

# SECTION 12 ELECTRICAL SYSTEM

**A. BATTERY SHUNT TEST AND REPLACEMENT (Figure 12-1)**

Using a multimeter, check for continuity across shunt in battery compartment. If continuity is not present, replace shunt.

**B. STARTER TESTING (Figure 12-1)**

**WARNING**

Negative battery cable must be disconnected before disconnecting any harness from protective control box. Failure to do so may result in injury to personnel or damage to equipment.

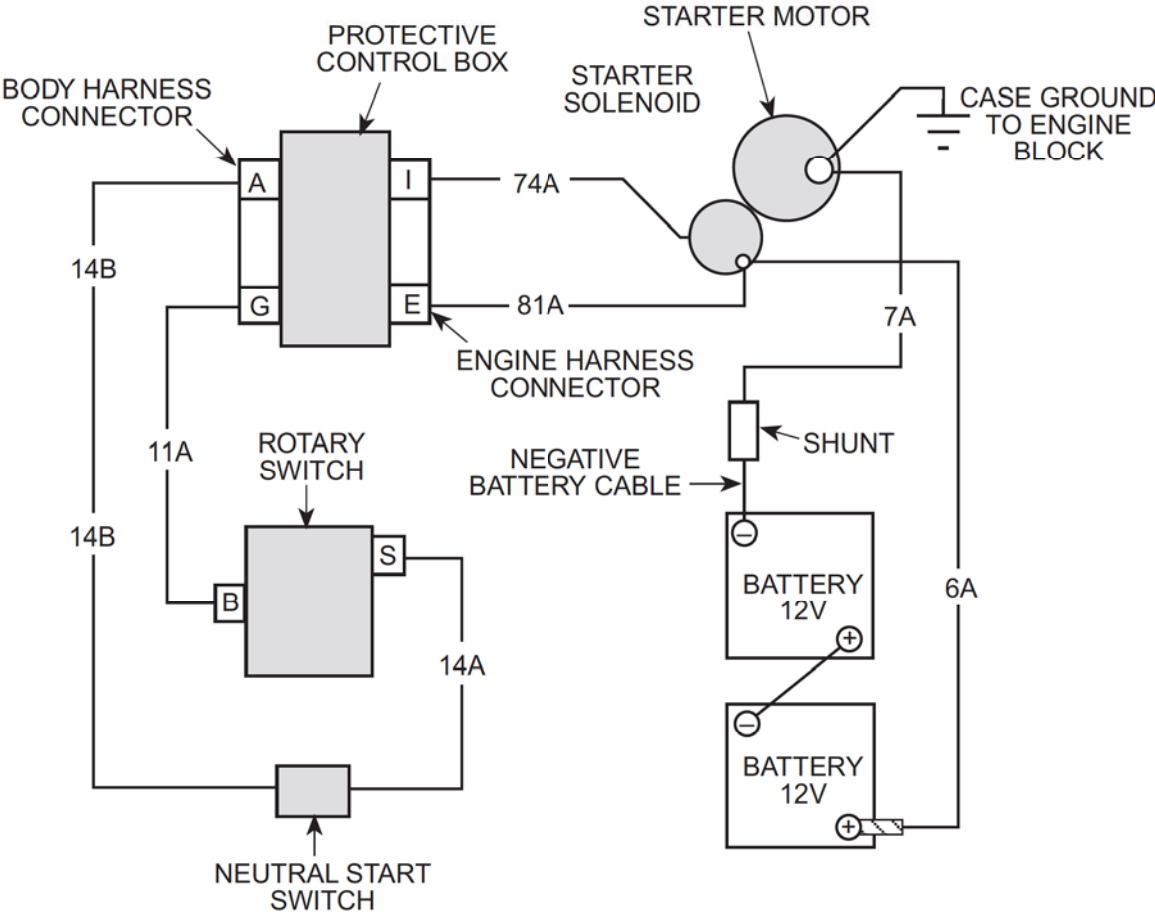


Figure 12-1. Starting System Schematic.

1. With rotary switch held in "START", check for battery voltage on lead 74A at the starter. If battery voltage is present, replace starter.
2. Disconnect lead 14B from neutral start switch. Check for battery voltage at neutral start switch connector 14 with rotary switch in "START" position. If battery voltage is present continue to step 3. If voltage is not present proceed to step 7.
3. Disconnect negative battery cable and both connector plugs from protective control box. Check continuity of lead 14B at neutral start switch to pin A at the control box body harness connector plug. If continuity is not present repair wiring harness.
4. Disconnect lead 74A from starter. Check continuity of lead 74A at starter to pin I of the control box engine harness connector plug. If continuity is not present, repair wiring harness.
5. Connect neutral start switch lead 14B, starter lead 74A, and both control box connector plugs. Disconnect lead 2A from alternator and connect battery ground cable. Attempt to start vehicle. If starter does not crank, replace protective control box. Check continuity of lead 2A.
6. If starter cranks engine, disconnect negative battery cable, and connect lead 2A to alternator after thoroughly cleaning terminal connection area. Connect negative battery cable and attempt to start vehicle. If starter does not crank replace alternator. If starter does crank, apply sealant to alternator terminal connections.
7. Disconnect lead 14A from neutral start switch. With rotary switch in "START" position, check for battery voltage at lead 14A. If voltage is present, continuity check the neutral start switch. Ensure the neutral start switch is activated mechanically. If continuity is not present, replace neutral start switch. Reconnect neutral start switch leads 14A and 14B.
8. Disconnect the rotary switch lead 14A and with rotary switch in "START" check for battery voltage at terminal S. If voltage is present, repair body wiring harness from rotary switch to neutral start switch.
9. Disconnect lead 11A at the rotary switch, check lead 11A for battery voltage. If voltage is present, replace rotary switch.
10. Disconnect negative battery cable from battery and disconnect protective control box connector plugs from protective control box. Reconnect negative battery cable to battery. Check pin E of engine wiring harness connector plug for battery voltage. If voltage is present, check for continuity from pin G on the control box wiring harness connector plug to lead 11A of rotary switch. If continuity is present, replace protective control box. If no continuity is present, repair body wiring harness.

### C. BATTERY CIRCUIT CHECKS (Figure 12-2)

1. Check batteries for loose or dirty connections.
  - a. Make sure all connection are clean and tight. This includes the interconnect cables, clamp, shunt, power stud and the slave connector. Also check wire 6A and 7A under vehicle where they enter the shunt.
2. Check batteries fluid level.
  - a. There is a ring inside the battery fill plugs. The water level should be at the ring.
3. Check batteries voltage for 23.5 to 25.5 volts.
  - a. If batteries voltage is low, check each battery individually. Voltage should be between 11to13 volts. (A good battery has 12 volts at 70°F (22°C).
  - b. If battery is below 11-13 volts, recharge battery.
  - c. If batteries are good, check the voltage drop across cables in battery box. Voltage drop should be less than 0.25 volts maximum.
4. Load test batteries. If batteries fail load test, replace batteries.

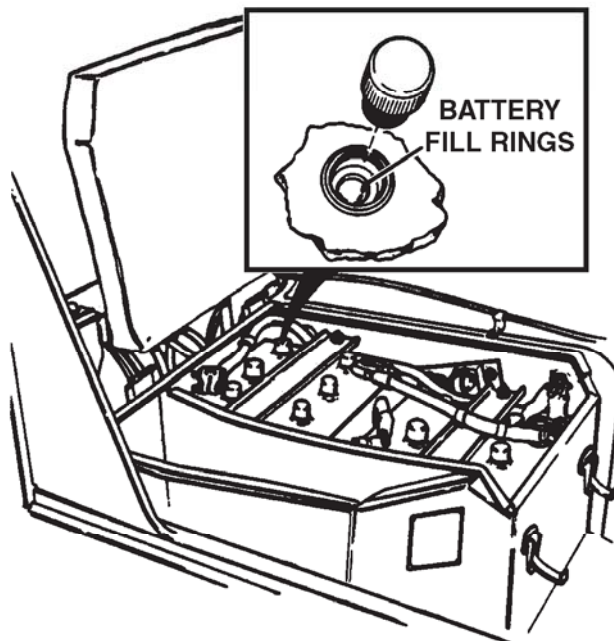


Figure 12-2. Battery Fill Rings.

Check starter voltage drop from power stud of 6A to starter ground. Voltage drop should be less than 0.25 volts. If voltage drop is more than 0.25 volts replace 6A cable.

**D. 6.2L ENGINE GLOW PLUG SYSTEM (Figure 12-3 through 12-6)**

The glow plug is basically an electric heater that is energized by the operator through the ignition switch. Once energized, electric current flows through the glow plug to cause it to glow or become red hot 1550°F to 1650°F (829° to 884°C). After a given time period when the starter motor is engaged, the ambient air that flows into the engine will be rapidly increased in temperature through the use of the hot glow plug within the combustion chamber.

Each cylinder in the 6.2L engine employs a glow plug that is actually a 12-volt unit operated from the 24-volt battery system when the ignition key is turned to the run position prior to engaging the starter motor. They remain pulsing for a short time after starting, then automatically turn off.

Within the instrument panel of the vehicle is a “glow plugs” light that will turn on immediately when the ignition switch is turned to the run position.

The major components of the glow plug system are described in the following paragraphs.

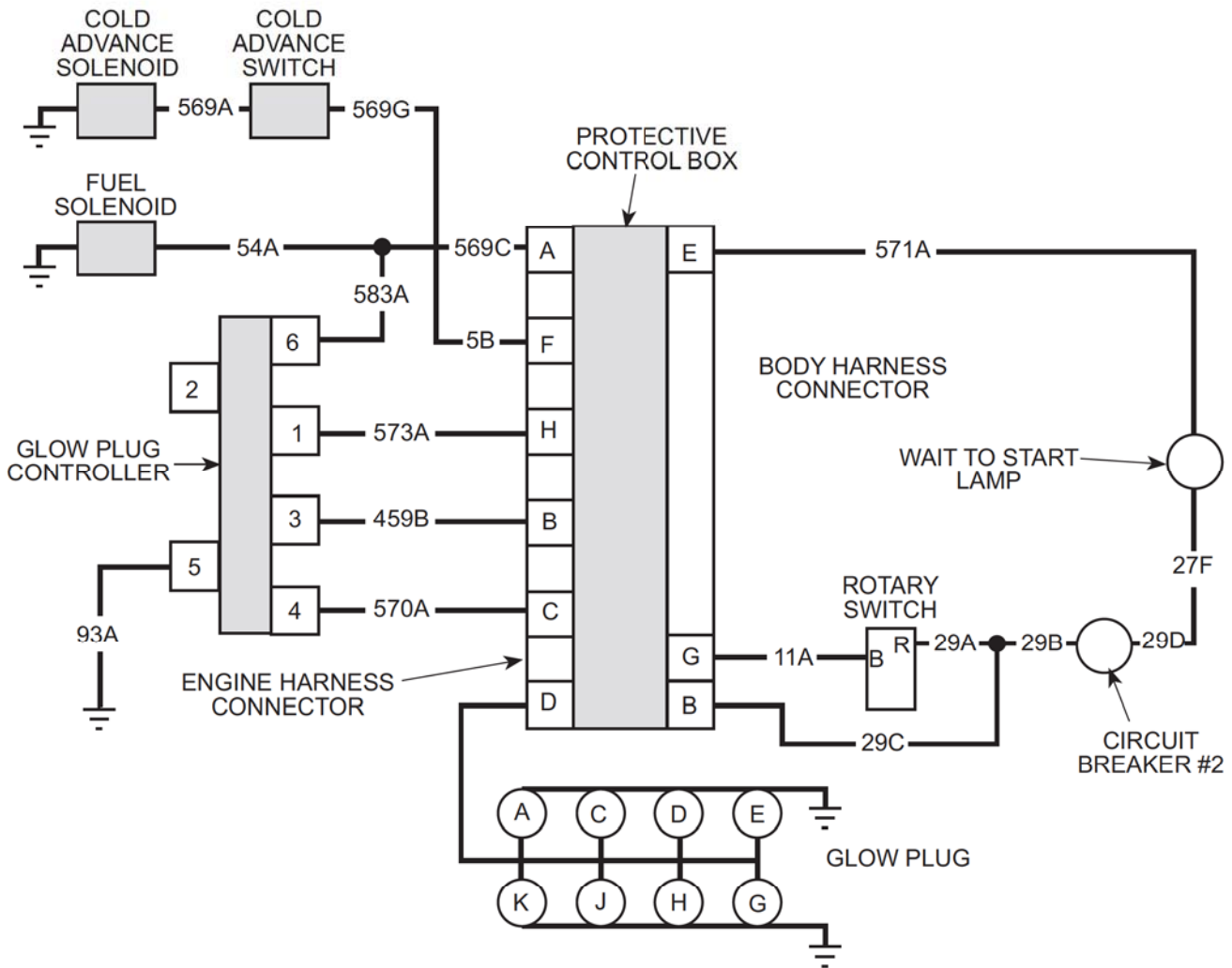


Figure 12-3. Glow Plug Controller Testing

**(MALFUNCTION)****a. Glow Plug System Continues To Cycle After Engine Is Warmed Up**

Start engine, and check for 12-14 volts DC signal at alternator lead 2A. If no voltage is present or voltage is not within limits, replace the alternator. If 12-14 volts DC is present, replace protective control box.

**b. Using multimeter, check glow plug internal resistance (Figure 12-5)**

Connect one test lead to terminal (1) and other test lead to threaded area (2).

Glow plug internal resistance should be 1.5-5.0 ohms. If resistance is not 1.5-5.0 ohms, replace glow plug.

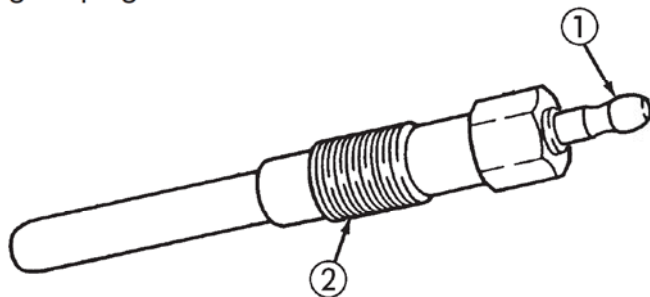


Figure 12-4. HMMWV Glow Plug.

**NOTE**

- The following will explain proper operation of glow plug system. When engine is below 120°F (48°C) and rotary switch is positioned to "RUN", "Wait-To-Start" lamplight then goes on for up to fifteen seconds, depending on engine temperature, then goes off, engine can then be started. After engine is started, glow plugs will continue to cycle (for up to 5 minutes) then stop cycling.
- Glow plug system is cycling normal when there is an on pulse for approximately 1 second and an off pulse for approximately 15 seconds.

- To detect glow plug system cycling, watch voltmeter. The gage needle will move to the left when glow plugs are on, then return to normal position when glow plugs are off. A relay click should be heard from the protective control box as the system switches on and off. Multimeter may be used on any glow plug wire to visually watch operation of glow plug system.
- If engine temperature is above 120°F (48°C), glow plugs are not required to start engine.
- Each glow plug draws approximately 11.25 amperes. To test system connect AMP meter across batteries. With glow plugs cycling, there should be approximately 90 ampere draw. Each bad glow plug will lower ampere draw approximately 11.25 amperes. (Example) With one bad glow plug, reading will be approximately 78.75 amperes. With two bad glow plugs, reading will be approximately 67.5 amperes etc.

**NOTE**

Allow engine to cool for 30 minutes before performing glow plug resistance checks.

1. Remove engine wiring harness connectors from all glow plugs. Using a multimeter, check glow plug resistance. Replace any glow plug not having 1.5-5.0 ohms resistance.

**NOTE**

Allow engine to cool 2-3 hours before performing glow plug controller resistance checks if continuous controller cycling is suspected.

**NOTE**

If solid state glow plug controller is being used, no test is available to test the controller. Replace if suspected of being faulty. If symptoms still exist, continue with step 3.

Refer to Figure 12-6 for the following steps.

2. Disconnect engine wiring harness connector from glow plug controller. Check the controller connector for dirt or moisture contamination, clean if required. Using multimeter, check controller for the following:
  - a. Check for continuity between pin 2 and pin 6 (continuity should exist).
  - b. Check resistance between pin 2 and pin 3. The resistance should be approximately 0.5 ohms.
  - c. Check resistance between pin 4 and pin 5. The resistance should be 24-30 ohms.
  - d. Check resistance between pin 1 and pin 5. The resistance should be 117-143 ohms.

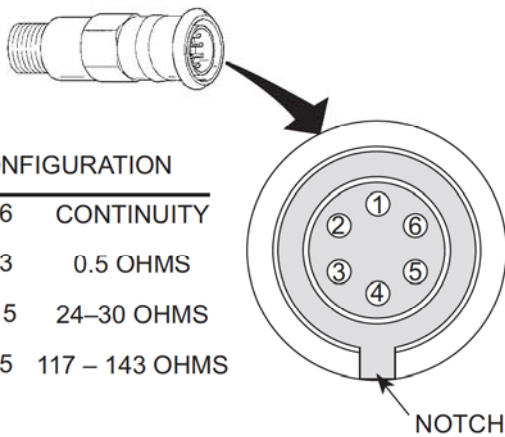


Figure 12-5. Glow Plug Controller

If any of the above conditions are not met, replace glow plug controller.

Refer to Figure 12-7 for the following steps.

3. Using a multimeter, check for continuity between terminal 5 at glow plug controller

connector (lead 93A) and ground. Repair engine wiring harness if continuity is not present.

**WARNING**

**Negative battery cable must be disconnected before disconnecting any harness from protective control box. Failure to do so may result in injury to personnel or damage to equipment.**

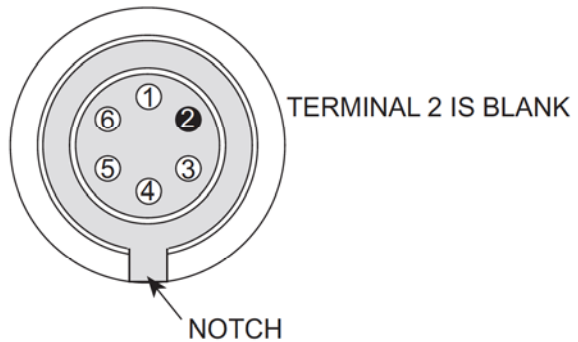


Figure 12-6. Glow Plug Controller Continuity Test.

4. Disconnect negative battery cable and disconnect engine wiring harness connector at protective control box. Inspect the control box and harness connector for dirt, or moisture contamination, clean if required. Using a multimeter, check for continuity between terminal "D" in protective control box engine wiring harness connector and eight glow plug connectors (leads 575). Repair engine harness, if any glow plug leads do not have continuity.
5. Using a multimeter, check for continuity between terminal "G" in engine wiring harness connector at protective control box and lead 2A at alternator. Repair engine wiring harness, if continuity is not present.

6. Using a multimeter, the following continuity checks must be made from engine wiring harness connector at protective control box to engine wiring harness connector at glow plug controller.
  - a. Terminal "C" at protective control box connector to terminal 4 at glow plug controller connector (lead 370A).
  - b. Terminal "B" at protective control box connector to terminal 3 at glow plug controller connector (lead 459B).
  - c. Terminal "H" at protective control box connector to terminal 1 at glow plug controller connector (lead 573A).
  - d. Terminal "A" at protective control box connector (lead 54B) to terminal 6 at glow plug controller connector (lead 583A).

If any leads did not have continuity, repair engine wiring harness.

7. If no problem is found in glow plugs, glow plug controller or engine wiring harness, replace protective control box and check system for proper operation.

#### **E. COLD START ADVANCE DOES NOT FUNCTION PROPERLY**

1. Remove engine access cover. Disconnect leads 569A and 569B from cold advance switch. Using multimeter, check for battery voltage at lead 569A with rotary switch in "RUN" position. If battery voltage is not present, repair engine wiring harness.
2. Disconnect lead 569B from fuel injection pump. Using multimeter, check for continuity through lead 569B from injection pump to cold advance switch. If continuity is not present, repair engine wiring harness.
3. Using multimeter, check for continuity through cold advance switch with engine temperature below 70°F (21°C). If continuity is not present, replace cold advance switch. Check for continuity through cold advance switch with engine temperature above 100°F (38°C). If continuity is present, replace cold advance switch.

END OF TESTING!

**F. NEIHOFF 100 AMP ALTERNATOR TESTING (Figure 12-7 through 12-9.**

**a. On Vehicle Test**

The alternator is examined most easily on the vehicle, where the charging and ignition systems of the vehicle can be examined at the same time.

**Equipment:**

Belt Tension Gauge

Voltmeter, 0-40 Volt Range

Ammeter, 0-400 Amp Range

**b. Preliminary Checks**

1. **Check Belt Tension.** Use Belt Tension Gauge to measure belt tension within range for the appropriate belting system: Dual Belt: 80-120 lbs each belt.

2. **Check Battery.** Battery must be in good condition and fully charged. If condition is marginal the battery should be replaced with one which is known to be in good condition.

3. **Check Electrical Connections in Charging Circuit.** Make sure all connections are clean, tight, and free of corrosion. Battery connections are especially important.

4. **Check Ignition Circuit.** If alternator is not charging, check for voltage at the alternator energize terminal (Red Terminal). Refer to Figure 12-7 for energize terminal location on the outside of the regulator. Look for 24V nominal.

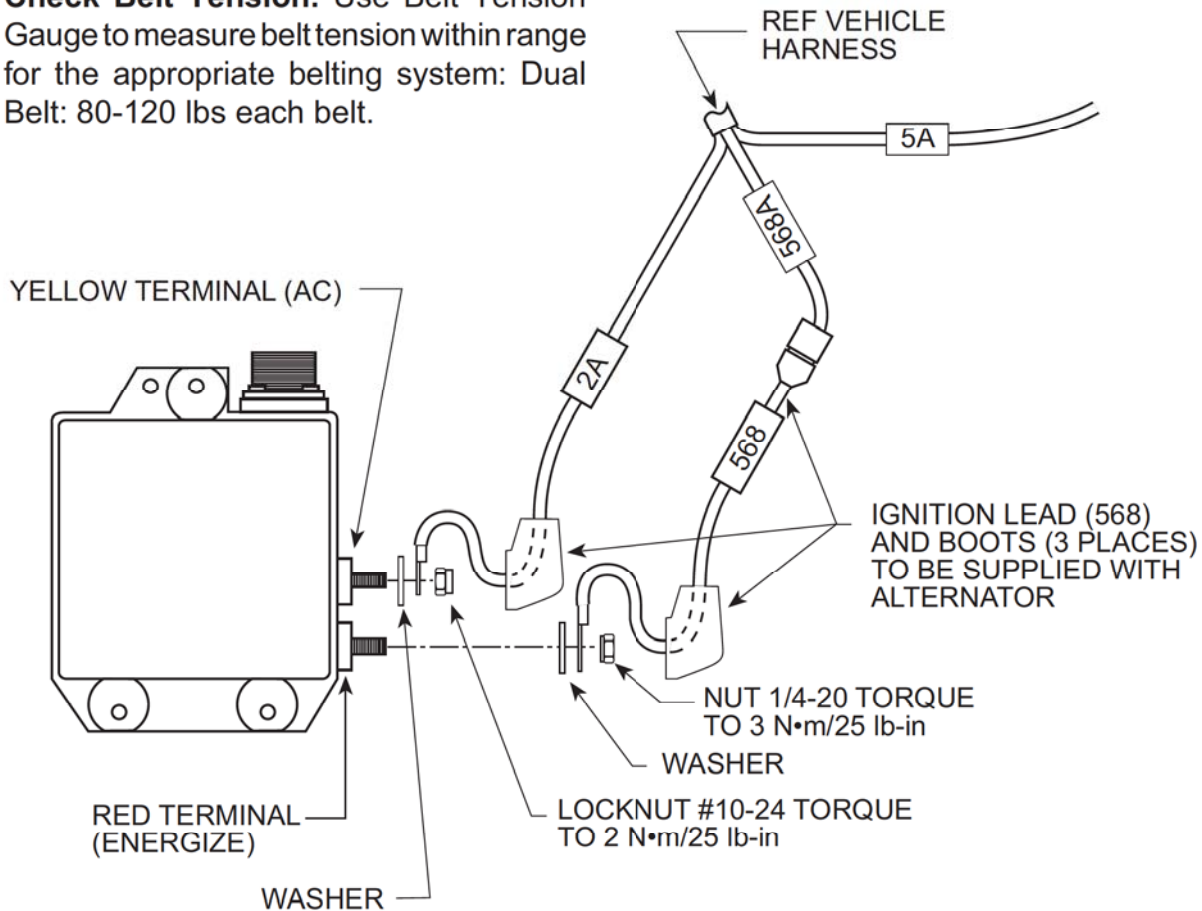


Figure 12-7.  
Regulator AC and Energize Terminals



### c. Test Setup

#### 1. Discharge Battery as Follows:

1. Remove wire 54A from injection pump.
2. Turn all lights and accessories. Crank the engine for 10-15 seconds to discharge battery, then stop cranking engine.
3. Turn all lights and accessories off.
4. Reconnect wire 54A to injection pump.

2. **Attach meter as indicated by Figure 12-8A.** Be sure to measure voltage and amperage at alternator, not battery or intermediate point.

If an in-line ammeter is used, disconnect battery ground cable before connecting ammeter. Then reconnect battery ground cable. Ammeter connections must carry rated output of alternator.

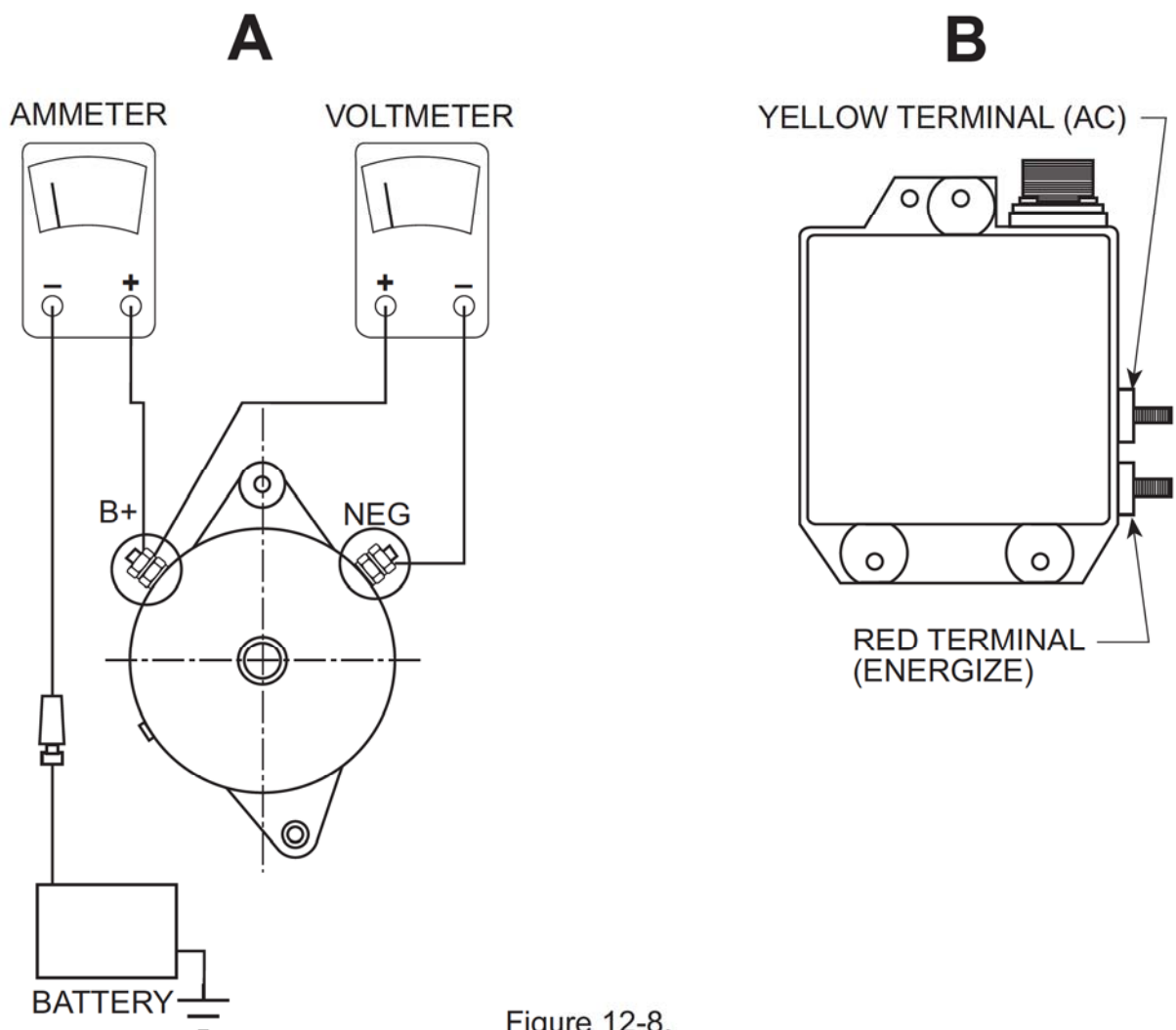


Figure 12-8.  
On Vehicle Test.

**d. Test Procedure**

1. **Start engine.** Accelerate to high idle. **Caution: If voltmeter reading exceeds 30.5V, stop engine immediately and refer to Table 1-1.**
2. **Watch meter reading.** If battery is sufficiently discharged, amps should be

“high”. Volts should be within or below the “normal range” of Table 1-2, as battery approaches full charge, amps should fall as volts rise. When amps and volts stabilize, note readings and refer to Table 1-1.

AMPS	VOLTS	DIAGNOSIS
HIGH	LOW	Charging system is OK. Battery is not yet fully charged. Wait for charging system to bring to full charge: AMPS should fall and VOLTS should stabilize within normal range (Table 1-2).
HIGH	NORMAL	Watch until AMPS fall or Volts exceed normal range (Table 1-2). If AMP fall and Volts remain normal, charging system is OK. If Volts exceed normal, regulator and/or tube assembly should be replaced. (Go to Static Tests)
HIGH	HIGH	<b>STOP TEST</b> Regulator and/or tube assembly should be replaced. (Go to Static Tests)
LOW	LOW	Make sure voltmeter leads attached at alternator. If connections are OK, alternator and/or regulator must be repaired or replaced.
LOW	NORMAL	Charging system is OK.
LOW	HIGH	<b>STOP TEST.</b> If battery and voltmeter check OK, regulator and/or tube assembly must be replaced.

TABLE 1-1.Troubleshooting.

ALTERNATOR (REGULATOR)	SYSTEM VOLTAGE	FACTORY SETTING	NORMAL ADJUSTING RANGE
N31 03	28	28.2 ±.2	27.0 – 29.4

Table 1-2.Voltage Regulator Specifications.

**NOTE:**

Regulator set at 28.2 ±.5 volts at 72°F and compensate for temperature variation of –0.1 volt per 10°F.

**e. Static Checks: Partially Disassembled Alternator**

Static Tests are performed on the partially disassembled alternator to confirm component failure indicated by On-Vehicle Test and Bench Tests

1. Equipment: Ohmmeter, Simpson 260 or equivalent Regulator Tester, Zetron or equivalent, or Ohmmeter Diode Tester or Ohmmeter.
2. Remove the pulley (refer to Disassembly Procedure).

**Disconnect all phase leads attached to the heatsink (“P1” through “P6”) in Figure 12-9. Disconnect alternator connector from voltage regulator.**

Before repairing the alternator, perform ALL Static Tests.

**f. Field Coil Test**

1. Remove both field coil (F+, F-) leads from terminal studs on the front housing. (See Figure 12-9).
2. Check for open field coil. Set ohmmeter to x1 scale and make sure meter is zeroed. Connect ohmmeter leads to each of the two field leads and measure the resistance. Ohmmeter should read less than 3 ohms. If ohmmeter reads above the specified limit, the field coil is open and must be replaced (replace or repair stator, shell assembly or alternator).
3. Check for grounded field coil. Set ohmmeter to x10k scale and make sure ohmmeter is zeroed. Connect one ohmmeter lead to either field lead, connect the other ohmmeter lead to the front housing ground stud. The ohmmeter should read very high. If the ohmmeter reads less than 100k ohm the field coil is grounded and must be replaced (replace or repair stator, shell assembly or alternator).
4. Replace both field coil (F+, F-) leads before performing electrical continuity check.

**g. Electrical Continuity Check**

Note

**Make sure coil (F+, F-) leads are connected to terminal studs.**

1. Set ohmmeter to x10 scale and make sure meter is zeroed.
2. Probe the alternator connector pins to insure all internal wiring is intact. (Refer to figure 12-9, page 14).

ALTERNATOR HARNESS CONNECTOR	MEASURE TO:	READING
Pin A	B+ Stud	2.3 ±.3
Pin B	"F" Terminal Test Point	Less than 1 ohm
Pin C	GND Stud	Less than 1 ohm
Pin D	B+ Stud	Less than 1 ohm

Table 1.3

**h. Diode Heatsink Tests**

Remove all phase leads (P1-P6) from front housing (refer to figure 12-9 page 14). Note: Do not allow sleeving on leads to slide down leads; phase terminals without sleeves can short to alternator body.

The diode heatsink assembly is normally checked using a diode tester. If a diode tester is used, refer to manufacturer's instructions for proper connections. When a diode tester is not available, use an ohmmeter and refer to the following procedure. Note: Do not use an AC device, such as a leakage tester to check the diode heatsink.

1. Check positive diodes (Refer to Figure 12-9, page 14). Set ohmmeter to x 100 scale and make sure ohmmeter is zeroed. Connect one ohmmeter lead to the B+ output connector. Connect the other ohmmeter lead to each of the six heatsink phase terminals "S". All six readings should be nearly alike; either less than 600 ohms, or very high. If all six readings are not alike, the diode rectifier assembly is defective and the heatsink assembly or front housing assembly must be replaced.

Reverse ohmmeter leads, and again observe resistance between the "B+" stud of the output connector and each of the six heatsink terminals "S". All six readings should be nearly alike, and opposite the readings obtained previously; if all readings were less than 600 ohms before, all readings should be very high now, and vice versa. If any reading is not alike the diode rectifier assembly is defective and the heatsink assembly must be replaced.

2. Check negative diodes (Refer to Figure 12-9). Set ohmmeter to x100 scale and make sure ohmmeter is zeroed. Connect ohmmeter lead to the ground terminal located on the outside of the front housing, connect the other ohmmeter lead to each of the six heatsink phase terminals "S". All six readings should be nearly alike; either less than 600 ohms, or very high. If all six readings are not alike, the diode rectifier assembly is defective and the heatsink assembly is defective, and the heatsink assembly or front housing assembly must be replaced.

Reverse ohmmeter leads, and again observe resistance between ground terminal and each of the six heatsink phase terminals "S". All six readings should be nearly alike, and opposite the readings obtained previously; if all readings were between less than 600 ohms before, all readings should be very high now, and vice versa. If any reading is not alike, the diode rectifier assembly is defective and the heatsink assembly or front housing assembly must be replaced.

## NOTE

**Heatsink diodes are derated for heavy duty performance. If diode failure is detected the entire charging system should be examined for loose connections (especially battery). If diode failure is indicated, stator failure must be suspected.**

### i . Stator Tests

The alternator has two separate stator assemblies that will be checked individually. Make sure that all phase leads are disconnected from the heatsink (Refer to Figure 12-9).

1. Check front stator. Set ohmmeter to x1 scale and make sure ohmmeter is zeroed. Check for open stator windings by connecting ohmmeter between each successive pair of stator phase leads (Refer to Figure 12-9), ("P1"- "P2", "P2"- "P3", and "P1"- "P3"). Note it may be necessary to probe under the sleeves of the phase leads in order to make electrical contact. Ohmmeter should read less than 1 ohm between each pair of stator phase windings. If ohmmeter reads very high (infinity) the stator is open and must be replaced (replace or repair stator and shell assembly).

Set ohmmeter to x10k scale and make sure ohmmeter is zeroed. Check for shorted stator windings by connecting ohmmeter between each phase lead ("P1", "P2", and "P3") and the ground terminal located on the outside of the front housing. Ohmmeter should read very high (infinity). If ohmmeter reads zero the stator is grounded and must be replaced (replace or repair stator and shell assembly).

Set ohmmeter to x10k scale and make sure ohmmeter is zeroed. Check for shorted stator windings by connecting ohmmeter between each phase lead ("P4", "P5", and "P6") and the ground terminal located on the outside of the front housing. Ohmmeter should read very

high. If ohmmeter reads zero the stator is grounded and must be replaced (replace or repair stator and shell assembly).

**NOTE:**

**Disassemble alternator only as far as necessary to replace defective part.**

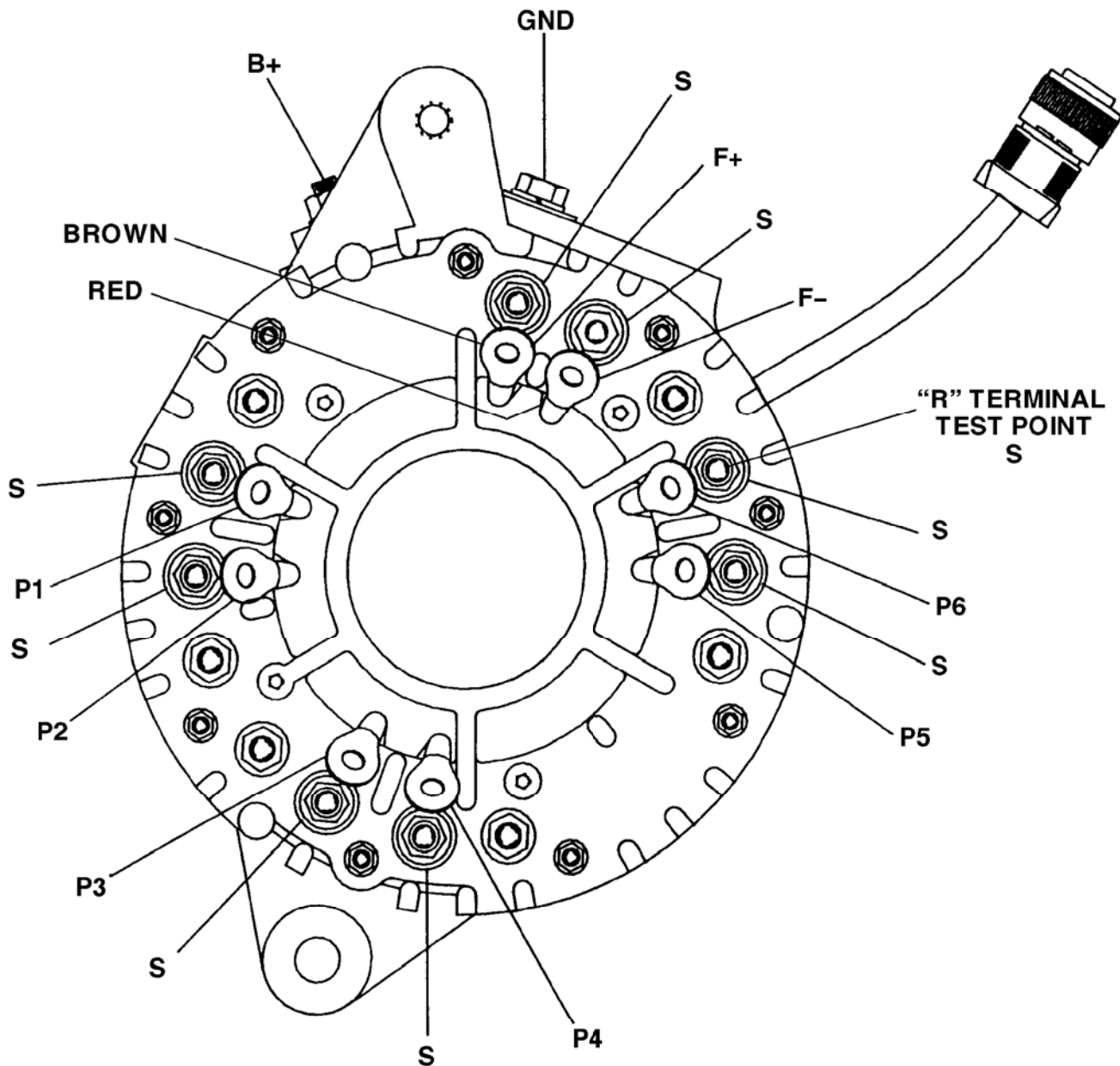


Figure 12-9.

## G. PROTECTIVE CONTROL BOX TESTING (Figure 12-10)

### WARNING

Negative battery cable must be disconnected before removing any connector from the protective control box, or injury to personnel or damage to equipment may result.

### NOTE

During continuity check of pin "A" and pin "G" at the body harness connector, the ignition switch must be in the "START" position.

1. Disconnect body harness connector and engine harness connector from protective control box. Check for continuity between pin "A" and "G" on the body harness

connector. Continuity should be between 0.1–0.3 ohms. If the incorrect reading is found go to step 2. If the correct reading is found, go to step 3.

2. Disconnect lead 14B from the neutral start switch. Check for battery voltage at neutral start switch lead 14 with rotary switch in "START". If battery voltage is present, disconnect the negative battery cable from battery, both cannon plugs from protective control box and lead 74A from starter. Ground lead 74A and check pin I on the engine wiring harness cannon plug for the control box. If continuity is present, check lead 14B on neutral start switch to pin A on the body wiring harness cannon plug for the control box. If continuity is present, replace the control box. If no continuity is present, repair wiring harnesses. Reconnect

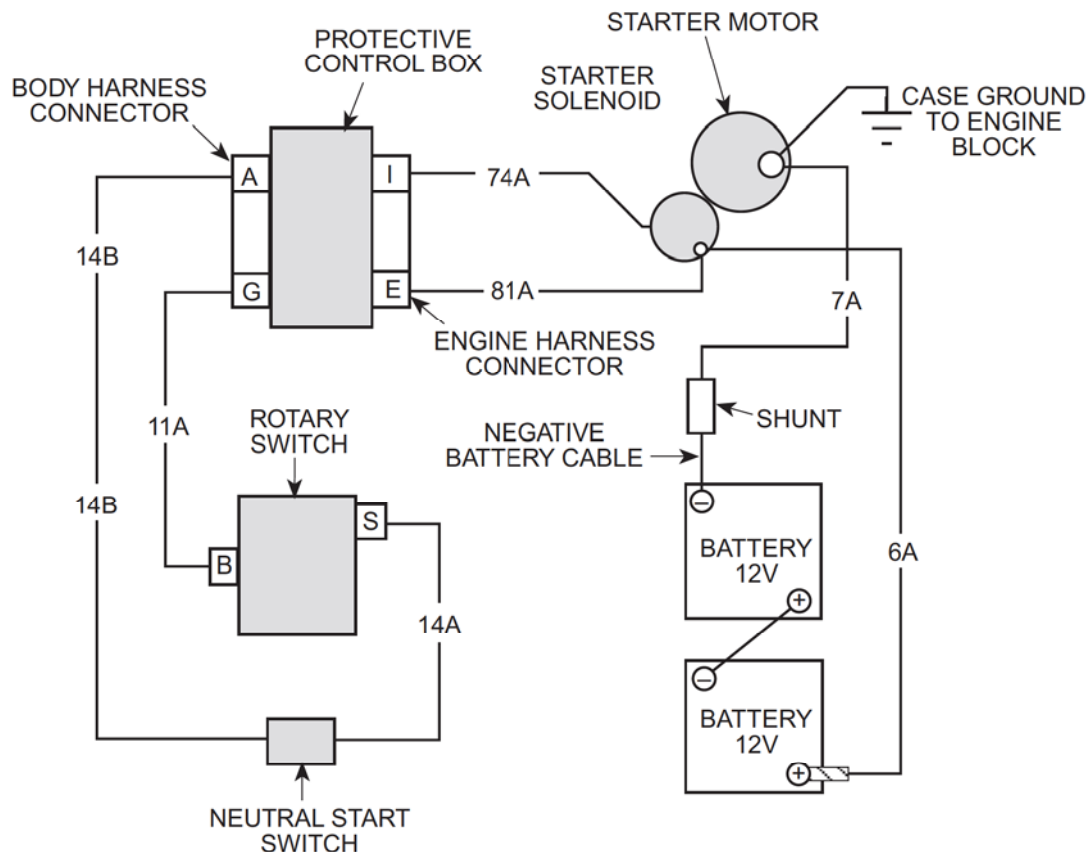


Figure 12-10. Starting System Schematic—Protective Control Box Testing.

protective control box cannon plugs, neutral start switch lead 14B, starter lead 74A to starter, and negative battery cable to battery.

3. Disconnect negative battery cable from battery and disconnect protective control box cannon plugs from protective control

box. Reconnect negative battery cable to battery. Check pin E of engine wiring harness cannon plug for battery voltage. If voltage is present, check for continuity from pin G on control box body wiring cannon plug to lead 11A of rotary switch. If continuity is present, replace protective control box. If no continuity is present, repair body wiring harness.

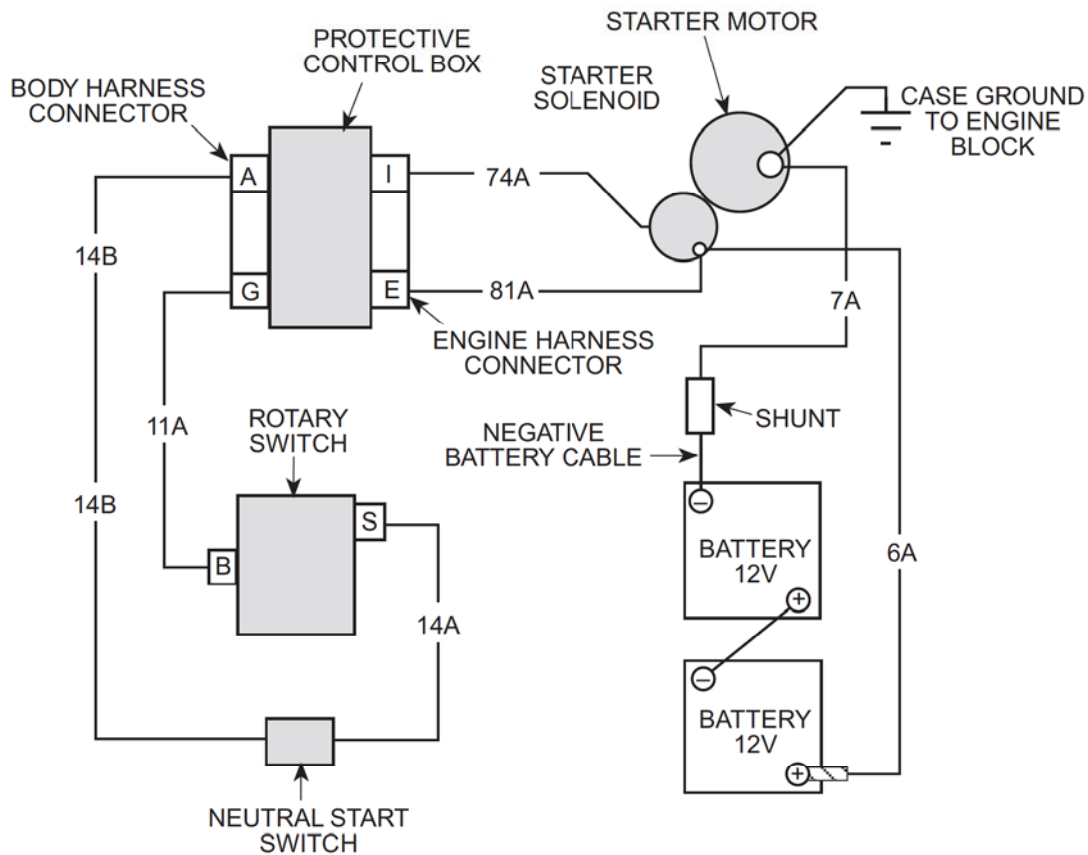


Figure 12-10. Starting System Schematic—Protective Control Box Testing.



**H. LIGHT TESTING**

1. Disconnect body wiring harness from light switch. Using multimeter, check for battery voltage at terminal "F" in body wiring harness connector. If battery voltage is not present, repair body wiring harness. If wiring harness cannot be repaired, replace the wiring harness.
2. Working from Table 12-8, Lighting Circuit Chart, connect a jumper wire from terminal "F" to circuit terminal being tested. If lamps light with jumper wire connected, replace main light switch. If lamps do not light, repair or replace hood wiring harness (front lights only), or repair body wiring harness.
3. Working from Table 12-9 light switch continuity chart, position light switch control levers to position indicated for circuit function being tested. Check for continuity between light switch connector pins as shown. If continuity is not present at the appropriate light switch connector pins, replace main light switch.

**CIRCUIT CHART**

PIN	WIRE NO.	CIRCUIT
B	40A	Panel Lights
C	22A	Directional Control (Service Stoplight)
D	19A	B. O. Driving Light
E	20-24A	B. O. Marker Lights
F	15A	Battery Pos. 24 Volts
H	21A-491A	Service Rear & Parking Lights
J	46C-461A	Directional Indicator
M	16A	Service Headlights
N	23A	B. O. Stoplight

Table 12-8. Lighting Circuit Chart

**LIGHT SWITCH CONTINUITY CHART**

CIRCUIT FUNCTION BEING TESTED	LIGHT SWITCH LEVER POSITION	CONTINUITY CHECK PINS
	Off	Check all pins (pin to pin) for infinity
Switch	Park	A to B, H to L
Switch	Dim	A to B, H to M
Switch	Panel Bright	A to B, H to M
Service Stoplights	Stoplights	A to F, C to K
Directional Indicators (turn signals)	Service Drive	F to H
Parking, Tail, and Side Marker Lights	Service Drive	F to H
Panel Lights	Service Drive (panel lights bright)	F to B
Headlights	Service Drive (panel lights bright)	F to M
Front and Rear Blackout Marker	Blackout Marker	F to E
Blackout Stoplamps	Blackout Marker	F to A, K to N
Blackout Headlamps	Blackout Drive	F to D

Table 12-9. Light Switch Circuit Chart.

### I. HIGH BEAM SELECTOR SWITCH TESTING (Figure 12-12)

Remove high beam selector switch and check for battery voltage at lead 16A. If voltage is present, check high beam selector switch for continuity between leads 16 and 17 in high

position, and leads 16 and 18 in low position. If continuity is not present in either position when selected, replace high beam selector switch.

END OF TESTING!

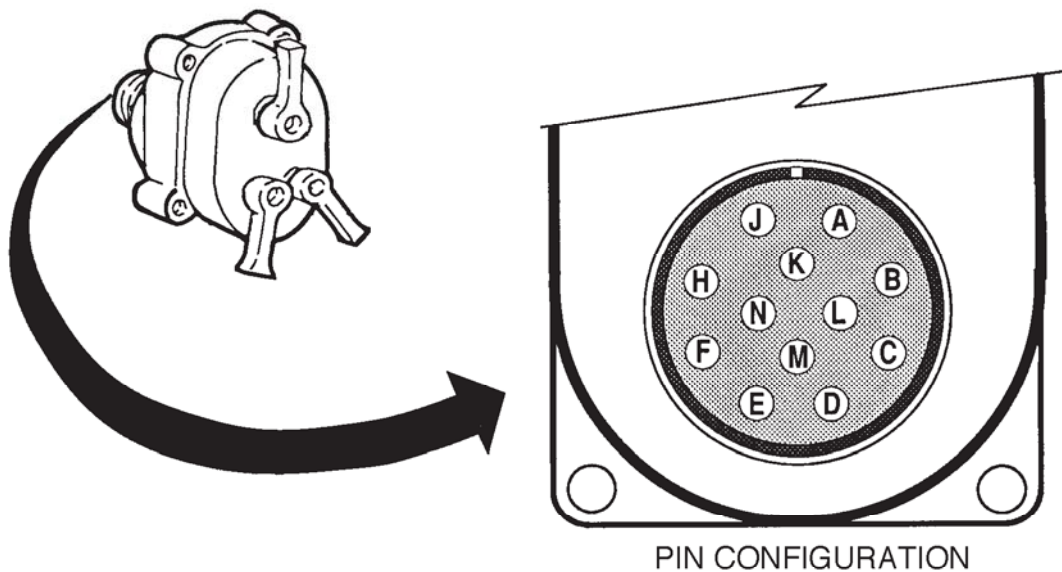


Figure 12-12. Master Lightswitch Pin Configuration.

**J. STOPLIGHTS INOPERATIVE OR DO NOT OPERATE PROPERLY (Figure 12-13)**

1. Check stoplight switch adjustment. Adjust stoplight switch.
2. Disconnect leads 75A and 75B from stoplight switch. Using multimeter, check leads on stoplight switch for continuity while operating switch. If continuity is not present, replace stoplight switch.
3. Check body wiring harness light switch cannon plug pins A to K for continuity while operating stoplight switch. If no continuity is present, repair body wiring harness.

**K. TURN SIGNALS INOPERATIVE OR DO NOT OPERATE PROPERLY (Figure 12-13 and 12-14)**

1. Disconnect negative battery cable and body wiring harness connection from turn signal switch. Using multimeter, check continuity of leads 467A and 467B from the body harness light switch connector pin J to body harness turn signal switch connector pin G. If continuity is not present, repair body wiring harness.

END OF TESTING!

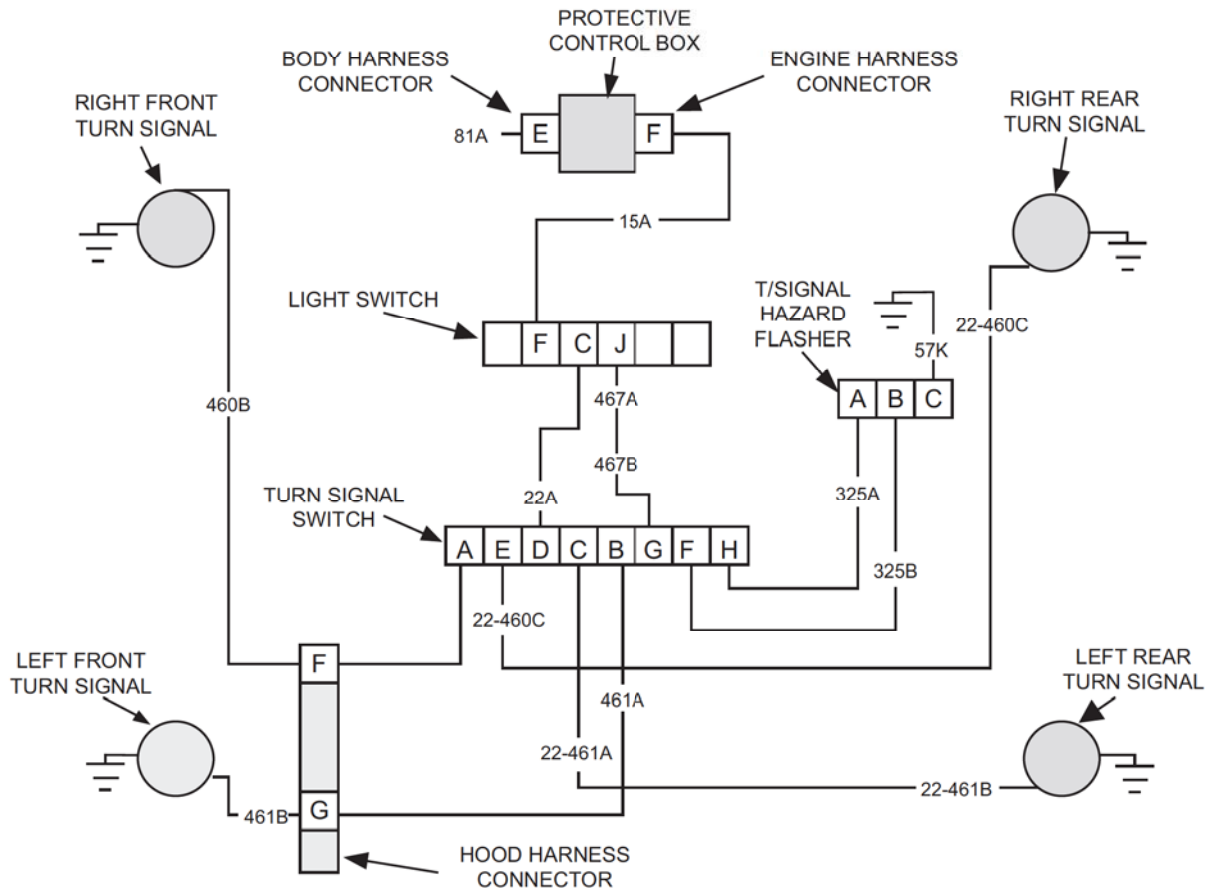


Figure 12-13. Turn Signal System Schematic.

Refer to Figure 12-14 for the following step.

2. Using multimeter, check continuity of turn signal switch from pin G to pin F with turn signal switch in left, right and hazard positions. If continuity is not present, replace turn signal switch.
3. Disconnect wiring harness from turn signal flasher. Using multimeter, check for continuity between lead 57K (terminal C) and ground. If continuity is not present, repair body wiring harness.
4. Set control lever in left hand or right hand positions. Using multimeter, check for battery voltage at lead 325B in turn signal flasher harness connector. If battery voltage is present, connect a jumper from lead 325A (terminal A) to lead 325B (terminal B) in flasher harness connector, if turn signal lamps light, replace flasher.
5. Disconnect wiring harness from directional signal control. Remove indicator lamp from control unit. Using multimeter, test for continuity using Table 12-3 Control Unit Test Chart. If any circuit does not test as shown on chart, replace directional signal control.

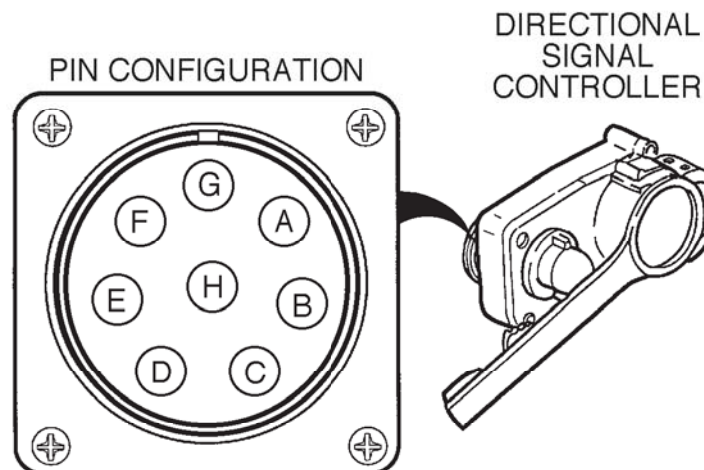


Figure 12-14. Turn Signal Pin Configuration.

CONTROL UNIT TEST CHART

A. DIRECTIONAL SIGNAL CONTROL LEVER IN "NEUTRAL" POSITION			C. DIRECTIONAL SIGNAL CONTROL LEVER IN "RIGHT TURN" POSITION		
FROM PIN	TO PIN	CONTINUITY INDICATION	FROM PIN	TO PIN	CONTINUITY INDICATION
H	A	OPEN	F	G	SHORTED
H	B	OPEN	H	A	SHORTED
H	C	OPEN	H	E	SHORTED
H	E	OPEN	H	B	OPEN
D	C	SHORTED	H	C	OPEN
D	E	SHORTED	D	C	SHORTED
F	G	OPEN	D	E	OPEN
B. DIRECTIONAL SIGNAL CONTROL LEVER IN "LEFT TURN" POSITION			D. DIRECTIONAL SIGNAL CONTROL LEVER IN "HAZARD WARNING" POSITION		
FROM PIN	TO PIN	CONTINUITY INDICATION	FROM PIN	TO PIN	CONTINUITY INDICATION
H	B	SHORTED	H	A	SHORTED
H	C	SHORTED	H	B	SHORTED
H	A	OPEN	H	C	SHORTED
H	E	OPEN	H	E	SHORTED
F	G	SHORTED	D	E	SHORTED
D	E	SHORTED	D	C	SHORTED
D	C	OPEN	F	G	SHORTED

Table 12-10. Control Unit Test Chart.

- Position main light switch lever to stoplight position. Working from Table 12-4 circuit chart, connect a jumper wire (minimum 14 AWG) from pin G of the turn signal switch body harness connector to the appropriate pin of the circuit being tested. If lamps do not light, repair or replace hood wiring harness.

CIRCUIT CHART

PIN	WIRE NO.	CIRCUIT
A	460A	Right Front Turn Signal
B	461A	Left Front Turn Signal
C	22-461A	Left Rear Turn Signal
E	22-460A	Rear Rear Turn Signal

Table 12-11. Circuit Chart.

**L. ONE OR MORE TRAILER LIGHTS INOPERATIVE (VEHICLE LIGHTING SYSTEM FUNCTIONS NORMALLY) (Figure 12-15)**

1. Position light switch to circuit being tested. Check for battery voltage at sockets. If battery voltage is present, replace bulb with bulb known to be operative. If bulb does not light, check for corroded connections, loose lamp sockets, or damaged wire terminals, repair or replace any damaged components.
2. Using multimeter, check for continuity between pins D and L of trailer receptacle to frame. If continuity is not present, repair body wiring harness.
3. Position light switch in circuit being tested. Using multimeter, connect ground lead to terminal L in trailer receptacle. Using Table 12-12 (page 12-26) Trailer Receptacle Circuit Chart, connect positive lead from multimeter to circuit terminal in trailer receptacle being tested. If battery voltage is present, repair trailer wiring harness. If battery voltage is not present, repair body wiring harness.

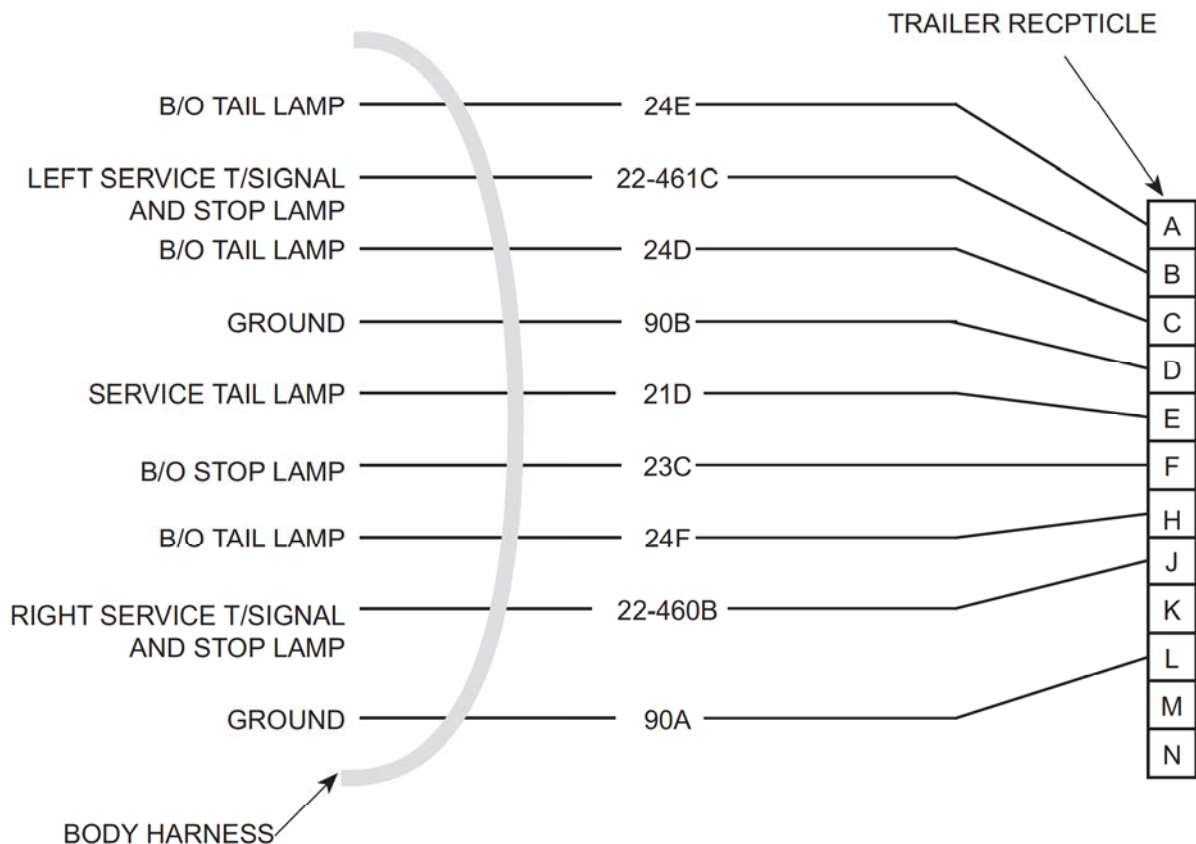


Figure 12-15. Trailer Lighting System Schematic.

**TRAILER RECEPTACLE CIRCUIT CHART**

PIN	WIRE NO.	CIRCUIT
A	24E	Rear B.O. Marker (LH)
B	22-461A	Service Stoplight (LH)
C	24D	Rear B.O. Marker (RH)
D	90B	Ground to Frame
E	21D	Service Taillight
F	23C	B.O. Stoplight
H	24F	B.O. Marker Lights
J	22-460B	Service Stoplight (RH)
K	None	Not Used
L	90A	Ground to Frame
M	None	Not Used
N	None	Not Used

Table 12-12. Trailer Receptacle Circuit Chart



## M. WARN 6000 POUND , 24 VDC WINCH ELECTRICAL TROUBLESHOOTING PROCEDURES

### a. Power Supply

Check for tight fit of all connections and use a volt meter to verify battery voltage at the bus bar connecting solenoids #1 and #3 (Figure 12-16). Connect black test lead to ground and red test lead to the hot bus bar, (**100 amps minimum required for testing, 200 amps minimum required for operation**).

### Note

The black insulating coating can sometimes contaminate electrical terminals and may need to be scraped off of contact surfaces.

### b. Grounding

The Solenoid mounting plate should be grounded to the motor by means of a band clamp. Newer model winches will also have a ground wire connecting the mounting plate with the motor ground bolt (-). Use an ohm meter to measure resistance between the mounting plate and the motor case; resistance should be less than 1 (ohm).

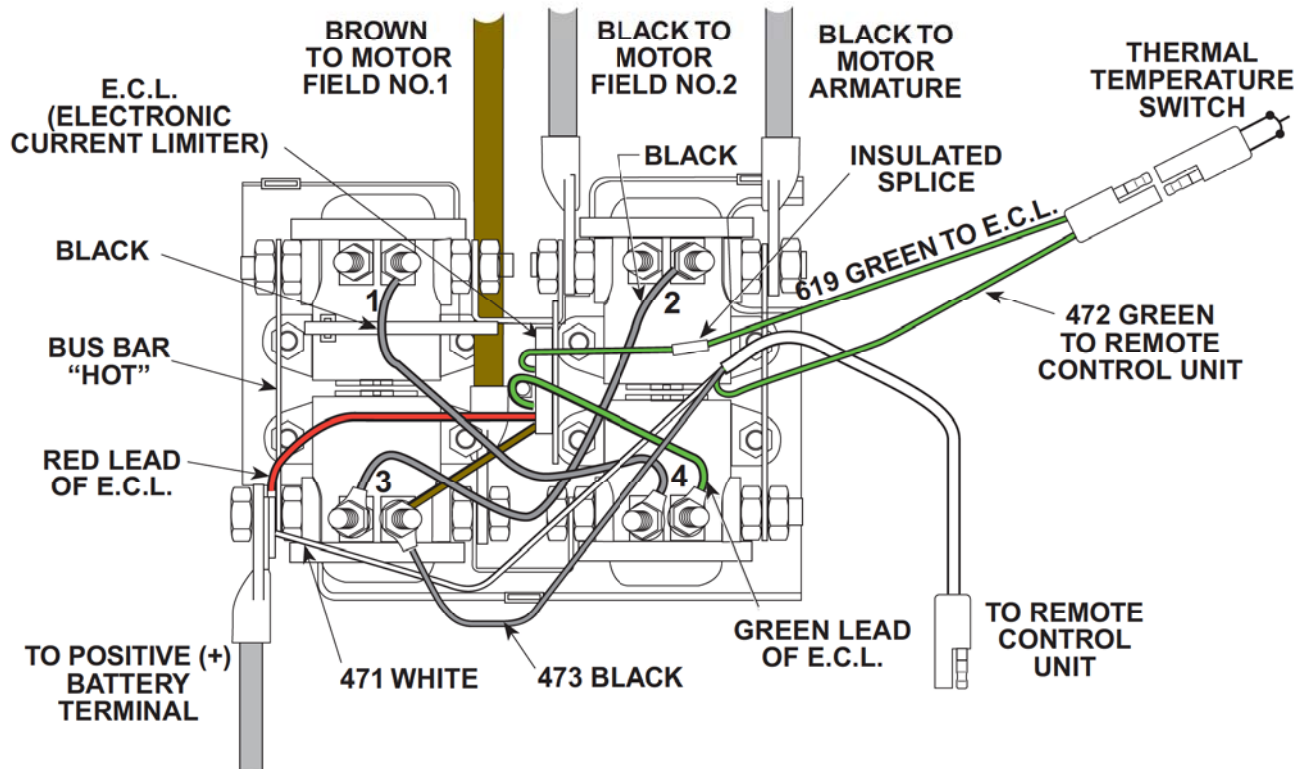


Figure 12-16. Winch Testing.

**c. Electronic Current Liiter (ECL)**

**Note**

The ECL can be tripped when first powered 'on' so always reset by powering out the wirerope for ten (10) seconds to reset the limiter.

1. If the winch will power-out but will not power-in, the ECL may be defective. First, check that the red wire coming from the charged bus bar is connected properly and that the mounting L-bracket of the ECL

circuit board is cleanly grounded to the solenoid plate.

1. If still no power-in, by-pass the ECL as follows: Cut the green ,(#619 ) wire coming from the thermal switch to the ECL near the splice on the ECL side (Figure 12-16). Take the cut wire coming from the thermal switch and connect it to solenoid #4 on the same terminal that the green ECL wire is attached (Figure 12-16). The winch should operate in both directions. If not, continue with the troubleshooting steps.

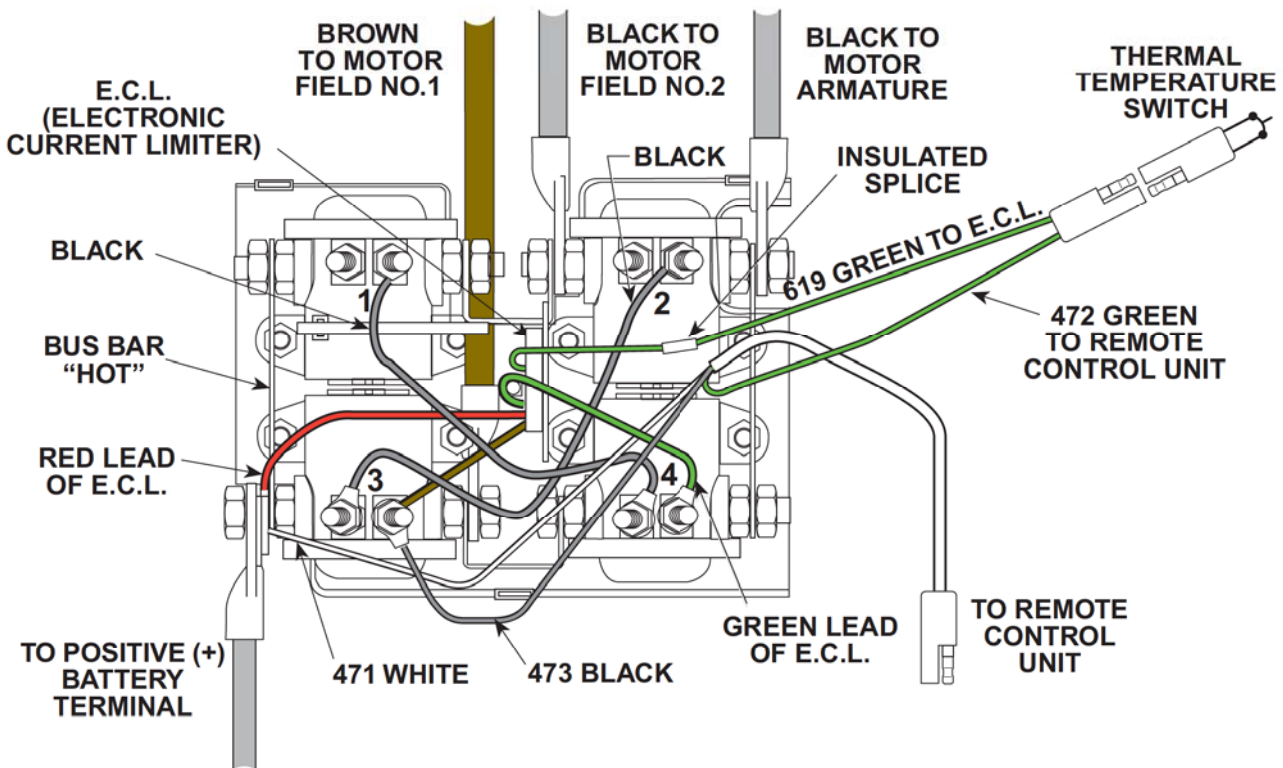


Figure 12-16 Repeat. Winch Testing.

d. Thermal Switch

**Note**

The motor will not run if the thermal switch is open or if its terminals are in contact with the motor case. The switch should normally open when the temperature at the motor brushes reaches 400+ F.

1. To check a faulting or shorting switch, use an ohm meter and measure the resistance of the thermal switch between the wire cut in the previous step and the socket pin (#472) of the plug, which is connected to the green wire (Figure 12-17). If the butt splice and switch are good, the resistance should be less than 1 (ohm) across the switch. If the switch is open at room

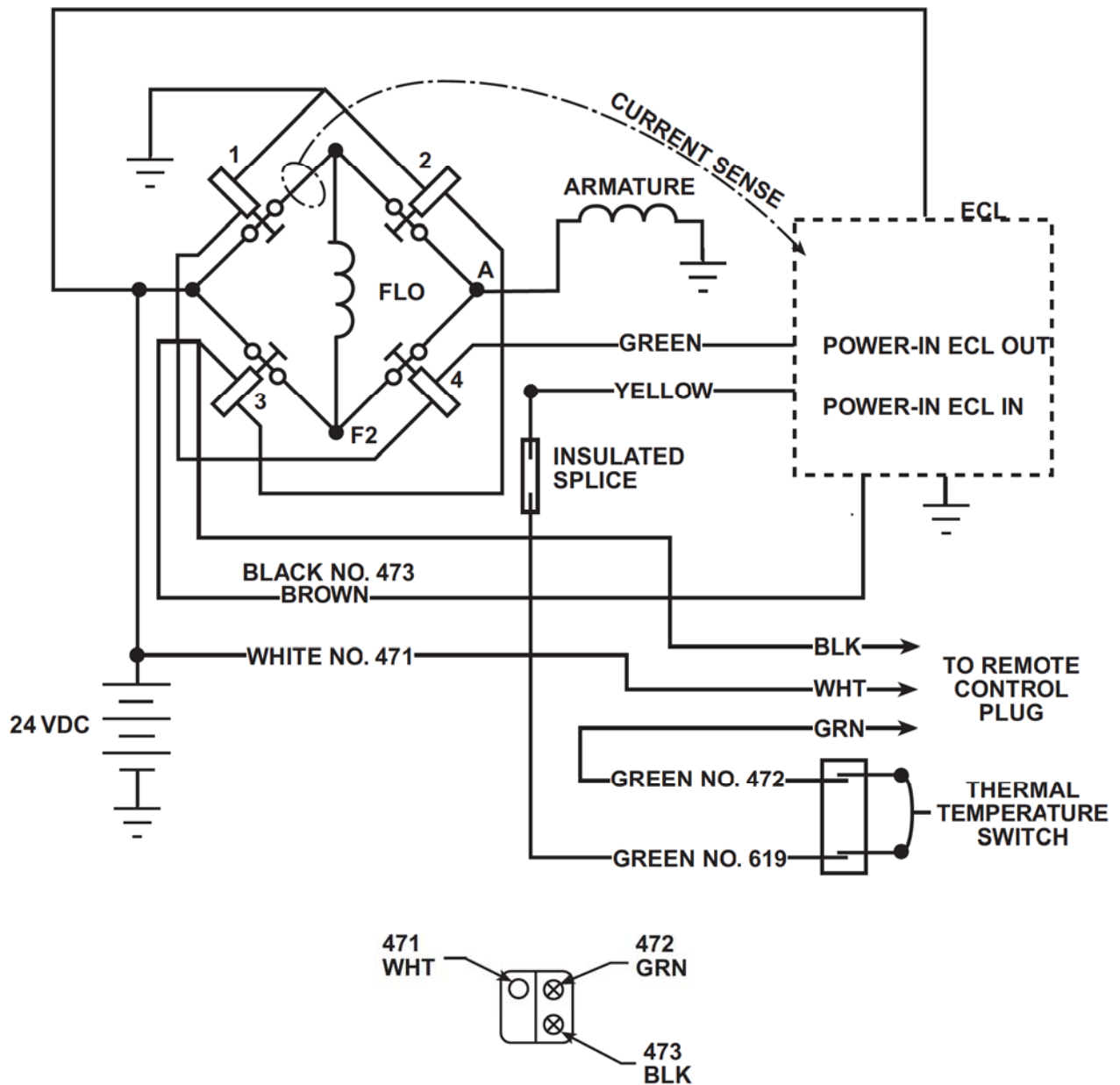


Figure 12-17 Figure 12-17.Repeat. Winch Testing.

temperature then the motor should be replaced. Next, check the resistance between the cut wire and the bare motor case. The resistance should be greater than one megaohm. If not, replace motor.

Measure the resistance from 'F1' and 'F2' and between 'A' and ground. Resistance should be less than 1 (ohm). The motor brushes could be worn, or the internal wiring could be burned and the motor should be replaced.

**e. Motor**

**Note**

If the motor is suspected to be failing check the following.

**Note**

If faults were not detected in steps A, B, C, D and E, replace solenoid pack.

Disconnect F1, F2 and A leads from motor.

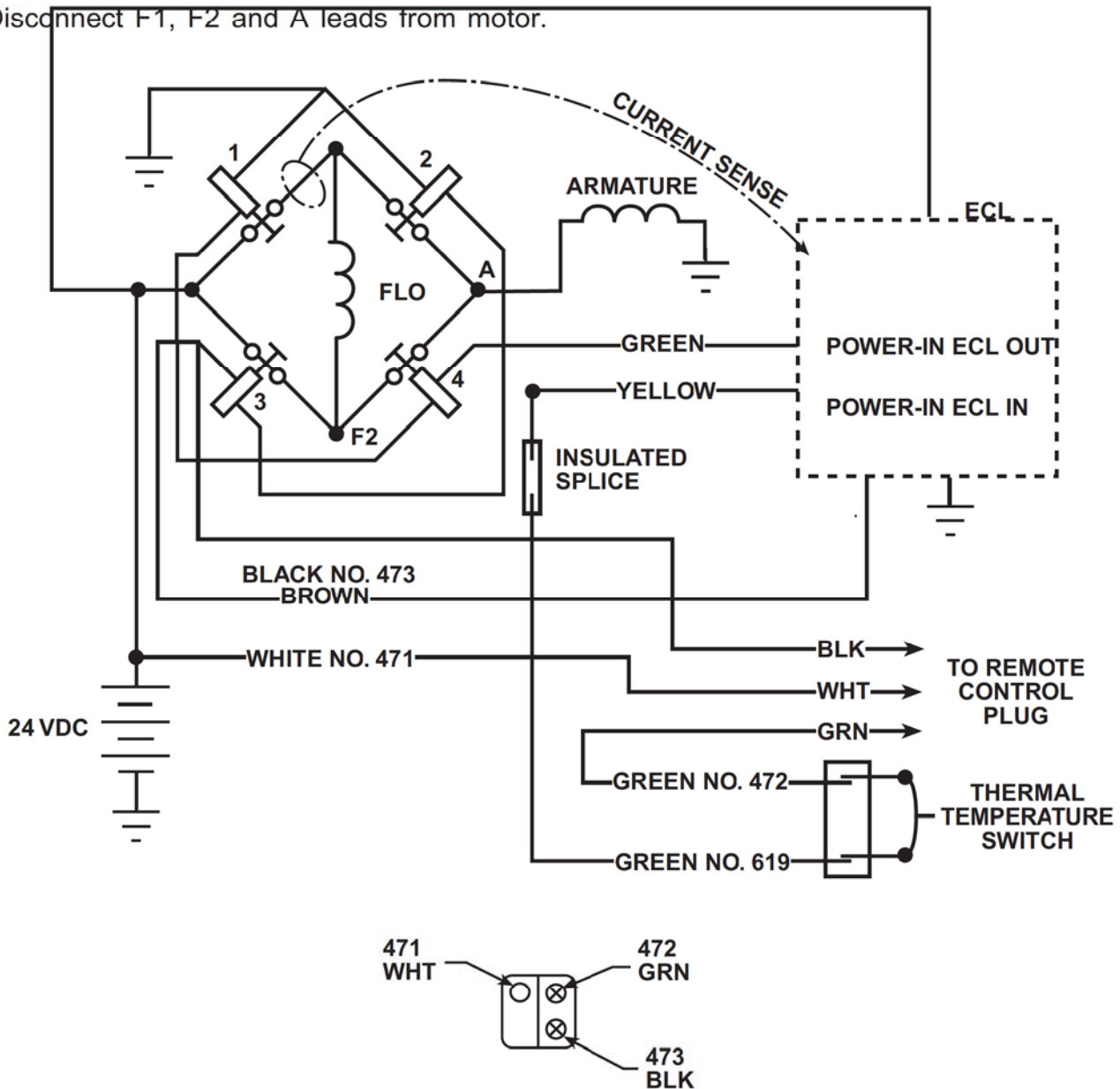


Figure 12-17.Repeat. Winch Testing.

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# SECTION 13

## TIME DELAY MODULE

## OPERATION

### PICTORIAL SCHEMATICS

#### NOTE

The following group of pictorial schematics are intended to be presented by a qualified instructor who is familiar with the Time Delay System and can properly color-code current and fluid flow.

**A. TIME DELAY MODULE OPERATION**  
(Figure 13-1).

**a. Fan Temperature Switch Closed**  
**Engine Not Running (Figure 13-1)**

With the rotary ignition switch (1) in the off position (open) there is no current flow to the fan temperature switch (2) or the time delay module (3) through the #458 wire. Since the electric solenoid (4) is not activated, there is no hydraulic flow through the hydraulic control valve (5) to release the fan clutch. The fan clutch remains engaged, locking the fan to the fan drive unit.

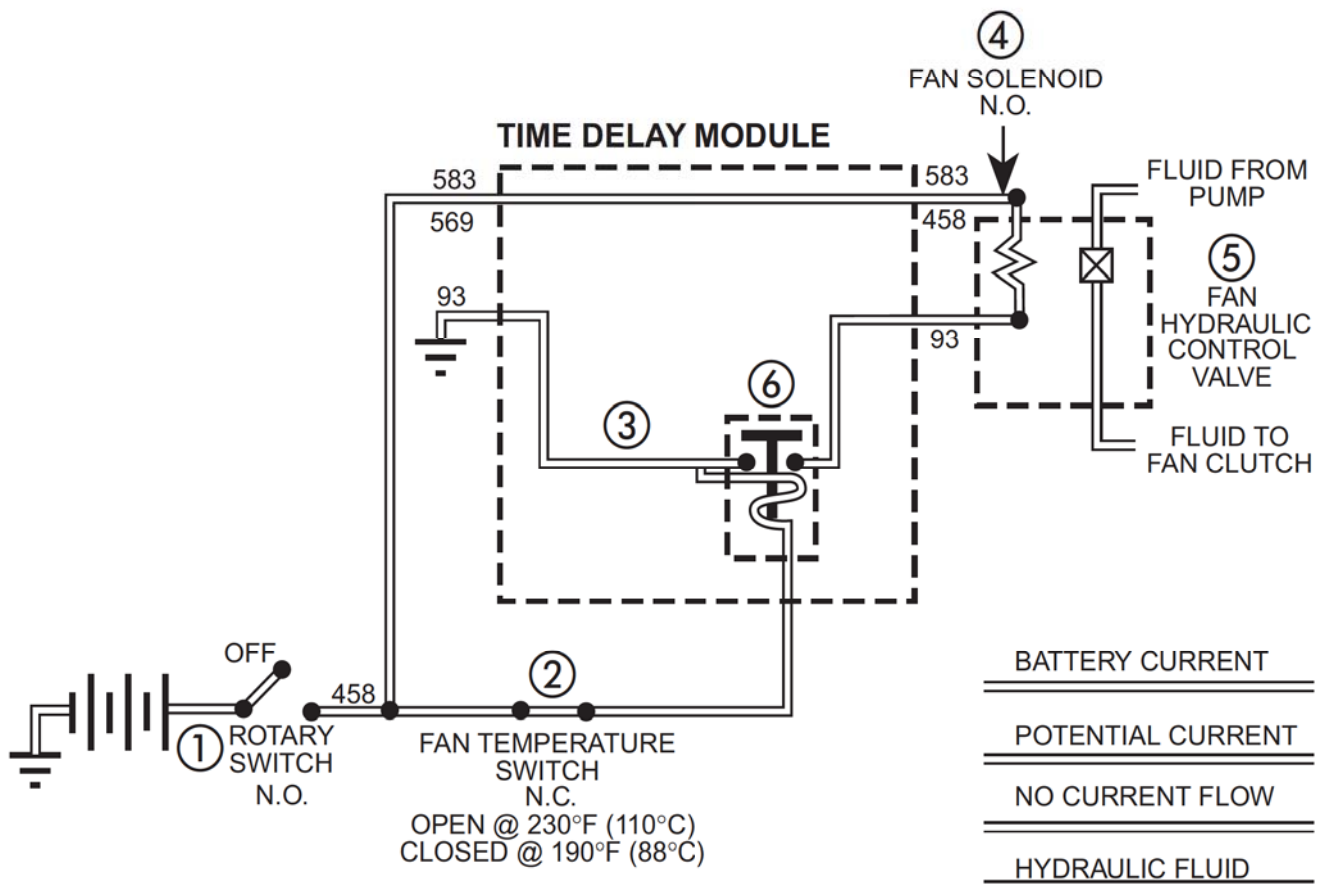


Figure 13-1. Fan Temperature Switch Closed  
Engine Not Running.

**b. Fan Temperature Switch Closed, Engine Temperature below 230°F. Engine Running. (Figure 13-2)**

1. With the rotary ignition switch (1) in the “R” (run position), current flows from the battery through the #458 wire across the normally closed (NC) fan temperature switch (2), through a relay (6), out the #98 wire to ground.
2. The current flowing through the relay (6) closes a set of points in the #93 circuit. This circuit completion now allows current to flow through the #583/569 wire, through the time delay module (3), out the time delay module via the #583/458 wire, through the fan solenoid (4), out the #93 wire, back through the time delay module (3), across the closed points (6) and out to ground.
3. This flow of current activates the fan solenoid (4), which opens the fan hydraulic control valve (5), allowing hydraulic oil to flow up to 160 PSI to the fan clutch, overcoming the spring and disengaging the fan from the fan drive, letting the fan free spin.

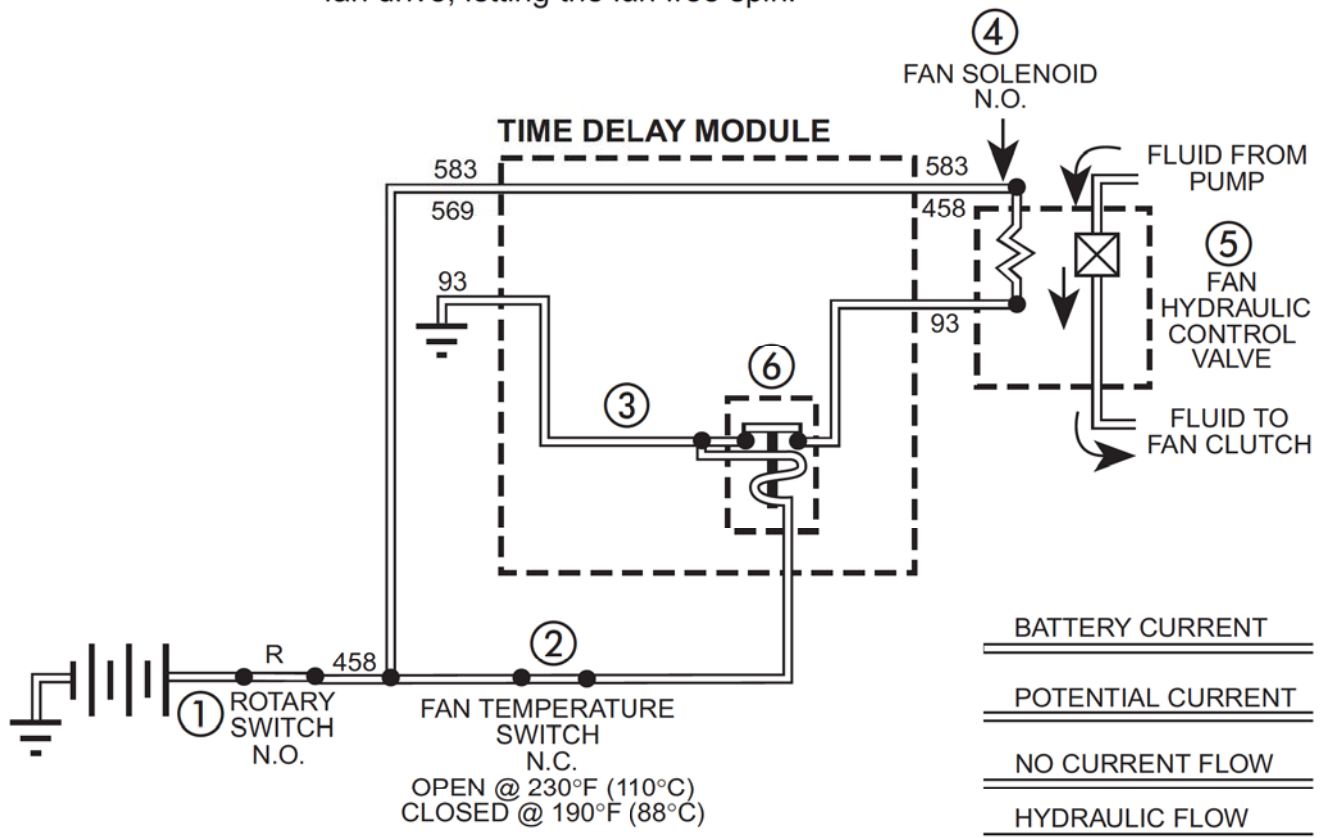


Figure 13-2. Fan Temperature Switch Closed, Engine Temperature below 230°F. Engine Running.

**c. Fan Temperature Switch Closed  
Engine Temperature Below 230°F.  
(Figure 13-3)**

1. When the engine temperature reaches 220°F, the normally closed fan temperature switch (2) opens. The open switch breaks the completed circuit through the relay (6) to the #93 ground wire.
2. The points opening, break the completed #583/458 circuit through the fan solenoid (4) to ground.
3. When the fan solenoid (4) is de-energized, the fan hydraulic control valve (5) closes, blocking hydraulic fluid flow from the pump to the fan clutch, letting the fan clutch lock the fan to the fan drive for engine cooling.

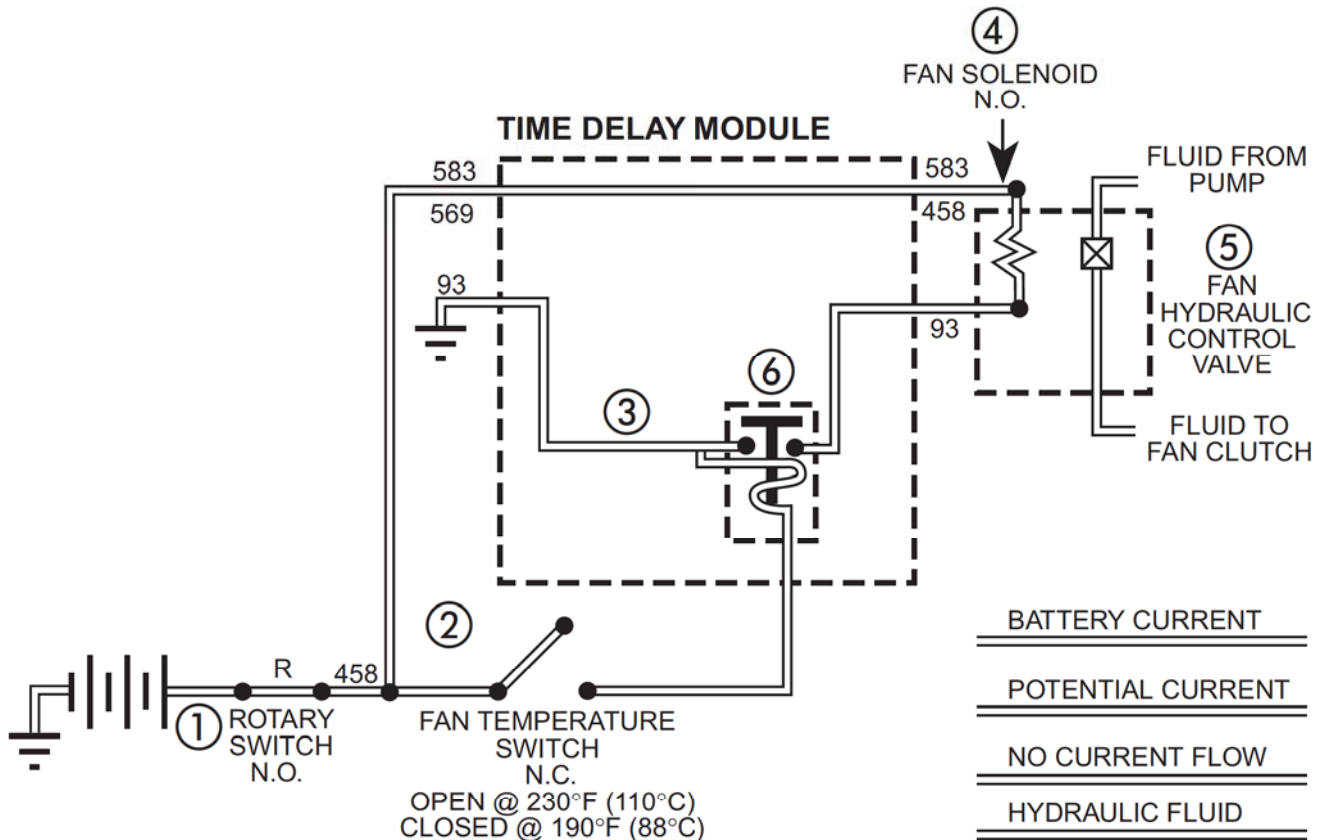


Figure 13-3. Fan Temperature Switch Closed  
Engine Temperature Below 230°F.



**d. Fan Temperature Switch Open  
Engine Temperature Above 230°F  
Kickdown Switch Closed (Figure 13-4)**

1. Engine temperature is above 220°F and the fan clutch is engaged, turning the fan for engine cooling.
2. When extra horsepower is required, the kickdown switch (7) is activated, completing the #315 circuit. Current flows from the batteries through the #458 wire, through the #315 wire, across the closed kickdown switch (7), through the normally open 20 second timer (8) and out the #93 wire to ground.
3. The 20 second timer closes the points (9) in the #93 circuit, letting current flow through the #583/458 circuit to the fan solenoid (4) through the #93 wire, across the closed points (9) and out to ground.
4. This flow of current through the fan solenoid (4) opens the control valve (5) and holds it open as long as the timer (8) is activated. This allows oil to flow to the fan clutch, overriding the spring pressure, disengaging the fan clutch and giving the engine an approximate 12-15 horsepower boost.

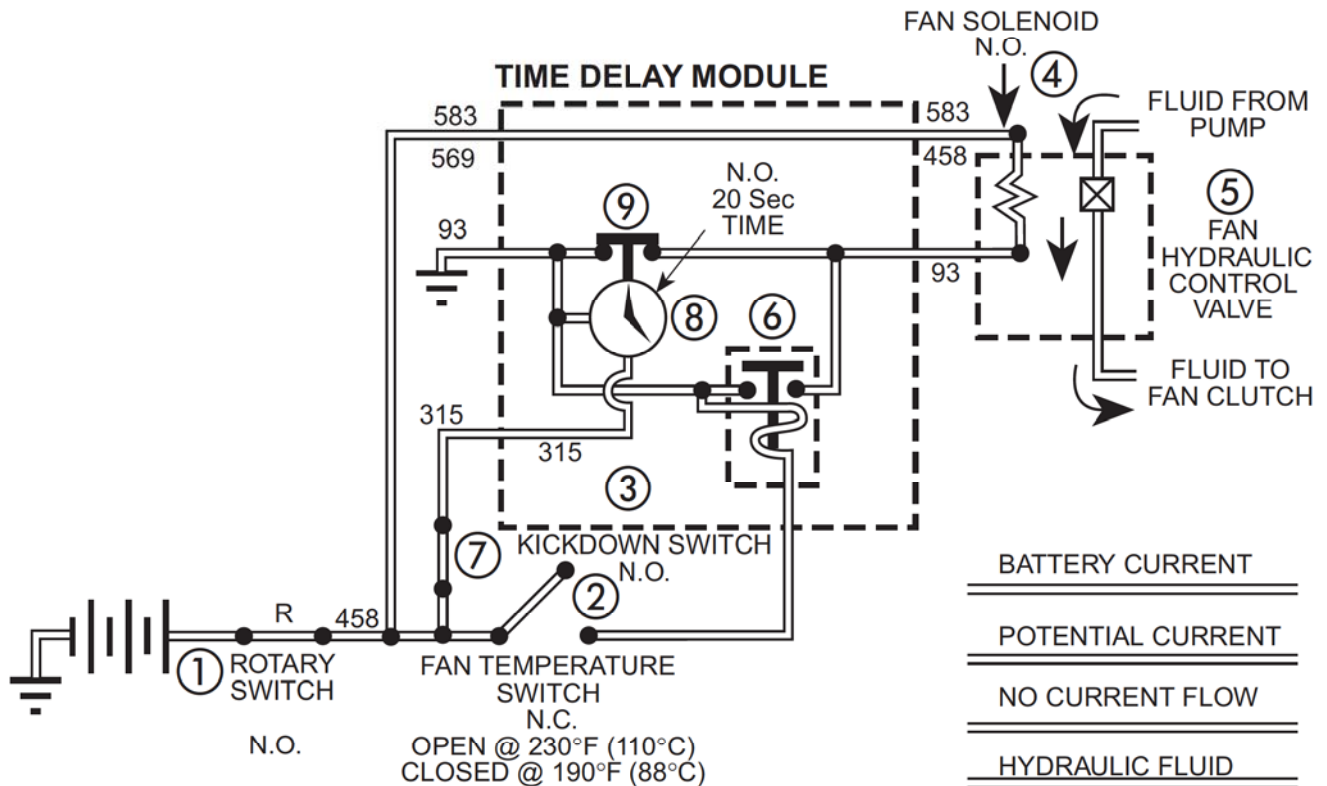


Figure 13-4. Fan Temperature Switch Open  
Engine Temperature Above 230°F  
Kickdown Switch Closed.

**e. Fan Temperature Switch Open  
 Engine Temperature Above 230°F  
 Kickdown Switch Closed (Figure 13-5)**

The first 20 second timer (8) actually operates a dual set of points (9) simultaneously. Current flows across the second set of points (9), into a capacitor (10), charging the capacitor.

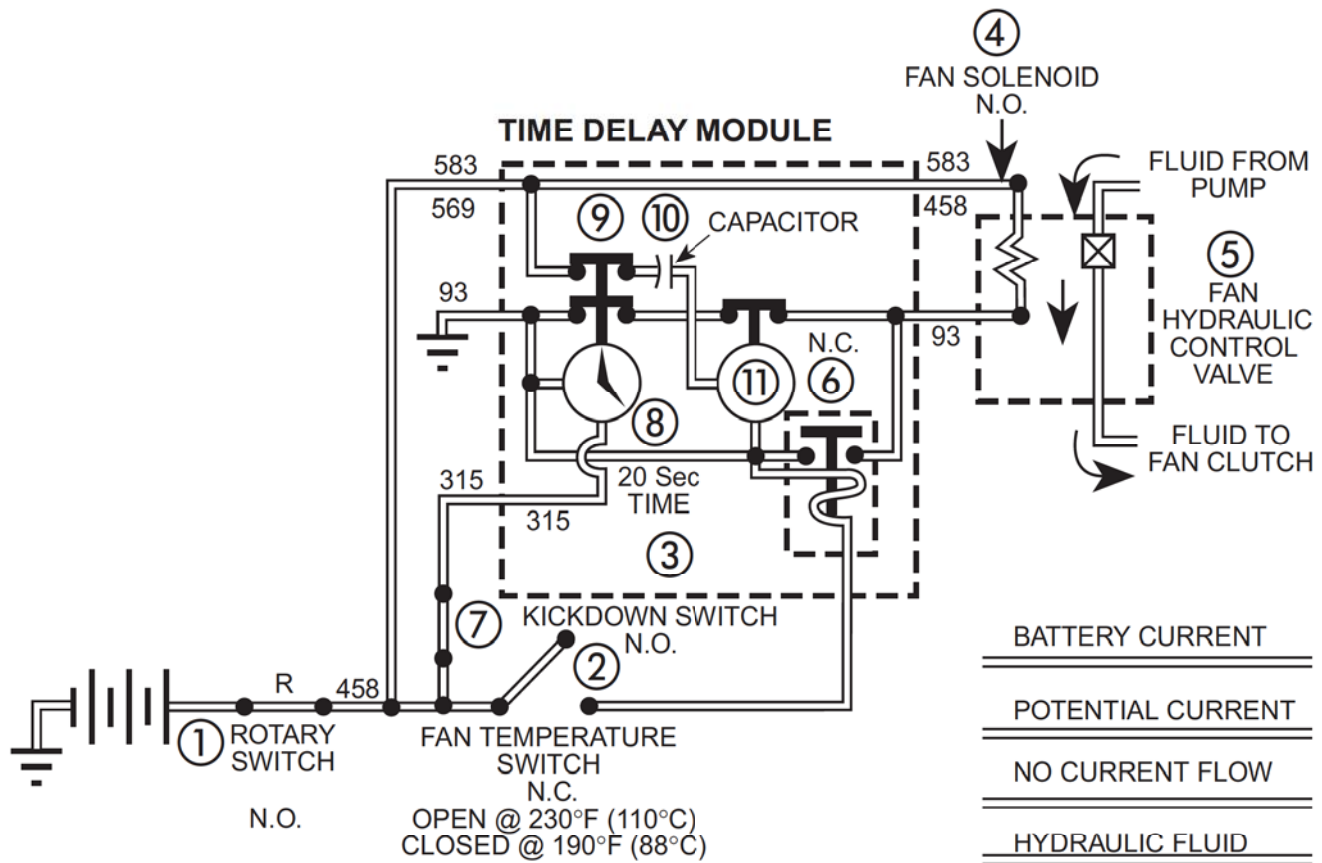


Figure 13-5. Fan Temperature Switch Open  
 Engine Temperature Above 230°F  
 Kickdown Switch Closed.

**f. Fan Temperature Switch Open  
Engine Temperature Above 230°F  
Kickdown Switch Open (Figure 13-6)**

1. After the first 20 second timer (8) expires, the dual points (9) open, breaking the completed #93 circuit and the fan clutch is engaged for extra engine cooling.
2. When the current to the capacitor (10) is interrupted, the capacitor (10) discharges its stored current through the second 20 second timer (11) and out the #93 wire to ground. This discharge of current activates the #2 timer (11), opening the points in the #93 circuit (12).
3. If the kickdown switch (7) is activated again (while the #2 timer is in its 20 second cycle) the fan will not disengage. After the #2 timer completes its 20 second cycle, the kickdown switch (7) can be activated and the fan will disengage again, giving the engine an additional gain in horsepower.

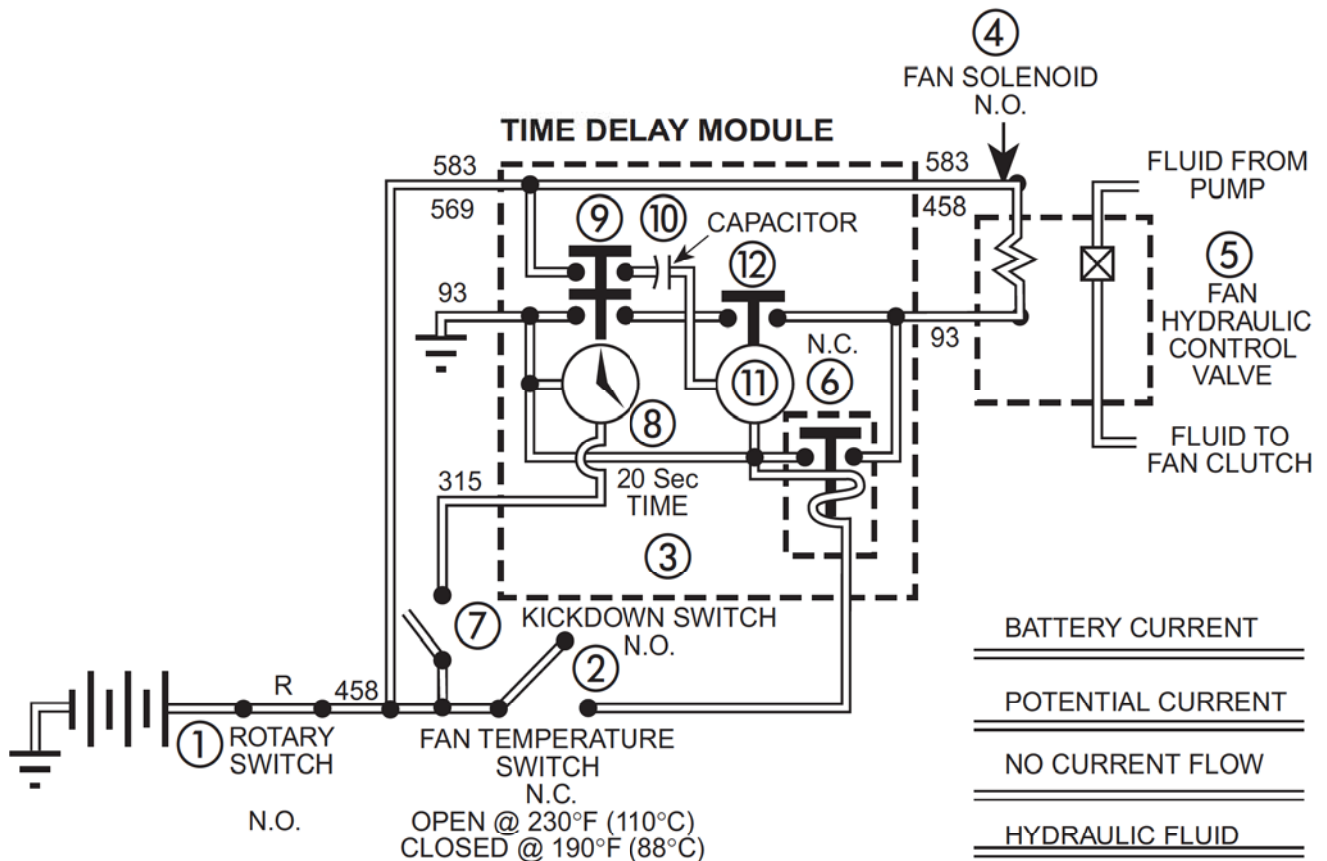


Figure 13-6. Fan Temperature Switch Open  
Engine Temperature Above 230°F  
Kickdown Switch Open.

## **B. TIME DELAY MODULE TESTING**

### **a. Description**

The time delay module sends a delayed signal to the fan clutch solenoid for delay of fan actuation to provide needed horsepower for engine acceleration. During normal engine operation [(engine coolant temperature below 230°F) (110°C)], current flows through the time delay module energizing the fan solenoid circuit. This provides hydraulic pressure to overcome spring pressure thereby disengaging the fan clutch.

When engine coolant temperature exceeds 230° F(110°C), current is interrupted by the fan temperature switch. This interruption of current causes the time delay relay to open, thereby de-energizing the fan solenoid circuit and allowing the fan to engage for additional cooling. If the kickdown switch is actuated during fan operation, the time delay is activated, disengaging the fan for approximately 20 seconds and providing additional horsepower. If the kickdown switch is activated again, an additional timer within the time delay module prevents the disengagement of the fan until 20 seconds has elapsed allowing for adequate engine cooling. After the timer completes its 20 second cycle, the kickdown switch can be reactivated and the fan will disengage, providing additional horsepower.

**b. On-Vehicle Testing (Figure 13-7)**

1. Disconnect glow plug controller.
2. Turn rotary switch to the RUN position.
3. Using a multimeter, measure voltage at the four and two prong connector of the time delay module (do not disconnect prongs).
4. Perform continuity test on control valve solenoid. 58 to 78 ohms both ways.

**c. Four Prong Connector**

- a. Leads 458 and 569 should indicate battery voltage. If no voltage is present, repair ignition circuit.
- b. Leads 93 and 315 should indicate 0 voltage. If voltage is indicated, repair live short.

**d. Two Prong Connector**

- a. Lead 483 should indicate battery voltage. If no voltage is indicated, replace time delay module.

b. Lead 93 should indicate 0 voltage. If battery voltage is indicated, replace time delay module.

3. Disconnect either lead (458) at fan temperature switch. [(This simulates engine coolant temperature at 230°F (110°C) or above)]. Using a multimeter, measure voltage at the four and two prong connectors. Leave 458 disconnected.

a. Lead 458 at the four prong connector should measure 0 volts. Replace time delay module if voltage is indicated.

b. Lead 315 at the four prong connector should “momentarily” measure battery voltage when kick down switch is manually actuated. If measured voltage remains, replace time delay module.

c. Lead 93 at the two prong should measure battery voltage with kickdown switch *not* engaged. Momentarily engage kickdown switch, battery voltage should drop to 0 for approximately 20 seconds. If measured voltage remains, replace time delay module. Immediately after test activate kickdown switch again. The time delay switch should not allow the voltage drop for another 20 seconds. After 20 seconds has passed, repeat 1st test.

4. Turn rotary switch to the OFF position.

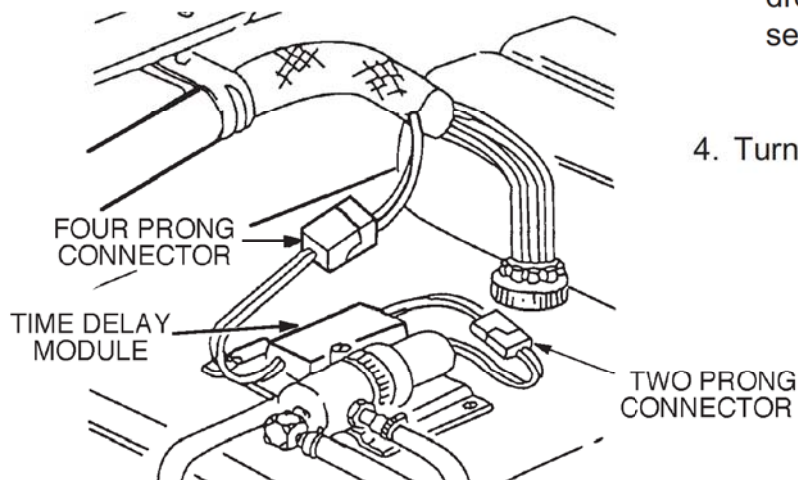


Figure 13-7. Time Delay Module Connector Testing.

**C. BENCH TESTING (Table 13-1)**

**NOTE**

**Time delay module may be bench tested without removing from vehicle.**

1. Disconnect four and two prong leads from module.
2. Using a multimeter, check for continuity at the following leads of the time delay module:
  - a. Lead 458 at the two prong and 569 at the four prong. If continuity is not present, replace time delay module.
  - b. Measure for continuity in the remaining leads at the time delay module. If continuity is detected at any remaining leads, replace time delay module.
3. Using a multimeter, check for resistance at the following leads. Set resistance range switch at R3 (see Table 13-1).

TWO PRONG	FOUR PRONG	
LEAD #	LEAD #	RESISTANCE
93+	458-	∞(Infinity)
93-	458+	∞
93+	569-/583*	∞
93-	569+/583*	∞
93+	93-	∞
93-	93+	∞
93+	315-	∞
93-	315+	∞
458+/583*	458-	∞
458-/583*	458+	∞
458+/583*	569-/583*	Continuity
458-/583*	569+/583*	Continuity
458+/583*	93-	∞
458-/583*	93+	∞
458+/583*	315-	∞
458-/583*	315+	∞

\* Wire #458 is superseded by wire #583, and #569 is superseded by #583 on Level III vehicles only.

Table 13-1. Time Delay Module Resistance Tests.