GENERAC®
POWER SYSTEMS, INC.

Option "C" Control Console

PART 6
OPTION C
CONTROL
CONSOLE

STANDBY
ELECTRIC
POWER
SYSTEMS
All Series

TABLE OF CONTENTS

Section 6.1

METERS, GAUGES AND CONTROLS

Standard Features

The Option "C" control console (Figure 1) incorporates the following features as standard equipment:

- Provides either manual or automatic start capability.
- Mounts an AC voltmeter, ammeter and frequency meter.
- Includes an oil pressure gauge, coolant temperature gauge, DC ammeter and hourmeter.
- Includes an auto-manual-off switch to prevent automatic startup during maintenance and servicing.
- Provides a "Not in Automatic Start Mode" advisory lamp which illuminates when the auto-manual-off switch is not set to "Auto".
- Includes an engine monitor panel with advisory lamps that turn on in the event of (a) overcrank, (b) poverspeed, (c) high coolant temperature, (d) low oil pressure, and (e) rpm sensor loss.

Available Options

Some of the options available for use with the Option "C" console include the following:

- An 18 lamp remote annunciator panel
- An annunciator panel, mounted on the control console, which provides up to nine (9) annunciator and pre-alarm lamps.
- A 3 -lamp remote mounted annunciator panel.
- A 5 -lamp remote mounted annunciator panel.
- A 14 -lamp remote mounted annunciator panel.
- A horn alarm.

For more information on available options, refer to Part 7, "Generator Options and Accessories".

Meters, Gauges, Lamps and Switches

ENGINE MONITOR PANEL:

See Part 6.2, "Engine Monitor Panel".

AC VOLTMETER:

The panel AC voltmeter provides an indication of the generator's AC voltage output. The meter may indicate selected line-to-line or line-to-neutral voltage (see "Line-Phase Selector Switch"). The nominal rated AC voltage of each generator model is listed on the unit data plate.

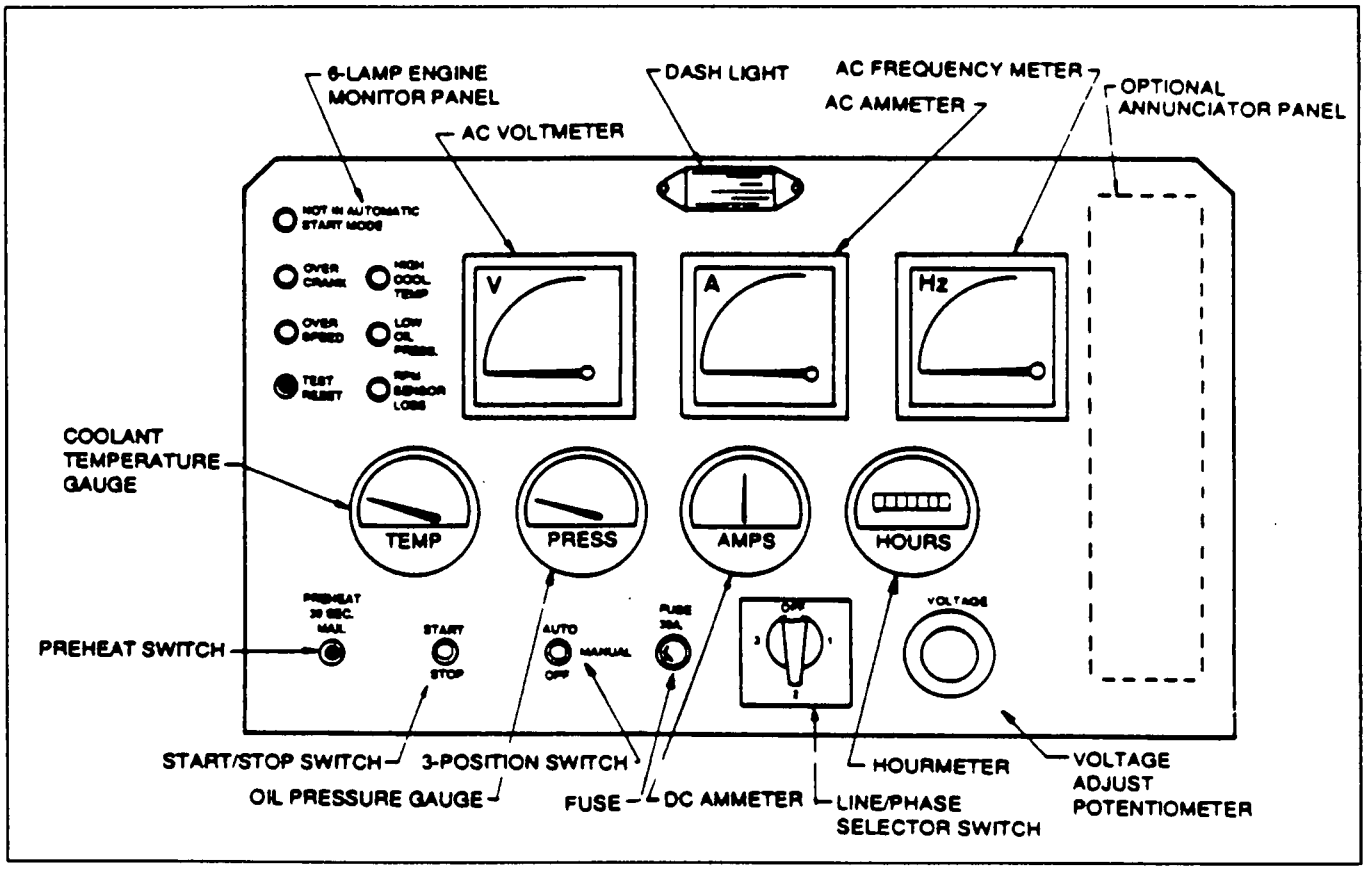


Figure 1. The Option "C" Control Console

Meters, Gauges, Lamps and Switches (Continued)

AC AMMETER:

The AC ammeter indicates the current draw of connected electrical loads, in "amperes". A line-phase selector switch permits operator selection of line-to-line or line-to-neutral amperage readings.

Generator AC output leads E1 and E3 (1-phase units) or E1, E2 and E3 (3-phase units) pass through current transformers in the AC connection panel. Current flow through E1, E2 and E3 induce a voltage and current flow into the transformers. Transformer output current is delivered to the AC ammeter via the line-phase selector switch.

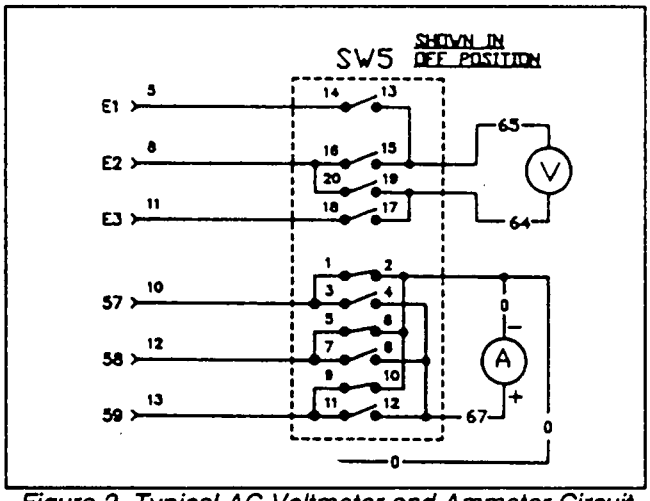


Figure 2. Typical AC Voltmeter and Ammeter Circuit

AC FREQUENCY METER:

Indicates generator AC output frequency, in "Hertz" or "cycles per second". The following facts apply:

- Units rated 60 Hertz and having a 2-pole rotor deliver a 60 Hertz AC output at 3600 rpm.
- Units rated 50 Hertz and with 2-pole rotor deliver a 50 Hertz output at 3000 rpm.
- Units rated 60 Hertz and with 4-pole rotor provide a 60 Hertz output at 1800 rpm.
- Units rated 50 Hertz and with 4-pole rotor supply 50 Hertz at 1500 rpm.
- Correct rotor speed and frequency is maintained by an engine governor which must be adhusted to maintain the desired AC frequency.
- Governed speed at no-load is usually adjusted to about 62 Hertz (1860 rpm for 4-pole rotors, 3720 rpm for 2-pole rotors). This slightly high no-load speed helps prevent excessive rpm, frequency and voltage droop under heavy electrical loading.
- Under heavy electrical loading, frequency may droop to about 59 Hertz but should never droop below about 58 Hertz.
- The frequency meter is operated by AC generator sensing leads S15 and S16.

NOTE: On some early production standby generators, the frequency meter was operated by the output of an rpm sensor. See Section 6.2, "Engine Monitor Panel".

COOLANT TEMPERATURE GAUGE:

The coolant temperature gauge provides a reading of engine coolant temperature. The gauge is operated by the Wire 14 circuit where that circuit's DC output is controlled by a coolant temperature sending unit on the engine. See Figure 3 below.

On a typical engine, normal operating temperature may be between 185°-200° F. (85°-94° C.). Actual coolant temperature may vary, depending on such variables as ambient temperature, applied load, cooling system condition, etc.

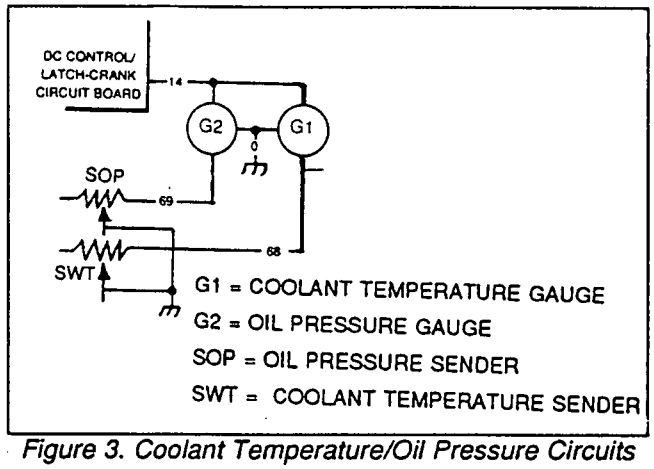


Figure 3. Coolant Temperature/Oil Pressure Circuits

OIL PRESSURE GAUGE:

The oil pressure gauge indicates engine oil pressure during operation. Oil pressure may vary depending on the specific engine, oil viscosity, oil temperature, engine speed, ambient temperature, etc.

The oil pressure gauge is powered by the Wire No. 14 circuit with the DC voltage controlled by an oil pressure sending unit on the engine. See Figure 3.

DC AMMETER:

The DC ammeter indicates rate of charge during operation from an engine-driven DC alternator.

HOURMETER:

Provides a continuous indication of engine-generator operating time, in hours and tenths of hours. A typical hourmeter will record operating times up to 99,999.9 hours. The meter will then start over again at "zero". Use the hourmeter in conjunction with the recommended periodic maintenance schedule on the generator.

START/STOP SWITCH:

Use this 3-position switch to crank and start the engine manually or to shut down manually, as follows:

Meters, Gauges, Lamps and Switches (Continued)

- To crank and start the engine manually, hold the switch at its "Start" position. When the engine starts, release the switch to its "Run" (centered) position.
- To shut down an operating engine, set the switch to its "Stop" position.

NOTE: When starting the engine manually, the auto-manual-off switch may be set to either "Auto" or "Manual". If that switch is set to "Off", neither manual or automatic startup will be possible.

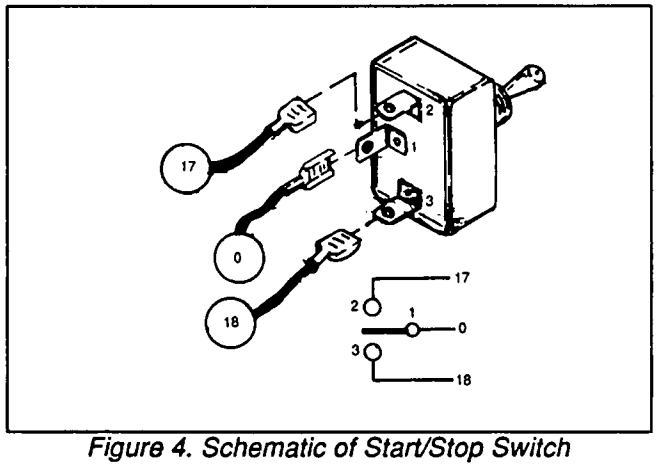


Figure 4. Schematic of Start/Stop Switch

AUTO-MANUAL-OFF SWITCH:

Use this safety switch to prevent automatic startup while servicing the generator set. Switch positions are as follows:

"Auto": Select this switch position for all automatic operations. When "Auto" is selected, closure of the Wires 178/183 circuit by "GTS" transfer switch action will result in automatic engine cranking and startup. Closure of the Wires 178/183 circuit is normally accomplished by transfer switch circuit board action when utility source voltage drops below a preset level. The circuit will also be closed when either "Fast Test" or "Normal Test" are selected on the transfer switch controls.

"Manual": When "Manual" is selected, automatic cranking and startup will not occur. This position is useful when testing or troubleshooting the unit where cranking and startup is necessary, but where automatic startup is undesireable.

"Off": When switch is set to "Off", neither automatic or manual engine cranking can occur.

Figure 5 is a schematic representation of the auto-manual-off switch.

30 AMP FUSE:

A 12 volts DC power supply is delivered to the control console from the generator battery. Units equipped with a 24 volts DC battery system use a DC converter to reduce the console voltage down to 12 volts.

The 12 volts DC power from the battery (or converter) is delivered to the control console via Wire No. 13, and to the 30 amp fuse. The fuse protects DC control system components against overload. If the fuse has blown due to an overload, use only an identical 30 amp replacement fuse.

NOTE: A 14 amp inline fuse is housed inside the control console, in series with Wire No. 15 to the DC control/latch-crank circuit board. This inline fuse protects the circuit board. Either a blown 30 amp fuse or a blown 14 amp fuse will prevent engine cranking and startup.

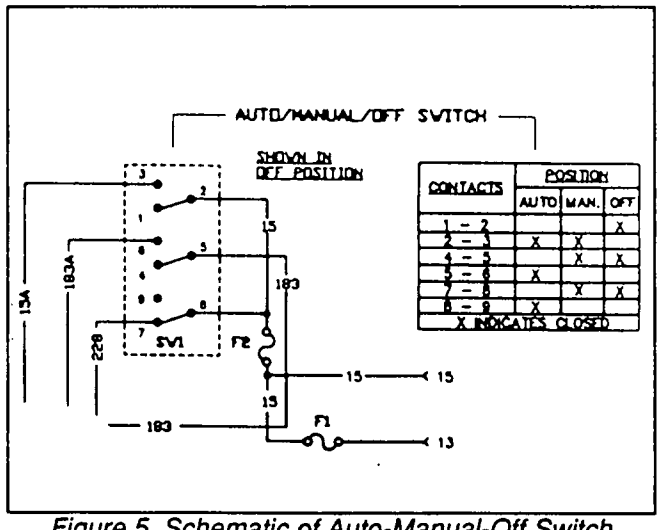


Figure 5. Schematic of Auto-Manual-Off Switch

LINE-PHASE SELECTOR SWITCH:

Use this 4-position switch to select either line-to-line or line-to-neutral AC voltmeter and ammeter readings. Switch positions and readings are listed in the chart below.

SWITCH POSITION	1-PHASE UNITS	3-PHASE UNITS
1	Line E1 to Neutral	Line E1 to E2
2	Line E3 to Neutral	Line E2 to E3
3	Line E1 to E3	Line E3 to E1
OFF	No Reading	No Reading

VOLTAGE ADJUST POTENTIOMETER:

This adjustable potentiometer permits the operator to "fine adjust" generator AC output voltage, within a range of plus or minus 5 percent. The potentiometer is connected in series with sensing lead S16 to the voltage regulator and acts to "bias" the sensing signal to the regulator. Turn the kinob clockwise to increase AC output voltage, counterclockwise to decrease it.

NOTE: When adjusting the voltage regulator, do so with the voltage adjust potentiometer centered at its mid-position.

Section 6.2
ENGINE MONITOR PANEL

General

The engine monitor panel (Figure 1) mounts five (5) engine fault advisory lamps, a test/reset switch, and a "Not in Automatic Start Mode" advisory lamp. The panel mounts the following engine fault advisory lamps:

- Overcrank.
- High Coolant Temperature/Low Coolant Level.
- Overspeed.
- Low Oil Pressure.
- RPM Sensor loss.

If one or more of the above fault conditions should occur, the engine will shut down and the appropriate lamp(s) will illuminate. The following rules apply:

- The engine cannot be cranked or started while any fault lamp is on.
- To turn all lamps off and allow the engine to be cranked, push the test/reset switch in.

NOTE: *On units option "C" control consoles manufactured after June of 1996 pressing the Test / Reset switch will result in the fault lights turning on momentarily and automatically turning off, enen if the switch is held in continuously.*

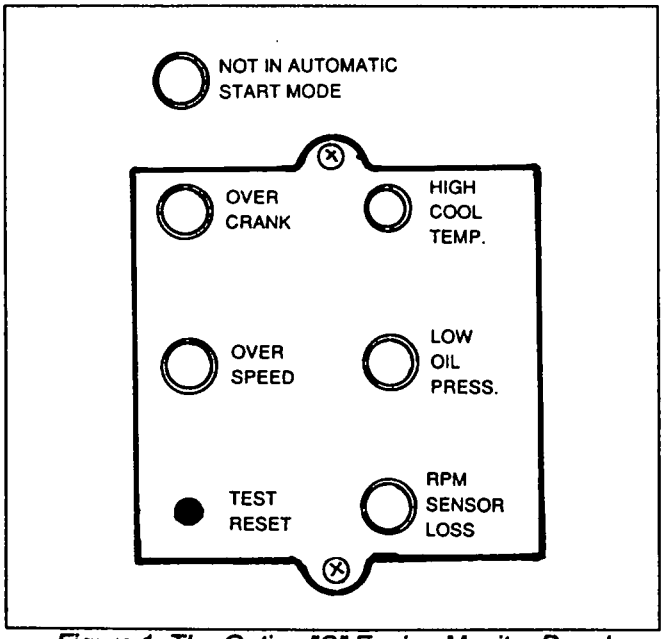


Figure 1. The Option "C" Engine Monitor Panel

Overcrank Condition

The generator console houses a DC control/latch-crank circuit board. The circuit board controls automatic and manual engine cranking, startup, running and shutdown operations.

Automatic cranking and startup normally occurs when a circuit board in the "GTS" automatic transfer switch closes the Wires 178/183 circuit. Closure of that circuit energizes a crank relay (K1) and a run relay (K2) on the control console's DC control/latch-crank board. Circuit board action will energize the crank relay (K1) for about eight (8) seconds, de-energize it for about eight (8) seconds, energize it again for eight (8) seconds, and so on. Each time the crank relay is energized, its normally-closed contacts close. On contacts closure, the engine cranks. The resultant cyclic cranking action will continue during automatic startup until either (a) the engine starts, or (b) until eight (8) crank/no-crank cycles have been used up. That is, if the engine has not started in eight cranking cycles, cranking will end and the "overcrank" lamp will turn on.

Neither manual or automatic cranking can be initiated while the lamp is on. If additional cranking is desired, push in the test/reset switch to turn the lamp out, then crank the engine.

High Coolant Temperature/Low Coolant Level

The engine mounts both a high coolant temperature switch and a low coolant level sensor. Both of these devices have normally-open contacts. Should engine coolant temperature exceed a safe level (above about 245° F.), the switch contacts will close. Should coolant level drop below a safe level, the sensor contacts will close. DC control/latch-crank circuit board action will then (a) shut the engine down, and (b) turn on the high coolant temperature lamp. Shutdown and lamp on condition will occur subject to the following conditions:

- If the engine is started with an existing high temperature or low coolant level, shutdown and lamp on will occur when the engine reaches starter cutout sped (about 1000 rpm).
- If engine starts normally but high temperature or low coolant level occur later, shutdown and lamp on will occur immediately.

Overspeed Condition

Units with Option "C" console mount an rpm sensor. This sensor is essentially a magnetic pickup which is installed so that its magnetic tip is directly over the engine flywheel gear teeth. As the flywheel gear rotates, an electrical pulse is emitted each time a flywheel gear passes the magnetic tip. These pulses are used by the DC control/latch-crank circuit board as a speed indicator to (a) establish starter cutout speed, (b) establish an overspeed shutdown point, and (c) calibrate the DC control/latch crank circuit board.

In the event of an overspeed condition, circuit board action will initiate engine shutdown and a lamp on condition, subject to the following:

- Automatic shutdown and lamp on condition will result if frequency exceeds 69-78 Hertz, providing the overspeed lasts longer than about four (4) seconds.
- If the overspeed exceeds approximately 78 Hertz, shutdown and lamp on condition will occur immediately.

NOTE: On units rated 1800 rpm, 69-78 Hertz is equal to 2070-2340 rpm. On 3600 rpm units, 69-78 Hertz equals 4140-4680 rpm.

Low Oil Pressure Condition

The engine mounts an oil pressure switch having normally-closed contacts. The contacts will be held open by engine oil pressure during cranking and running operations. Should engine oil pressure drop below a preset value (about 10 psi), automatic engine shutdown and illumination of the advisory lamp will occur. Operation of the low oil pressure fault system can be described briefly as follows:

- When the engine is cranking and after speed has reached approximately 800-1000 rpm, the DC control/latch-crank board allows about four (4) seconds for oil pressure to build before it takes any action.
- Above 800-1000 rpm, with oil pressure still low, and if longer than four (4) seconds have elapsed, engine shutdown will occur but the fault will not "latch". That is, the lamp will not turn on. Since the lamp is not on (condition is not latched), the circuit board will allow the engine to crank until all eight (8) of the allotted crank cycles have been used up. If oil pressure is still low after eight (8) crank cycles, shutdown will occur and the LOW OIL PRESSURE light will turn on.
- If engine cranks and starts normally, but oil pressure drops later, the circuit board will wait about four (4) seconds for oil pressure to be restored. If oil pressure is still low after four (4) seconds, shutdown and lamp on will occur.

RPM Sensor Loss Lamp

Also see "Overspeed Condition" on this page. Loss of signals to the DC control/latch-crank circuit board from the rpm sensor means that (a) the board has no signal for starter cutout, and (b) no signal is present for overspeed shutdown. This is a potentially damaging situation. For that reason, the circuit board will effect an automatic shutdown and a lamp on condition if sensor signals to the board are lost. Operation of the rpm sensor loss circuit may be briefly described as follows:

- **During Manual Startup:** If the engine starts within two (2) seconds after cranking is initiated and the board senses no rpm sensor signals, engine shutdown will occur as soon as the start/stop switch is released. However, the condition will not latch, i.e., the rpm sensor loss lamp will not turn on. If engine startup occurs more than two (2) seconds after cranking is initiated, engine cranking will end and the advisory lamp will illuminate.
- **During Automatic Startup:** On loss of rpm sensor output, the engine will shut down. About one (1) second after engine stoppage, it will crank again. If rpm sensor loss persists longer than two (2) seconds after cranking has resumed, shutdown and lamp on condition will occur. If the engine started within two (2) seconds after recrank was initiated, the starter will remain engaged until after the two (2) second delay has elapsed.

NOTE: The rpm sensor loss lamp will turn on only while cranking and only if the cranking period exceeds two (2) seconds. During startup, the circuit board will allow the rpm sensor about two (2) seconds to provide an output signal. If an output signal is not received, the run relay (K2) will de-energize to stop the engine.

RPM Sensor Loss Lamp (Continued)

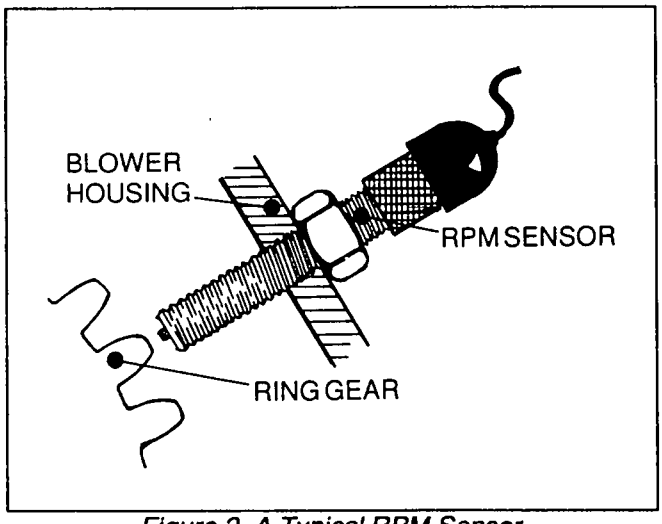


Figure 2. A Typical RPM Sensor

Test-Reset Switch

Use this switch to (a) test all engine monitor panel lamps, and (b) to reset a monitored engine fault and permit further cranking.

- To test all lamps, push the switch in. All lamps should turn on.
- If any lamp is on, cranking is inhibited. To turn the lamp(s) off, push the switch in.
- If the switch is actuated while the engine is running, only the lamps will be tested (engine will not shut down).

Occurence of an Unmonitored Fault

Should engine shutdown occur due to some unmonitored fault (out of gas, faulty ignition, etc.), none of the advisory lamps will light. If the auto-manual-off switch is set to "Auto" when such an unmonitored fault occurs, the engine will recrank and attempt to start until all eight (8) of the allotted crank cycles have been used up. Cranking will then terminate and the "Overcrank" lamp will illuminate.

Section 6.3
INTERNAL CONSOLE COMPONENTS

General

Components housed in the generator control console are shown in Figure 1, below. Option "C" control consoles may be arbitrarily divided into three general types, as follows:

- Units with a gas engine and having a 12 volts DC engine electrical system.
- Units with diesel engine and a 12 volts DC engine electrical system.
- Units with diesel engine and a 24 volts DC engine electrical system.

DC components housed in the control console require 12 volts DC power for their operation. This DC power is taken from the generator battery. If the engine has a 24 volts DC electrical system, a 24 to 12 volts DC converter is used to reduce battery output down to 12 volts for console operation.

NOTE: *24 VDC systems manufactured after the last quarter of 1991. DO NOT use a 24 to 12 volt converter. Refer to Section 6.10.*

ITEM	DESCRIPTION	ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	AC Voltage Regulator	9	Start/Stop Switch	17	Panel Lamp
2	Excitation Circuit Breaker	10	Auto-Manual-Off Switch	18	Hourmeter
3	Terminal Board TB1	11	30 Amp Fuse	19	DC Ammeter
4	DC Alternator Resistor	12	Line-Phase Selector Switch	20	Oil Pressure Gauge
5	Field Boost Diode	13	Voltage Adjust Potentiometer	21	Coolant Temperature Gauge
6	DC Control/Latch-Crank Board	14	Frequency Meter	22	Engine Monitor Panel Circuit Board
7	Wiring Harness	15	AC Ammeter	23	Engine Run Relay (24 volts diesel only)
8	Preheat Switch (Diesel Only)	16	AC Voltmeter	24	Preheat Relay (diesel engine units only)

Item 25= Diode
Item 26= Field Boost Resistor

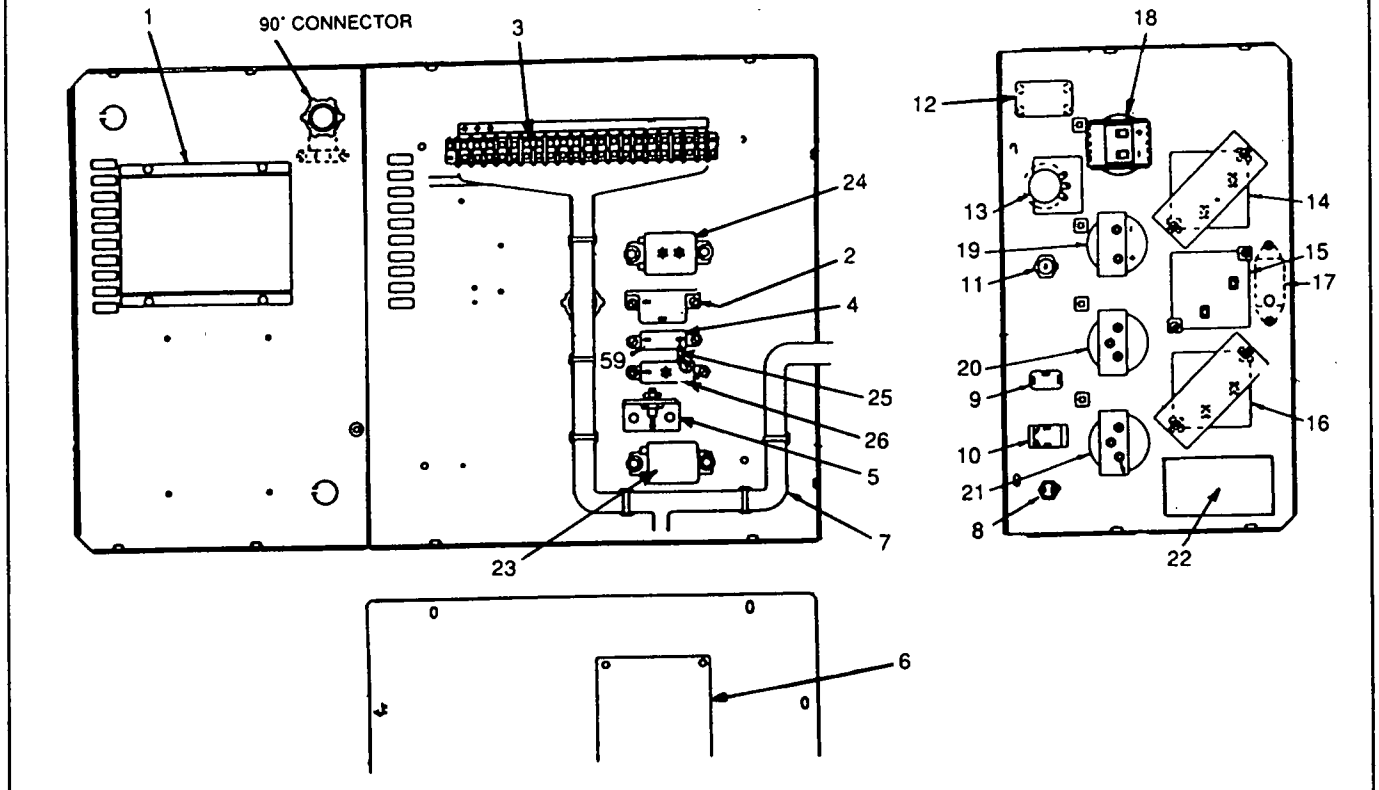


Figure 1. Internal Control Console Components (24 Volts Diesel Unit Shown)

AC Generator Components

Some components housed in the control console are part of the AC generator system. Refer to the Part 2, 3 or 4 as appropriate for information on these components.

- AC voltage regulator (Item 1).
- Excitation circuit breaker (Item 2).
- Field boost resistor (Item 4).
- Field boost diode (Item 5).

NOTE: Operation of the AC voltmeter, ammeter and frequency meter circuits will be discussed in Section 6.4, "AC Circuits Operation".

Terminal Board TB1

This 20-position terminal board provides a convenient method of interconnecting engine electrical components with control console circuits. Terminal numbers and functions are listed in the chart that follows.

TERMINAL & WIRE NO.	CIRCUIT FUNCTION
0	Common ground.
79	RPM Sensor output signal to DC control/ latch-crank circuit board.
13	Unfused battery voltage (12 volts DC).
14	"Engine run" circuit, electrically hot only with engine running. Circuit turns on engine ignition, fuel flow, etc.
15	Fused battery voltage (12 volts DC).
47	Used only on units with 24 volts DC engine electrical system. DC alternator output to an engine run relay.
49	Field excitation to engine DC alternator.
56	Engine cranking circuit.
68	From coolant temperature sender to gauge.
69	From oil pressure sender to gauge.
85, 86	Low oil pressure and high coolant temperature
150	Engine preheat circuit (diesel only)
218, 219	24 volts DC circuits on diesel only.

DC Control/Latch-Crank Circuit Board

The DC control/latch-crank board is the "control center" for engine cranking, startup, running and shutdown operations.

- The board is powered by fused 12 volts DC power from Wire 15.
- The circuit board mounts two relays, a crank relay (K1) and a run relay (K2).
- Circuit board action energizes crank relay (K1) to deliver 12 volts DC to the Wire 56 circuit, which initiates engine cranking.
- Board action energizes the run relay (K2) to energize engine components required for operation (fuel solenoid, engine ignition, etc.).
- When energized, relay K2 delivers 12 volts DC to a Wire 14 circuit (the "engine run" circuit).

A 13-pin connector plug interconnects the DC control/latch-crank board with the various wiring circuits. Connector plug pin numbers, associated wires and functions of each circuit are listed in the chart below.

PIN NO.	WIRE NO.	FUNCTION
1	15A	Fused battery voltage (12 volts DC).
2	0	Common Ground.
3	86	Low oil pressure switch circuit. When grounded by switch contacts closure, engine shutdown occurs.
4	85	High coolant temperature and low coolant level circuit.
5	79	RPM sensor signals to circuit board.
6	183A	Automatic start circuit.
7	17	Manual crank circuit from start/stop switch.
8	18	Manual stop circuit from start/stop circuit
9	228	Fused 12 volts DC to board when auto-manual-off switch is set to "Manual" or "Off".
10	221	Preheat circuit (diesel only).
11	14	12 volts DC when running only.
12	56	12 volts DC cranking signal.
13	229	12 volts DC output to optional alarm relay on occurence of a monitored fault shutdown.

A second 8-pin connector interconnects the DC control circuit board with an engine monitor panel board. Connector pins, associated wire numbers and functions of each circuit are listed in the chart that follows.

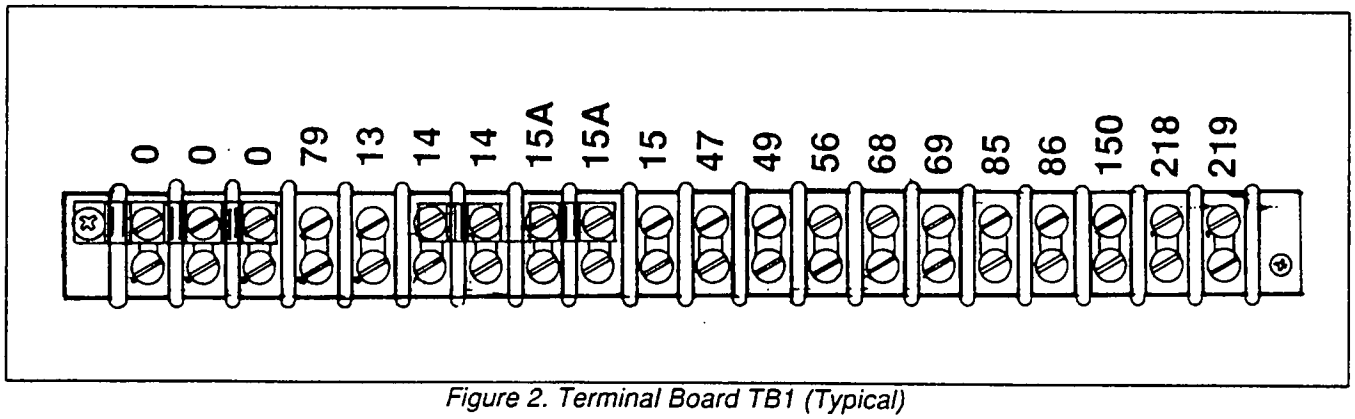


Figure 2. Terminal Board TB1 (Typical)

DC Control / Latch-Crank Circuit Board (Continued)

PIN	WIRE	FUNCTION
1	137	12 VDC from board to engine monitor panel's test/reset switch.
2	0	Common ground.
3	94	12 VDC output to "low oil press" lamp on closure of oil pressure switch contacts.
4	95	12 VDC to "overspeed" lamp on on closure of "high coolant" temperature switch or low coolant level sensor contacts.
5	97	12 VDC to "overspeed" lamp on occurance of engine overspeed.
6	96	12 VDC to "overcrank" lamp following occurance of an overspeed condition.
7	98	12 VDC to "rpm sensor loss" lamp on loss of sensor output to circuit board.
8	503	12 VDC to "not in automatic start mode" lamp when the manual-auto-off switch is set to either "Manual" or "Off".

CIRCUIT BOARD OVERSPEED ADJUSTMENT:

The DC control / latch-crank board must be calibrated each time it is replaced, for the following reasons:

- The board must be matched to the specific engine flywheel or engine speed sensing errors will result.
- The board must be calibrated to establish an overspeed shutdown setting that is about 10 hertz above the normal operating speed.

When overspeed setting is correct, starter cutout will also be correct.

To calibrate the circuit board, (See Figure 3) proceed as follows:

1. On the circuit board, locate the "Fine" and "Coarse" potentiometers. Also, locate the red LED (light emitting diode).
2. Turn the 'Coarse" all the way "counterclockwise (CCW).
3. Turn the "FINE" pot all the way clockwise (CW).

CAUTION:
Steps 2 and 3 above MUST be completed before the engine is started following circuit board replacement. If the engine is started before Steps 2 and 3 are completed, an overspeed shutdown may occur at normal rated operating speed.

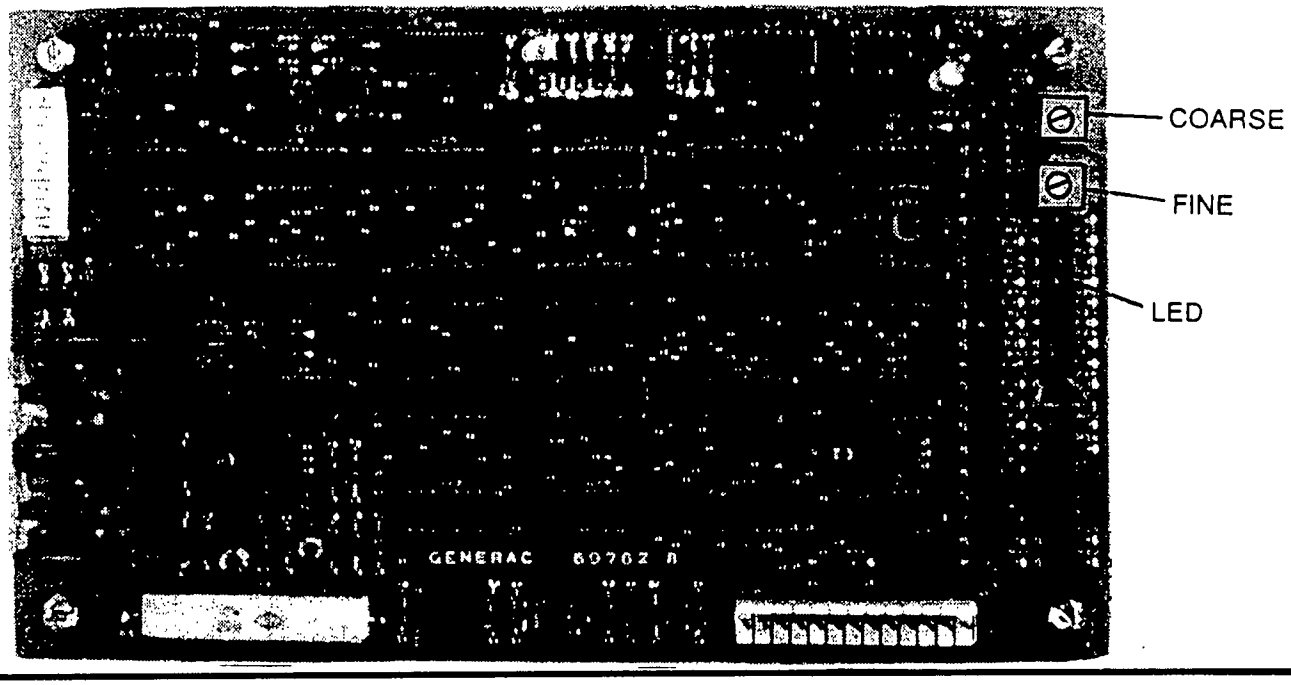
4. Start the engine manually. Let it stabilize and warm up at normal rated no-load speed. If necessary, adjust the engine governor to obtain the no-load frequency reading.

NOTE: *If "OVERSPEED" shutdown occurs upon engine start in step four (4), reverse initial pot settings in steps two (2) and three (3).*

5. Slowly turn the "Coarse" adjustment pot clockwise (CW) until the red LED just turns on.
6. Slowly turn the "Fine" adjustment pot counterclockwise until the red LED just goes out.
7. Slowly turn the "Fine" adjustment pot clockwise (CW) until the red LED just turns on.

With the above calibration completed, overspeed shutdown will occur about 10 Hertz above the no-load speed. For example, if the unit was running at 62 Hertz during calibration, overspeed shutdown will occur at about 72 Hertz.

Figure 3. DC Control / Latch-Crank Circuit Board



Wiring Harness

The control console wiring harness interconnects control console electrical components. Harnesses for gas and diesel engine units are NOT interchangeable.

Preheat Switch (Diesel Only)

The preheat switch permits the operator to warm the combustion chambers of a cold engine prior to a manual startup. During automatic startup, the preheat function is controlled by the DC control/latch-crank board.

Fused 12 volts DC power is always available to the preheat switch, via Wire 15A, the preheat relay coil, and Wire 221. When the switch contacts are closed by the operator, Wire 221 is connected to ground. The preheat relay then energizes, its contacts close, and DC power is delivered to the diesel engine glow plugs or air intake heater.

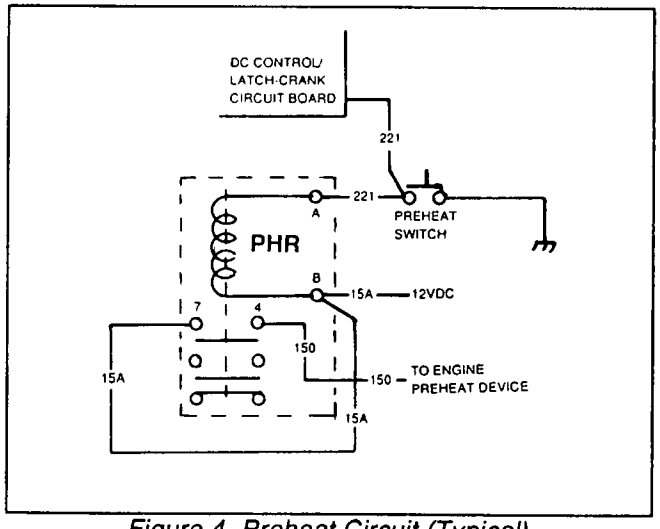


Figure 4. Preheat Circuit (Typical)

Start/Stop Switch

The 3-position start/stop switch connects Wire 17 to ground when set to "Start" position. Circuit board action will then energize a crank and a run relay to crank and start the engine.

When the switch is set to "Stop", Wire 18 is connected to ground. Circuit board action will then de-energize the run relay and shutdown will occur.

When set to its "Run" (centered) position, Wires 17 and 18 circuits are both open.

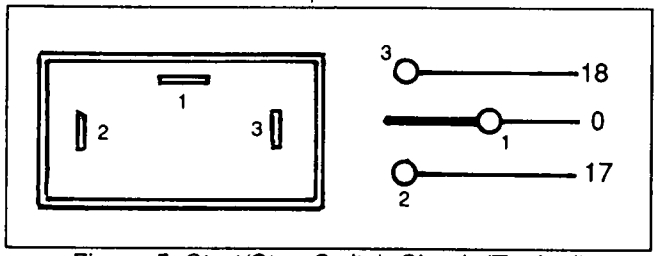


Figure 5. Start/Stop Switch Circuit (Typical)

Auto-Manual-Off Switch

Also see "Auto-Manual-Off Switch" in Section 6.1. The switch is shown pictorially and schematically in Figure 6. The schematic shows the switch in its "Off" position. Switch contacts positions with the switch set to "Auto", "Manual" and "Off" are given in the following chart.

TERMINAL NUMBERS	CONTACTS POSITION		
	AUTO	MANUAL	OFF
1 and 2	Open	Open	Closed
2 and 3	Open	Closed	Open
4 and 5	Open	Closed	Closed
5 and 6	Closed	Open	Open
7 and 8	Open	Closed	Closed
8 and 9	Closed	Open	Open

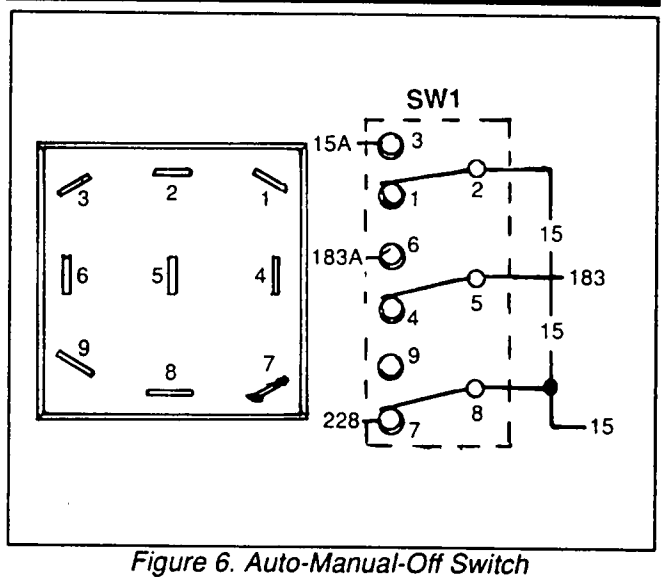


Figure 6. Auto-Manual-Off Switch

Voltage Adjust Potentiometer

This adjustable potentiometer permits the operator to "fine adjust" generator AC output voltage, within a range of approximately plus or minus 10 percent. The potentiometer is electrically connected in series with one of the sensing leads to the voltage regulator.

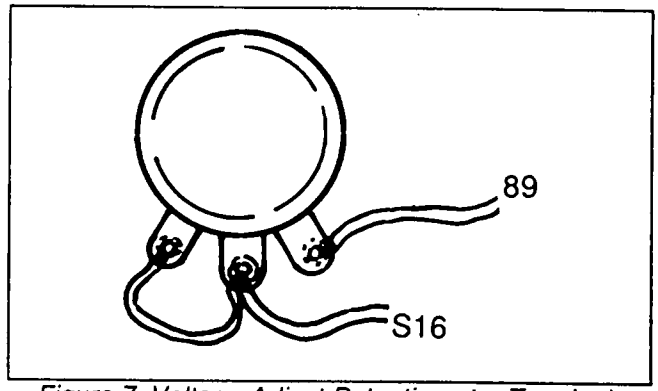


Figure 7. Voltage Adjust Potentiometer Terminals

Line-Phase Selector Switch

Also see "Line-Phase Selector Switch" in Section 6.1. A schematic representation of the switch is shown in Figure 8, with the switch shown in its "Off" position. The condition of the switch contacts at each position of the switch are shown in the following chart.

CONTACT NUMBERS	SWITCH POSITION			
	1	2	3	4
1 and 2	Open	Closed	Closed	Closed
3 and 4	Closed	Open	Open	Open
5 and 6	Closed	Open	Closed	Closed
7 and 8	Open	Closed	Open	Open
9 and 10	Closed	Closed	Open	Closed
11 and 12	Open	Open	Closed	Open
13 and 14	Closed	Open	Closed	Open
15 and 16	Open	Closed	Open	Open
17 and 18	Open	Closed	Closed	Open
19 and 20	Closed	Open	Open	Open

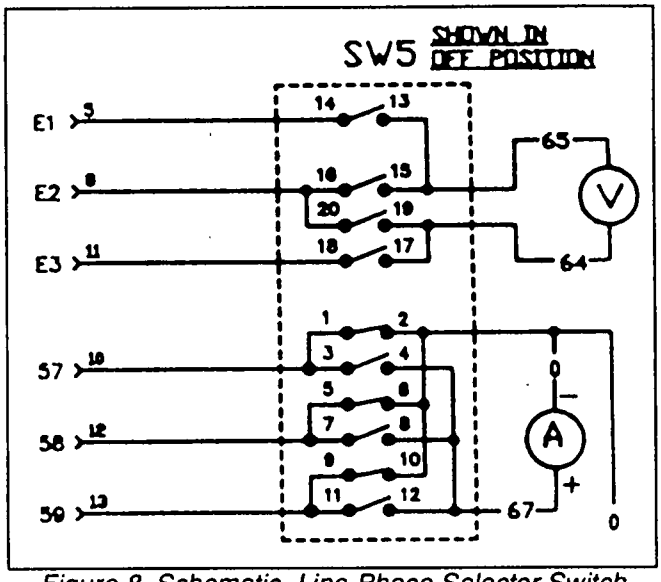


Figure 8. Schematic- Line-Phase Selector Switch

Engine Monitor Circuit Board

This "display" circuit board mounts six (6) advisory lamps, which are really LED's or light emitting diodes. A connector plug and wire set interconnects the circuit board with the DC control/latch-crank board.

Engine Run Relay (24 Volts Diesel Units Only)

Generator models having engines with 24 volts DC electrical systems use the standard Option "C" console. This console requires 12 volts DC for its operation. Engine starters, DC alternators, fuel solenoids, glow plugs or air intake heaters, etc., may require 24 volts DC power for their operation. Some method of energizing these 24 volts components with 12 volts console power must be provided. This is the engine run relay.

The engine run relay is energized by a 12 volts DC output from the DC control/latch-crank circuit board. When the relay is energized, its normally-open contacts close. On closure of those contacts, 24 volts DC can be delivered to those engine components requiring the higher voltage.

In Figure 9, 24 volts DC is available to the normally-open relay contacts via Wire No. 218. When the DC control circuit board's run relay (K2) energizes, 12 volts DC is delivered to relay terminal "A" via Wire 14. The relay then energizes, its contacts close and 24 volts DC is delivered to an engine fuel solenoid via Wire 219, and to the engine DC alternator via Wire 47.

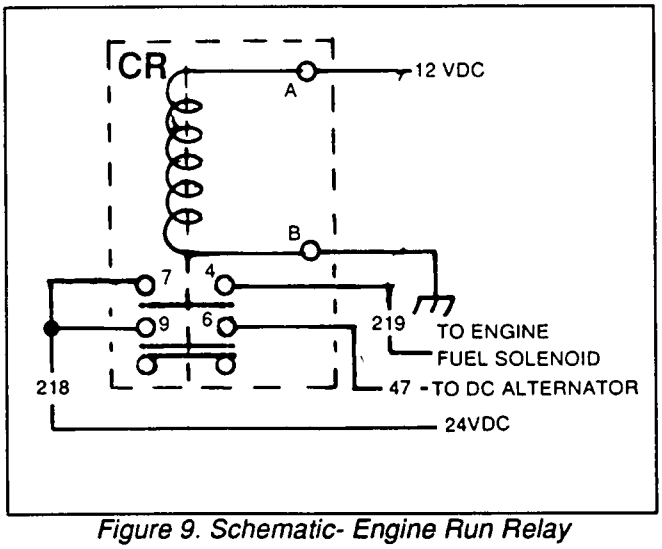


Figure 9. Schematic- Engine Run Relay

Preheat Relay (Diesel Engines Only)

The preheat relay (Figure 10) can be energized by (a) actuating the console mounted preheat switch, or (b) circuit board action during automatic startup. When energized, the relay contacts close to deliver 12 volts DC to an engine preheat contactor via Wire No. 150. Energizing the preheat contactor delivers 24 or 12 volts DC to an air intake heater or to engine glow plugs.

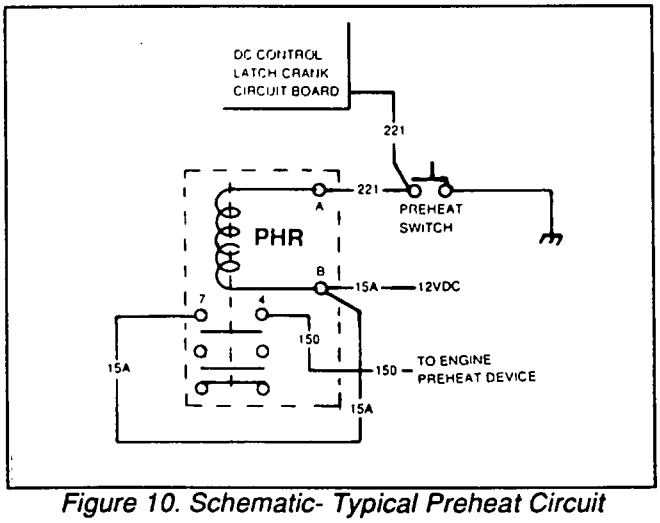


Figure 10. Schematic- Typical Preheat Circuit

Optional Alarm Relay

Some Option "C" consoles may be equipped with an optional alarm relay. The alarm relay can be used to turn on a remote mounted alarm device in the event of a monitored engine shutdown (see Section 6.2, "Engine Monitor Panel").

See Figure 11. Fused 12 volts DC is always available to the relay coil via Wire 15A, and to the circuit board via Wire 229. On occurence of any monitored shutdown fault, circuit board action will complete the Wire 229 circuit to ground. The alarm relay will then energize, its normally-open contacts will close and its normally-closed contacts will open. Note that the connected remote alarm device must have its own power supply.

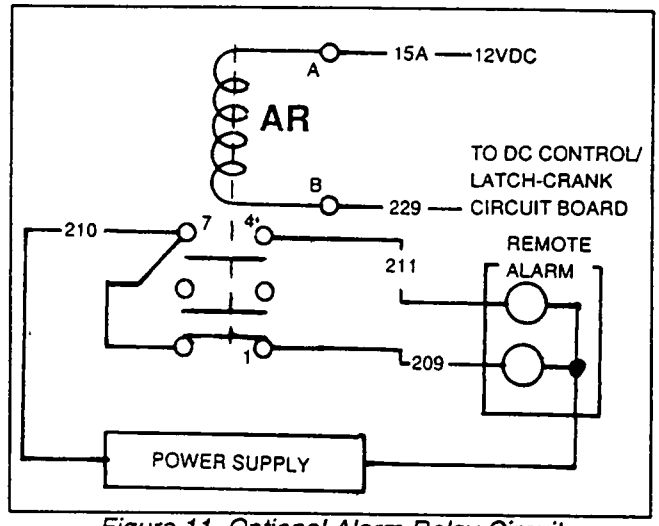


Figure 11. Optional Alarm Relay Circuit

Section 6.4
AC CIRCUITS OPERATION

General

A schematic diagram of the control console's AC circuits is shown in Figure 1, below. The console's AC circuits include (a) AC voltmeter circuit, (b) AC ammeter circuit, and (c) the frequency meter circuit.

In addition to the meter circuits, some field (rotor) excitation circuits are housed in the control console.

The AC Voltmeter Circuit

CIRCUIT DESCRIPTION:

Generator AC output voltage signals are delivered to the console AC voltmeter, via Wires No. E1, E2 and E3 (for 3-phase generators), and a line-phase selector switch. A 15-pin connector plug, located in the AC connection (lower) panel, connects the control console wiring to lower panel wiring.

LINE-PHASE SELECTOR SWITCH:

See "Line-Phase Selector Switch" on Page 6.3-4.

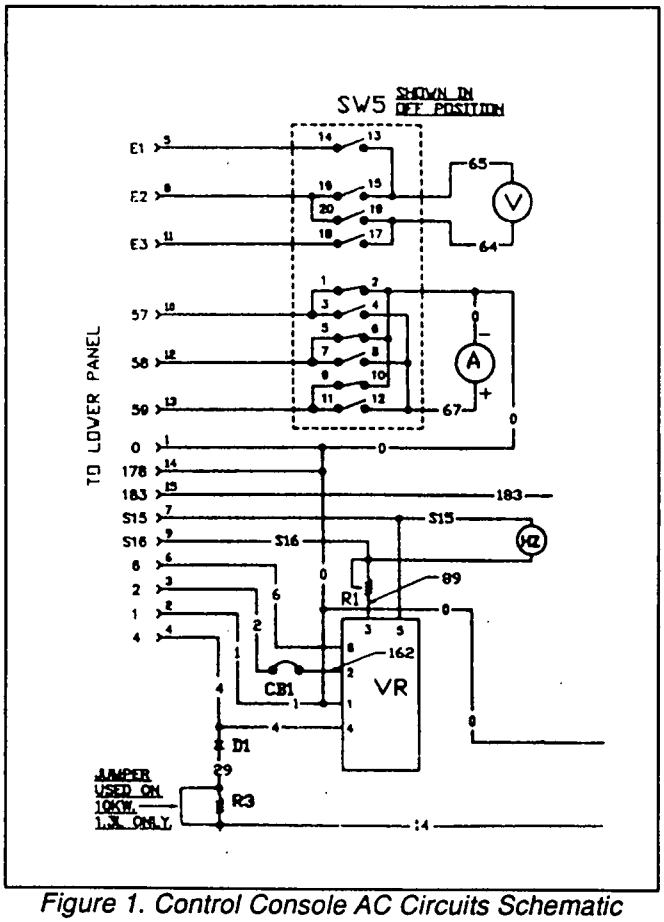


Figure 1. Control Console AC Circuits Schematic

The AC Ammeter Circuit

In the AC connection (lower) panel, generator AC output leads E1, E2 and E3 are routed through three current transformers. Current flow through leads E1/E2/E3 induce a current flow into the transformers. Transformer output current is then delivered to the console AC ammeter, via Wires 57, 58 and 59.

NOTE: The above is true of 3-phase units. On 1-phase units, generator AC output leads E1 and E3 are routed through transformers and only two transformers are required.

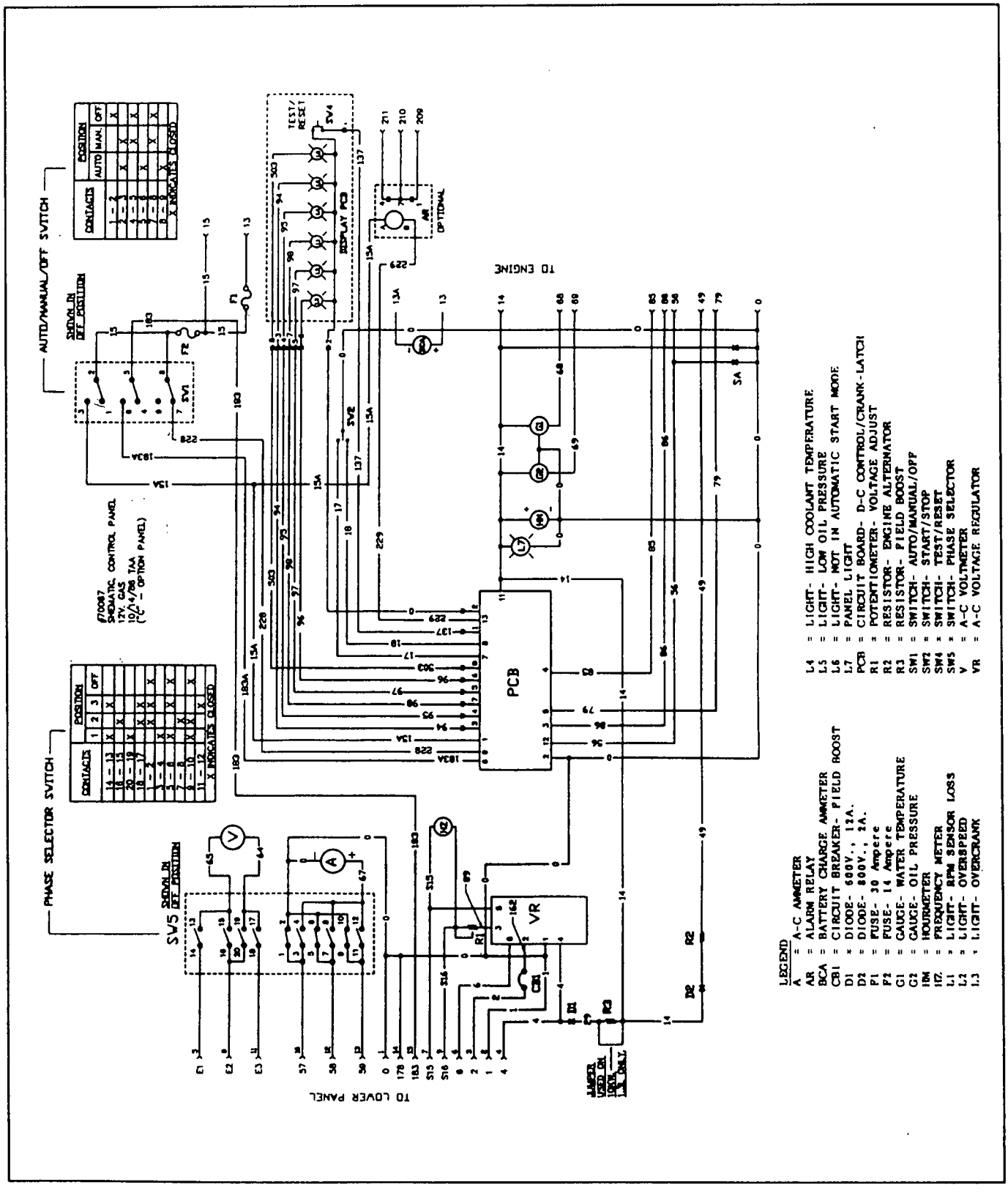
The AC Frequency Meter Circuit

The console's AC frequency meter is powered by sensing leads S15 and S16. Leads S15/S16 also deliver voltage/frequency sensing signals to the voltage regulator.

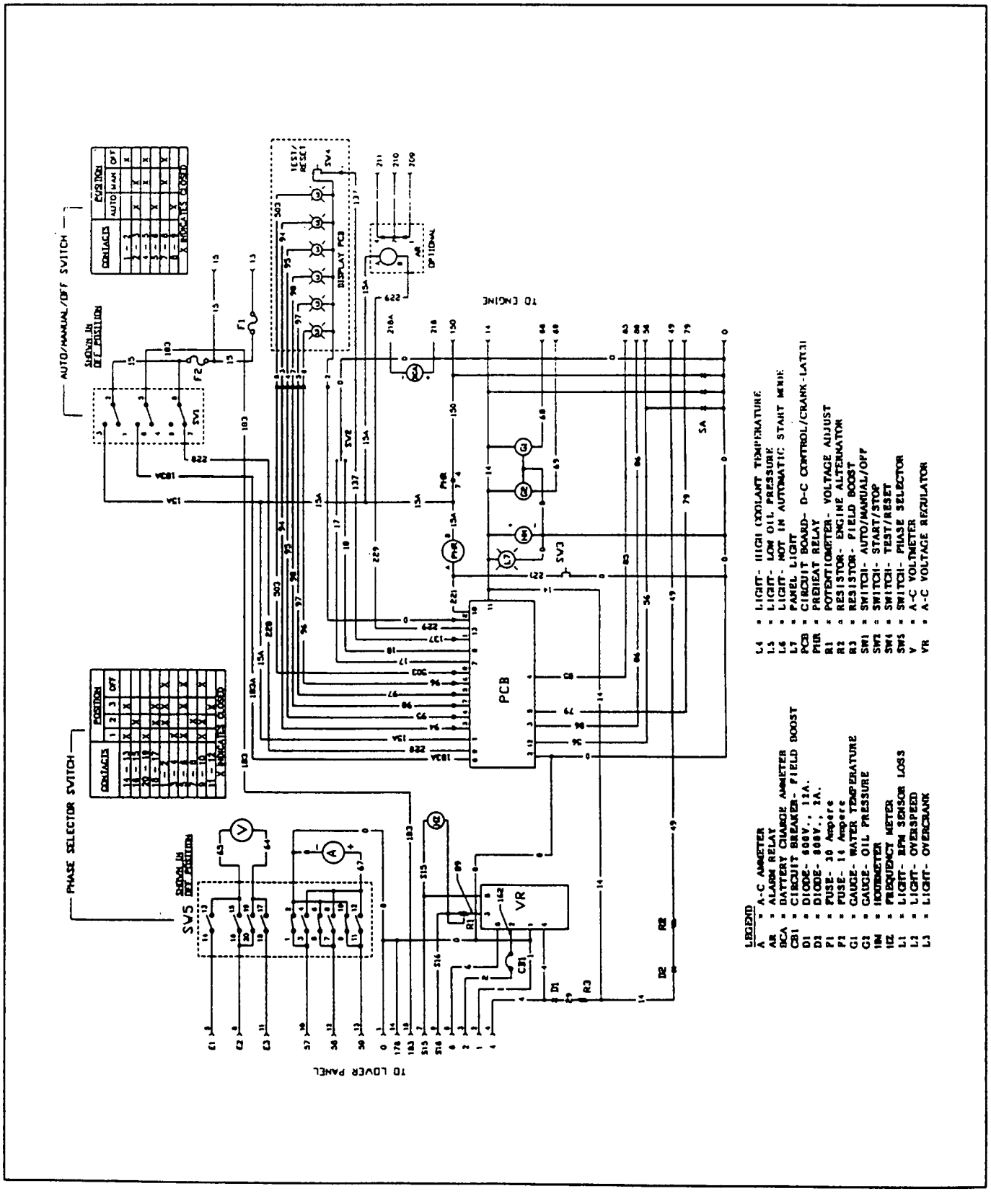
The Field Excitation Circuit

Refer to Part 2, Part 3 or Part 4 as appropriate for excitation circuit instructions and information.

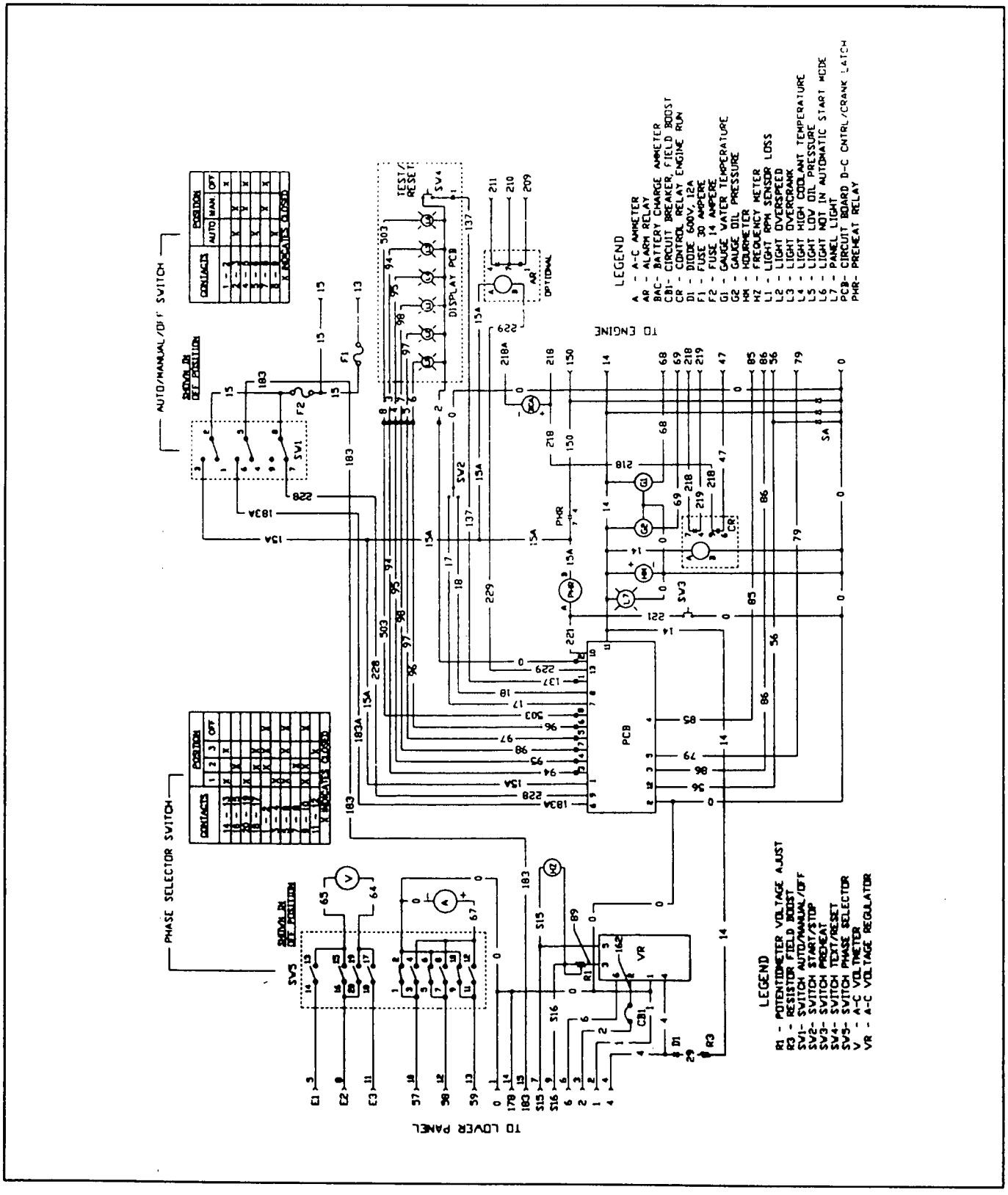
Section 6.5
DC CONTROL- 12 VOLTS GAS UNITS



Section 6.6
DC CONTROL- 12 VOLTS DIESEL UNITS

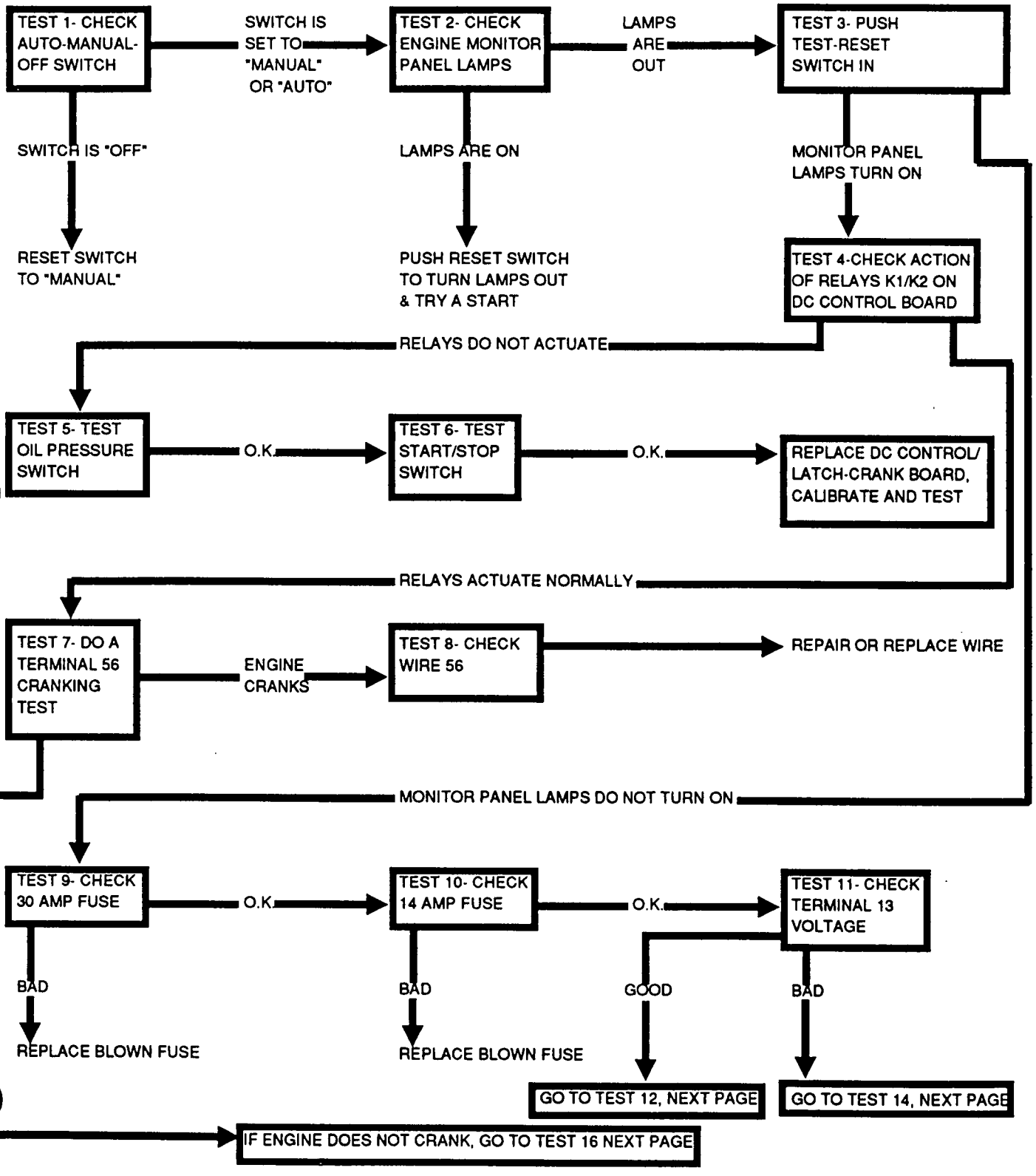


Section 6.7
DC CONTROL- 24 VOLTS DIESEL UNITS

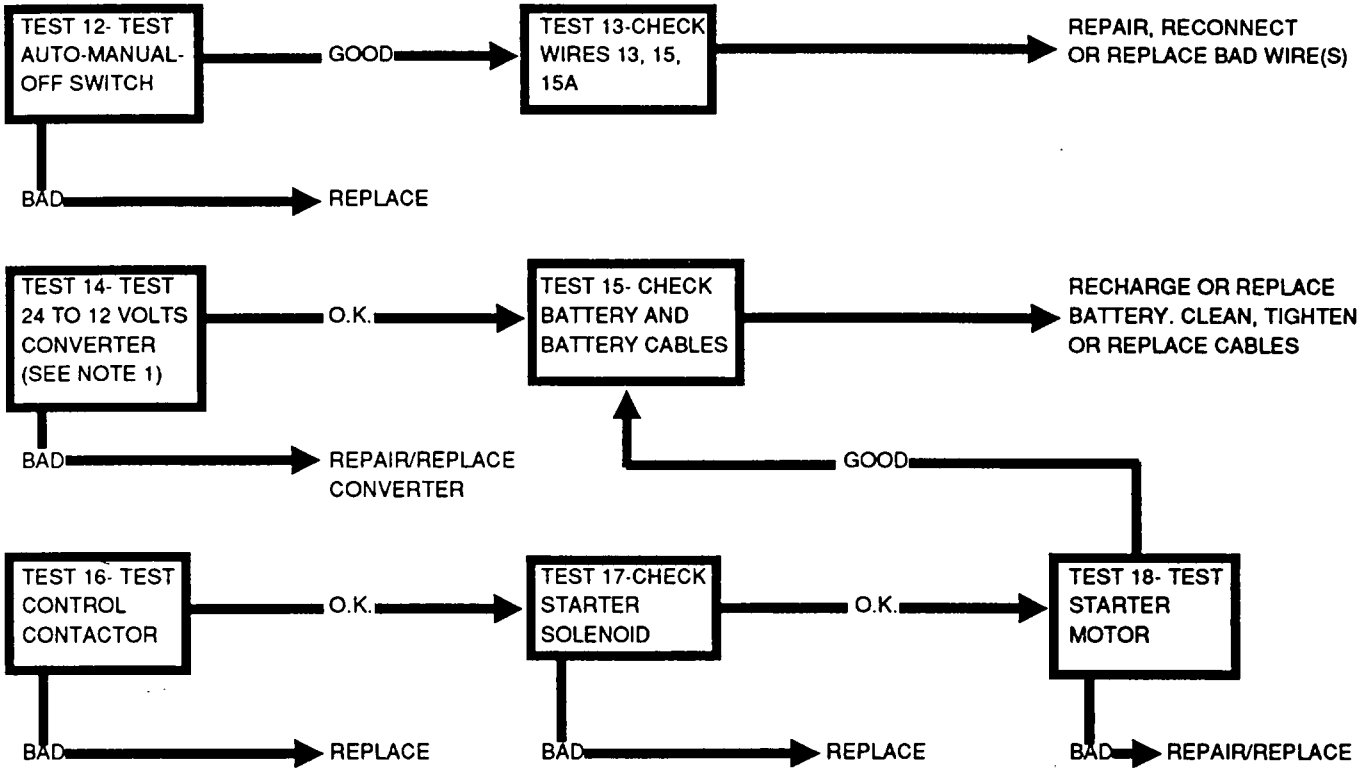


Section 6.8
TROUBLESHOOTING CHARTS

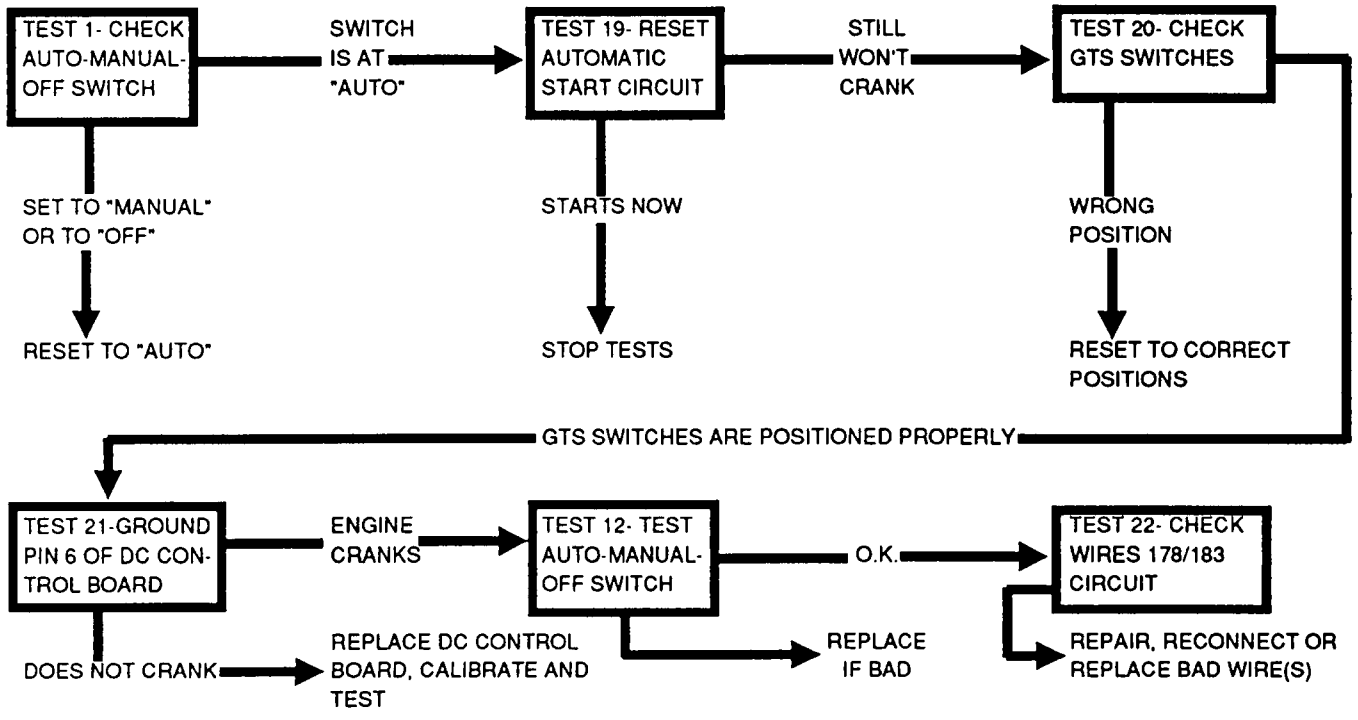
Problem 1- Engine Won't Crank Manually



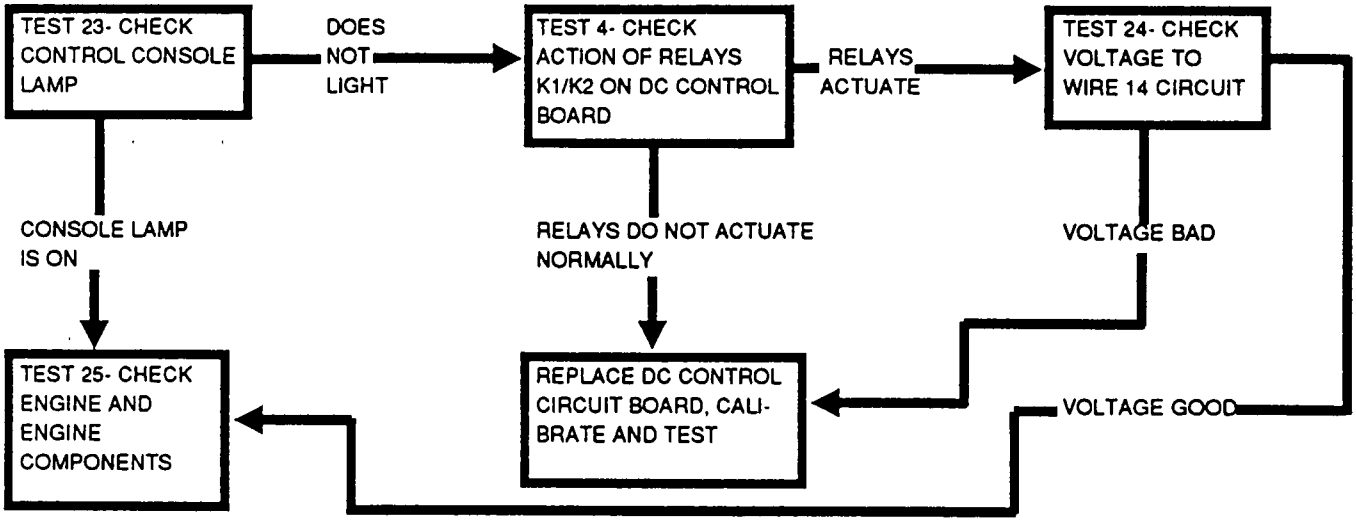
Problem 1- Engine Won't Crank Manually (Continued)



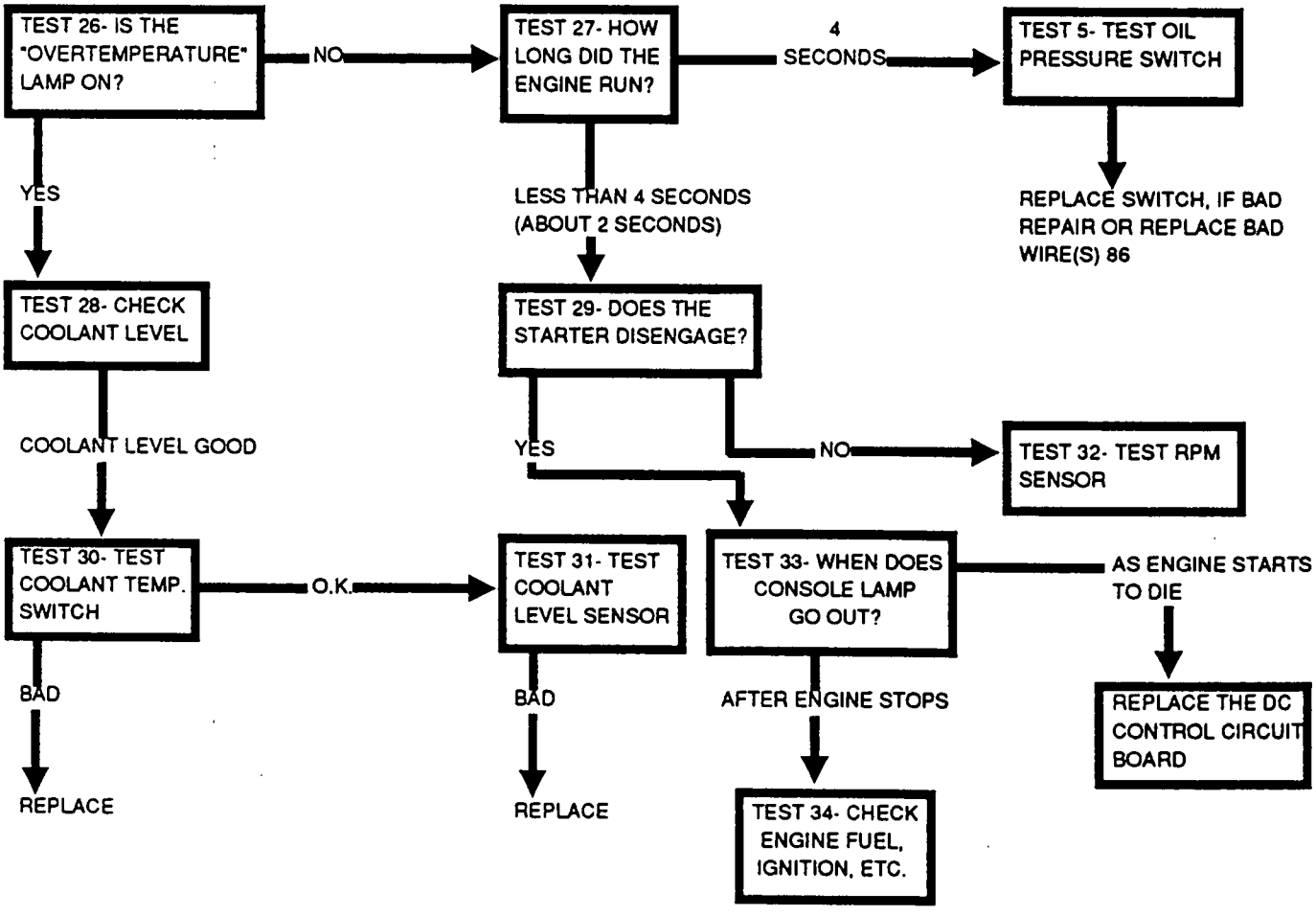
Problem 2- Engine Won't Crank in Automatic Mode



Problem 3- Engine Cranks But Won't Start



Problem 4- Engine Cranks, Starts, Then Shuts Down



Section 6.9
DIAGNOSTIC TESTS

NOTE: The numbered tests in this section coincide with test numbers in Section 6.8, "Troubleshooting Charts".

Test 1- Check Auto-Manual-Off Switch

DISCUSSION:

The generator engine will not crank either manually or in automatic mode if the console auto-manual-off switch is set to "Off". When the switch is set to "Manual", the engine can be cranked manually but not automatically. With "Auto" selected, the engine can be cranked manually or automatically.

If the switch is set to either "Manual" or "Off", the "Not in Automatic Start Mode" lamp will be on.

PROCEDURE:

Note the position of the Auto-Manual-Off switch. For manual operation, the switch should be set to "Manual". For automatic operation, set the switch to "Auto".

RESULTS:

1. Reset the switch to "Manual" or "Auto" as required.
2. If switch position is correct but engine will not crank, go to Test 2.

Test 2- Check Engine Monitor Panel Lamps

DISCUSSION:

If any one of the advisory lamps on the engine monitor panel is on, the engine will not crank automatically and cannot be cranked manually.

PROCEDURE:

Observe the engine monitor panel. If any lamp is on, push the test-reset switch in to reset the system. The lamp(s) should go out and further cranking should be possible.

RESULTS:

If all engine monitor panel lamps are out but engine will not crank, go to Test 3.

Test 3- Push Test-Reset Switch In

DISCUSSION:

If the engine will not crank manually or automatically, one possible cause of the problem is loss of power to the DC control/latch-crank circuit board. Such a power loss may be caused by (a) an open 30 amp fuse, or (b) an open 14 amp fuse, or (c) an open circuit in the power supply circuit (i.e., Wires 13, 15, 15A). Instead of testing fuses and wiring, we shall use a faster method to test the circuit board's power supply circuit.

PROCEDURE:

On the engine monitor panel, push the test-reset in. All lamps should light, indicating that DC power is available for circuit board operation.

RESULTS:

1. If all panel lamps turn on, go to Test 4.
2. If panel lamps do NOT turn on, go to Test 9.

Test 4- Check Action of Relays K1/K2 on DC Control Board

DISCUSSION:

During either a manual or automatic startup, DC control circuit board action will energize a crank relay (K1) and a run relay (K2). These two relays are mounted on the DC control/latch-crank circuit board. When crank relay (K1) energizes, its contacts close to deliver 12 volts DC to a Wire 56 circuit. This energizes a control contactor which, in turn, energizes a starter solenoid. The energized starter solenoid, in turn, energizes the starter motor and the engine cranks.

When run relay (K2) energizes, its contacts close to deliver 12 volts DC to a Wire 14 circuit. Wire 14 (a) turns on the console lamp, and (b) delivers DC power to the engine ignition system, to a fuel solenoid, etc. The engine can now start and run.

PROCEDURE:

Gain access to the control console interior where the DC control/latch-crank circuit board relays can be observed. Then, proceed as follows:

1. Set a VOM to a DC voltage scale greater than 12 volts.
2. Connect the positive (+) VOM test lead to terminal 56 of terminal board TB1. Connect the common (-) VOM test lead to terminal 0 (ground).
3. Try to crank the engine by holding the start/stop switch at "Start". Crank relay (K1) should energize, the VOM should indicate 12 volts DC, and the engine should crank.
4. Try to crank the engine. Run relay (K2) should energize, engine should start and run.

RESULTS (IF ENGINE DOES NOT CRANK):

1. If crank relay K1 does NOT actuate, go to Test 5.
2. If relay K1 actuates, but VOM does NOT read 12 volts in Step 3, replace the DC control/latch-crank circuit board. Calibrate the new board and test operation.
3. If crank relay K1 actuates, 12 volts DC is read in Step 3, but engine does not crank, go to Test 7.

Test 4- Check Action of Relays K1/K2 on DC Control Board (Continued)

RESULTS (ENGINE CRANKS BUT WON'T START):

1. If the run relay (K2) energizes in Step 5 and if the engine cranks but won't start, go to Test 24 ("Check Output Voltage to Wire 14 Circuit").
2. If the run relay does NOT actuate in Step 4, replace the DC control/latch-crank circuit board. Calibrate and test the new board.

Test 5- Test Oil Pressure Switch

DISCUSSION:

The oil pressure switch has normally-closed contacts which are held open by oil pressure during cranking and running (approximately 10 psi and higher). With the engine shut down, the switch contacts should be closed and its Wire 86 circuit should be closed to frame ground. The DC control/latch-crank board will initiate engine cranking only if the oil pressure switch circuit is closed to ground, i.e., when zero volts is read in the circuit. During a cranking and startup operation and after the switch contacts have opened, the circuit to ground will be broken and circuit voltage will build to approximately 11 volts DC.

PROCEDURE:

1. Set a VOM to read DC voltage and to a voltage scale greater than 12 volts DC.
2. Connect the positive (+) VOM test lead to Terminal 86 of terminal board TB1 and the common (-) test lead to terminal 0 (ground). With the engine shut down, voltage reading should be zero.

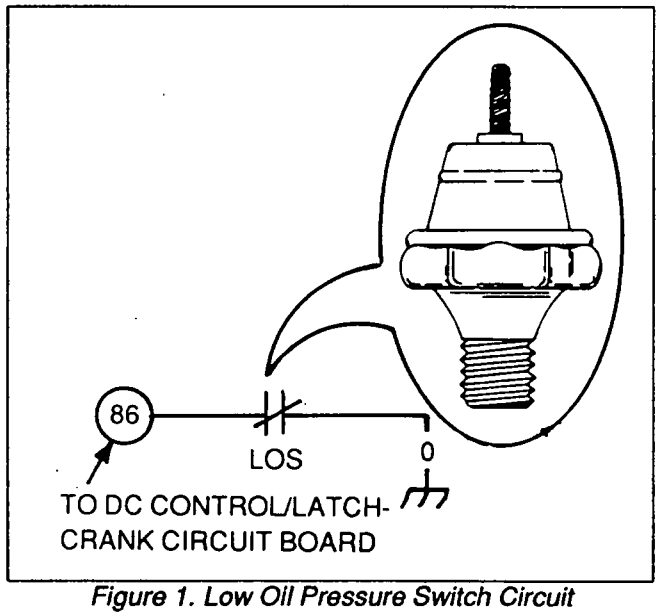


Figure 1. Low Oil Pressure Switch Circuit

RESULTS:

1. If the VOM reads about 11 volts, either the switch contacts or the Wire 86 circuit is open.
   a. Replace the oil pressure switch if its contacts are open.
   b. If switch contacts are closed, check the Wire 86 circuit for an open condition. Repair, reconnect or replace wiring as necessary.
2. If the VOM read zero volts, go on to Test 6.

Test 6- Test Start/Stop Switch

DISCUSSION:

Failure of the engine to crank manually can be caused by a defective start/stop switch. When the switch is set to its "Run" (centered) position, approximately 11 volts DC should be read across the switch Wire 17 terminal to ground. Set the switch to its "Start" position and the voltage reading should drop to "zero".

PROCEDURE A:

1. Set the VOM to read DC volts and to a scale greater than 12 volts.
2. Connect the positive (+) VOM test probe to the Wire 17 terminal of the start/stop switch and the common (-) test probe to terminal 0 of terminal board TB1.
   a. Set the start/stop switch to "Run" (centered) position. The VOM should read approximately 11 volts DC.
   b. Now, set the switch to "Start". The VOM should read "zero" volts.

RESULTS:

1. If the VOM reads about 11 volts DC in Step 2(a) and the voltage drops to "zero" in Step 2(b), but engine will not crank, replace the DC control/latch-crank circuit board. Calibrate the board and test operation.
2. If the VOM reads 11 volts DC in Step 2(a) but voltage does NOT drop to zero in Step 2(b), either the switch is defective or Wire 0 (switch terminal to ground) is open. Go to Step 3 of this test (under PROCEDURE B, below).
3. If the VOM does NOT read about 11 volts DC in Step 2(a), check Wire 17 between the switch and the DC control/latch-crank board.
   a. Repair, reconnect or replace Wire 17, if defective.
   b. If Wire 17 is good but the VOM does not read 11 volts in Step 2(a), replace the DC control/latch-crank board. Calibrate the board and test operation.

PROCEDURE B:

3. Inspect and test Wire 0 from the start/stop switch to its grounded connection. If Wire 0 is bad, it must be repaired, reconnected or replaced.
4. Test the start/stop switch as follows:

Test 6- Test Start/Stop Switch (Continued)

a. Set a VOM to its "Rx1" scale and zero the meter.
b. To prevent interaction, disconnect Wires 17, 18 and 0 from the start/stop switch.
c. Connect the VOM test leads across the switch Wire 17 and Wire 0 terminal. Set the switch to "Start", "Run" and "Off" while observing the meter readings. Readings at each switch position should be as indicated in the chart below.
d. Now, connect the meter test leads across the switch Wire 18 and Wire 0 terminals. Observe the meter reading with the switch set to "Start", "Run" and "Off". Readings should be as indicated in the chart below.

VOM TEST LEADS ACROSS TERMINALS	DESIRED METER READING		
	START	RUN	STOP
17 and 0	Continuity	Infinity	Infinity
18 and 0	Infinity	Infinity	Continuity

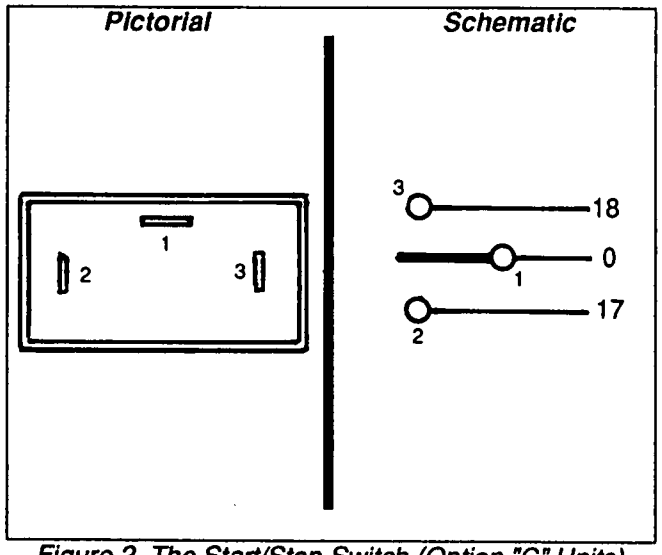


Figure 2. The Start/Stop Switch (Option "C" Units)

RESULTS:
1. Repair, reconnect or replace Wire 0 as necessary.
2. Replace the start/stop switch if it fails the test.

Test 7- Do a Terminal 56 Cranking Test

DISCUSSION:
During startup, a crank relay (K1) on the DC control/latch-crank board must be energized by circuit board action. When the K1 relay is energized, its contacts close to deliver a DC voltage to the Wire 56 circuit. Wire 56 circuit then energizes a control contactor (CC) to initiate engine cranking.

When the engine will not crank, this test will tell you the following:

- If the problem is in the Wire 56 circuit betwen terminal board TB1 and the circuit board, or in the circuit board itself.
- If the problem is in the Wire 56 circuit to the control contactor or in the engine cranking system.

PROCEDURE:
Connect a jumper wire from terminal 13 of terminal board TB1 to terminal 56. The engine should crank.

RESULTS:
1. If the circuit board crank relay K1 actuated in Test 4 and the engine did not crank, but the engine cranks now, go to Test 8. The problem must be in Wire 56 between terminal board TB1 and the DC control circuit board.
2. If the engine does not crank during this test, go to Test 16. The problem must be in the engine cranking circuit.

Test 8- Check Wire 56

DISCUSSION:
During startup, the DC control/latch-crank board must deliver a DC voltage to the Wire 56 circuit to initiate engine cranking. This test will determine if there is a DC output to terminal 56 of TB1 and, if there is no DC output to that terminal, if Wire 56 or the circuit board is/are at fault.

PROCEDURE:
1. Set a VOM to read DC volts and to a scale greater than 12 volts.
2. Connect the positive (+) VOM test probe to terminal 56 of terminal board TB1. Connect the common (-) test lead to terminal 0 of TB1.
3. Hold the start/stop switch at "Start". Crank relay K1 on the circuit board should actuate and the VOM should read approximately 11-12 volts DC.

RESULTS:
1. If the crank relay K1 actuates but the VOM does not indicate a DC voltage, proceed as follows:
   a. Inspect and test Wire 56 between terminal board TB1 and the DC control board. Repair, reconnect or replace Wire 56 as required.
   b. If DC voltage was NOT indicated during the test and Wire 56, between terminal 56 and the circuit board, checks good replace the DC control/latch-crank circuit board. Calibrate the new board and test operation.
2. If voltage reads good in Step 3 but engine did not crank, go to Test 16.

Test 9- Check 30 Amp Fuse

DISCUSSION:

In Test 3, if the test-reset switch was actuated and the engine monitor panel lamps did not light, one possible cause is a blown fuse.

PROCEDURE:

Remove the 30 amp fuse from the fuse holder. Use a VOM to test the fuse for "continuity".

RESULTS:

1. If fuse has blown, it must be replaced.
2. If the 30 amp fuse checks good, go to Test 10.

Test 10- Check 14 Amp Fuse

DISCUSSION:

Failure of the engine monitor panel lamps to turn on when the test-reset switch is pushed in can be caused by a blown 14 amp fuse.

PROCEDURE:

Gain access to the control console interior. Remove the 14 amp fuse from its in-line fuse holder. Test and inspect the fuse.

RESULTS:

1. Replace the 14 amp fuse, if it has blown.
2. If the 14 amp fuse checks good, go to Test 11.

Test 11- Check Terminal 13 Voltage

DISCUSSION:

Terminal 13 is unfused battery voltage from the generator battery. This terminal is always electrically hot. If, for any reason, battery voltage is not available to terminal 13, the engine will not crank and start (either in automatic or manual mode). This test will determine if battery voltage is available to terminal 13.

PROCEDURE:

1. If so equipped, turn off the power supply to the utility powered battery charger to prevent the charger from affecting the battery voltage reading.
2. Set a VOM to read DC volts and to a scale greater than 12 volts.
3. Connect the positive (+) VOM test probe to terminal 13 of TB1; the common (-) test probe to terminal 0. The meter should read normal battery voltage (between 12-13 volts DC).

NOTE: Units with a 24 volts engine electrical system will be equipped with a 24-to-12 volts DC converter. The converter will reduce the 24 volts DC output of the unit batteries to approximately 12 volts DC. It is the converter output of 12 volts DC that is available to terminal 13.

RESULTS:

1. If battery voltage is good, go on to Test 12.
2. If battery voltage is zero or low, go to Test 14.

Test 12- Test Auto-Manual-Off Switch

DISCUSSION:

The power for DC control/latch-crank board operation is delivered to the board through the auto-manual-off switch contacts. Thus, failure of the engine to crank in either manual or automatic mode may be caused by a defective switch. The switch is shown in Figure 3.

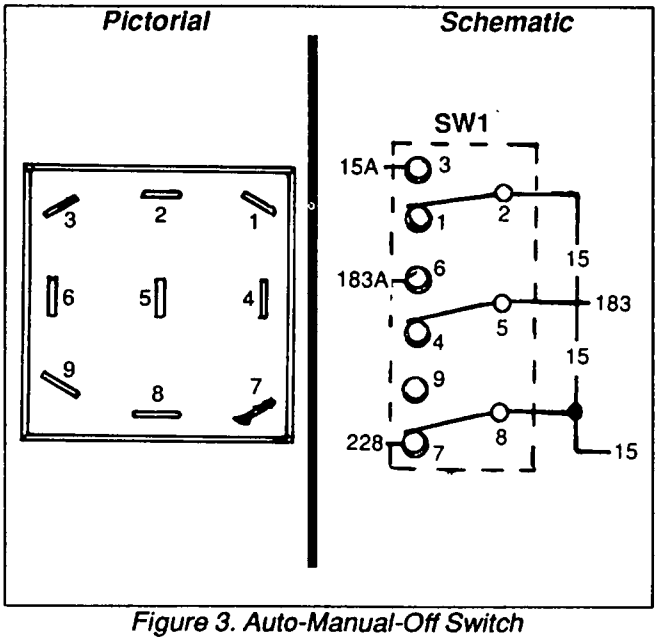


Figure 3. Auto-Manual-Off Switch

PROCEDURE:

1. Disconnect wires from the switch terminals to prevent interaction.
2. Set a VOM to its "Rx1" scale and zero the meter.
3. Connect VOM test probes across switch terminals as listed in the following chart. Actuate switch to "Auto", "Man" and "Off" and note the VOM readings.

Test 12- Test Auto-Manual-Off Switch (Continued)

VOM readings at each switch position should be as stated in the chart for the appropriate switch contacts.

TEST ACROSS CONTACTS	SWITCH POSITION		
	AUTO	MAN	OFF
1 & 2	Infinity	Infinity	Continuity
2 & 3	Continuity	Continuity	Infinity
4 & 5	Infinity	Continuity	Continuity
5 & 6	Continuity	Infinity	Infinity
7 & 8	Infinity	Continuity	Continuity
8 & 9	Continuity	Infinity	Infinity

Reconnect all wires to the correct switch terminals before proceeding.

RESULTS:

1. Replace the auto-manual-off switch, if defective.
2. If the switch checks good, go to Test 13.

Test 13- Check Wires 13, 15 and 15A

DISCUSSION:

Wires 13, 15 and 15A deliver battery voltage to the DC control/latch-crank board via the auto-manual-off switch, the 30 amp fuse and the 14 amp fuse. An open condition in these circuits can be the cause of a "no-crank" condition. A shorted condition will probably result in a blown fuse. You should have already tested the fuses and the auto-manual-off switch. If those components tested good and the engine still won't crank, the Wires 13, 15 and 15A circuits should be inspected and tested.

PROCEDURE:

Inspect the Wires 13, 15, 15A circuits between terminal board TB1 and the auto-manual-off switch. Also inspect and test those wires between the auto-manual-off switch and the DC control/latch-crank board.

RESULTS:

Repair, reconnect or replace any open or shorted wire(s).

Test 14- Test 24 to 12 Volts Converter

DISCUSSION:

Units equipped with engines having a 24 volts DC engine electrical system require a DC converter to reduce the battery voltage down to the 12 volts DC required by control console components. If a check of the voltage at terminal 13 of terminal board TB1 indicates that voltage is extremely low or zero, perhaps the DC converter is defective. Figure 4 below shows the DC converter circuit board, located in the AC connection (lower) panel.

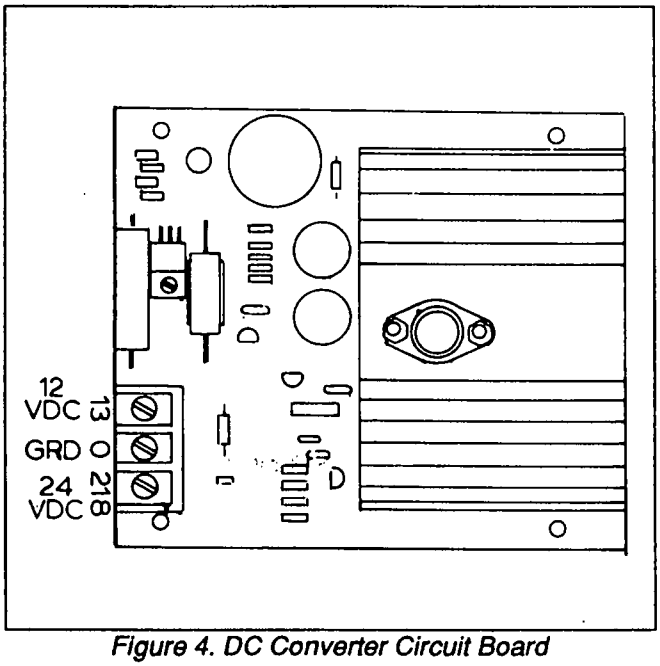


Figure 4. DC Converter Circuit Board

PROCEDURE:

1. Locate the DC converter in the AC connection (lower) panel.
2. Connect the VOM positive (+) test probe to the converter's terminal 13, the common (-) test probe to terminal 0. The meter should read approximately 12 volts DC (control console voltage).
3. Connect the positive (+) VOM test probe to converter terminal 218 and the common (-) test probe to terminal 0. The meter should read approximately 24 volts DC (engine system voltage).

RESULTS:

1. If 24 volts DC was indicated in Step 3, but 12 volts was NOT read in Step 2, replace the DC converter.
2. If normal DC voltage was indicated in both Steps 2 and 3, go to Test 15.

Test 15- Check Battery and Battery Cables

DISCUSSION:

A discharged battery or defective battery cables can result in failure of the engine to crank.

NOTE: A "quick test" of the battery system is to set the start/stop switch to "Start". If the engine monitor panel lamps flash dimly when the switch is released, the battery may be weak, the DC converter (24 volts units) may be bad, or battery cable(s) may be defective.

PROCEDURE:

Inspect the battery cables and cable connections carefully. Battery posts and cables must be clean, tight and free of corrosion. Clean cables and connections as required. Replace any damaged or defective cable(s).

Use an automotive type battery hydrometer to test the battery (or batteries) for (a) state of charge and (b) condition. Follow the hydrometer manufacturer's instructions carefully.

State of Charge: If the hydrometer does not have a percentage of charge scale, compare the specific gravity reading obtained with the following chart.

SPECIFIC GRAVITY	PERCENTAGE OF CHARGE
1.260	100%
1.230	75%
1.200	50%
1.170	25%

Condition: Charge the battery to a 100 percent state of charge. Then, test the specific gravity of fluid in all battery cells. If the difference in specific gravity between the highest and lowest reading cell is greater than 0.050 (50 points), the battery is nearing the end of its useful life and should be replaced.

RESULTS:

1. Recharge or replace battery as needed. Replace any defective battery cable(s).
2. If battery and battery cables are good, go to Test 16.

Test 16- Test Control Contactor

DISCUSSION:

See "Troubleshooting Charts" in Section 6.8. If Test 7 was completed and the engine did not crank, it is likely that one or more of the engine cranking system components has failed. Engine cranking system components include (a) a control contactor, (b) a starter solenoid, and (c) a starter motor.

12 Volts Engine Electrical Systems: See Figure 5. Battery voltage is available to one of the large terminal studs via Wire 13. When the DC control/latch-crank board's crank relay (K1) is energized, a DC voltage is delivered to the Wire 56 terminal stud to energize the control contactor. The contactor's normally-open contacts then close to deliver battery voltage to the starter solenoid (SC) via Wire 16.

24 Volts Engine Electrical Systems: See Figure 6. Battery voltage (24 volts DC) is available to one of the large terminal studs via Wire 218. When the DC control board's crank relay (K1) is energized, 12 volts DC is delivered to the contactor via Wire 56. The contactor's normally-open contacts close to deliver 24 volts DC to the starter solenoid (SC) via Wire 16.

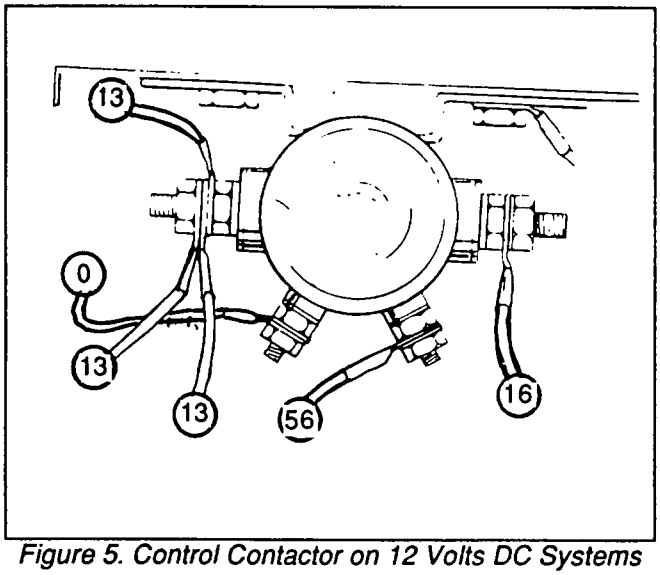


Figure 5. Control Contactor on 12 Volts DC Systems

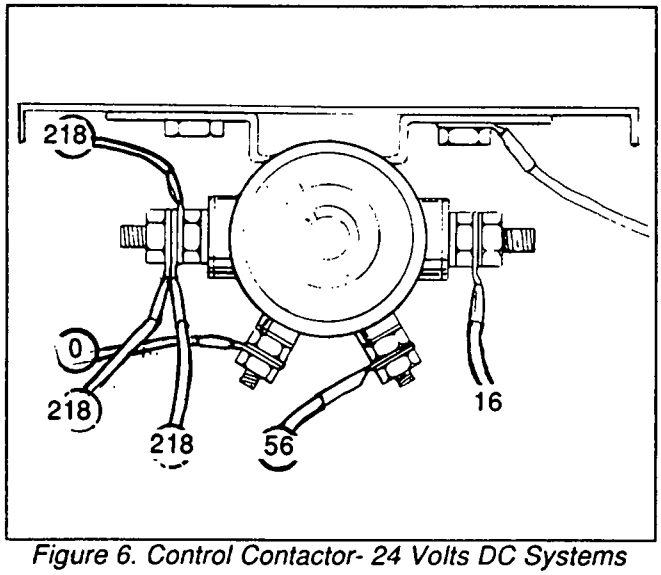


Figure 6. Control Contactor- 24 Volts DC Systems

PROCEDURE:

1. Set a VOM to read DC voltage.
2. Connect one VOM test probe to the Wire 56 terminal stud of the control contactor, the other test probe to to the Wire 0 (grounded) terminal.
3. Set the start/stop switch at "Start". The VOM should read approximately 11-12 volts DC. Release the switch and VOM reading should drop to zero.

Test 16- Test Control Contactor (Continued)

4. Now, connect the VOM test probes to the control contactor terminal studs as follows:
   a. On units with 12 volts DC engine electrical system, connect the positive (+) VOM test probe to the large Wire 13 terminal stud. Connect the the common (-) VOM test probe to frame ground. The VOM should read battery voltage (about 12 volts DC).
   b. On units with 24 volts DC engine electrical system, connect the positive (+) VOM test probe to the large Wire 218 terminal stud and the common (-) test probe to frame ground. The VOM should read read battery voltage (about 24 volts DC).
5. Finally, connect the positive (+) VOM test probe to the Wire 16 terminal stud and the common (-) test probe to frame ground. Set the start/stop switch to "Start" and the VOM should read battery voltage. Release the switch and the VOM reading should drop to zero.

RESULTS:

1. If the VOM does not read normal battery voltage in Step 4, inspect and test the positive battery cable. Clean or replace the cable as necessary.
2. If the VOM reads normal battery voltage in Step 4 but not in Step 5, replace the control contactor.
3. If the VOM reads normal battery voltage in both Steps 4 and 5, but the engine does not crank, go to Test 17.

Test 17- Check Starter Solenoid

DISCUSSION:

On most standby engines, the starter solenoid is a part of the starter motor (see Figure 7). When energized by DC battery voltage from Wire 16, the starter solenoid (SC) should energize to (a) move the starter pinion gear into mesh with the engine ring gear, and (b) close a set of contacts to energize the starter motor itself.

NOTE: Complete Test 16 first before performing this test or the test results may not be valid.

PROCEDURE:

Connect the positive (+) VOM test probe to the Wire 16 terminal of the starter solenoid and the common (-) test probe to frame ground. Check for the following results:

- Battery voltage should be indicated when the start/stop switch is set to "Start". The reading should drop to zero when the start/stop switch is released.
- The starter pinion gear should throw out to engage the engine ring gear.
- The starter motor should energize and operate.

For additional tests of the starter solenoid and starter motor, refer to the appropriate engine service manual. Follow the instructions in the engine service manual for testing, servicing and repair of starter motors.

RESULTS:

1. If battery voltage is NOT indicated at the Wire 16 terminal when the start/stop switch is set to "Start", inspect and test the Wire 16 cable between the control contactor and the starter solenoid. Replace the cable if it is defective.
2. If battery voltage is indicated at the Wire 16 terminal, but the starter solenoid does not throw out or the starter does not operate, test the starter solenoid and the starter motor as outlined in the appropriate engine service manual.

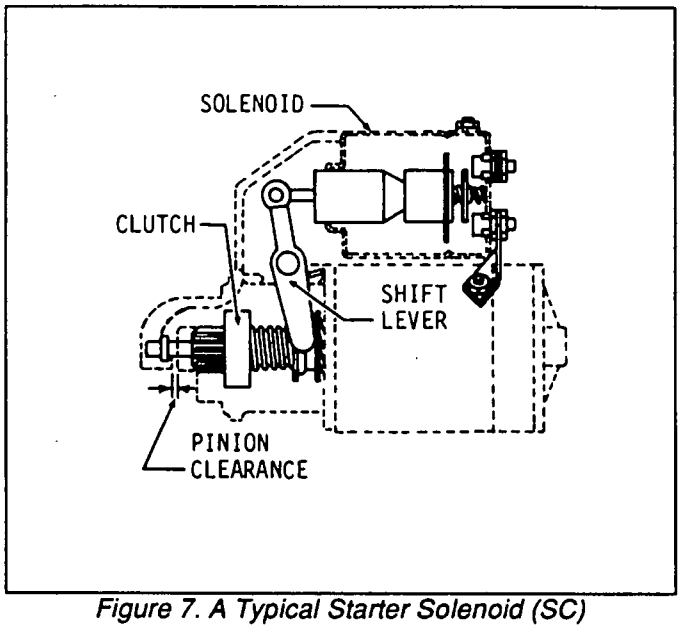


Figure 7. A Typical Starter Solenoid (SC)

Test 18- Test Starter Motor

DISCUSSION:

Read "Discussion" under Test 17.

PROCEDURE:

Test the starter motor as outlined in the appropriate engine service manual.

RESULTS:

Repair or replace the starter motor, if necessary.

Test 19- Reset Automatic Start Circuit

DISCUSSION:

If the engine will not crank in automatic operating mode, it is possible that the automatic start circuit needs to be reset. Automatic cranking and startup normally occur when solid state circuit boards in a "GTS" automatic transfer switch detect a utility power source dropout below a pre-set voltage. Transfer switch action will then close the automatic start circuit (Wires 178/183) to initiate engine cranking and startup. After an automatic start attempt that has failed, the automatic start circuit may have to be reset.

Test 19- Reset Automatic Start Circuit (Continued)

PROCEDURE:

If any fault lamp on the engine monitor panel is on, reset the automatic start circuit as follows:
Method 1: On the engine monitor panel, push the test-reset switch in. All panel fault lamps must go out.
Method 2: Set the auto-manual-off switch to "Off" and then back to "Auto".

RESULTS:

1. If, after resetting the auto start circuit, the engine cranks in automatic mode, discontinue tests.
2. If, after resetting the auto start circuit, engine still won't crank in automatic mode, go to Test 20.

Test 20- Check GTS Switches

DISCUSSION:

Cranking and startup in automatic mode cannot occur unless transfer switch action closes the automatic start circuit. The GTS transfer switch is equipped with (a) a system test switch on the switch enclosure door, and (b) a maintenance disconnect switch housed in the GTS enclosure. Both switches must be properly positioned in order for automatic operation to occur. Refer to Part 8 or 9 of this manual as appropriate.

PROCEDURE:

1. On the GTS transfer switch enclosure door, set the system test switch to "Automatic" position.
2. In the GTS enclosure, set the maintenance disconnect switch to "Automatic".

RESULTS:

If GTS switches are positioned correctly but automatic startup will not occur, go to Test 21.

Test 21- Ground Pin 6 of DC Control Board

DISCUSSION:

Normal automatic cranking and startup are initiated when solid state circuits in the GTS transfer switch sense that a utility power source dropout has occured. On occurence of a utility power source dropout, GTS circuit board action closes the automatic start circuit (Wires 178 and 183) to ground. With that circuit closed to ground, the generator's DC control/latch-crank board initiates engine cranking. This test will determine if the DC control/latch-crank circuit board will respond properly when the auto start circuit is grounded.

PROCEDURE:

Connect a jumper wire from Pin 6 (Wire 183A) of the DC control/latch-crank board and to terminal 0 (ground) of terminal board TB1. The engine should crank as in automatic operation.

RESULTS:

1. If automatic cranking occurs now but does not occur normally, complete Test 12, "Test Auto-Manual-Off Switch".
   a. If auto-manual-off switch is good, go to Test 22, "Check Wires 178/183 Circuit".
   b. Replace auto-manual-off switch if it is bad.
2. If engine did NOT crank when Pin 6 of the circuit board was grounded, replace the DC control/latch-crank board. Calibrate the board and test operation.

NOTE: Wire 183 (Pin 6) is the "high side" of the 2-wire start circuit, while Wire 178 is the "grounded" side of the circuit. Automatic startup is normally initiated when GTS circuit board action closes the 183 circuit to the grounded side.

Test 22- Check Wires 178/183 Circuit

DISCUSSION:

An open condition in the Wires 178/183 circuit will result in failure of the engine to crank in automatic mode.

PROCEDURE:

1. Start at the GTS transfer switch terminal board, as follows:
   a. Connect a jumper wire across terminals 178/183 in the transfer switch enclosure. The generator engine should crank in automatic mode.
   b. Disconnect the jumper wire and the engine should shut down.
2. Now, do the same thing across the 178/183 terminals in the generator's AC connection (lower) panel. The engine should crank. Disconnect the jumper and engine should shut down.
3. In the generator control console, connect a jumper wire to the Wire 183 terminal of the auto-manual-off switch and to terminal 0 (ground) of terminal board TB1. The engine should crank in automatic mode.

RESULTS:

1. If the engine cranks and starts in Step 1 but will not crank on occurence of a utility power outage, the problem is in the GTS transfer switch.
2. If engine cranked in Step 2 but did not crank in Step 1, look for an open condition in Wires 178/183 between the generator and the transfer switch.
3. If engine cranks in Step 3 but did not crank in Step 2, look for an open condition in Wires 178/183 between the control console and the AC connection (lower) panel.

Test 23- Check Control Console Lamp

DISCUSSION:

If the engine cranks normally but will not start, the generator's control console lamp can be a valuable troubleshooting aid. During manual or automatic startup, the DC control board's run relay (K2) should energize to deliver 12 volts DC to a Wire 14 circuit. The Wire 14 circuit then energizes engine components needed for engine startup and running operations. That circuit

Test 23- Check Control Console Lamp (Continued)

also turns on the control console lamp. Thus, if the lamp turns on while cranking, it is evident that the Wire 14 circuit has been energized. If the Wire 14 circuit is energized but the engine will not start, look for a problem in the engine itself (fuel flow, ignition, etc.).

PROCEDURE:

Crank the engine while observing the control console lamp (the "dash light"). The lamp should illuminate, indicating the DC control board is functioning properly and the Wire 14 circuit is energized.

RESULTS:

1. If the lamp (dash light) comes on but engine will not start, go to Test 25.
2. If the console lamp does NOT turn on, perform Test 4 to check the DC control circuit board and relays.
   a. If relay K2 actuates normally during Test 4, but engine will not start, go to Test 24.
   b. If relay K2 does NOT actuate normally during Test 4, replace the DC control/latch-crank board. Calibrate and test the circuit board.

Test 24- Check Voltage to Wire 14 Circuit

DISCUSSION:

It is remotely possible for the relay K2 to actuate normally during cranking and startup but fail to deliver a voltage to the Wire 14 circuit. This could happen if the relay contacts were defective or if the contacts remain open. Before performing this test, you should have completed Test 23 and observed that the console lamp did not light. Secondly, you should have completed Test 4 and noted that the relay K2 actuated but engine startup did not occur. This test will verify whether or not a DC voltage is actually being delivered to Wire 14.

PROCEDURE:

1. Set a VOM to read DC volts and to a scale greater than 12 volts.
2. Connect the positive (+) VOM test probe to terminal 14 of terminal board TB1; the common (-) test probe to terminal 0 of TB1.
3. Set the start/stop switch to "Start". The VOM should read approximately 12 volts DC.
4. Release the start/stop switch to its "Run" position. The VOM should read zero volts.

RESULTS:

1. If normal battery voltage is indicated in Step 3, but engine will not start, go to Test 25.
2. If normal battery voltage is NOT indicated in Step 3, replace the DC control/latch-crank board. Calibrate the board and test operation.

Test 25- Check Engine and Engine Components

DISCUSSION:

If the Wire 14 circuit was electrically hot in Test 24, and if engine cranks but will not start, the problem must be in one of the engine systems (fuel, ignition, compression, mechanical damage, etc.). In some engines, the Wire 14 circuit energizes a fuel solenoid to turn on fuel flow. In other engines, Wire 14 may open a fuel shutoff valve and turn on the engine ignition system.

PROCEDURE:

Refer to the specific engine service manual for the engine involved. Test and troubleshoot the engine fuel system, ignition system, and mechanical systems as outlined in that manual.

RESULTS:

Repair or replace defective engine components as required.

NOTE: Tests 26 through 34 are tests that should be performed if the engine cranks, starts and then shuts down. Refer to Problem 4 in Section 6.8.

Test 26- Is the "Overtemperature" Lamp On?

DISCUSSION:

If the engine cranks, starts and then shuts down, it is possible that an overtemperature condition exists. If the engine is started with an existing high coolant temperature or low coolant level, shutdown will occur when the engine reaches starter cutout speed (about 1000 rpm).

PROCEDURE:

On the engine monitor panel, observe the "High Cool. Temp." lamp. If that lamp is on, it is normal for the engine to crank, start and then shut down.

RESULTS:

1. If the lamp is on, go to Test 28, "Check Coolant Level".
2. If the lamp is NOT on, but engine started and then shut down, go to Test 27, "How Long Did the Engine Run?".

Test 27- How Long Did the Engine Run?

DISCUSSION:

Review the information in Section 6.2, "Engine Monitor Panel". The following are repeated here:

- If a low oil pressure condition exists, the DC control board will allow about four (4) seconds after starter cutout speed for oil pressure to build. If oil pressure has not built in the allotted four (4) seconds, shutdown will occur.

Test 27- How Long Did the Engine Run? (Continued)

- Once the engine speed reaches approximately 800-1000 rpm, the DC control/latch-crank board will wait about two (2) seconds to receive rpm signals from the rpm sensor. If, at the end of two seconds, rpm signals are not detected, engine shutdown will occur.

PROCEDURE:

Crank the engine and let it start. Time the wait between initial startup and shutdown.

RESULTS:

1. If the engine started and ran for about four (4) seconds before shutdown occured, go to Test 5, "Test Oil Pressure Switch".

2. If the engine started and ran for less than four (4) seconds and then shut down, go to Test 29, "Does the Starter Disengage?".

Test 28- Check Coolant Level

DISCUSSION:

If the engine started, then shut down and the high coolant temperature lamp is on, the next step in correcting the problem is to check engine coolant level.

PROCEDURE:

Check coolant level in the coolant recovery bottle. Fill the recovery bottle about half full with a 50-50 mixture of the recommended coolant.

DANGER: Wait for engine to cool before removing the radiator pressure cap. Remove the radiator cap slowly. Be careful. The coolant mixture in the radiator is under pressure. Removal of the radiator cap while coolant is hot may result in serious burns from boiling liquid or steam.

Check coolant level in the radiator. If necessary, fill the radiator to the proper level with the recommended coolant mixture.

RESULTS:

If coolant level is good, but overtemperature lamp is on, go to Test 30.

Test 29- Does the Starter Disengage?

DISCUSSION:

If the engine runs less than four (4) seconds (about 2 seconds) and then shuts down, try to determine if the engine starter has disengaged. If the starter does NOT disengage, rpm sensor output may be lost.

PROCEDURE:

Crank the engine while listening for the sound of the starter motor. There is a distinct difference in the sound of the starter while it is engaged and when it disengages. Note whether the starter disengages before the engine shuts down.

RESULTS:

1. If the starter does NOT disengage, and engine shuts down in less than four (4) seconds, go to Test 32, "Test RPM Sensor".
2. If the starter disengages, go to Test 33, "When Does the Console Lamp Go Out?".

Test 30- Test Coolant Temperature Switch

DISCUSSION:

If the coolant temperature lamp is on, the radiator and coolant recovery bottle are properly filled, and engine cranks, starts and shuts down, a defective coolant temperature switch or coolant level sensor may be the problem. This test will provide instructions on testing the coolant temperature switch.

PROCEDURE:

Testing with Switch Installed: To test the temperature switch while it is installed, proceed as follows:
1. Disconnect Wire 85 from the high coolant temperature switch terminal.
2. Set a VOM to its "Rx1" scale and zero the meter.
3. Connect one VOM test lead to the switch terminal from which Wire 85 was just removed. Connect the remaining test lead to a clean frame ground. The meter should read "infinity".
4. Check that no electrical loads are connected to the generator, then crank and attempt to start the generator.
5. If the generator starts, hold the terminal end of Wire 85 firmly against a clean frame ground. After a short delay, the engine should shut down.

RESULTS:

1. If the VOM reads other than "infinity" in Step 3, the switch has failed closed and should be replaced.
2. If the engine starts in Step 4, but will not start when Wire 85 is connected to the switch terminal, replace the high coolant temperature switch.
3. If the engine will not shut down in Step 5 when Wire 85 is grounded, check Wire 85 (along its entire length between the switch and the DC control/latch-crank board) for an open condition. Repair, reconnect or replace Wire(s) as needed. If all of Wire 85 checks good, replace the DC control/latch-crank circuit board. Calibrate the board and test operation.

Testing with the Switch Removed: Remove Wire 85 from the switch terminal. Remove the switch and test as follows:
1. See Figure 8. Immerse the switch in a 50-50 mixture of ethylene glycol base anti-freeze and water.

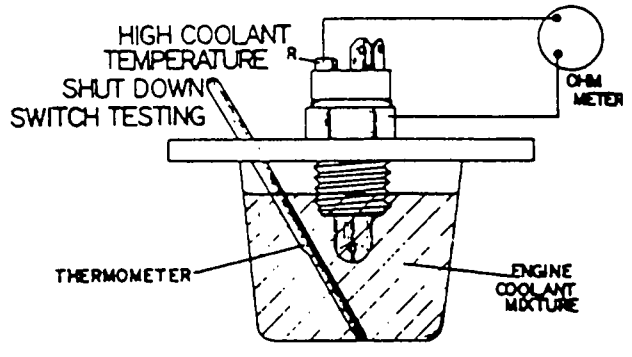
Test 30- Test Coolant Temperature Switch (continued)

2. Set a VOM to its Rx1 scale and zero the meter.
3. Connect one VOM test probe to the terminal from which Wire 85 was disconnected. Connect the remaining test probe to the switch housing. The meter should read "Infinity".
4. Place an actuate the thermometer into the fluid mixture (See Figure 8).
5. Heat the fluid, at approximately 245° - 266° F., the switch contacts should close and the VOM should read "continuity".
6. Remove the fluid mixture from its source for heat and allow it to cool. As the temperature drops below about 245° - 266° F., the switch contacts should open and the VOM should read "infinity".

RESULTS:

Replace the coolant temperature switch if it fails any part of the test. If the switch checks good, go to Test 31, "Test Coolant Level Sensor".

Figure 8. Testing Coolant Temperature Switch



Test 31- Test Coolant Level Sensor

DISCUSSION:

A defective low coolant level sensor will produce the same effects as a failed high coolant temperature switch.

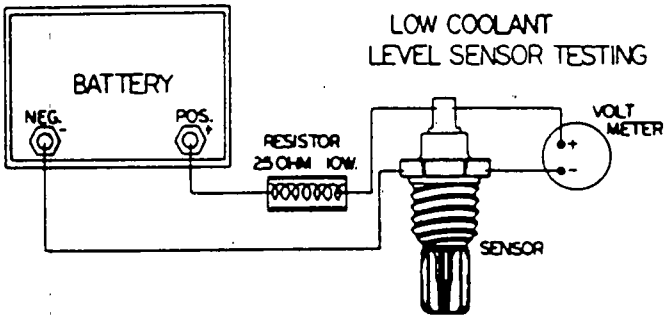
PROCEDURE:

See Figure 9. Connect a test harness as shown to the sensor terminals and to a fully charged 12 volt battery. Then, set a VOM to read DC volts. Connect the VOM across the sensor terminals. Initially, the VOM should read approximately 7-11 volts DC. After about 15 seconds, as the sensor becomes hot, the voltage reading should drop off to less than 5 volts.

RESULTS:

Replace the sensor if it fails the test.

Figure 9. Testing Low Coolant Level Sensor



Test 32- Test RPM Sensor

DISCUSSION:

The rpm sensor is installed in a threaded hole on the engine flywheel housing. To install the rpm sensor,thread it into the flywheel housing until the sensor tip just contacts the flywheel gear. Then, turn the sensor counterclockwise about ¾ to 1 turn. Hold that setting and tighten the sensor locknut.

PROCEDURE:

1. Gain access to the control console interior. Connect an accurate AC voltmeter across terminals 79 and 0. At engine cranking speed, the meter should read approximately 0.4 to 0.6 volt.
2. Use a VOM to test sensor resistance.
   - ☐ Older sensors (with cable connector plug) should measure about 130 ohms ± 10%.
   - ☐ Newer sensors (with cable molded into sensor) should measure about 1,000 ohms ± 10%.

NOTE: *If the resistance is within limits but voltage reading is slightly low, voltage can be increased by adjusting the rpm sensor closer to the flywheel. DO NOT LOCATE THE SENSOR TIP CLOSER THAN ½ TURN FROM THE FLYWHEEL.*

RESULTS:

Replace the rpm sensor if it fails the tests.

Test 33- When Does the Console Lamp Go Out?

DISCUSSION:

Remember, the control console lamp is turned on by a DC voltage from the DC control/latch-crank board. This DC voltage is delivered to the lamp via the Wire 14 circuit. If the engine cranks, starts, then shuts down, this test will help you determine is (a) the DC control/latch-crank board or (b) engine system component is bad. If the console lamp goes out and then the engine dies, the DC control/latch-crank board is suspect. On the other hand, if the engine comes to a stop and the the lamp goes out, check the engine fuel system, ignition system, etc.

Test 33- When Does the Console Lamp Go Out? (Continued)

PROCEDURE:

Crank the engine while observing the control console "dash light". If the engine starts and then shuts down note when the lamp went out.

RESULTS:

1. If the lamp goes out as the engine starts to die, replace the DC control/latch-crank circuit board. Calibrate the new board and test operation.
2. If the lamp goes out after the engine stops, go to Test 34.

Test 34- Check Engine Fuel, Ignition, etc.

DISCUSSION:

In test 33, the console lamp stayed on until the engine came to a stop. This indicates that the Wire 14 circuit is energized and power should be available to the engine fuel solenoid, ignition system, etc. Thus, if the engine shuts down, a problem must exist in the engine electrical system.

PROCEDURE:

Refer to the appropriate engine service manual for the specific engine involved. Troubleshoot the engine systems as outlined in the service manual.

RESULTS:

Repair or replace defective engine part(s), as necessary.

Section 6.10

DUAL 12 OR 24 VOLTS DC CONTROL

Introduction

Sections 6.5, 6.6 and 6.7 provide information on DC control systems that are no longer being manufactured. Those older control consoles housed a DC control/latch-crank circuit board that required 12 volts DC for its operation. Other console components were also rated 12 volts DC.

On those older units, engines with a 24 volts DC electrical system required that a DC converter be installed to reduce the 24 volts DC battery voltage to 12 volts DC. Later production units have been equipped with a dual (12 or 24 volts) control system and do not require this DC converter.

In the last quarter of 1991, the following changes were incorporated:

- ☐ All control console components, including the DC control/latch-crank circuit board, were changed to dual voltage type. That is, all control console components can now be operated on either 12 or 24 volts DC.
- ☐ These later production control consoles can be installed on units with 24 volts DC engine electrical system without requiring a 24-to-12 volts DC converter.
- ☐ Units with a 24 volts DC engine system no longer require an engine run relay.
- ☐ Later production units with Option A or B control consoles are equipped with a dual voltage (12 or 24 volts) engine control circuit board (Part No. 82495).
- ☐ Later production units with Option C control console are equipped with a dual voltage engine control circuit board Part No. 83089.

NOTE: The new style dual voltage engine control circuit board will be shipped as a replacement part. This new board will work with any old or new style system, since it will operate on either 12 or 24 volts DC.

Schematic Diagrams

Figure 2 is a schematic diagram for a typical Option C console when the engine electrical system is rated 12 volts DC.

Figure 3 is a schematic diagram for a typical Option C control console when the engine is equipped with a 24 volts DC system.

Adjusting Overspeed Shutdown

The dual voltage circuit board (Figure 1) must be calibrated each time it is replaced, for the following reasons:

The circuit board must be matched to the specific engine flywheel or speed sensing errors will result.

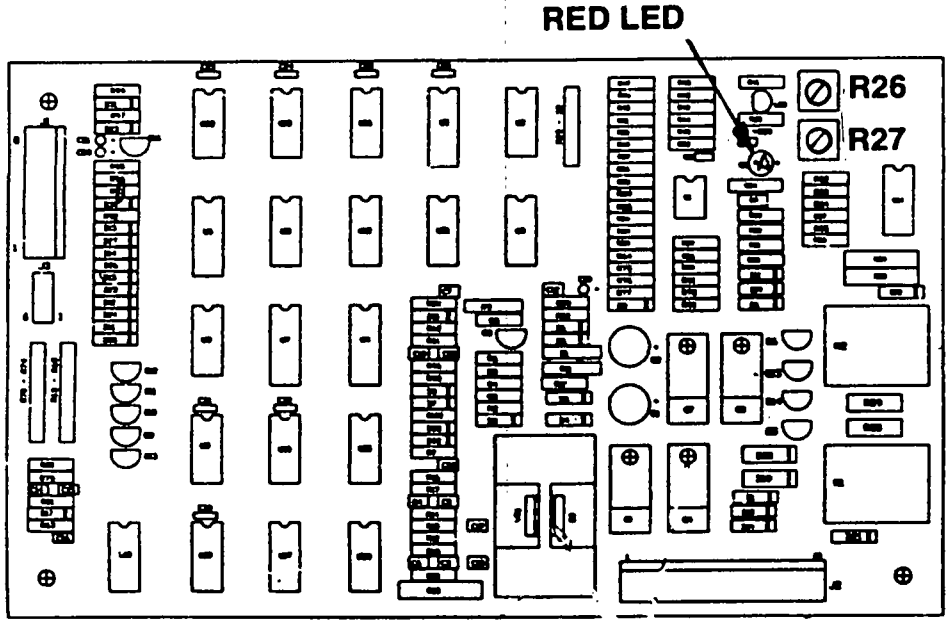
The board must be calibrated to establish an overspeed shutdown setting that is about 10 Hertz above the unit's normal operating speed.

When the overspeed shutdown setting is correct, starter cutout speed during automatic startup will also be correct.

To calibrate the engine control circuit board, proceed as follows:

1. On the circuit board, locate potentiometers R26 and R27. See Figure 1. Also, locate the red LED.

Figure 1. Option C Engine Control Circuit Board



Adjusting Overspeed Shutdown (Continued)

2. Turn the COARSE (R26) pot all the way clockwise (CW).
3. Turn the FINE (R27) pot all the way counterclockwise (CCW).

CAUTION: Steps 2 and 3 MUST be completed BEFORE THE ENGINE IS STARTED. If the engine is started before the steps are completed, an overspeed shutdown may occur at normal rated operating speed.

4. Start the generator engine manually, using the Start/Stop switch. Let the engine stabilize and warm up at no-load. If necessary, adjust the engine governor to obtain normal rated operating speed.
5. With the unit running at no-load and at its normal rated speed, slowly turn the COARSE (R26) pot counterclockwise (CCW) until the red LED just turns on.
6. Slowly turn the FINE (R27) pot clockwise (CW) until the red LED just goes out.
7. Slowly, turn the FINE (R27) pot counterclockwise (CCW) until the red LED just turns on.

With the board properly calibrated, overspeed shutdown will occur at approximately 10 Hertz above the unit's normal operating frequency. For example, if the engine no-load speed is 62 Hertz, overspeed shutdown will occur at approximately 72 Hertz.

Terminal Strip J1 on Engine Control Circuit Board

UNITS WITH 12 VDC ENGINE SYSTEM:

PIN NO.	WIRE NO.	FUNCTION(S
1	15A	Fused battery voltage to circuit board (12 Volts DC)
2	0	Common Ground
3	86	From engine high coolant temperature & low coolant level shutdown switch
4	85	From engine low oil pressure shutdown switch
5	79	From engine RPM sensor
6	183A	Automatic start/stop circuit
7	17	Manual start signal from start/stop switch
8	18	Manual stop circuit
9	228	Auto enable- circuit is hot when Auto-Off-Manual switch is set to "Auto"
10	221	Engine preheat circuit (diesel only)
11	14	Engine run circuit
12	56	Starter circuit

UNITS WITH 24 VDC ENGINE SYSTEM:

PIN NO.	WIRE NO.	FUNCTION(S)
1	220A	Fused battery voltage to circuit board
2	0	Common Ground
3	86	From engine low coolant level/high coolant temperature switches
4	85	From engine low oil pressure switch
5	79	From engine RPM sensor
6	183A	Automatic start/stop circuit
7	17	Manual cranking circuit
8	18	Manual stop circuit
9	228	Auto enable- circuit is hot when Manual-Off-Auto switch is at "Auto"
10	221	Engine preheat circuit (diesel only)
11	219	Engine run circuit
12	56	Engine starter circuit

Figure 2. Electrical Schematic- Option C Console with 12 VDC Engine System (Typical)

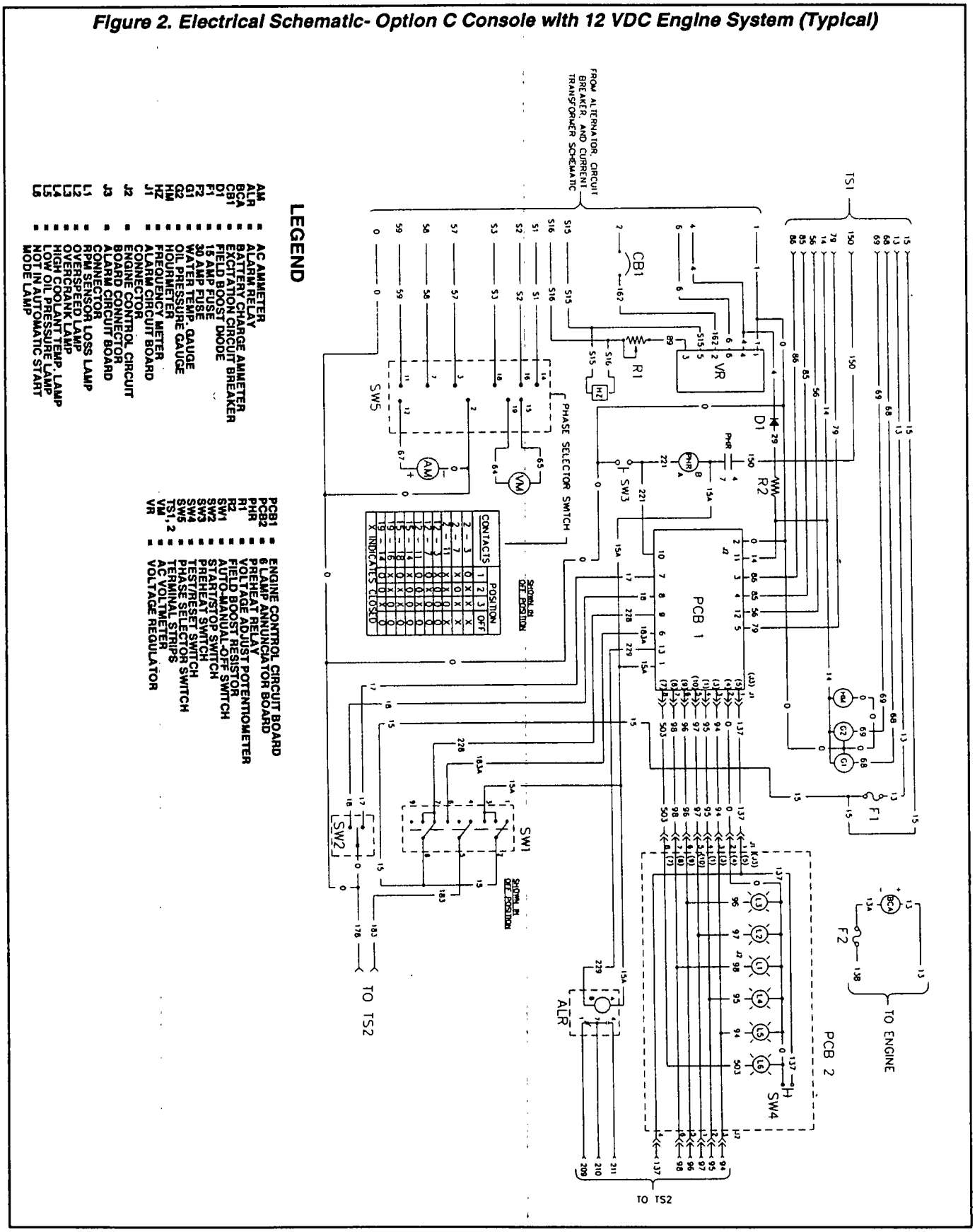


Figure 3. Electrical Schematic- Option C Console with 24 VDC Engine System (Typical)