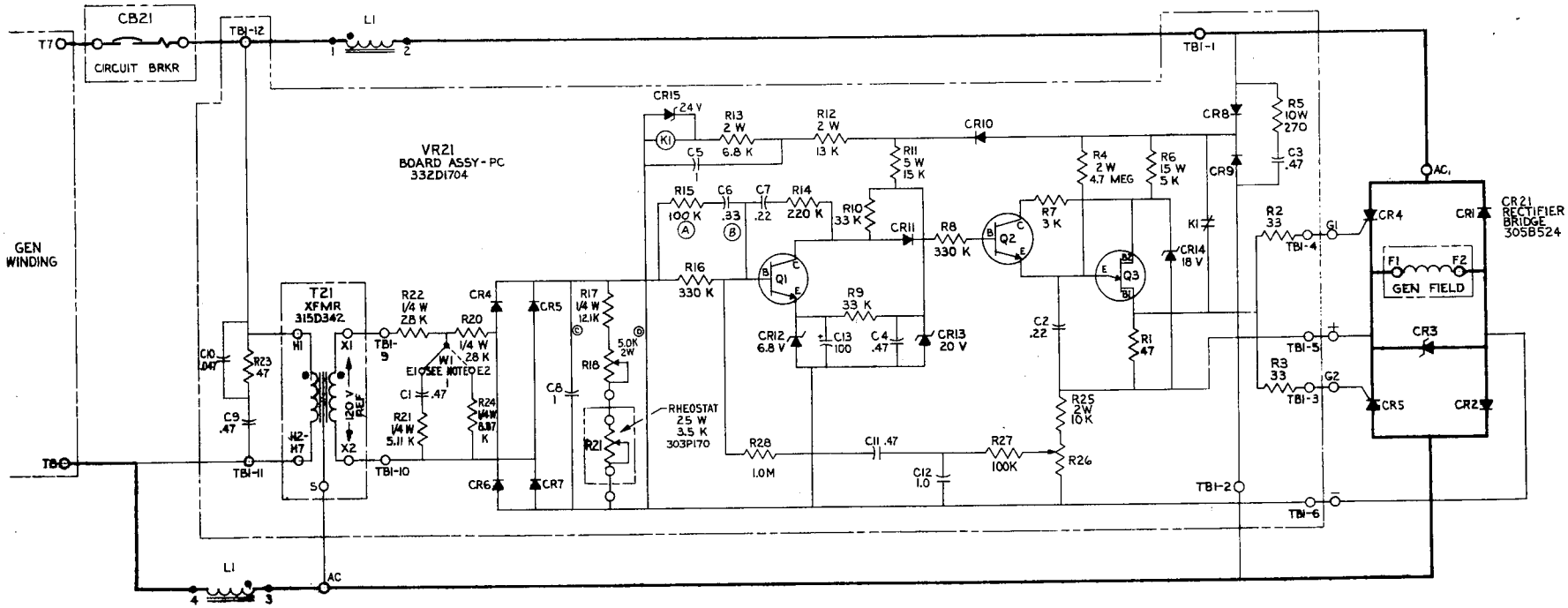


SCHEMATIC DIAGRAM



MODEL No.
300-500 kW
CODE 9X SPEC 1A
347/600V 3 PH
4 WIRE 60 Hz

612-3973



NOTES:

1. NORMAL CONNECTION IS W1 TO E1 FOR VOLTAGE REFERENCE CIRCUIT SENSITIVE TO FREQUENCY. WHEN W1 IS CONNECTED TO E2 VOLTAGE REFERENCE CIRCUIT IS NOT SENSITIVE TO FREQUENCY
2. ALL PART NUMBERS AND VALUES ARE REFERENCE ONLY
3. ALL RESISTORS 1/2 WATT EXCEPT WHERE NOTED
4. ALL CAPACITOR RATING IN MICROFARADS
5. FOR TYPE AND RATING OF SEMI CONDUCTORS SEE INDIVIDUAL ASSEMBLY MATERIAL LISTS.

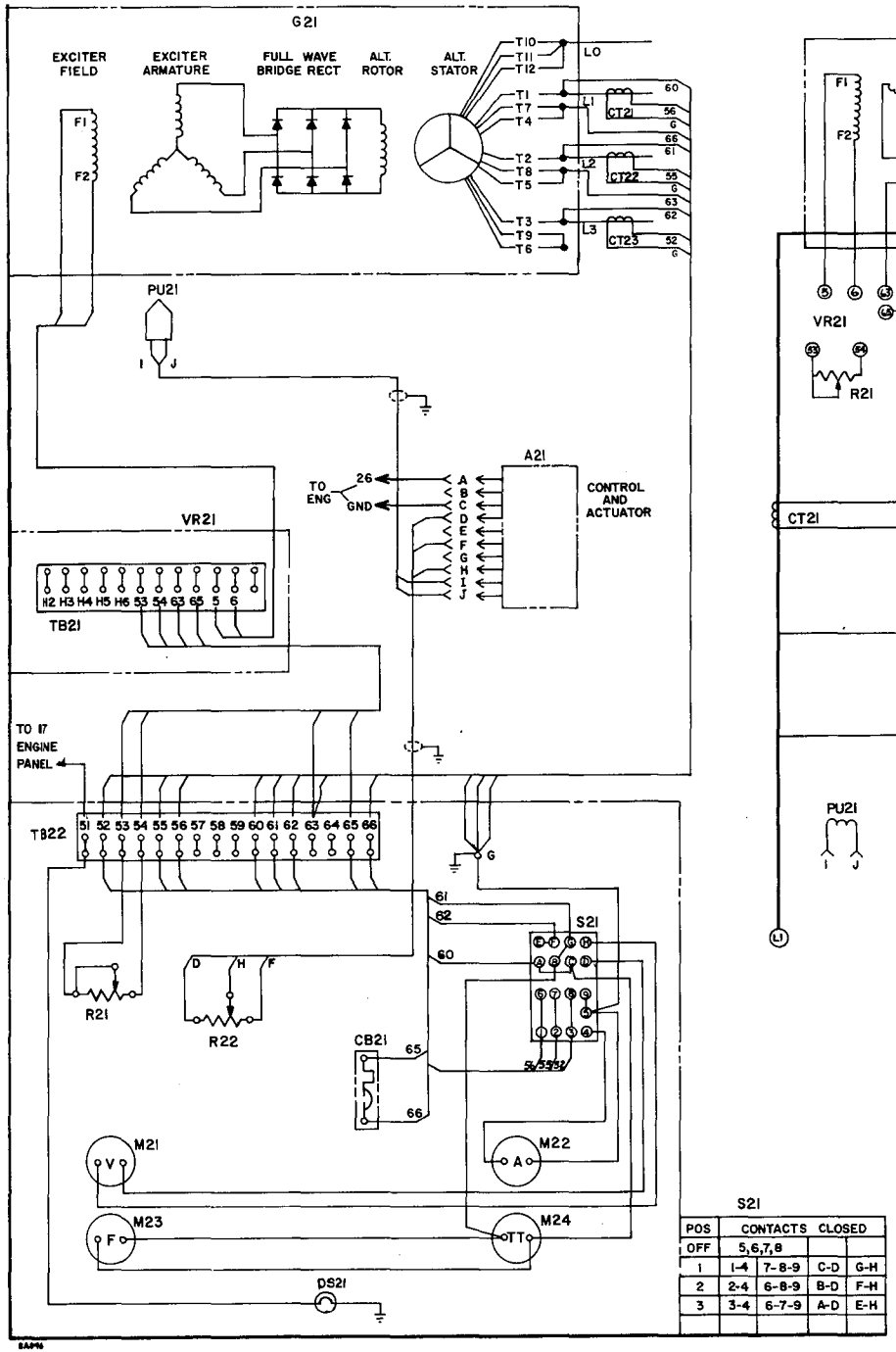
Ⓔ

VOLTAGE REGULATOR VR 21

600 kW

625-1344

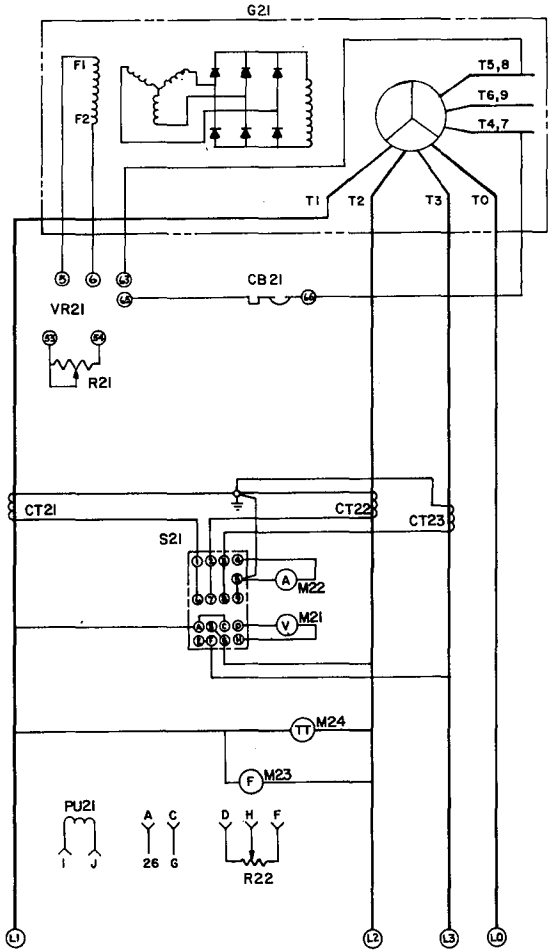
WIRING DIAGRAM



S21

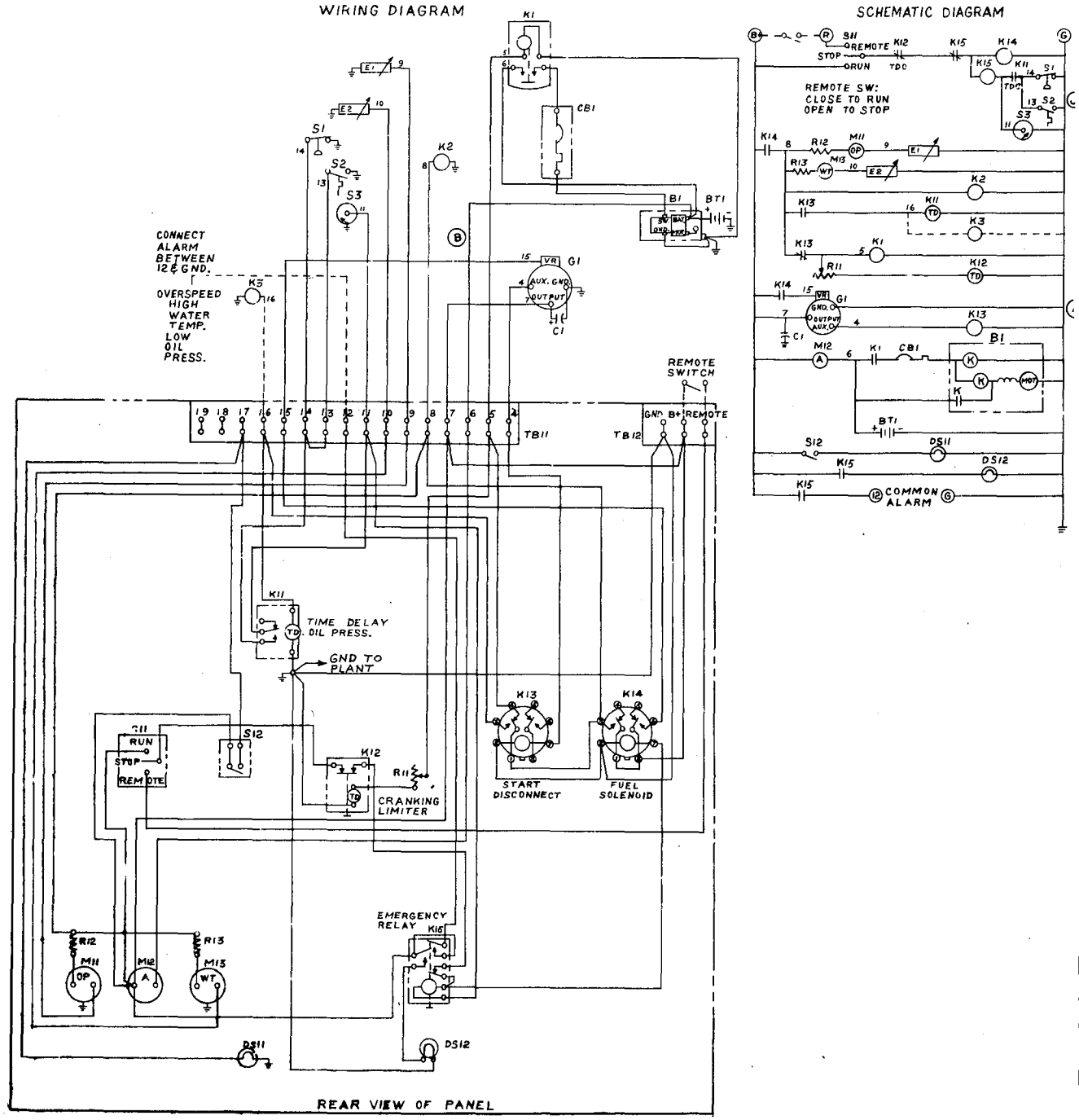
POS	CONTACTS CLOSED			
OFF	5,6,7,8			
1	1-4	7-8-9	C-D	G-H
2	2-4	6-8-9	B-D	F-H
3	3-4	6-7-9	A-D	E-H

SCHEMATIC DIAGRAM



MODEL No.
600 kW
CODE 4X SPEC 1A
277/480 3 PH
4 WIRE 60 Hz

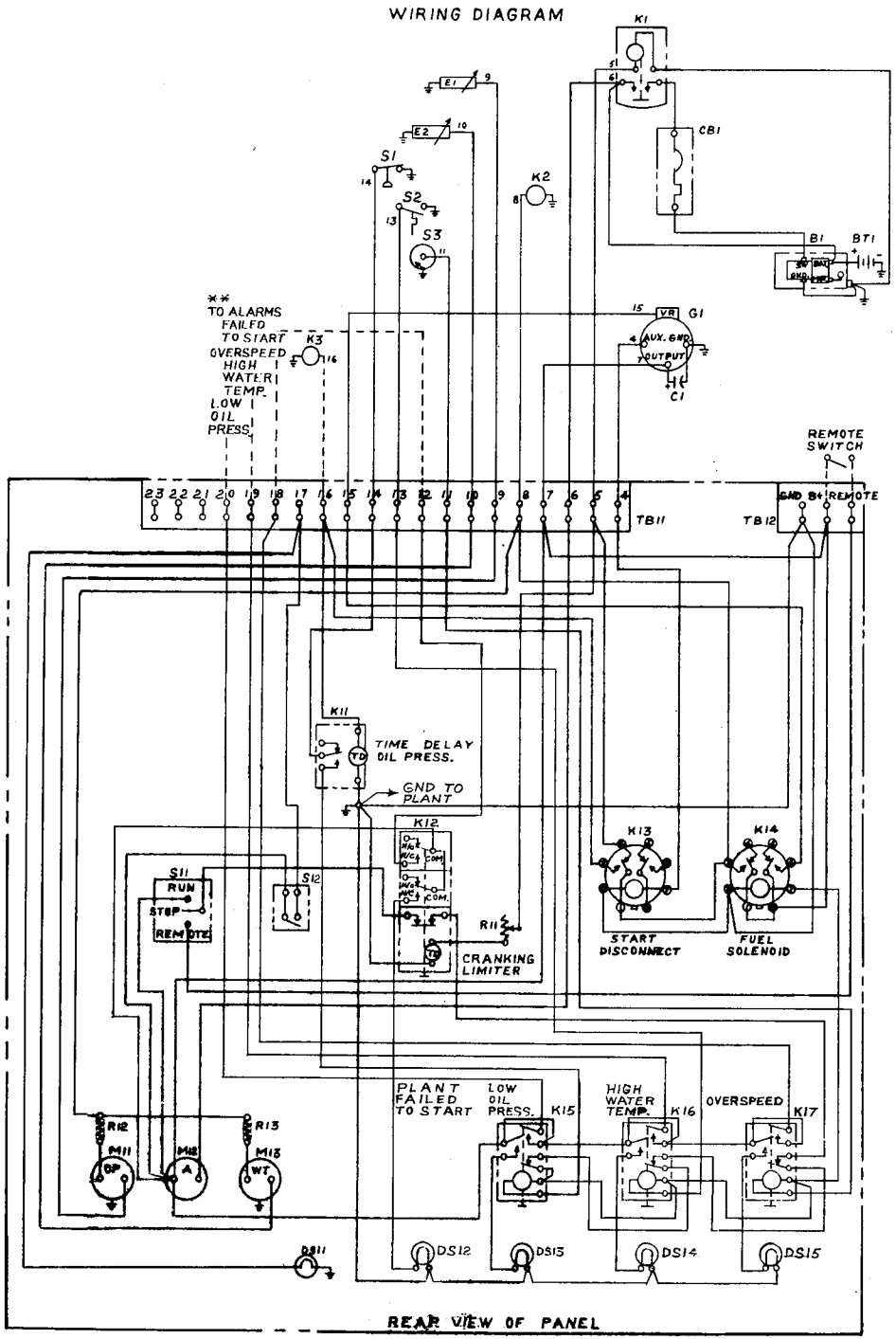
612-5028

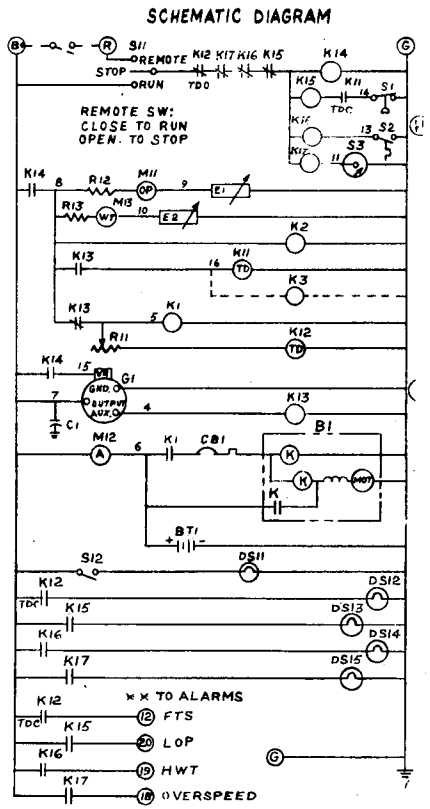


MODEL No.

DFT/1A	1 LIGHT
DFU/1A	1 LIGHT
DFV/1A	1 LIGHT
DFW/1A	1 LIGHT

612-3184

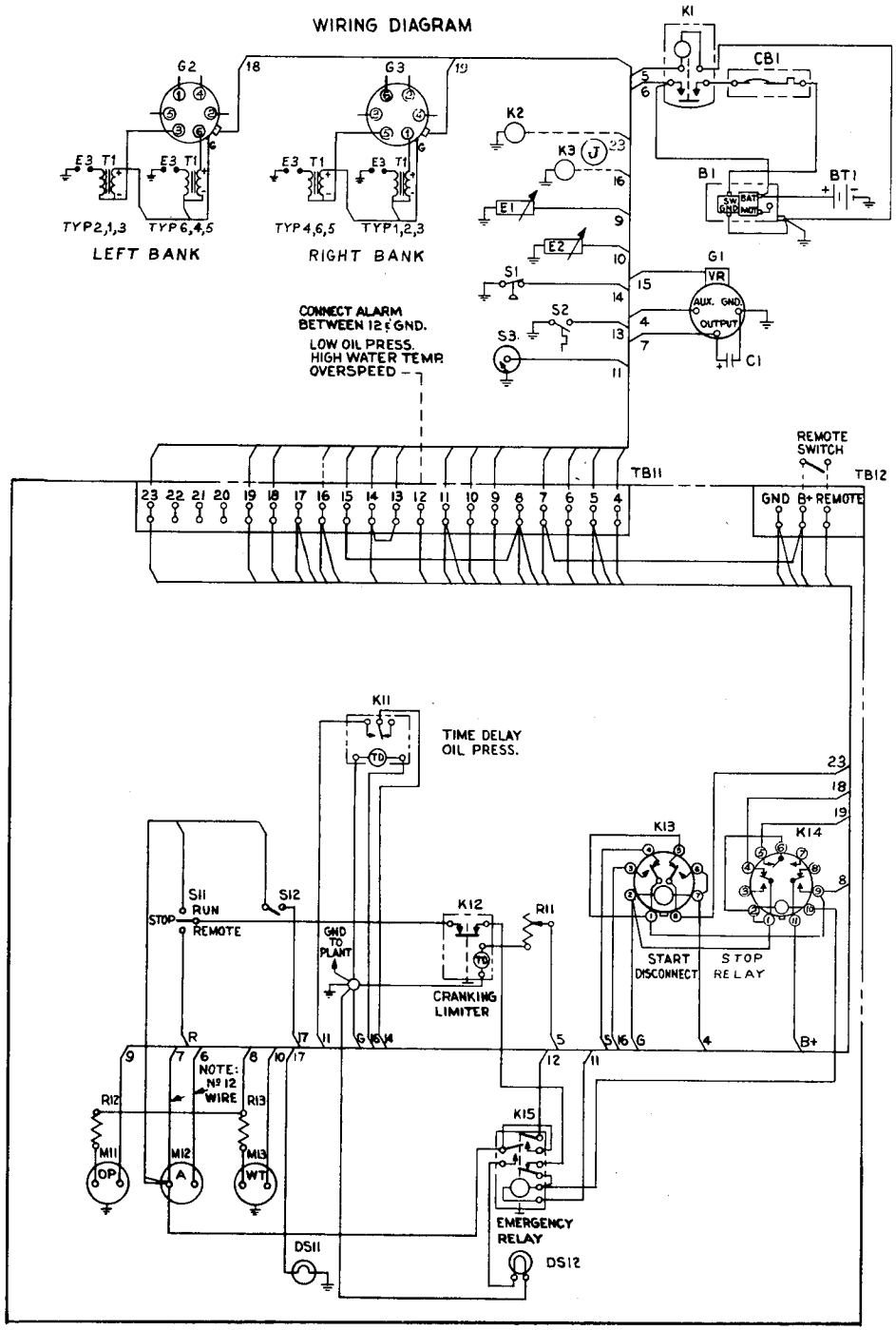


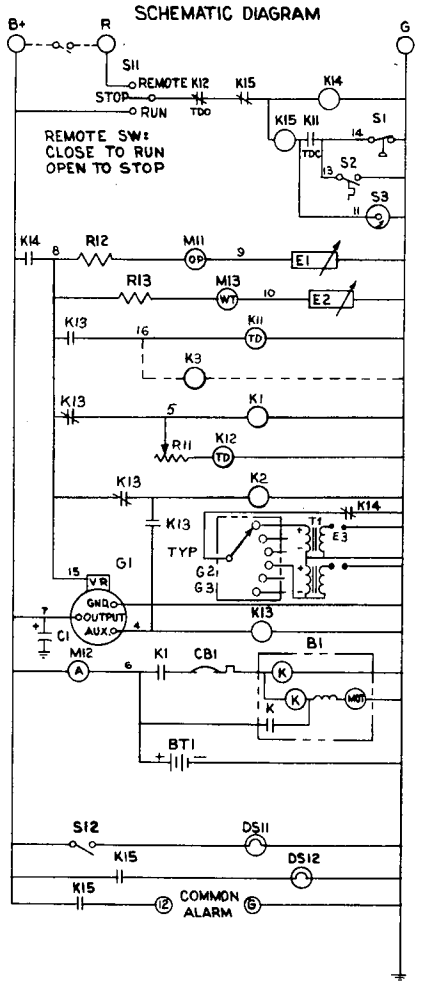


** CONNECT 24VDC INDIVIDUAL ALARMS BETWEEN DESIGNATED TERMINAL & GND. CONNECT 24VDC COMMON ALARM BETWEEN TERMINAL 12 & GND. WITH TERMINALS 12, 18, 19 & 20 JUMPERED TOGETHER.

MODEL No.	
DFT/2697A	5 LIGHT
DFU/2697A	5 LIGHT
DFV/2697A	5 LIGHT
DFW/2697A	5 LIGHT

612-3185

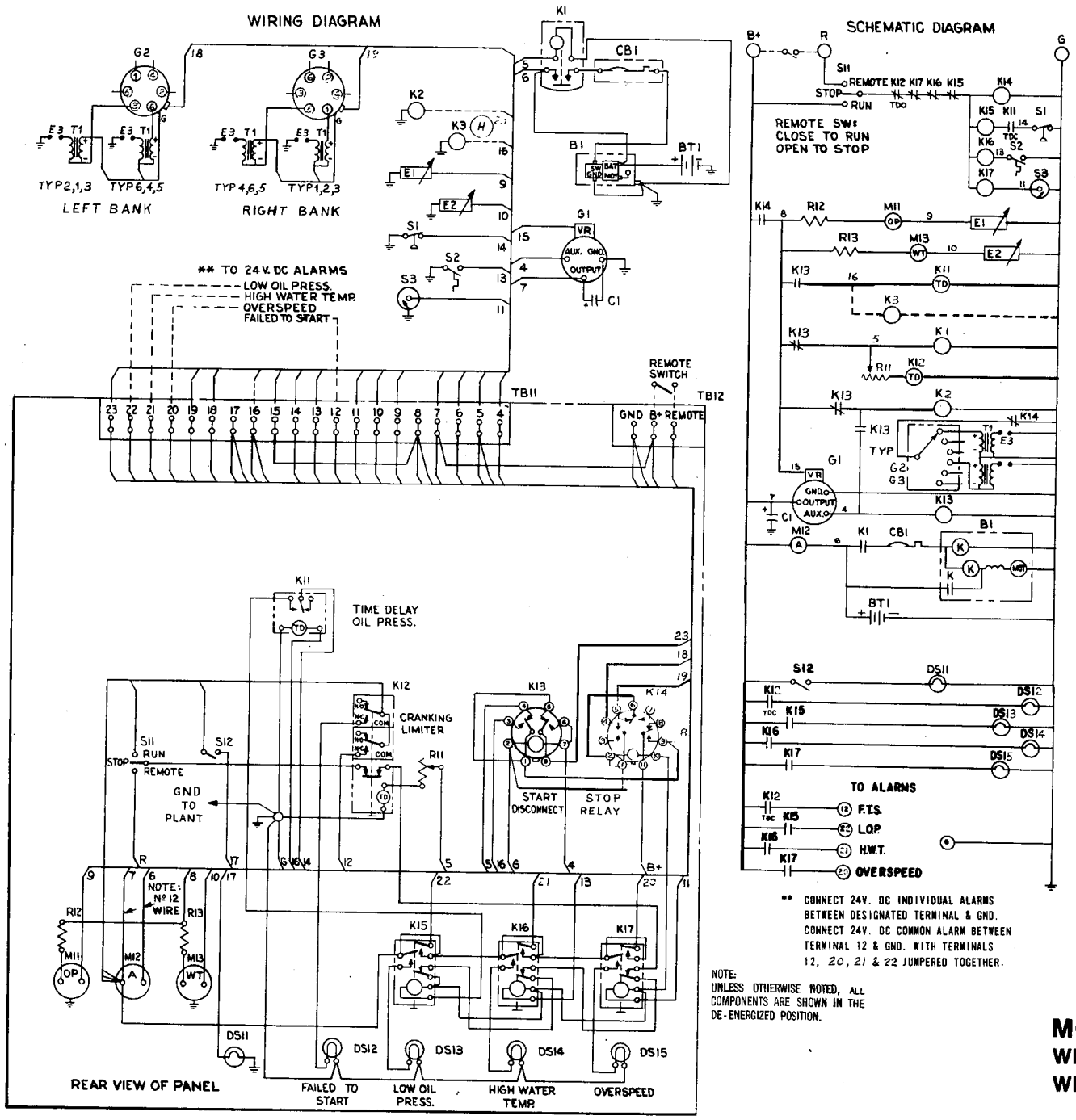




MODEL No.

WF/1A	1 LIGHT
WK/1A	1 LIGHT

612-3720



** CONNECT 24V. DC INDIVIDUAL ALARMS BETWEEN DESIGNATED TERMINAL & GND. CONNECT 24V. DC COMMON ALARM BETWEEN TERMINAL 12 & GND. WITH TERMINALS 12, 20, 21 & 22 JUMPERED TOGETHER.

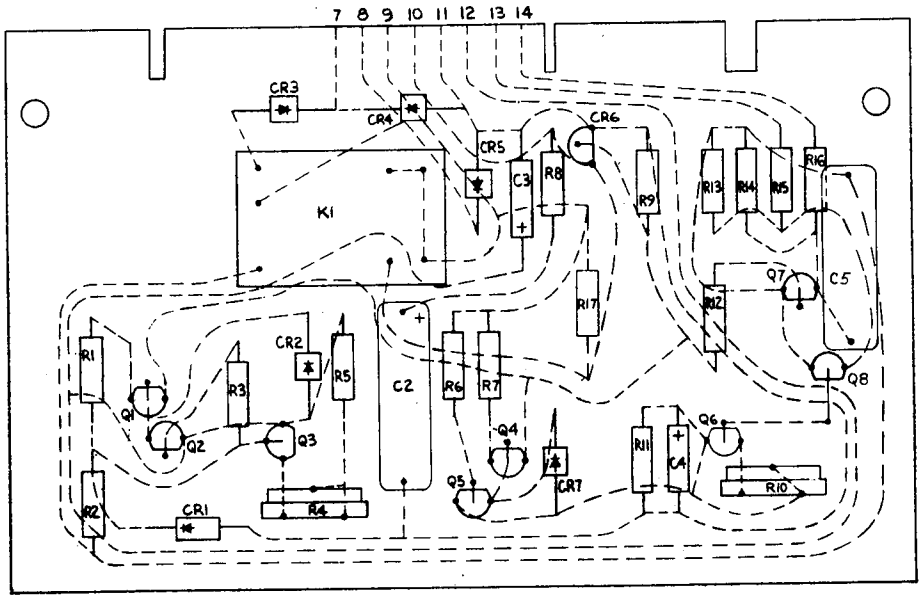
NOTE:
UNLESS OTHERWISE NOTED, ALL COMPONENTS ARE SHOWN IN THE DE-ENERGIZED POSITION.

MODEL No.

WF/2697A 5 LIGHT

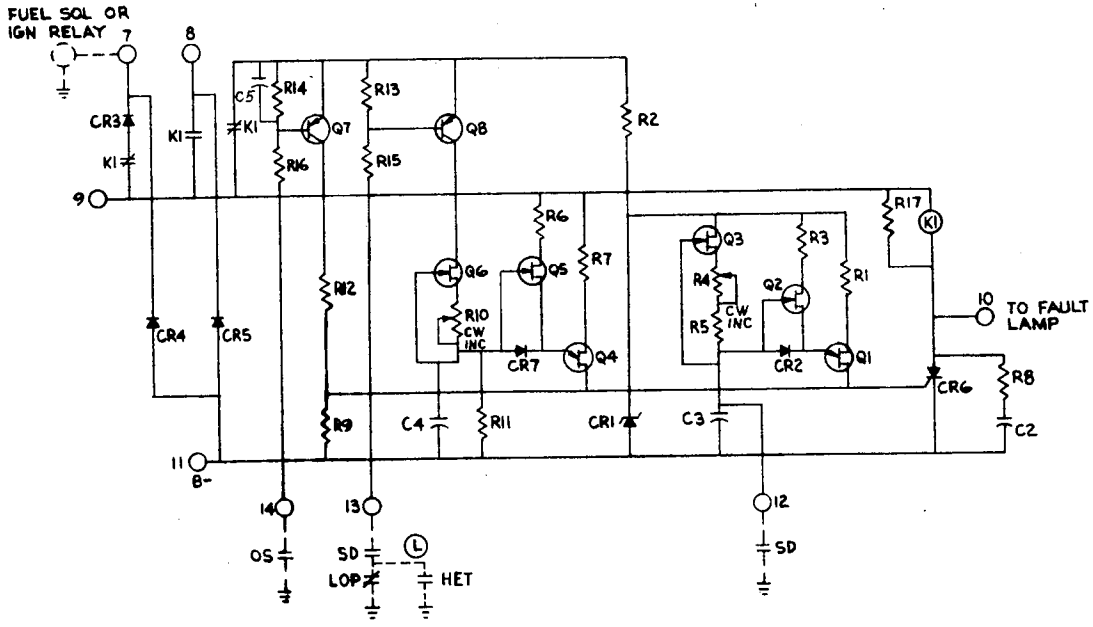
WK/2697A 5 LIGHT

612-3721



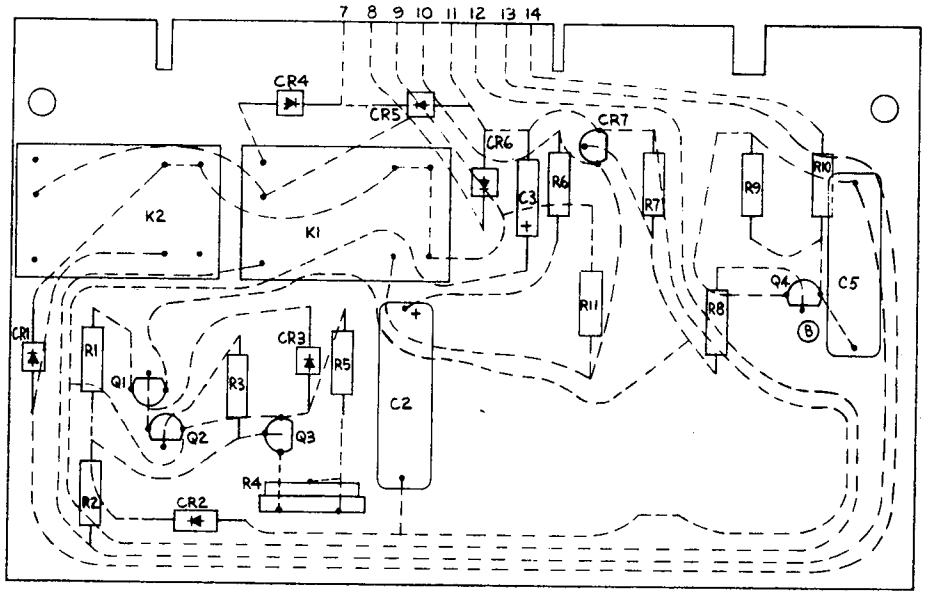
SET R4 FOR AN OVERCRANK TIME DELAY OF 75±5 SECONDS

LOW OIL PRESS TIME DELAY SHOULD BE 12.5±2.5 SECONDS

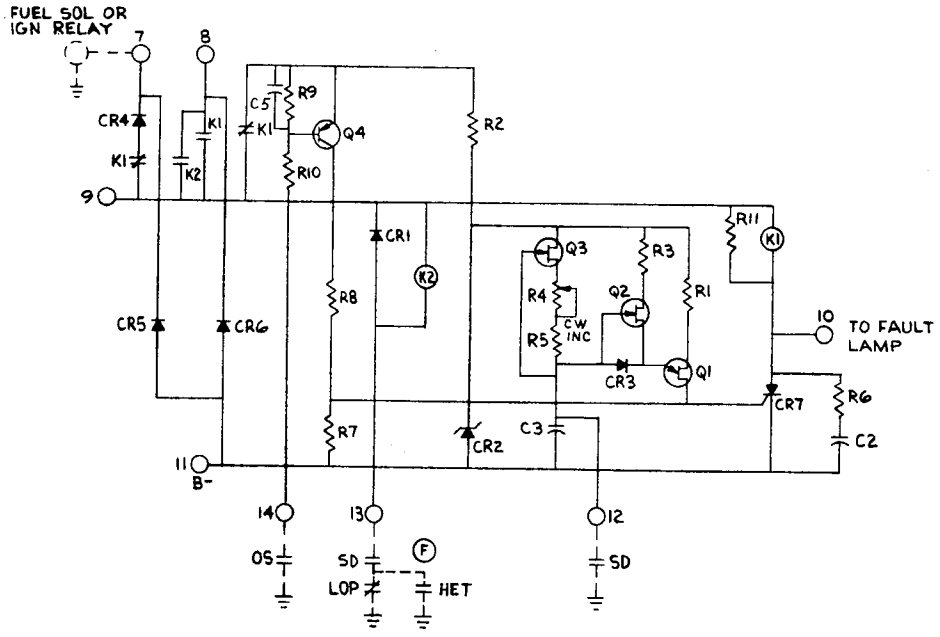


MONITOR, ENGINE CONTROL
1 LIGHT

300-0680

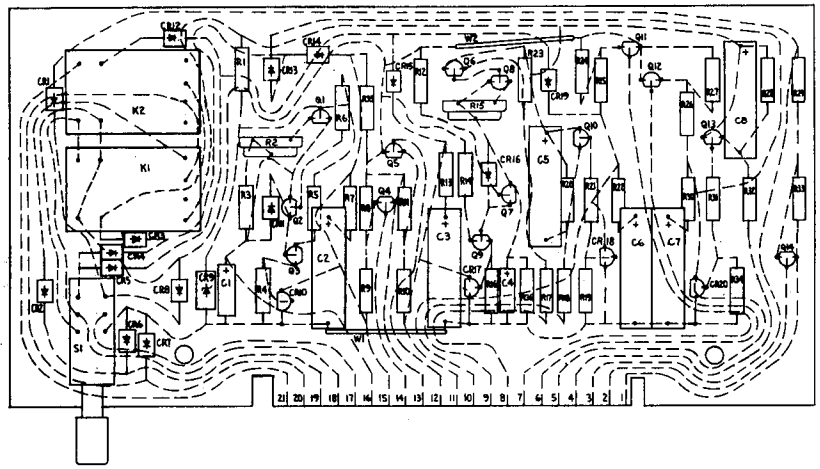


SET OVERCRANK TIME DELAY POT R4 TO 75±5 SECONDS



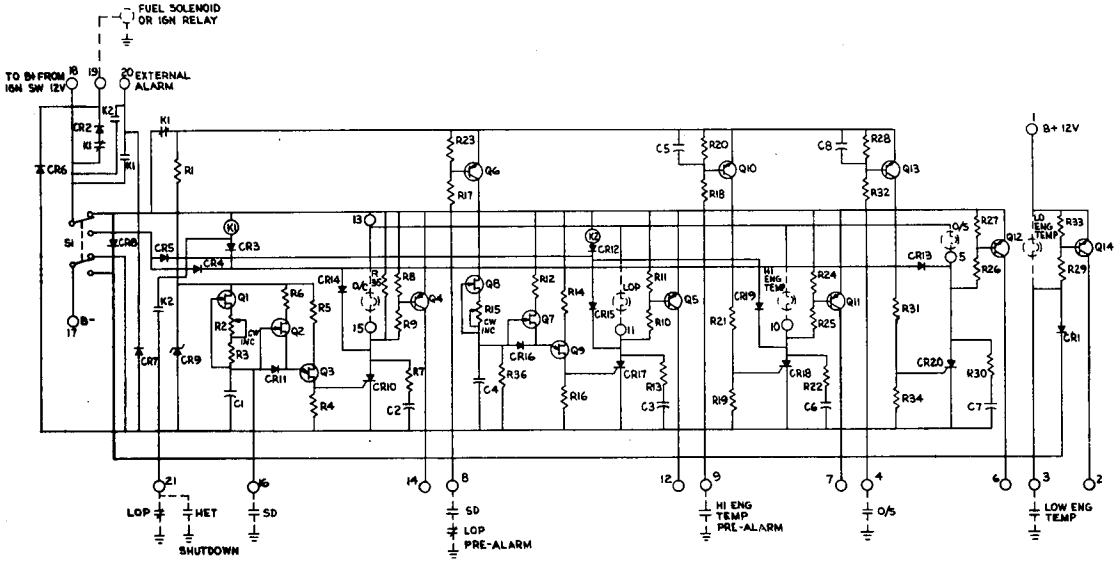
MONITOR, ENGINE CONTROL
1 LIGHT, PENN STATE

300-0731



SET R2 FOR AN OVERCRANK TIME DELAY OF 75 ± 5 SECONDS

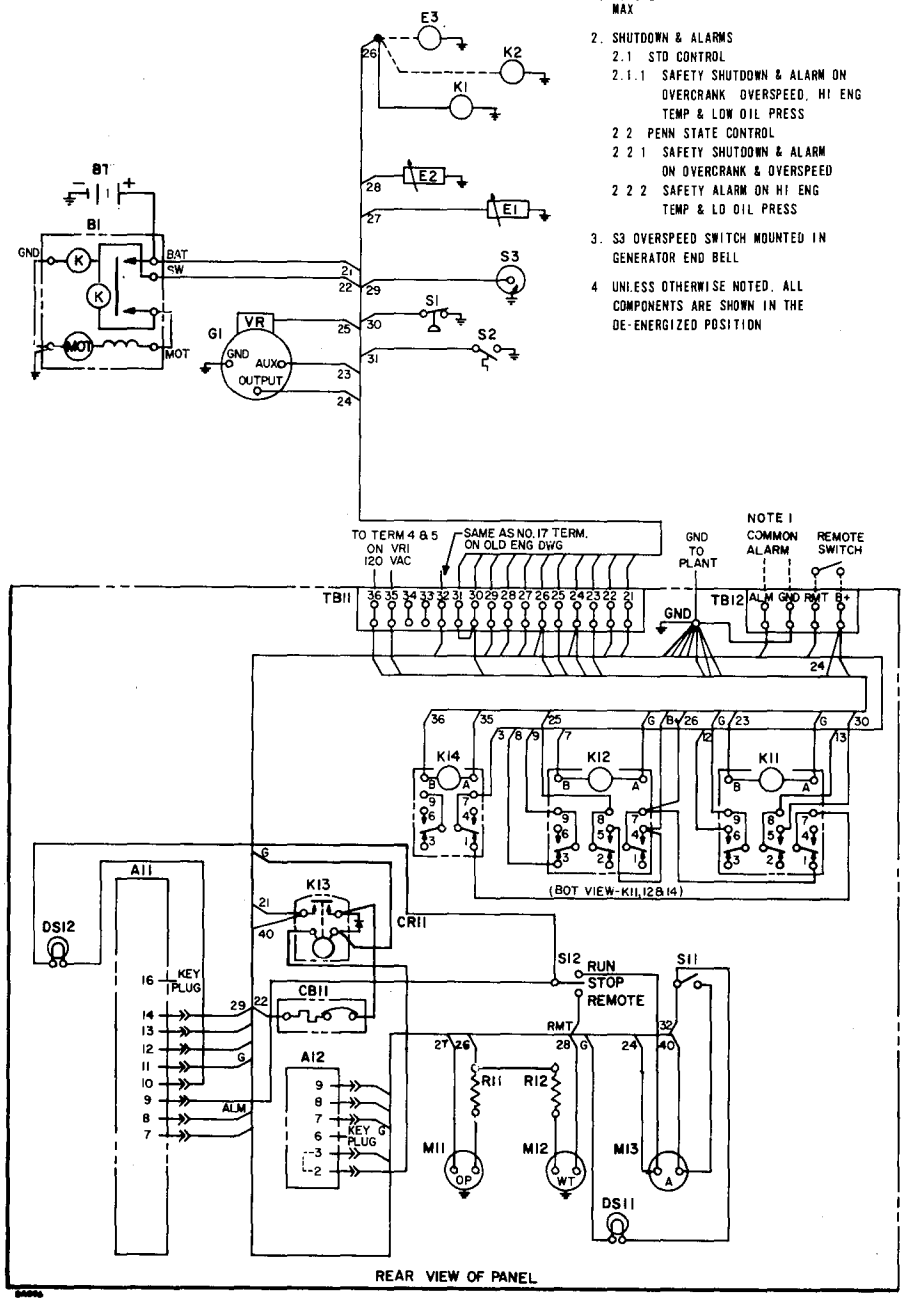
OIL PRESS TIME DELAY SHOULD BE 12.5 ± 2.5 SECONDS.



MONITOR, ENGINE CONTROL
5 LIGHT

300-0682

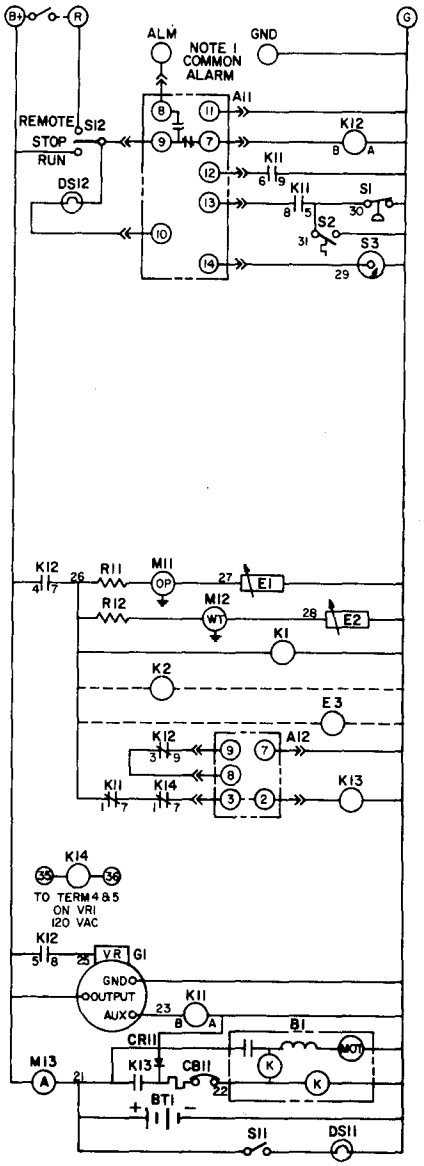
WIRING DIAGRAM



NOTES:

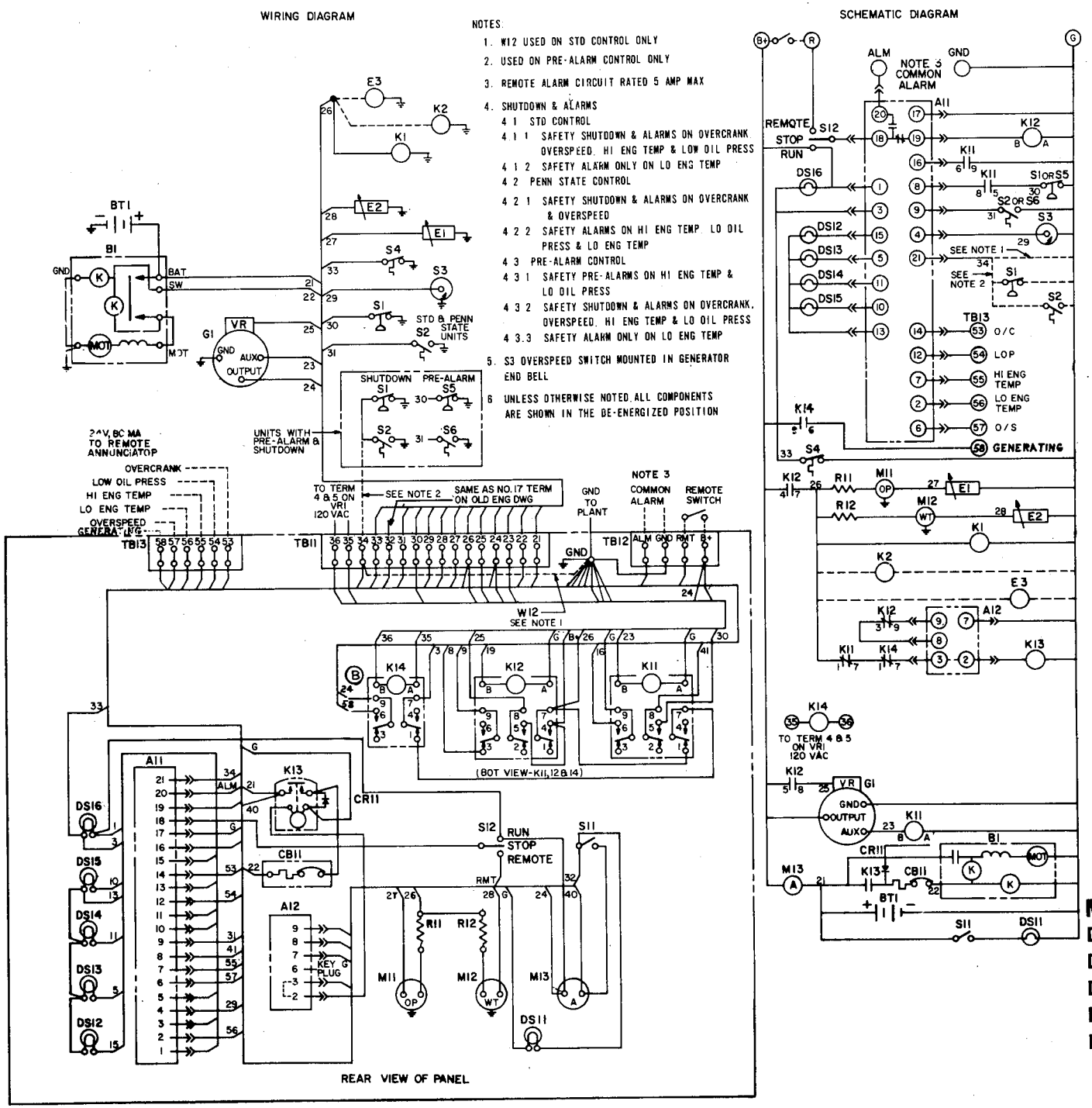
1. REMOTE ALARM CIRCUIT RATED 5 AMP MAX
2. SHUTDOWN & ALARMS
   - 2.1 STD CONTROL
     - 2.1.1 SAFETY SHUTDOWN & ALARM ON OVERCRANK OVERSPEED, HI ENG TEMP & LOW OIL PRESS
   - 2.2 PENN STATE CONTROL
     - 2.2.1 SAFETY SHUTDOWN & ALARM ON OVERCRANK & OVERSPEED
     - 2.2.2 SAFETY ALARM ON HI ENG TEMP & LO OIL PRESS
3. S3 OVERSPEED SWITCH MOUNTED IN GENERATOR END BELL
4. UNLESS OTHERWISE NOTED, ALL COMPONENTS ARE SHOWN IN THE DE-ENERGIZED POSITION

SCHEMATIC DIAGRAM



MODEL No.	
DFT/1C	1 LIGHT
DFU/1D	1 LIGHT
DFV/1E	1 LIGHT
DFW/1B	1 LIGHT
DFY/1A	1 LIGHT

612-4360

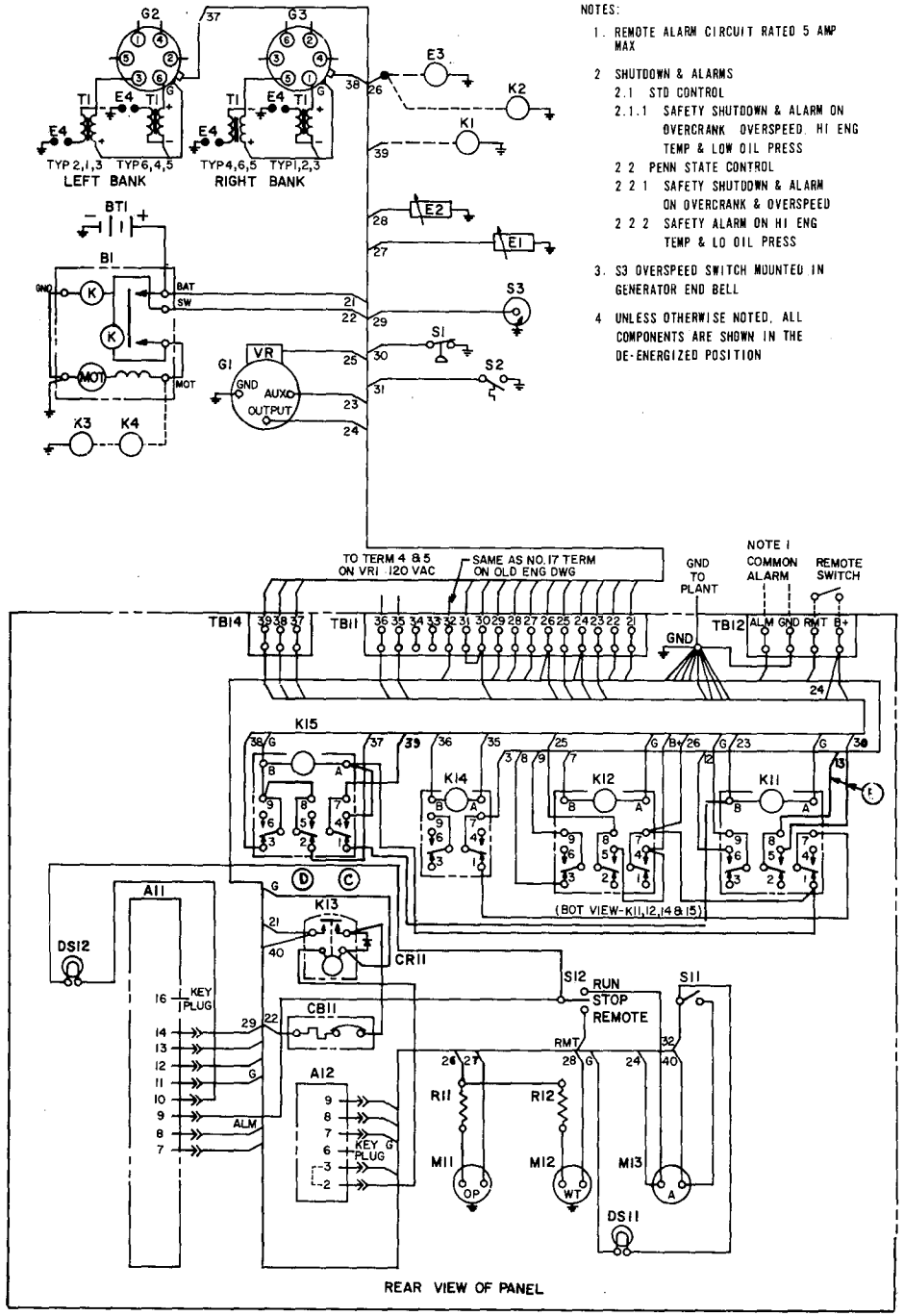


MODEL No.

DFT/9222C	5 LIGHT
DFU/9222D	5 LIGHT
DFV/9222E	5 LIGHT
DFW/9222B	5 LIGHT
DFY/9222A	5 LIGHT

612-4366

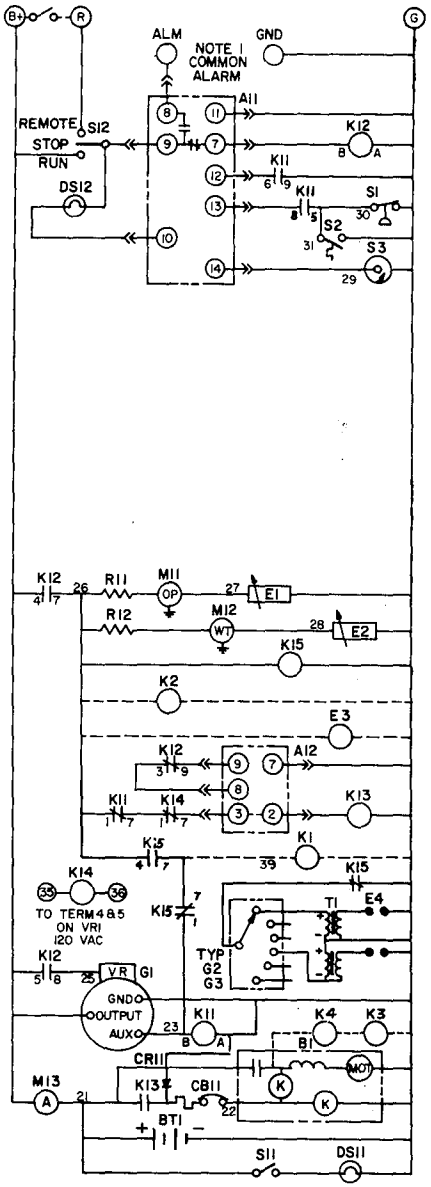
WIRING DIAGRAM



NOTES:

1. REMOTE ALARM CIRCUIT RATED 5 AMP MAX
2. SHUTDOWN & ALARMS
   - 2.1 STD CONTROL
     - 2.1.1 SAFETY SHUTDOWN & ALARM ON OVERCRANK OVERSPEED HI ENG TEMP & LOW OIL PRESS
   - 2.2 PENN STATE CONTROL
     - 2.2.1 SAFETY SHUTDOWN & ALARM ON OVERCRANK & OVERSPEED
     - 2.2.2 SAFETY ALARM ON HI ENG TEMP & LO OIL PRESS
3. S3 OVERSPEED SWITCH MOUNTED IN GENERATOR END BELL
4. UNLESS OTHERWISE NOTED, ALL COMPONENTS ARE SHOWN IN THE DE-ENERGIZED POSITION

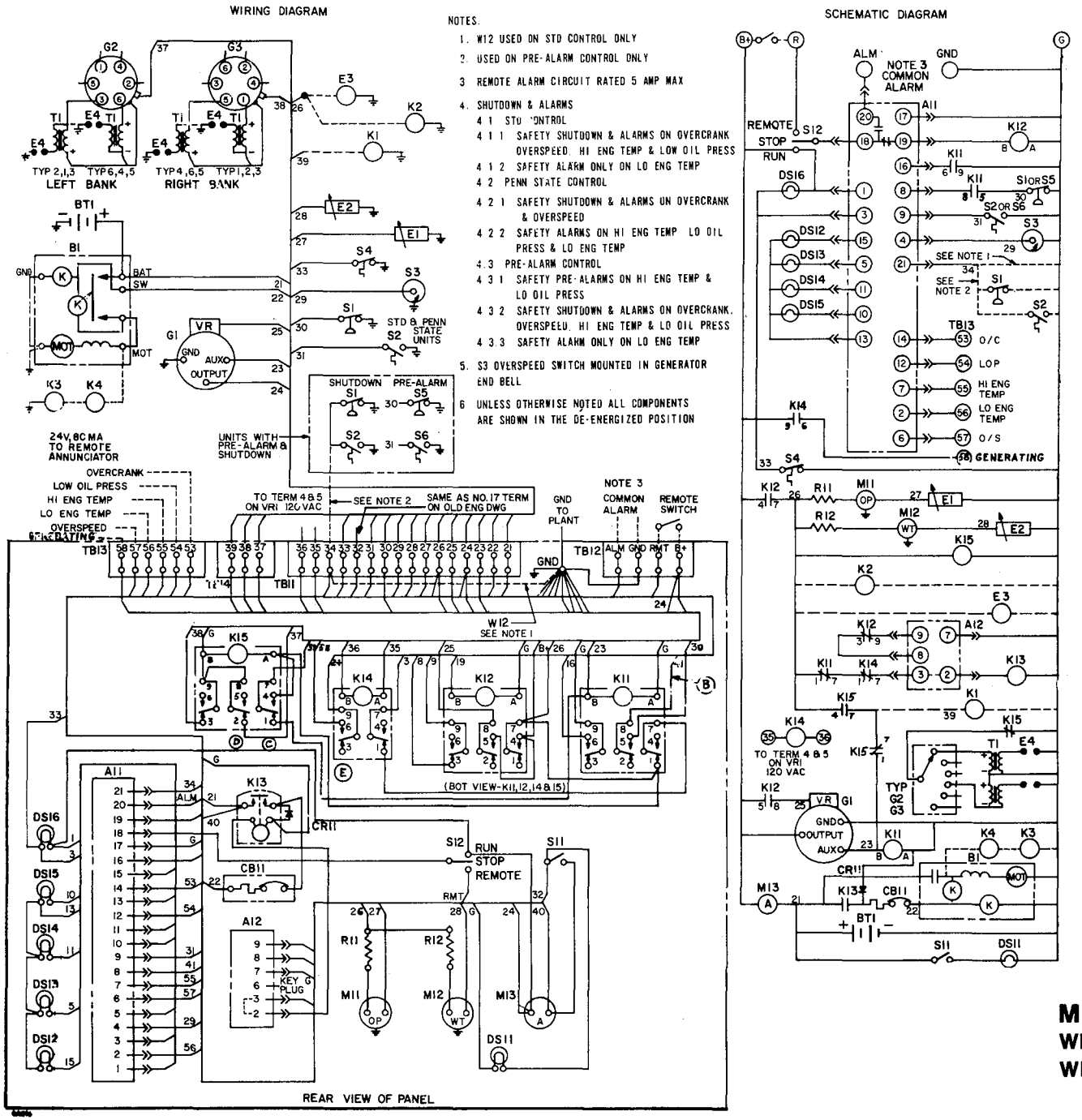
SCHEMATIC DIAGRAM



MODEL No.

WF/1B	1 LIGHT
WK/1B	1 LIGHT

612-4361

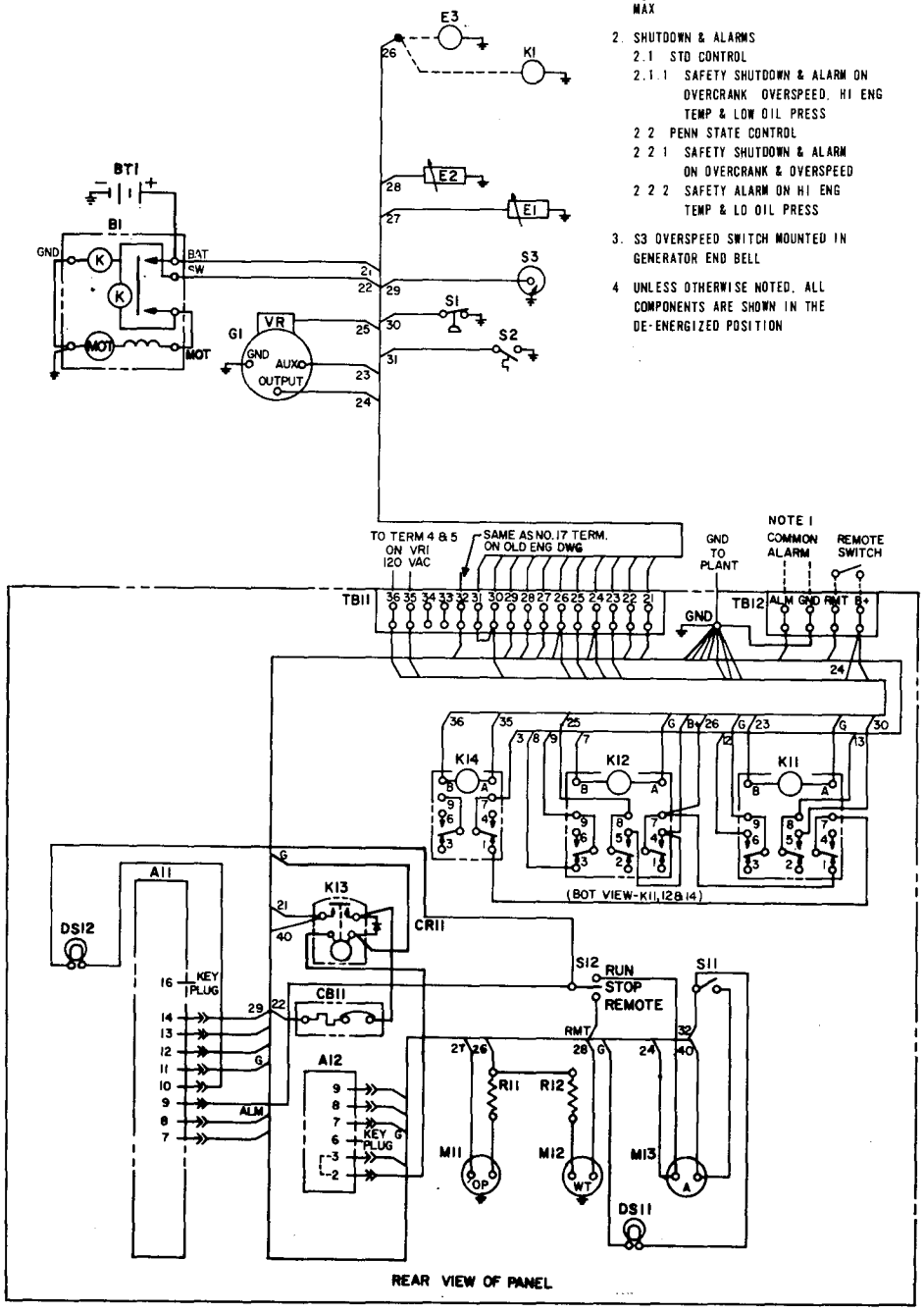


MODEL No.

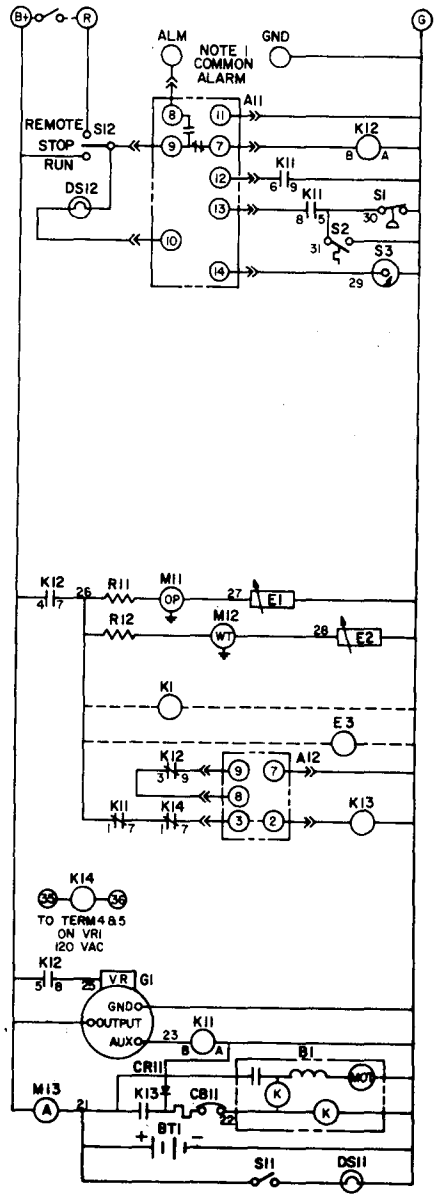
WF/9222B	5 LIGHT
WK/9222B	5 LIGHT

612-4367

WIRING DIAGRAM

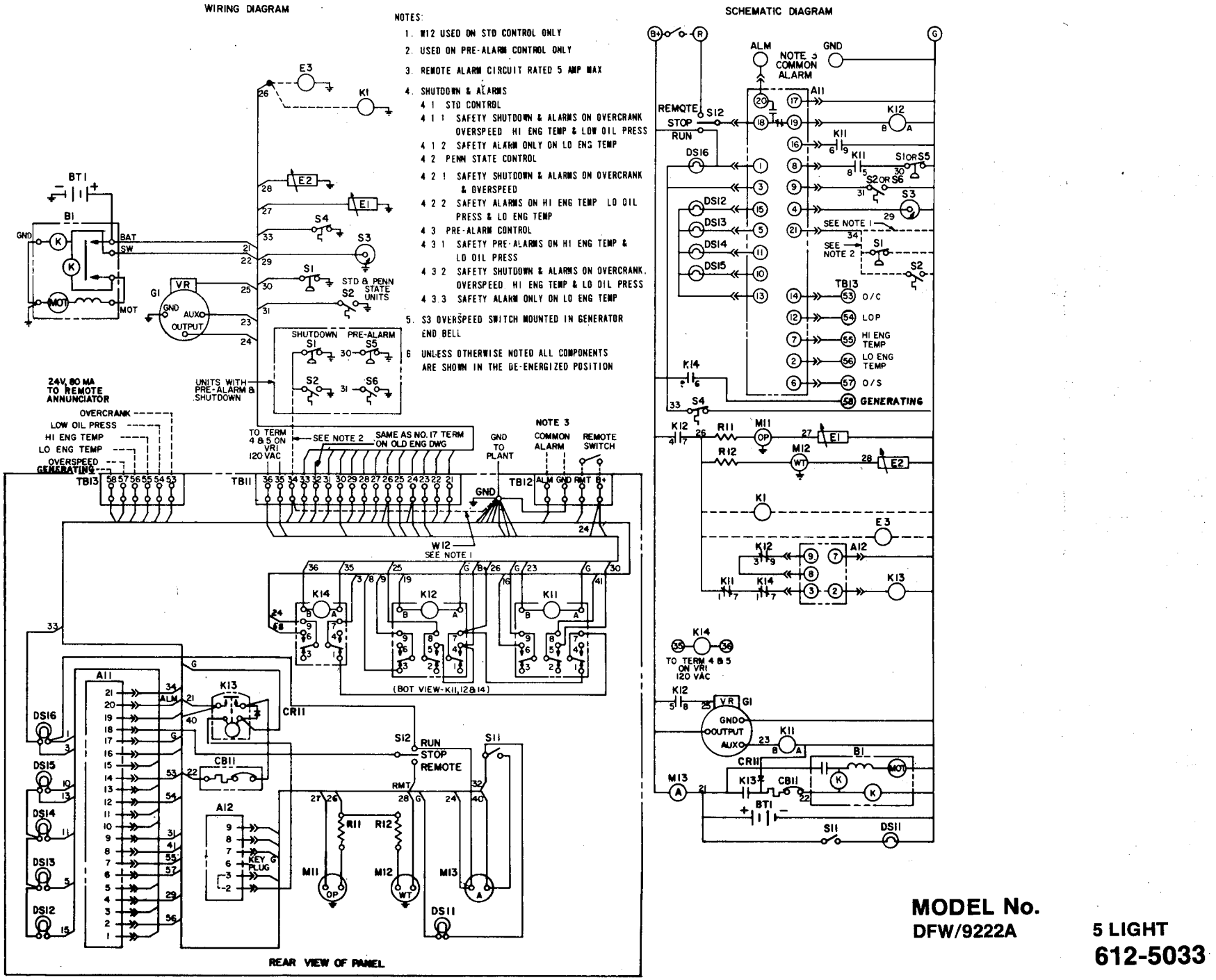


SCHEMATIC DIAGRAM



MODEL No.
DFW/1A

1 LIGHT
612-5029



MODEL No.
DFW/9222A

5 LIGHT
612-5033