EVC

ELECTRIC VEHICLE CONTROLS

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GEK-25351

EV-10* SCR CONTROL

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GENERAL ELECTRIC

JANUARY, 1983

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CHAPTER 2	CONTROL SPECIFICATIONS
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The information contained herein does not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purhcaser's purposes, the matter should be referred to General Electric Company.

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CHAPTER 1
GENERAL DESCRIPTION OF THE EV-10 SCR CONTROL

INSTRUCTIONS

GENERAL DESCRIPTION OF THE EV-10* SCR CONTROL

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CHAPTER 1
GENERAL DESCRIPTION

SECTION 1
INTRODUCTION

SCR VS. RESISTOR CONTROL

Before the introduction of the Silicon Controlled Rectifier (SCR), the traction motor control most widely used on electric trucks was resistor stepped control. The operator using stepped control had a very limited number of operating speeds. Moreover, speed change with resistor stepped control was accompanied by jerky operation and a loss of battery power, being burned up as heat in the resistors. Stepless SCR control, however, is smooth from zero speed to 90% speed. SCR uses just enough power from the battery to perform the required task.

Forward and reversing contactors are still required on SCR-controlled trucks. These contactors reverse the current flow in the series field to control the truck's direction once power is applied. However, with SCR-equipped trucks, the operator has more complete control of speed from zero through slow inching and on up to maximum speed. All speed changes are smoothly completed because SCR control operates with a programmed build-up of pulses. Resistor control, on the other hand, must get the truck to a pre-set or "stepped" speed as soon as the forward or reverse contactor is closed. Each step causes an abrupt jump or jerk in the motion of the truck.

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Figure 1.1.1 shows the additional range of extended battery life that can be obtained from a given battery charge when SCR control is used instead of resistor control. The savings are greater when the duty cycle is conducted at lower speeds.

When the accelerator is fully depressed, both SCR and resistor controls use a bypass contactor to connect the motor directly across the battery. This bypass technique provides maximum power, speed, and efficiency in response to complete acceleration.

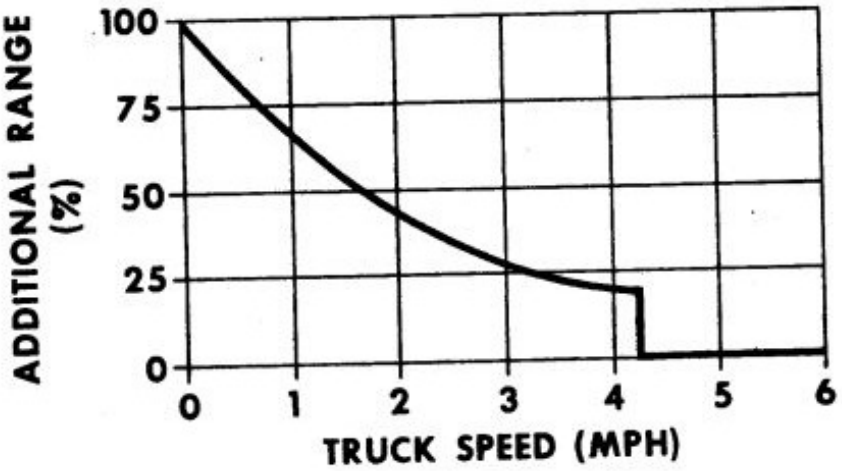


Figure 1.1.1
ADDITIONAL RANGE OF EXTENDED BATTERY LIFE
WITH SCR CONTROL*

* Assuming that the pump motor utilizes half the battery capacity and that the truck is rated at 6 mph.

Ref. 91.TMP.1

PERFORMANCE CHARACTERISTICS

The curves in Figure 1.1.2 show performance characteristics of a typical General Electric motor. These curves indicate the currents drawn by the motor for any speed during the entire range of normal vehicle operation.

The upper curve represents performance with the motor connected to full voltage on a battery (1A contactor closed). The lower curve represents motor performance under SCR control.

With SCR control, the truck motor can be operated at any given point on or below its top SCR speed curve. For example, SCR control gives an infinite number of speed-torque curves between the SCR curve and zero, illustrating the controllability range of the motor while on SCR control.

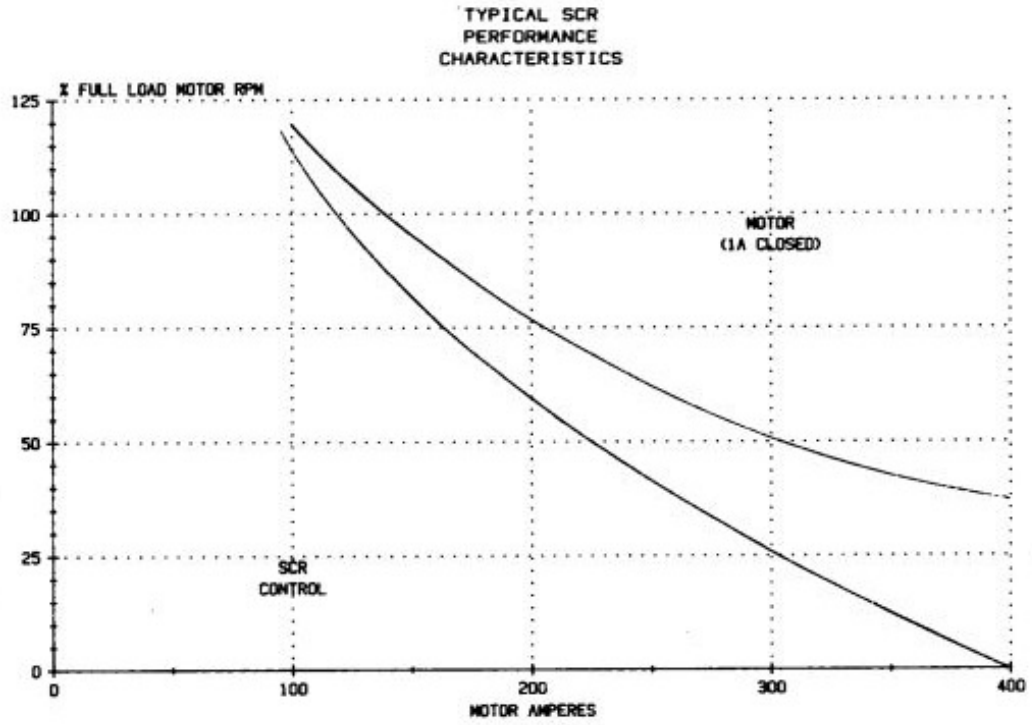


Figure 1.1.2
PERFORMANCE CHARACTERISTICS OF A TYPICAL MOTOR

Ref. 91.TMP.2

Table 1.1.1
RESISTOR vs. EV-10 SCR CONTROL

	RESISTOR CONTROL	EV-10 SCR CONTROL
ENERGY SAVINGS:	An electric vehicle's speed is proportional to the motor voltage. With resistor control, the battery continuously provides rated voltage (24, 36, 48, etc.). At the slower speed steps, resistor control only uses 30 to 70 percent of the available voltage. The remainder is wasted in the form of heat in the resistors.	The high efficiency of the EV-10 SCR control reduces power bills for recharging batteries. SCR control has proved to be approximately 90% efficient at reduced speeds. Trucks equipped with SCR control operate from 10 to 40% longer on a given charge, depending on the duty cycle. The more time run at low speeds, the greater the savings realized with SCR control.
PERFORMANCE:		
Acceleration	Acceleration to top speed is determined by time delays built into each speed step.	The EV-10 provides smooth controlled acceleration to top speed in approximately 2 seconds.
Reversing	Either reversal is very rough, or the operator loses control of the vehicle (all contactors opened) when changing direction.	SCR plugging provides smooth deceleration and change in direction from any operating speed. Operator movements are minimized. The only operation required is to move the directional lever or grip. This significantly reduces maneuvering time.
Maneuvering	Maneuvering can be difficult when discrete speed changes occur.	The truck can be maneuvered, or even inched, through tight aisles or in crowded storage areas.

Table 1.1.1 (Continued)
RESISTOR vs. EV-10 SCR CONTROL

	RESISTOR CONTROL	EV-10 SCR CONTROL
SAFETY:		
Uncontrolled Vehicle Movement	Contactors which repeatedly make and break load currents are susceptible to welding themselves closed at the tips.	The EV-10 contains circuitry which minimizes the chances of uncontrolled vehicle movement.
Load Handling	When a load is raised on the forks, any sudden movement of the vehicle will be transmitted to that load.	The smooth speed control of the EV-10 greatly reduces this reaction.
PROTECTION OF COMPONENTS:		
Speed Changes/ Reversal	Discrete speed changes associated with resistor control impose shock loading on drive train components.	Smooth speed control greatly reduces the wear on the drive train. In addition, with plugging, the service brakes are used less often.
Battery Connection	Inadvertent reverse battery connection can damage the control components.	The EV-10 contains reverse battery connection protection.
Overloading	Abuse of the vehicle can cause damage or shorten the life of electrical components.	The EV-10 contains a thermal protector and current limit circuit which protects the control from abuse.

Table 1.1.1 (Continued)
RESISTOR vs. EV-10 SCR CONTROL

	RESISTOR CONTROL	EV-10 SCR CONTROL
MAINTENANCE:		
Contactors	All contactors require regular inspection and replacement of expensive contact tips.	Only one contactor makes and breaks load currents, reducing this costly maintenance aspect.
System	Control circuits and replacement parts may vary from one truck builder to another. This makes troubleshooting and parts inventory more expensive.	The basic EV-10 circuit and parts are the same from one truck builder to another.

SECTION 2
WHAT IS THE EV-10?

THE EV-10 IS AN SCR CONTROL.

The basic principle used in the EV-10 SCR truck control is the chopping, or pulsing, of the battery voltage to the motor. The effective voltage at the motor terminals (thus, the speed of the vehicle) is a function of the number of pulses over a period of time. The frequency and duration of these pulses is varied according to the position of the speed control potentiometer mounted in the accelerator switch or the control handle.

Below 90% of full speed, the SCR control varies motor voltage by alternately conducting and blocking current at the rate of 50 to 300 Hz.

When the accelerator is fully depressed, the SCR control uses a bypass contactor to connect the motor directly across the battery. This bypass technique provides maximum power, speed, and efficiency in response to complete acceleration.

The EV-10 is the major element of a complete drive system. Other components include:

- A directional switch.
- An accelerator switch.
- Forward/reverse contactors.
- A bypass contactor.

COMPONENTS

The EV-10 itself consists of several major groups of components, which are described below. (For a complete description of these components, see Section 6, Circuit Operation.)

Table 1.2.1
EV-10 COMPONENTS

COMPONENT GROUP	FUNCTION
Main SCR (1 REC)	Switches battery power to the motor.
3 REC and 4 REC power devices	Carry motor currents during prescribed times, during 1 REC off time, and during plugging.
Commutation circuit	Consists of the 2 REC, the 5 REC capacitor, and the transformer or the reactor. Turns off the 1 REC for each pulse.
Heat sink	Holds 1 REC through 5 REC. Helps to keep these devices within their temperature ratings.
Logic card	Performs all control functions: controls the rate of pulsing of 1 REC, turns on or off the directional and 1A contactors, maintains currents within prescribed limits, and initiates a shutdown in case of a component failure.

SECTION 3
GLOSSARY

This glossary of commonly used terms will make it easier to understand this publication and other material on the EV-10 SCR control for electric trucks.

1A CONTACTOR (BYPASS) - During gradual acceleration (ramp operation) or high-speed travel, the drive motor may need a large current beyond the rating of the SCR to overcome the increase of the traveling load. To meet this requirement, an additional contactor having a large current capacity is installed in parallel to 1 REC. This contactor, when closed, applies full battery voltage and current to the drive motor. The 1A contactor is closed automatically when either of the following conditions occurs:

1. The accelerator potentiometer ohms fall below 500 ohms (.5 volts), and the 1A timer times out.

2. The accelerator potentiometer ohms fall below 500 ohms (.5 volts) after the truck is stopped by plugging and starts traveling back and after the 1A timer times out. (The truck is prevented from being subjected to a shock caused by energizing the 1A contactor immediately after plugging even when the accelerator pedal is fully depressed during plugging.)

ACCELERATOR - The accelerator consists of the start switch, which closes the traveling signal circuit, and the potentiometer (precise variable resistor), which turns in proportion to the angle of the control handle. Travel speed is controlled by variation of the resistance of the potentiometer. In standup vehicles the accelerator also contains directional switches.

ANODE - The positive terminal of a semiconductor device through which current flows into the device.

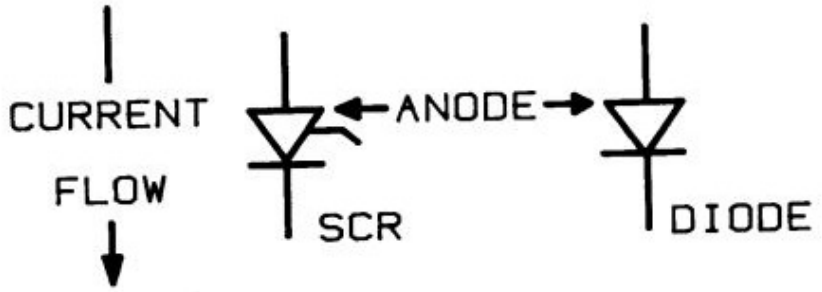


Figure 1.3.1
ANODE

AVERAGE CURRENT - On a pulsed system, the effective value of current that performs work. Average current can be read with a conventional dc ammeter.

CAPACITOR - A device which stores an electric charge in 2 metal sheets on opposite sides of an insulator (similar to a quick-charge and discharge battery).

CATHODE - The negative terminal of a semiconductor device through which current flows out of the device.

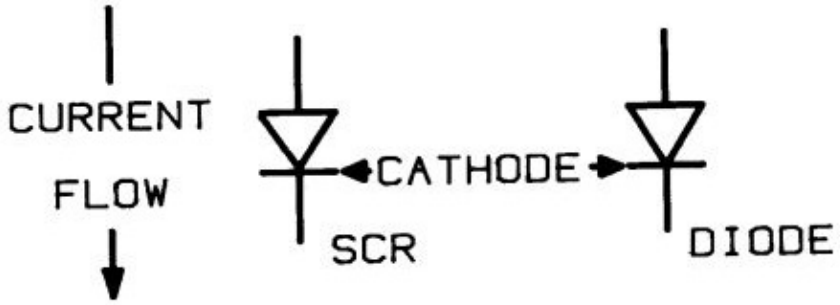


Figure 1.3.2
CATHODE

CHARGING TRANSFORMER - A transformer which uses its primary winding to increase the charge on commutation capacitor 1C. Its secondary winding reverses the charge on commutation capacitor 1C.

COMMUTATE - To turn off.

CONTROL CARD - A printed circuit board containing electronic components which control all circuit functions.

CONTROLLED REVERSING (PLUGGING) - To brake a motor electrically and allow it to rotate in reverse. During Forward (F) to Reverse (R) traveling or (R to F), one contactor which is closed (energized) opens; and the other contactor which is open (de-energized) closes. The reversal of the connection of the field coil causes the motor to act as a generator which delivers current to 3 REC. This causes the motor to stop quickly. To prevent excessively quick braking, which gives a large shock to the truck and its operator, 4 REC is installed in parallel to the armature of the motor. This forms a shunt circuit, which effectively restricts the excessive increase of current so that reversal in the direction of travel is made smoothly.

The potential difference (voltage) produced between the cathode and the anode of 4 REC is input to the SCR control to restrict the conduction rate of 1 REC during plugging, so that current sent to the motor from the battery through the SCR control is minimized in order to regulate the armature current to a preset value.

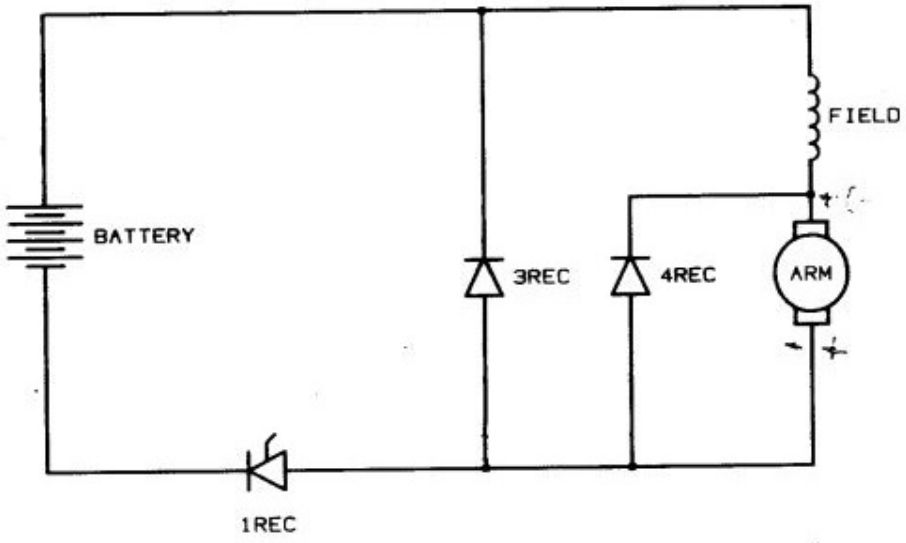


Figure 1.3.3
CONTROLLED REVERSING (PLUGGING)

Ref. 91.TMP.5

DIODE - A semiconductor consisting of an anode and a cathode. A diode passes current in the direction from the anode to the cathode and blocks the flow of current in the other direction.

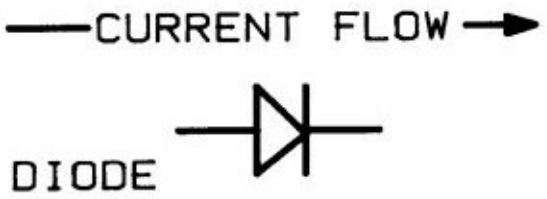


Figure 1.3.4
DIODE

DIRECTIONAL SWITCH - A device which contains switches that actuate the forward or reverse contactors in order to change the vehicle's direction.

DRIVE MOTOR - The series dc motor that provides large starting torque and allows a wide variation of travel speeds.

F AND R CONTACTORS - A magnetic switch which determines the direction of motor rotation.

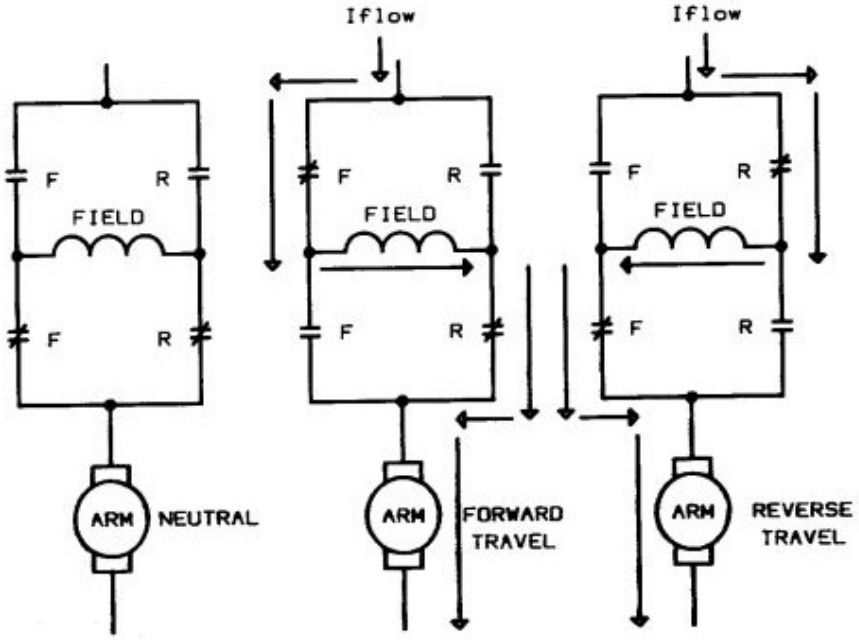


Figure 1.3.5
F AND R CONTACTORS

By reversing field current flow, the motor rotates in the opposite direction.

FILTERING - The use of a circuit (typically a resistor and diode) to remove spikes of voltage from the control. These spikes are generated by switching contactors on and off or by switching other circuit devices, such as the horn.

FREQUENCY MODULATION - The method of obtaining adjustable speed control by varying the number of pulses per second.

FUSE - The fuse serves to protect the electrical system against excessive current flow. Whenever an excessive current flows, the fuse melts down to open the circuit.

GATE - The control element of an SCR. A small signal applied to this element causes the SCR to conduct large amounts of current between the anode and the cathode.

HEAT SINK - A mounting device for a semiconductor which dissipates any heat generated within the semiconductor.

KEYSWITCH - The keyswitch cuts off the control power supply to the control system. Electrical control devices will not operate unless the keyswitch is turned on.

NOTE

The power transmitting line is directly connnected to the battery, not through the keyswitch.

POTENTIOMETER - A small variable resistor.

PULSE - Electrical energy which flows for a very brief interval.

REACTOR - Reverses the charge on the commutating capacitor.

SEMICONDUCTOR - Any of a family of solid state electronic devices, such as diodes, transistors, and SCR's.

SILICON CONTROLLED RECTIFIER - Functions as an on/off current switch by allowing a very small amount of current from the cathode to the gate to switch the SCR on. When current flows into the gate, the SCR is switched on to allow a large current flow from the anode to the cathode. Once switched on, the SCR continues to conduct, even after the gate pulse current is stopped.

To switch off the SCR, it is necessary to reduce current flowing through the SCR to zero (or below the holding current nearby zero) or to apply a counter voltage to the cathode against the anode (called reverse bias.) This transference from on to off is called "turn off." Once turned off, the SCR does not allow current to pass. SCR's are able to switch on and conduct several hundred amperes of current by applying a very small pulse current to the gate.

TRANSISTOR - A semiconductor device which carries varying amounts of current, depending on the applied control signal. Transistors are used as switches on the EV-10 circuit to turn contactors on and off (i.e., PMT driver and 1A driver).

SECTION 4
ELEMENTARY DIAGRAM SYMBOLS

TYPICAL ELEMENTARY DIAGRAM SYMBOLS

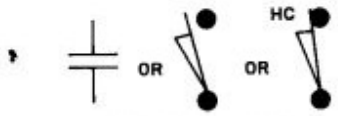
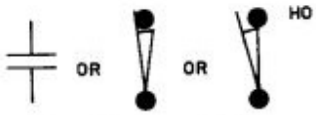
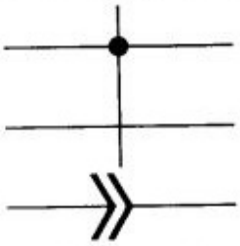
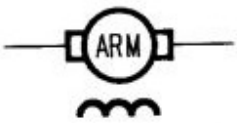
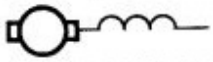
SYMBOL	DEVICE	EXAMPLE
	BATTERY	 LONG LINE IS ALWAYS POSITIVE.
 NORMALLY OPEN NORMALLY CLOSED	CONTACTORS (CONTACTOR TIPS)	 NORMALLY CLOSED FORWARD CONTACTOR
 NORMALLY OPEN	CONTROL SWITCHES (HC- HELD CLOSED).	 NORMALLY OPEN BRAKE SWITCH.
 NORMALLY CLOSED	CONTROL SWITCHES (HO- HELD OPEN).	 NORMALLY CLOSED BRAKE SWITCH.
	WIRING (1) CONTROL WIRE. (2) POWER WIRE.	(1) NORMALLY 18 GUAGE FOR PANELS AND 16 GUAGE FOR TRUCK WIRING. (2) 0 TO SIZE 4 WIRE FOR MOTOR LEADS.
	CONNECTED INTERSECTION OF CONDUCTORS. NOT CONNECTED CROSSING OC CONDUCTORS. MECHANICAL CONNECTION.	AS USED IN SCHEMATIC DRAWINGS. AS USED IN SCHEMATIC DRAWINGS. BATTERY PLUG.
	MOTOR MOTOR ARMATURE MOTOR FIELD	 SERIES FIELD PUMP MOTOR AS IT MAY APPEAR ON SCHEMATIC DRAWING

Figure 1.4.1
ELEMENTARY DIAGRAM SYMBOLS

Ref. 91.TMP.8

TYPICAL ELEMENTARY DIAGRAM SYMBOLS

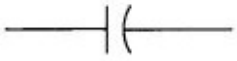
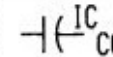
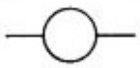
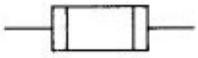
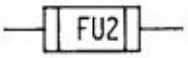
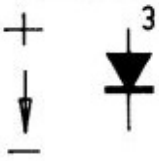
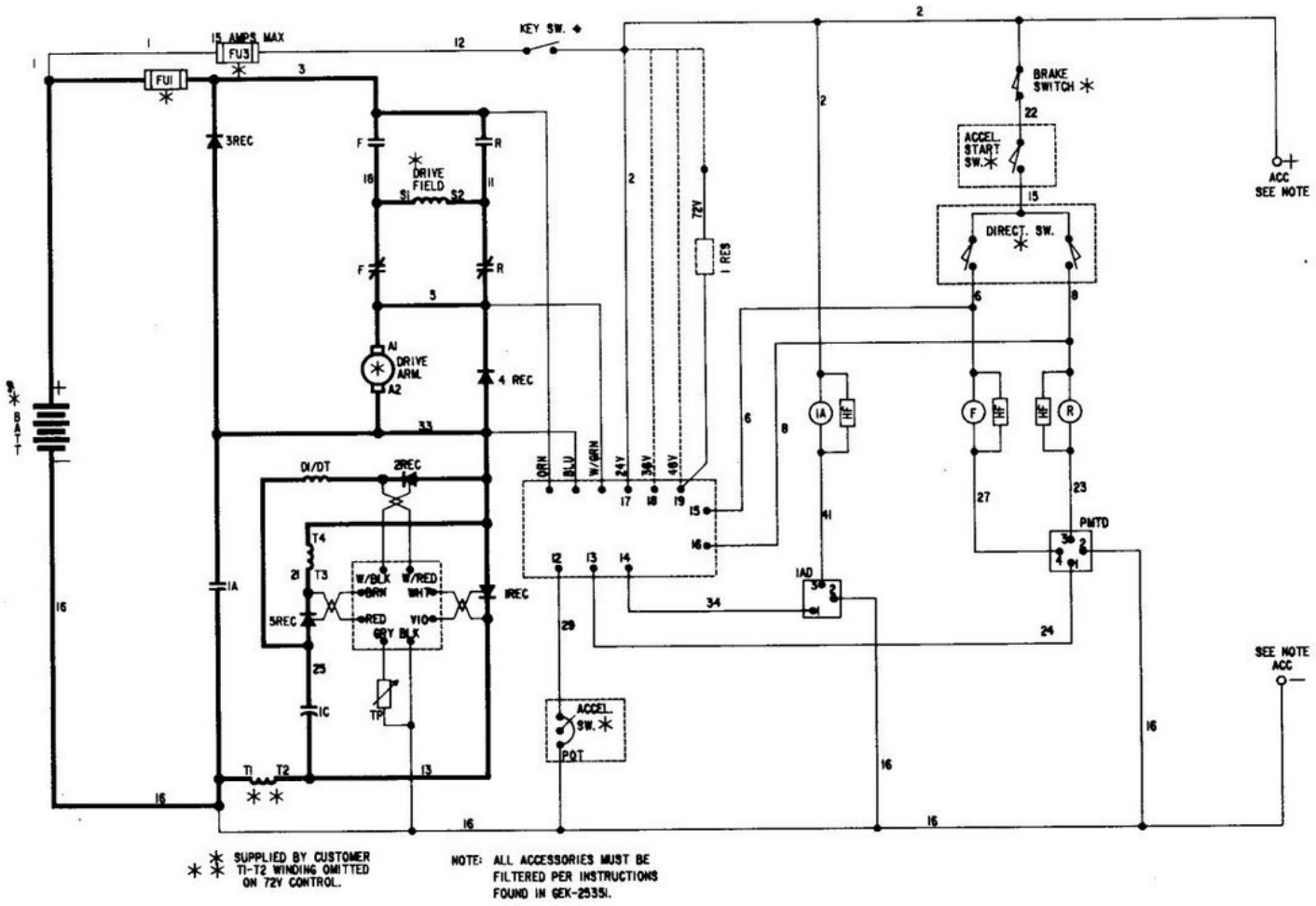
SYMBOL	DEVICE	EXAMPLE
	CAPACITOR	 IC COMMUTATING CAPACITOR FOR TURN OFF OF I REC. MAY BE USED AS SUPPRESSORS OR DEVICE FILTERS.
	COIL	 FORWARD CONTACTOR COIL
	FUSE	 FU2 CONTROL CIRCUIT FUSE
 RESISTOR FIXED  VARIABLE  POTENTIOMETER (VARIABLE)		   ACC. POT ACCELERATOR POTENTIOMETER METER SCR CONTROL
	RECTIFIER OR DIODE	 3 REC ALLOWS CURRENT TO FLOW FROM POSITIVE TO NEGATIVE ONLY
	SILICON CONTROLLED RECTIFIER (SCR)	 IREC A VERY FAST SWITCH (WITH NO MOVING PARTS) USED TO TURN CURRENT ON AND OFF UP TO 350 TIMES PER SECOND

Figure 1.4.1 (Continued)
ELEMENTARY DIAGRAM SYMBOLS

Ref. 91.TMP.8A

SECTION 5
EV-10 ELEMENTARY



NOTE

Heavy lines are power circuits;
light lines are control circuits.

Figure 1.5.1
EV-10 ELEMENTARY

Ref. 91.TMP.9

SECTION 6
EV-10 CIRCUIT OPERATION

The control circuit is energized by closing the keyswitch and actuating the control handle which closes either directional switch and the start switch. The control checks for more than 7 volts at terminal board point BLU. (0 volts would indicate a welded 1A or shorted 1 REC.) If Pulse Monitor Trip (PMT) requirements are met, the PMT driver turns on with a control signal applied to PMTD terminal 1. This will allow the selected directional contactor to close, completing the traction motor circuit.

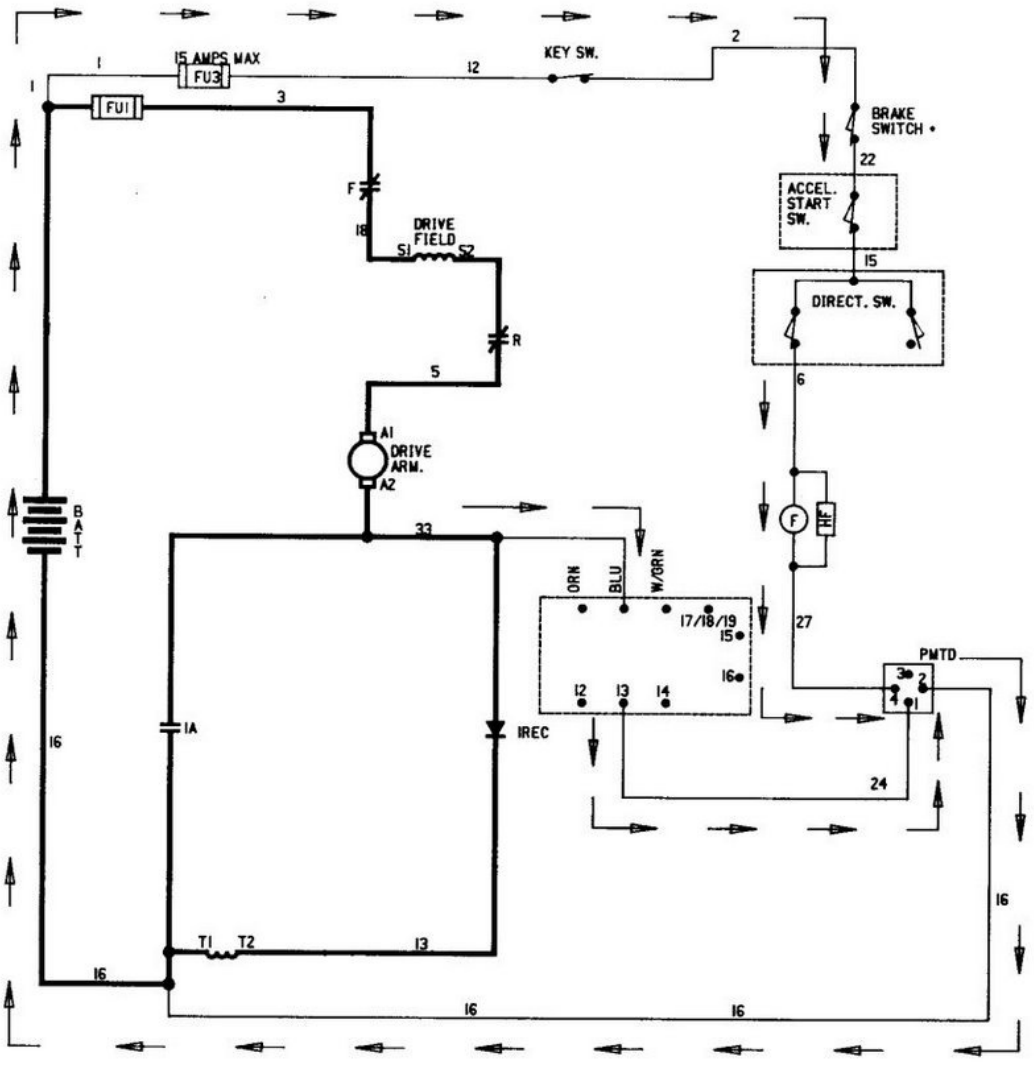


Figure 1.6.1
INITIAL DIRECTIONAL CLOSURE

Ref. 91.TMP.10

The control card supplies a gate pulse to 2 REC, turning it on. This recharges the commutating capacitor (1C). The current path is from 2 REC, 1C; through the battery, motor field and armature; and back to 2 REC. After 1C charges, 2 REC shuts off due to lack of current. The control card checks that 1C is charged and then unlocks the gate circuits to 1 REC and 5 REC, allowing the current to flow through 1 REC and 5 REC.

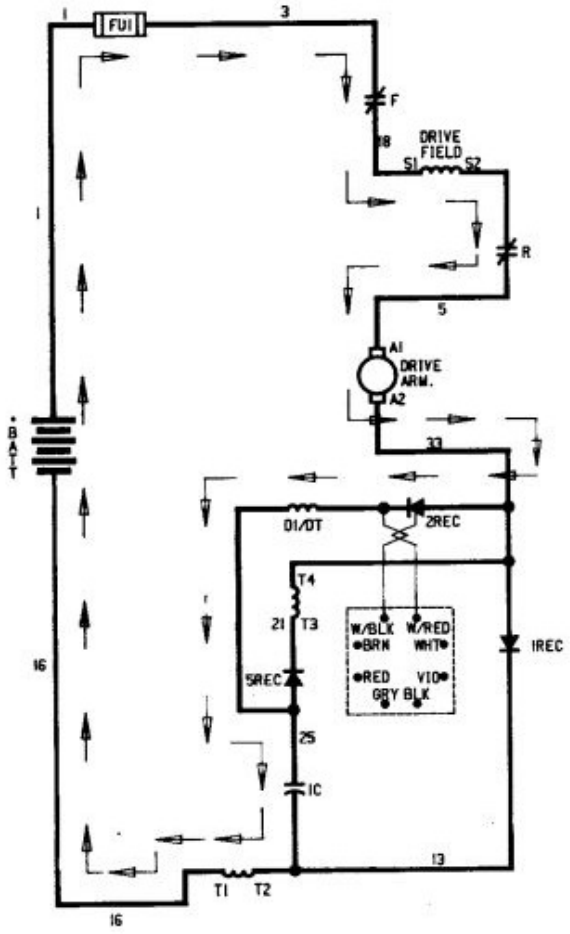


Figure 1.6.2
CAPACITOR FREE CHARGE CIRCUIT

Ref. 91.TMP.11

The control card then supplies a gate pulse to 1 REC, turning it on and allowing current to flow from the battery through the motor field and armature, 1 REC, and back to the battery. 5 REC turns on in order to turn the charge on 1C around. The turn-around current path is T3 - T4, 1 REC, T2 - T1, 1C, and back to 5 REC. This charging cycle occurs in less than 1 ms. The charge is stored until it is time to turn 1 REC off.

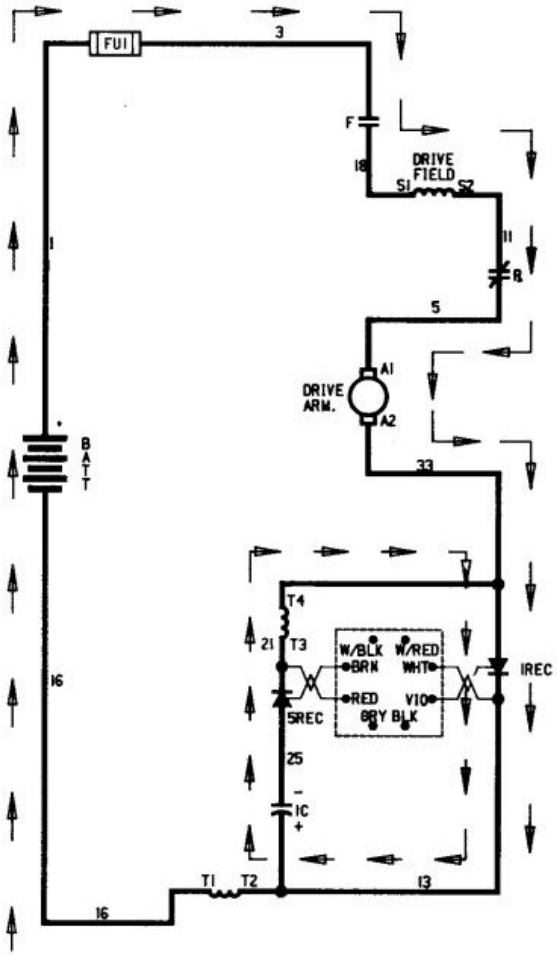


Figure 1.6.3
1 REC AND 5 REC TURN-ON

Ref. 91.TMP.12

The current continues to flow in 1 REC until the control card turns on 2 REC. When this occurs, 1 REC momentarily reverses bias, turning itself off. The capacitor continues to discharge until it is fully charged positive with respect to battery negative. Maximum voltage is a function of source inductance, battery voltage, and peak motor current at the time 1 REC was turned off.

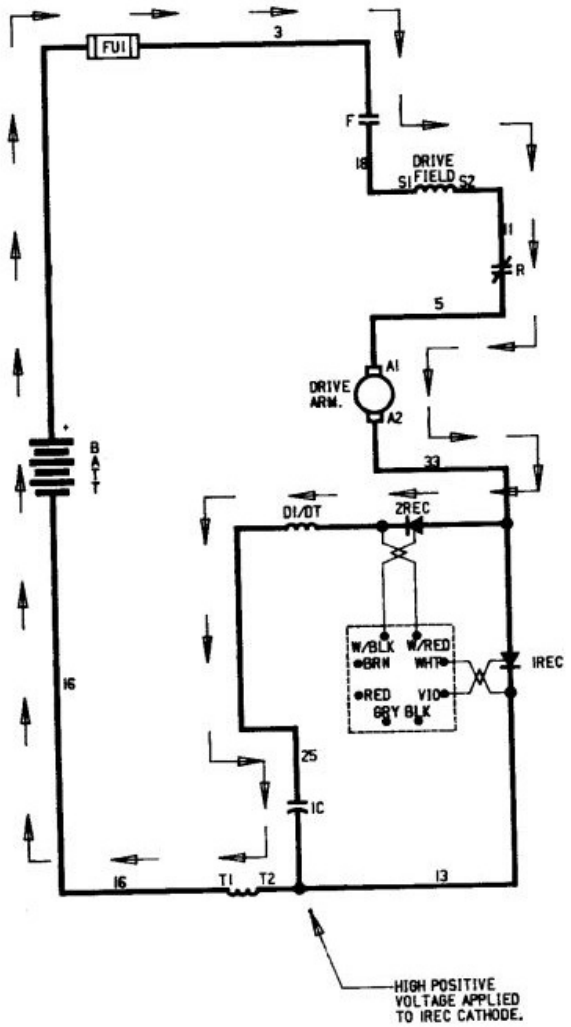


Figure 1.6.4
1 REC TURN-OFF

Ref. 91.TMP.13

During the off time, the energy stored in the motor, by virtue of its inductance, causes current to circulate through the motor around the loop formed by 3 REC, thus providing what is called "flyback current."

NOTE

The average motor current measured will usually be greater than the average battery current. The SCR control, in effect, converts battery current at battery volts into a higher motor current at a lower motor voltage.

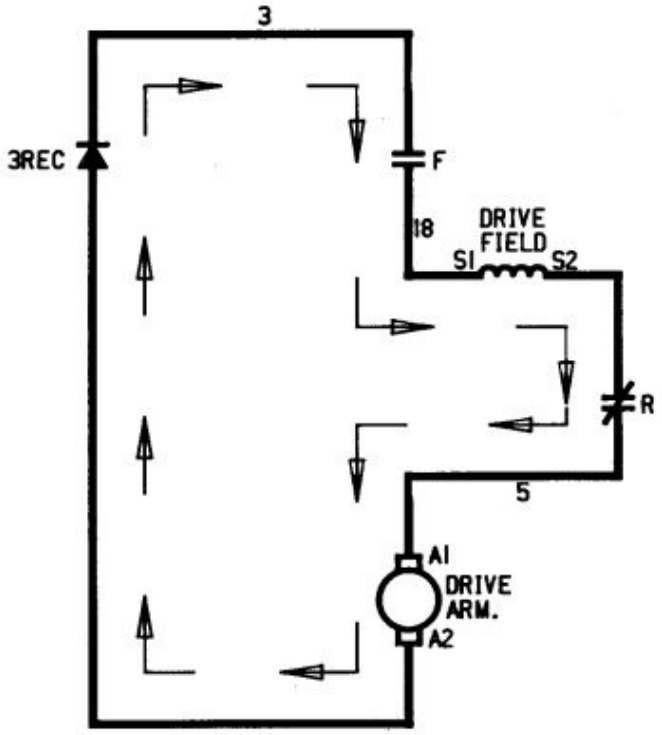


Figure 1.6.5
FLYBACK CIRCUIT

Ref. 91.TMP.14

The control card determines the start of the next on and off cycle. The accelerator potentiometer controls the oscillation rate. Slow speed occurs when the potentiometer is at maximum ohms (5000 ohms). As the resistance decreases, motor speed increases. The speed decreases to about 90% of full speed; then the 1A contactor closes when the accelerator potentiometer has a resistance of about 500 ohms and the 1A timer times out.

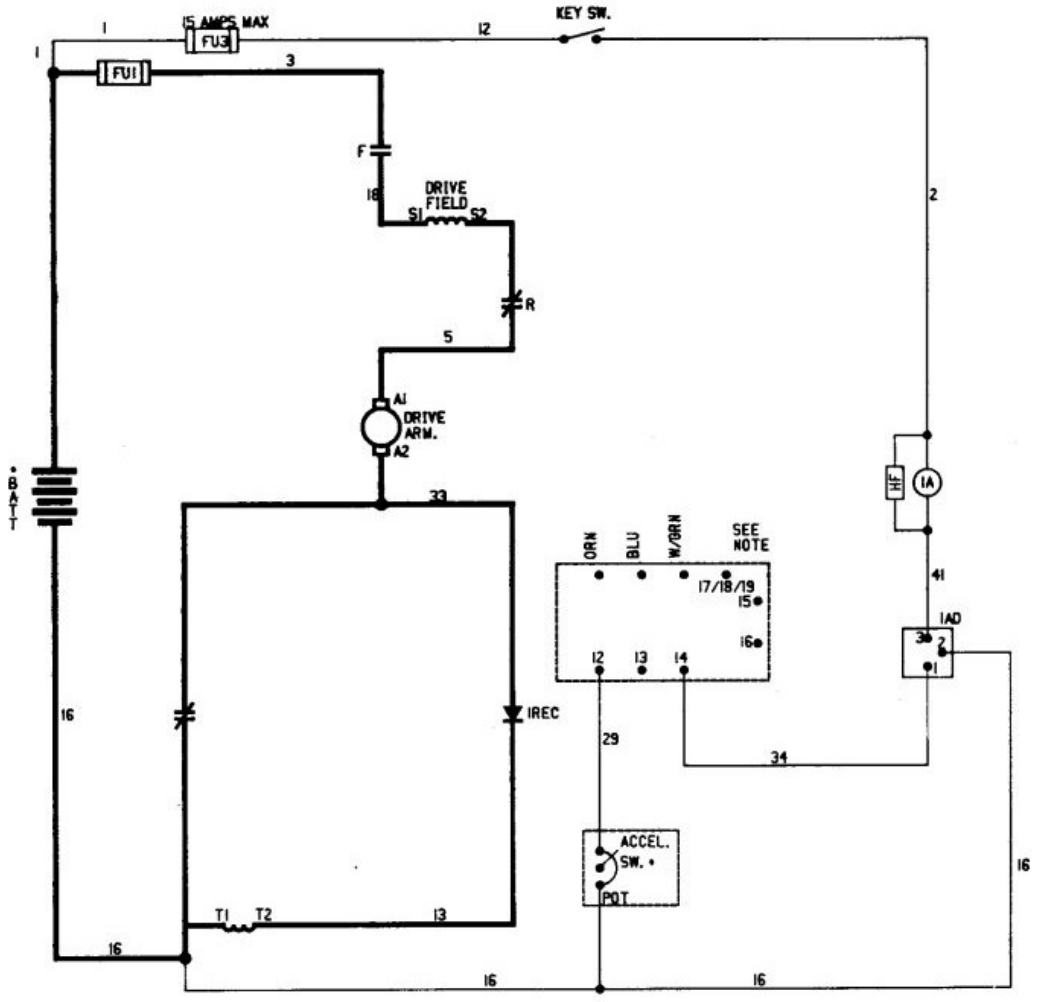


Figure 1.6.6
1A CIRCUIT

Ref. 91.TMP.15

SECTION 7
CONTROL FEATURES

The EV-10 SCR control contains the following basic control features:

- Oscillator
- Current Limit
- Plugging (accelerator controlled)
- 1A Control
- Pulse Monitor Trip
- Tip Bounce Timer
- Thermal Protection
- Low Voltage

These features are described below.

OSCILLATOR

The accelerator potentiometer controls the rate of oscillation. The percentage of 1 REC on time is controlled from 0% to 95%. The center operating condition of the oscillator is at 50 percent on time with a nominal 2 ms on time and 2 ms off time. This corresponds to a maximum operating frequency of 250 Hz. At creep speed, the on time decreases to approximately 1 ms; and off time increases to approximately 50 ms. At full SCR operation, this condition is reversed (short off time, long on time). The variation of on and off time of the oscillator produces the optimum frequencies through the SCR range. The rate at which the oscillator can increase its percentage of on time (0% to 95%) is the controlled acceleration, which is fixed at about 1.5 seconds.

CURRENT LIMIT

The Current Limit circuit controls peak motor current by limiting the voltage drop across 3 REC when it is in the conductive state. When 2 REC turns 1 REC off, 3 REC starts conducting the flywheel current. The peak flywheel current is equal to the peak 1 REC current during the previous 1 REC on time. This peak flywheel current generates a peak voltage across 3 REC, which the current limit circuit monitors and controls. The peak current limit value is a function of the percent on time of the oscillator and the current limit trimpot. With the potentiometer set at maximum (clockwise direction), peak current limit is 500 amps at 0% on time and 350 amps at 100% on time. These two points are connected with a straight line on graph paper; thus, peak current limit at other percent on times can be established. With the trimpot set at minimum, peak current limit at 0% on time is 300 amps and 150 amps at 100% on time.

CAUTION

WITH THE POTENTIOMETER SET FULLY CLOCKWISE, THE CURRENT LIMIT MAY BE IN EXCESS OF THE RATING OF THE PANEL. TO AVOID DAMAGE TO THE CONTROL, THE CURRENT LIMIT MUST NEVER BE SET HIGHER THAN THE MAXIMUM VALUE ABOVE. (REFER TO PAGES 2-3 and 2-4.)

PLUGGING

Slowdown when reversing is accomplished by providing a small amount of retarding torque for deceleration. If the vehicle is moving and the directional lever is moved from forward to reverse, the motor field is reversed. The inertia of the vehicle drives the motor armature, which acts as a generator. The generated current passes through 4 REC. When the plug signal is initiated, the oscillator circuit regulates at a plug current limit level as set by the plug trimpot on the control card. Current is regulated by referencing the voltage drop across 4 REC. The pulsing of 1 REC is controlled by the position of the accelerator, bringing the vehicle to a smooth stop and reversal. The plug current range is 75 amps to 480 amps.

CAUTION

WITH THE POTENTIOMETER SET FULLY CLOCKWISE, THE CURRENT LIMIT MAY BE IN EXCESS OF THE RATING OF THE PANEL. TO AVOID DAMAGE TO THE CONTROL, THE CURRENT LIMIT MUST NEVER BE SET HIGHER THAN THE MAXIMUM VALUE ABOVE. (REFER TO PAGES 2-3 and 2-4.)

1A CONTROL

The full power transition feature provides smooth transition into 1A by continuing to pulse 1 REC until the tips close. When the accelerator voltage falls to approximately .5 volts (at 500 ohms), the 1A control automatically energizes after a 2 to 4 second delay. The contactor is held off during plugging. The SCR panel must be pulsing to enable 1A to close.

PULSE MONITOR TRIP (PMT)

The Pulse Monitor Trip (PMT) function contains 2 main features: the look ahead and the look again. If 1 REC is shorted, 1A is welded, or the capacitor does not pre-charge, the look ahead does not allow a directional contactor to close. During operation, if 1 REC fails to turn off when it is supposed to or if 1A welds, the look ahead again will open F or R. Once the PMT has been tripped, it can only be reset by opening and reclosing the keyswitch.

TIP BOUNCE TIMER

After F or R is closed or 1A opens, the control card checks that the capacitor has been charged by 2 REC. The battery volts appear across 1 REC. Then after approximately 150 ms, SCR pulsing begins.

THERMAL PROTECTION

This temperature-sensitive device is mounted in the 1 REC heat sink. If the 1 REC temperature exceeds design limits, the thermal protector lowers the maximum current limit and does not allow 1 REC to exceed its temperature limits. Even at reduced current limit, 1A operates, allowing the panel to cool. The 1A contactor is not disabled when it is in thermal cutback.

LOW VOLTAGE

Batteries under load or more than 80% discharged produce low voltages at the SCR panel. The EV-10 works at 60% of nominal battery volts.

CHAPTER 2
EV-10 SCR CONTROL SPECIFICATIONS

GEK-83482

INSTRUCTIONS

EV-10* SCR CONTROL SPECIFICATIONS

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GENERAL ELECTRIC

*Trademark of General Electric

JANUARY, 1983

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SECTION 3	OUTLINE DRAWINGS OF STANDARD REVERSER PANELS	2-9
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CHAPTER 2
SPECIFICATIONS

SECTION 1
INTRODUCTION

GENERAL ELECTRIC

EV-10 SCR CONTROL

SPECIFICATIONS TRACTION-MOTOR CONTROLS

24-48V DC

APPLICATION

EV-10 SCR controls have been designed as traction drives for use with series-wound dc motors. Primary uses include small to medium electric vehicles such as order pickers, reach trucks, pallet trucks and other industrial lift trucks. EV-10 is designed to meet UL-583, applicable NEMA standards for Industrial Control Equipment ICI-1965, CSA, British ITA (BITA). EV-10 controls will enable the user to comply with OSHA standard subpart N-Sec. 1910-178 Powered Industrial Trucks.

DESCRIPTION

EV-10 SCR controls contain all the SCR's, commutation and logic circuits that, when used with appropriate contactors, accelerators and switches, comprise a complete electric vehicle drive system.

STANDARD ELECTRICAL FUNCTIONS

CONTROLLED ACCELERATION - A fixed function that allows smooth acceleration of vehicle to top speed (2 seconds ±20%).

CURRENT LIMIT - An adjustable function that regulates peak motor current to protect the control.

PULSE MONITOR TRIP - PMT continuously monitors for a full power fault both before and during operation, minimizing chances of a runaway vehicle.

THERMAL PROTECTOR - A protective circuit that gradually reduces current limit, if needed, to maintain rated SCR temperature.

ELECTRICAL BRAKING - Plugging distance is controllable by the operator, as a function of handle/pedal position. Minimum stopping distance is achieved with the handle/pedal fully actuated. An adjustment is provided on the control to vary the minimum stopping distance.

CREEP SPEED - The speed at which the vehicle runs when the control is first initiated; non-adjustable.

REVERSE BATTERY PROTECTION - Prevents damage to electronics when battery inadvertently connected in reverse.

COLD CONTACTOR SWITCHING - Forward/Reverse contactors do not make or break load currents, except for fault situation.

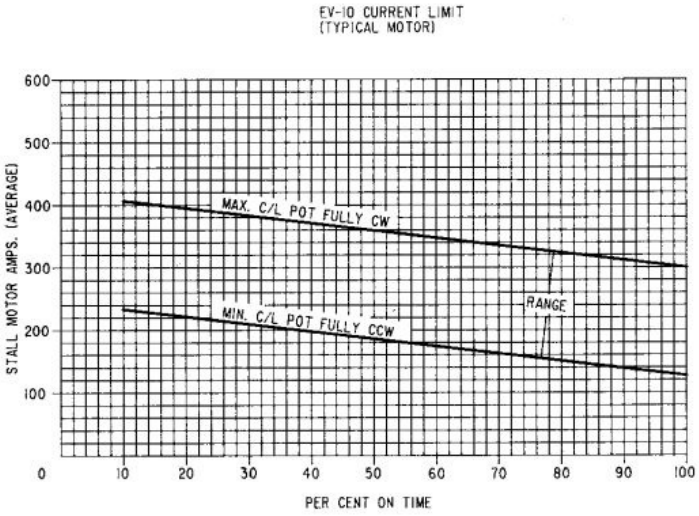
BYPASS -Output available to pick up bypass contactor driver as a function of time. This is actuated by accelerator travel (less than 400 ohms). This eliminates the need for bypass switchette in the accelerator.

BENEFITS

- Improved Reliability
  - Custom integrated circuit is used as the "brain" of the signal electronics.
  - All power semiconductors are mounted on the same heat sink. This is accomplished by using an isolated SCR (5 REC) and unique power circuit design. Fewer bus connections also result.
  - Opto couplers gate the SCRs, providing the highest "noise" immunity possible.
  - A smaller commutating capacitor results in less heating of all components in the commutating circuit.
  - Solid state circuit replaces the bypass contactor switchette.
- Performance
  - Extended operating range compared to step speed controls.
  - Extra power available for performance on ramps through use of an optional bypass contactor.
- Simplified Maintenance and Start-up
  - Contact tip life extended due to cold switching on forward/reverse contactors.
  - Easy trouble-shooting and installation due to a single customer control terminal board for the system.
  - Drive train protection is possible by soft setting of the adjustable functions of current limit and plugging.
- Higher Productivity and Less Driver Fatigue
  - Smooth stops, starts, and acceleration are possible to position loads quickly and easily while providing maximum driver comfort.

PRODUCT RATINGS - - @ 25°C

- Full Load level Motor Current (No 1A).....*80A
- Full Load Level Motor Current (With 1A) *120A
- Plugging Motor Current.....300A
- Voltage .....24-48 volts
- Accelerator Inputs..... 5K to 0 ohms or 3.5 to 0.6 volts
- Current Limit



*Current rating will vary with the quality of the heat sinking to the vehicle frame and the actual duty cycle.

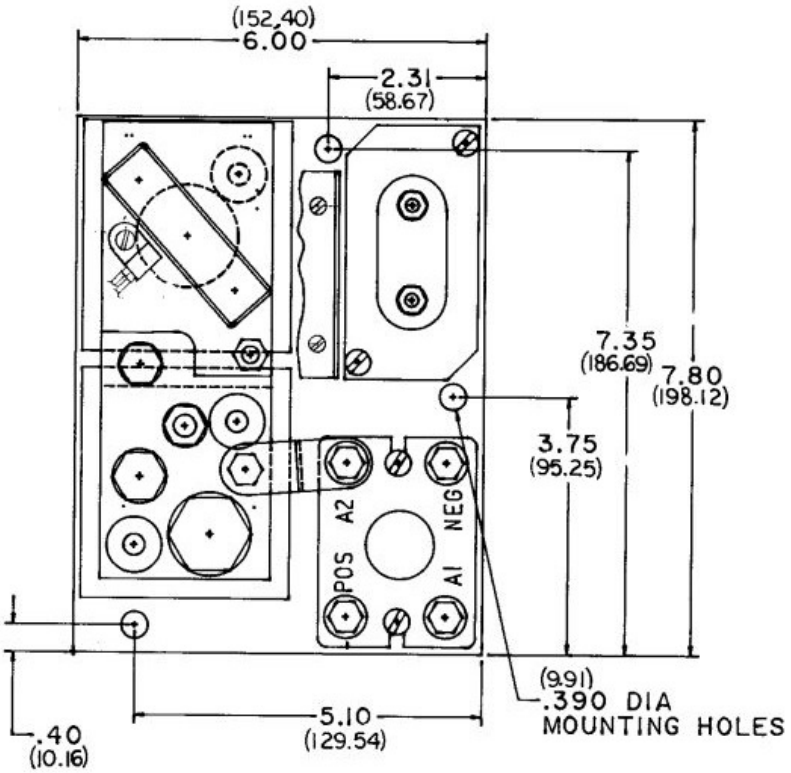
ORDERING DIRECTIONS - EV 10 SCR IC3645WB2A3AA

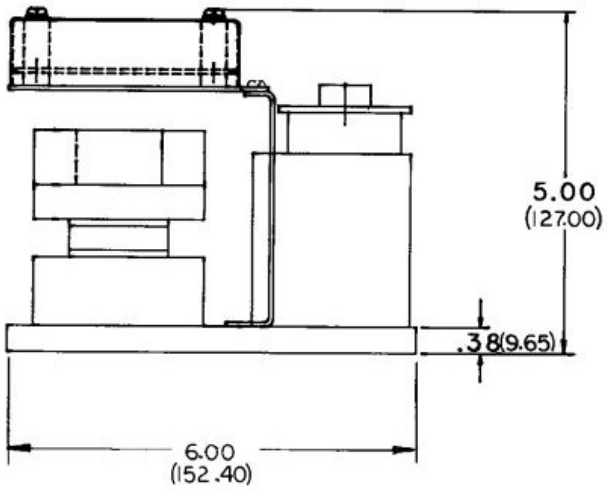
PRODUCT QUALITIES

- Ambient Temperatures - rated for operation in $-30^{o}C$ to $+ 50^{o}C$ ambients; reduced performance until control is up to operating temperature in ambients below $0^{o}C$.
- Environment - for best results, control should be enclosed (this will not reduce performance); control is resistant to battery acids, cleaning solutions and hydraulic fluids; care should be taken to avoid direct steam cleaning.
- Low Voltage - rated for operation down to 66% of nominal battery volts.
- Shock and Vibration - the control will withstand shock and vibration specified by U.S. Department of Forestry for electronic devices.
- Radio Frequency - the control is not affected by EMR of 50 KH_Z when mounted in the vehicle.
- Mounting - 3 holes (.390 dia.) provided; may be mounted in any plane.
- Connections - all customer connections are solderless and accessible from the direction perpendicular to the component side of the base; logic level connections are located on one terminal strip on oscillator card.
- Maintenance - standard volt-ohm meter and hand tools are used for troubleshooting; control should be cleaned periodically with a low pressure air hose. See GEK-83451 for troubleshooting and maintenance instructions.

CONTACTORS AND CONTACTOR PANELS

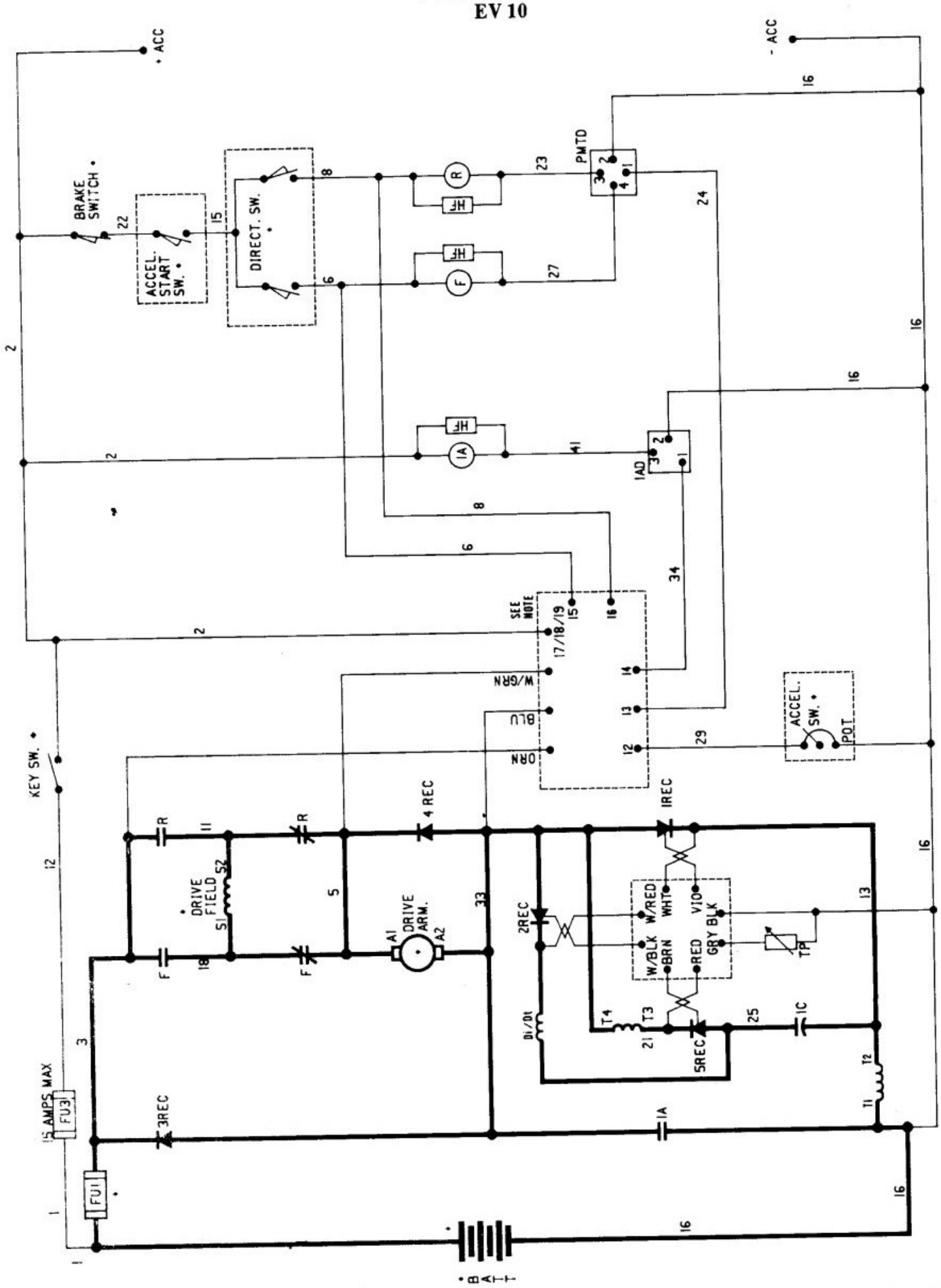
See General Electric Specification GET-6747 for contactors designed for use with the EV-10 SCR control.





DIMENSIONS IN ( ) ARE MILLIMETERS

ELEMENTARY
EV 10

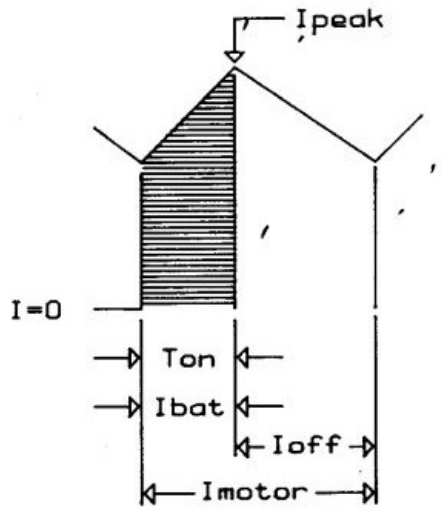


INDUSTRIAL CONTROL DEPARTMENT, GENERAL ELECTRIC COMPANY, CHARLOTTESVILLE, VIRGINIA

SECTION 2
PERFORMANCE CURVES

EXPLANATION OF PERFORMANCE CURVES

The SCR functions as a switch which alternately connects and disconnects the motor from the battery. During the period when the motor is disconnected (off time), the motor current decays through a flyback diode (3 REC). The switching rate is kept high enough so that the current does not decay completely to zero before the switch is closed again (on time).



Percent on time = t on/t on + t off or $I_{battery}/I_{motor}$
$I_{battery}$ = percent on time x I_{motor}
I_{motor} = $I_{battery}$/percent on time
V_{motor} = percent on time x $V_{battery}$

Figure 2.2.1
MOTOR CURRENT TRACE (ONE CYCLE)

Percent on time is a function of motor current, motor resistance, battery volts, battery resistance, and cable resistance.

Ref. 91.TMP.16

STALL MOTOR AMPS (PEAK) VS. PERCENT ON TIME

This curve defines the adjustment range of I_{peak} using the current limit trimpot. I_{peak} should not be adjusted above the maximum current limit line at any given percent on time; to do so will exceed the current rating of 1 REC. I_{peak} can be measured using an oscilloscope and non-inductive shunt.

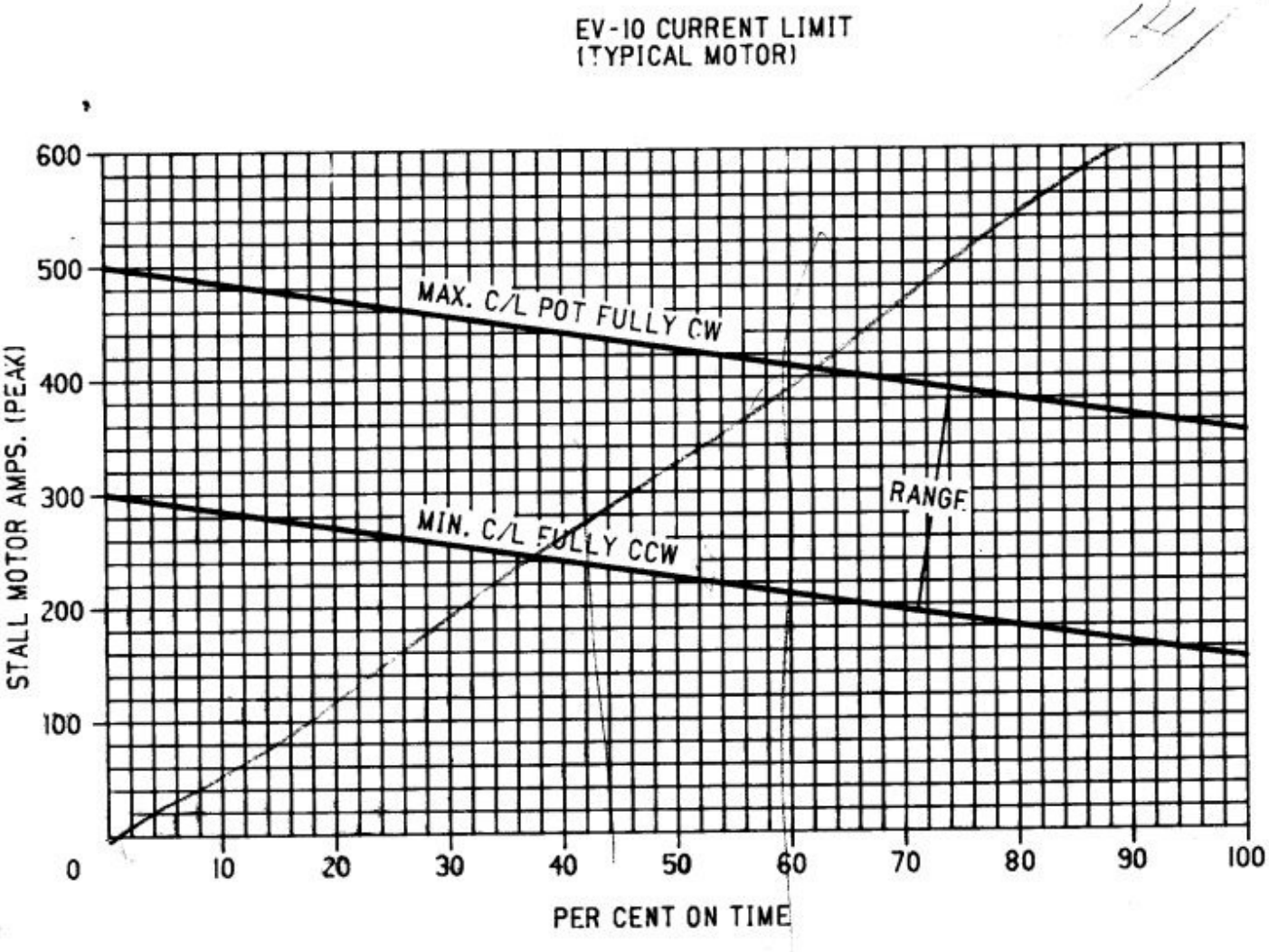


Figure 2.2.2
STALL MOTOR AMPS (PEAK) VS. PERCENT ON TIME

Ref. 91.TMP.17

STALL MOTOR AMPS (AVERAGE) VS. PERCENT ON TIME

The following curves show the resultant I_{motor} and $I_{battery}$ when I_{peak} has been adjusted. During factory testing at General Electric, the I_{peak} is set to the maximum allowable limit. The customer must, on receipt of the first panel, measure either I_{motor} or $I_{battery}$. This is the maximum current level for current limit adjustment. This measurement should be made on a cold vehicle, since the current level may be 15% higher after the control is heated. The current level of preset panels may vary $\pm$10% from vehicle to vehicle due to varying tolerances in motors, cables, and batteries. Current limit reference is the voltage drop across 3 REC. Therefore, any time 3 REC is replaced, current limit should be measured and adjusted, if necessary, to assure that the current is still within its maximum limit.

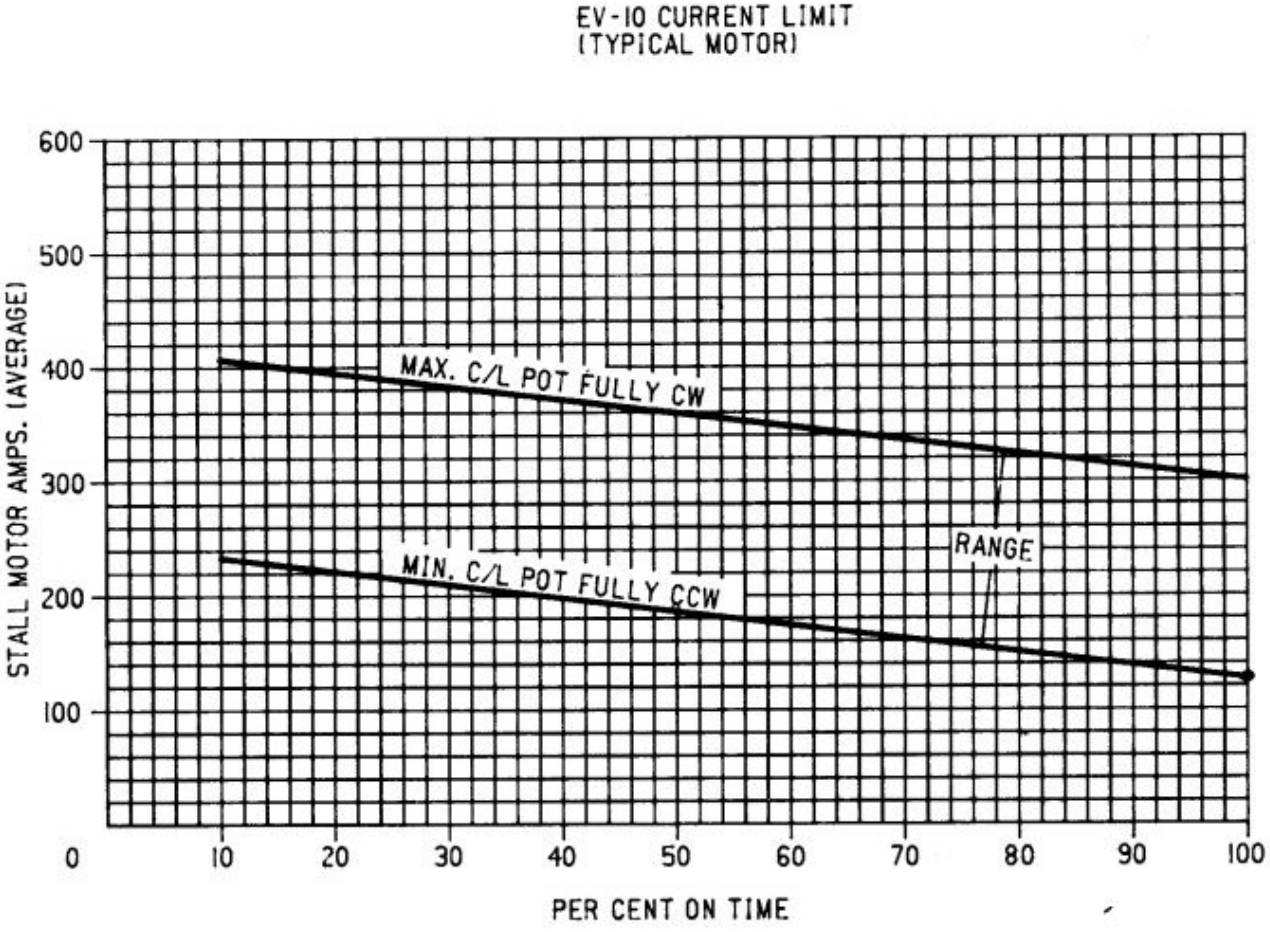


Figure 2.2.3
STALL MOTOR AMPS (AVERAGE) VS. PERCENT ON TIME

Ref. 91.TMP.18

EV-10 CURRENT LIMIT
(TYPICAL MOTOR)

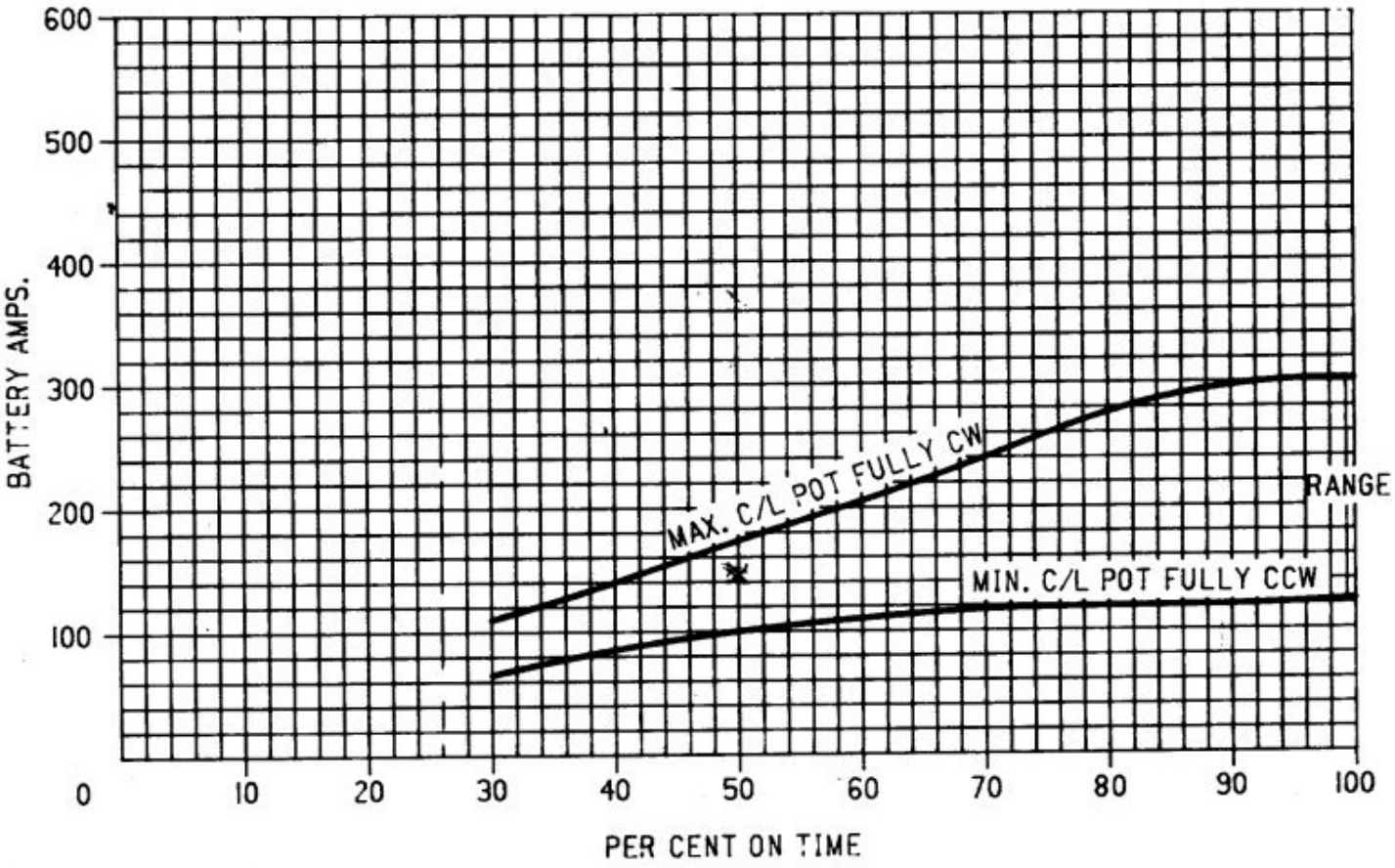


Figure 2.2.4
CURRENT LIMIT

Ref. 91.TMP.19

FREQUENCY OF CONTROL OSCILLATION

This curve defines the frequency at which the control oscillates at any given percent on time.

NOTE

The frequency at low and high speed operation has been reduced to decrease switching heat loss in those ranges.

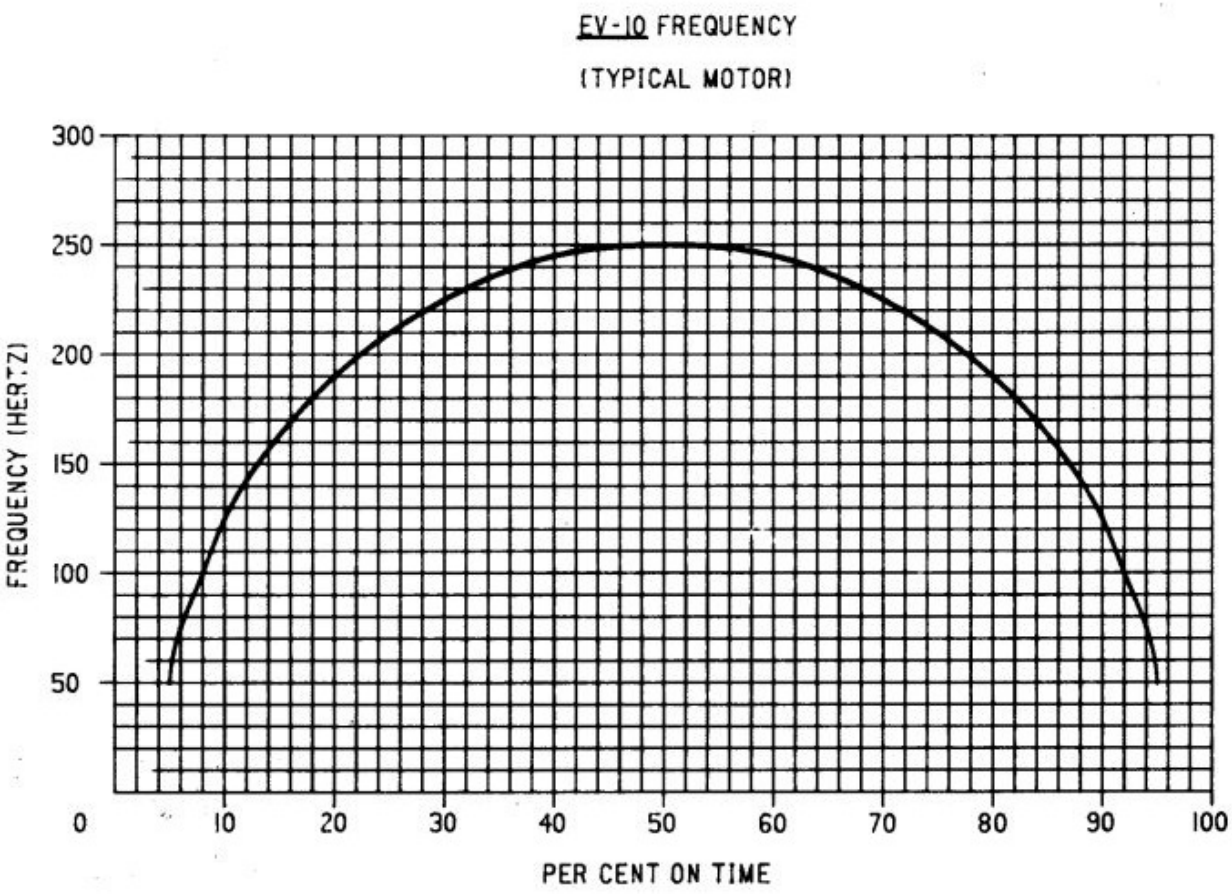


Figure 2.2.5
FREQUENCY OF CONTROL OSCILLATION

Ref. 91.TMP.20

INPUT RESISTANCE REFERENCE

The curve below defines input resistance reference and the voltage input reference to obtain a given percent on time of the SCR control. For example, an input resistance of 3000 ohms or voltage input of 2.50 volts would give 30% on time, which is 30% of top speed.

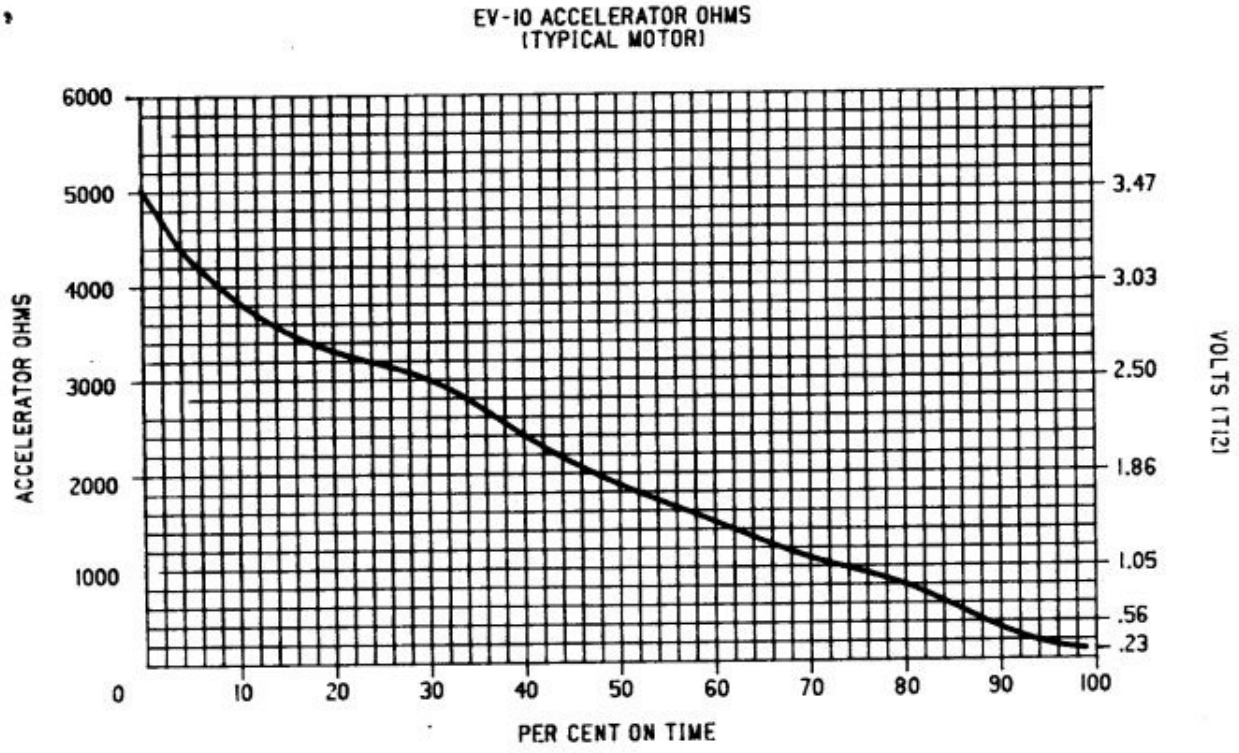


Figure 2.2.6
INPUT RESISTANCE REFERENCE

Ref. 91.TMP.21

SECTION 3
OUTLINE DRAWINGS OF STANDARD REVERSER PANELS

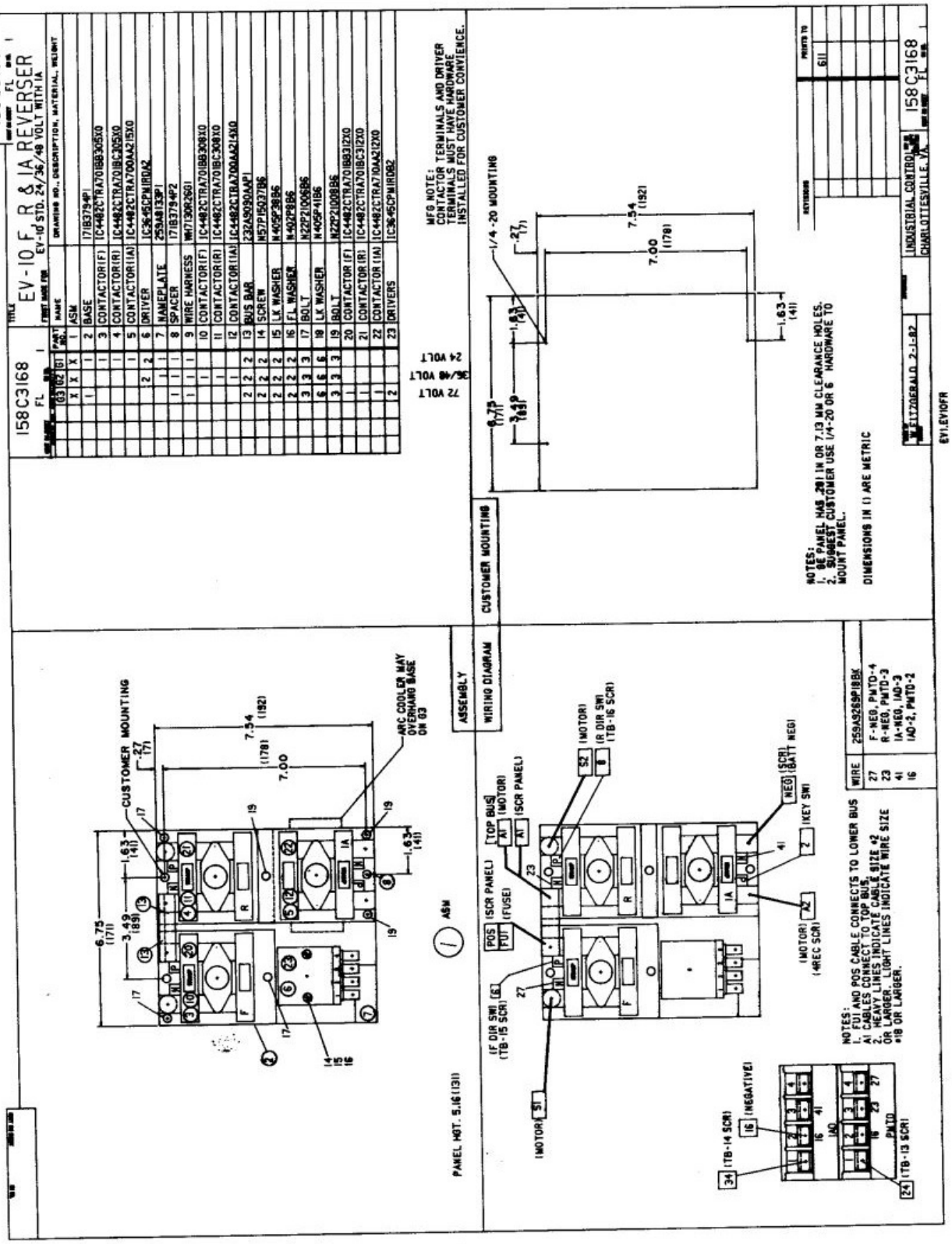


Figure 2.3.1
150 AMP CONTACTOR PANEL

Ref. 158C3168

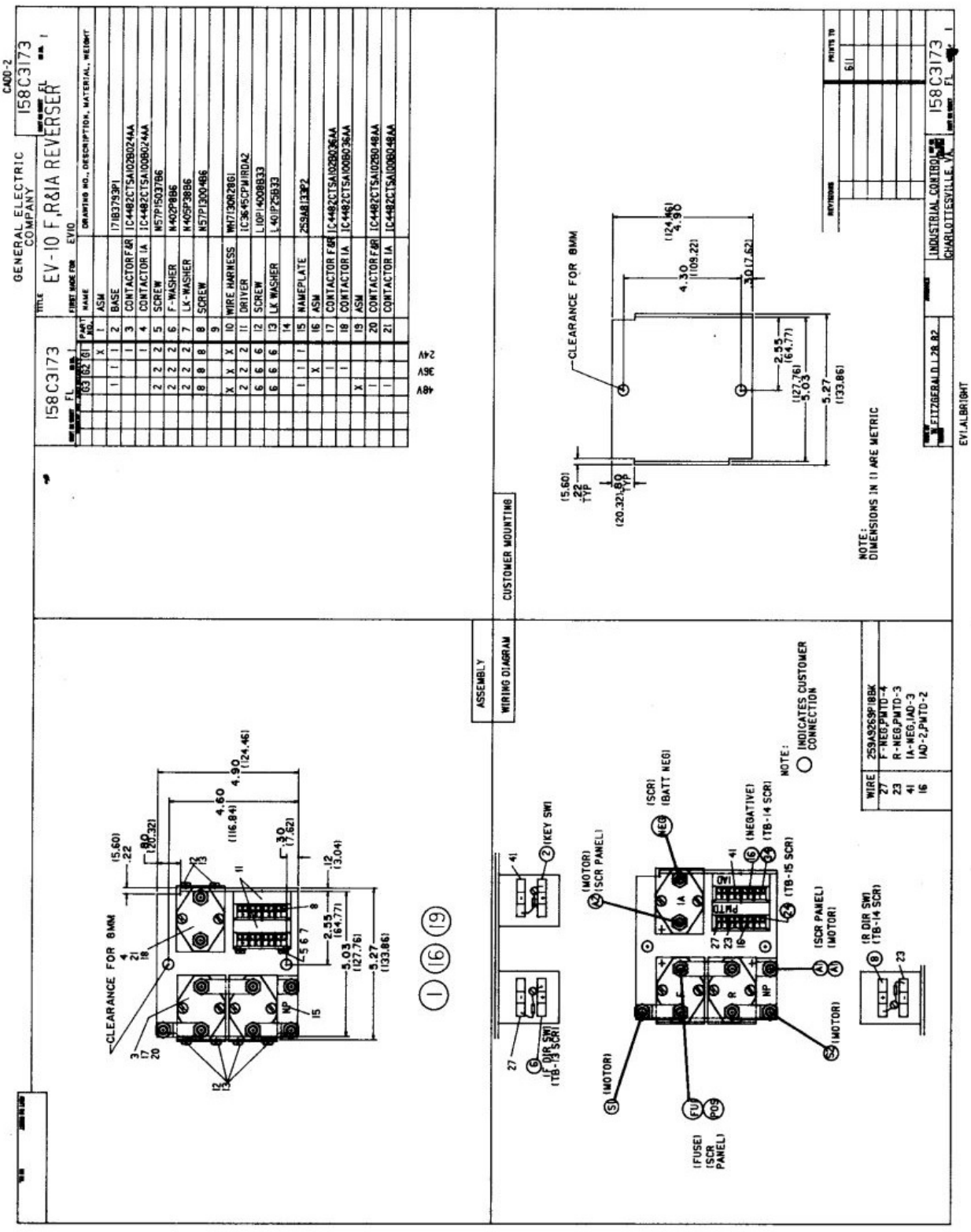


Figure 2.3.2
100 AMP CONTACTOR PANEL

Ref. 158C3173

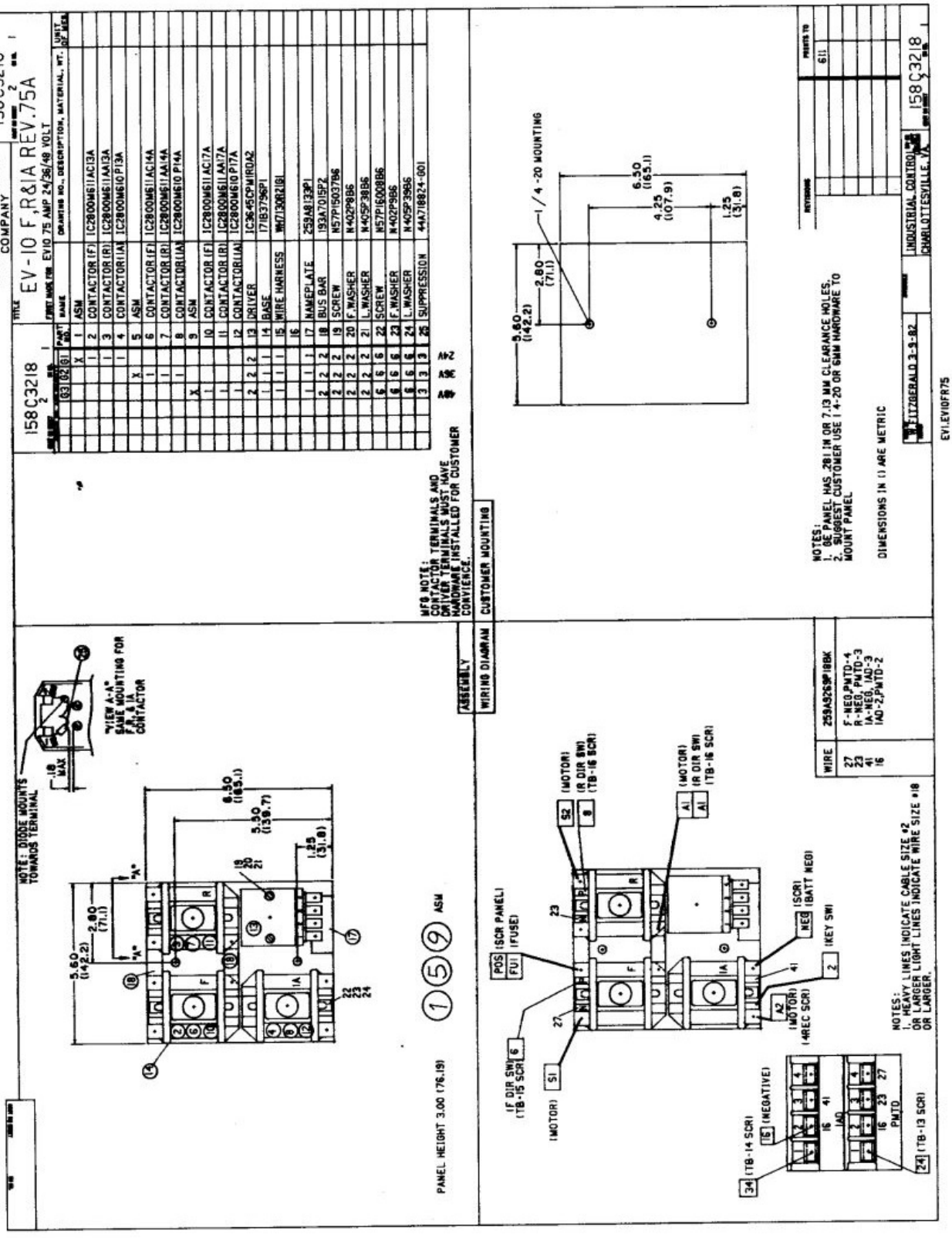


Figure 2.3.3
75 AMP CONTACTOR PANEL

SECTION 4
DC CONTACTORS FOR ELECTRIC VEHICLES

GENERAL ELECTRIC

EV-1* SCR CONTROL

GET-6686

SPECIFICATIONS
DC CONTACTORS for ELECTRIC VEHICLES

(For 24- to 80-volt Systems)
150 Amperes (50% Duty Cycle)

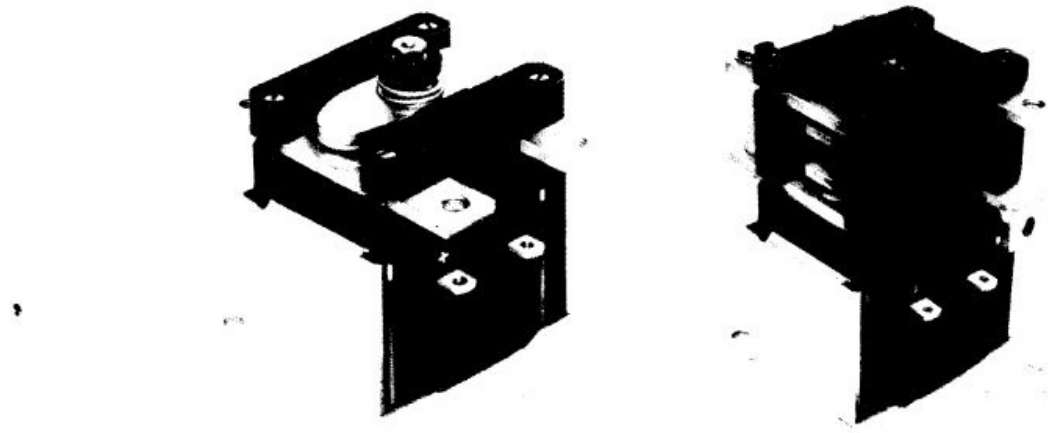


Fig. 1. Typical EV-1 contactors, single-pole, normally open, and single-pole, double throw.

APPLICATION

EV-1 contactors are designed for use in dc applications, with lead-acid battery or rectified power. They perform power switching functions for traction drives as well as pump and other vehicle applications.

The contactors have been successfully applied to meet Underwriter's Laboratories, Factory Mutual, automotive and government standards. They are listed under U/L file number AU1793B.

STANDARD FEATURES

Tip Reliability - EV-1 contactors are more reliable because the tips are made of a special alloy that is bonded to the support in an exacting manner in order to maximize tip life.

Double Break - All forms of these contactors are double-break type. This assures good contact and minimizes bounce which improves tip life.

Solenoid Design - EV-1 contactors are solenoid type which allows smaller size and mounting flexibility.

Make Characteristics - EV-1 contactors are designed for excellent pick-up characteristics. The design criteria takes tip closing velocity, pick-up time, tip bounce and low-voltage conditions into consideration for optimum performance.

Break Characteristics - The speed at which the contacts separate is crucial to tip life. High-fidelity mechanical operation assures consistent high tip parting velocities.

Maintenance - For additional information see GEH-4469.
- Tighten loose connections.
- Visually inspect and replace tips and springs as needed.
- No adjustments required.

PERFORMANCE DATA

Mechancial Life

The 150-ampere contactors have an expected mechanical life of six-million operations without detrimental wear of moving parts, springs, or interlocks.

Electrical Life

General Electric contactors are thoroughly tested before delivery. They are continually re-evaluated, using actual vehicle components. Testing includes reversing and full-load pump and traction by-pass operations. The normal electrical life of contacts that may be expected is two-million operations. This figure will vary depending on the particular vehicle design, duty cycle, maintenance and battery condition.

Coils

All EV-1 contactor coils are filtered for proper operation with EV-1 SCR controls. Contactors will pick up at 50 percent of intermittent coil voltage rating at 25 C. Coils are fungus and moisture resistant.

*Trade Mark of the General Electric Company

PERFORMANCE SPECIFICATIONS

150 AMPERE

Current Ratings

Current	Duty Cycle % On-Time	Max. Time on
100 Amps	100	Continuous
150 Amps	50	20 Min.
600 Amps	5	30 Sec.
900 Amps	2	5 Sec.

Make and Break Ratings†

MAKE		
IC4482CTRA700-712	1500 Amps	24-80 Volts
INTERRUPT		
IC4482CTRA700-702	1500 Amps	24-48 Volts
IC4482CTRA710-712	1100 Amps	48-80 Volts

Interlock Ratings-Amps (Inductive)

Volts	Amps (Inductive)	
	Make and Break	Carry
24	3.5	10
36	2.5	10
48	2.0	10
72	1.5	10

†These ratings were established in accordance with Arc Rupturing tests as described in Part 8 of Underwriter's Laboratories, Inc. Bulletin No. 583. The ratings are based on a rate of rise of 30 to 250 amperes per millisecond.

NOTES:

1. For ratings below 24 or above 80 volts, refer to Company.
2. Each coil is stamped with part number.
3. Contactor mounting can be in any plane.
4. Interlocks not required for use with EV-1 SCR; however, 1 NO/NC and 2 NO/NC interlocks are available.
5. Recommended cable size 1/0.
6. Base mounting is standard. For information on available side-mounted form, refer to Company.

ORDERING DIRECTIONS

Basic Catalog Number (Fill in spaces)

IC4482CTRA7 _ _ _ _ _

arg # 1 2 3 4 5

arg# 1 - Arc Suppressors
- 0 = without arc suppressors (24-48 volts)
- 1 = with arc suppressors (48-84 volts)

arg # 2 - Contactor Type
- 0 = SPNO (traction/pump)
- 1 = SPDT (forward/reverse with EV-1 SCR)
- 2 = SPDT heavy-duty tips (forward/reverse)

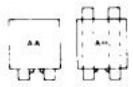
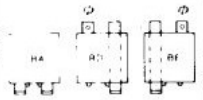
arg # 3 - Terminal Form
(See above)

arg #4 - Coil Group Number
(See above)

arg # 5 - Interlocks
- X0 = no interlocks
- A1§ = 1 NO, 1 NC interlock
- A2§ = 2 NO, 2 NC interlock
- B0§ = provisions for interlock

§ Available only with terminal forms AA and BA.

TERMINAL FORMS/COIL BURDENS

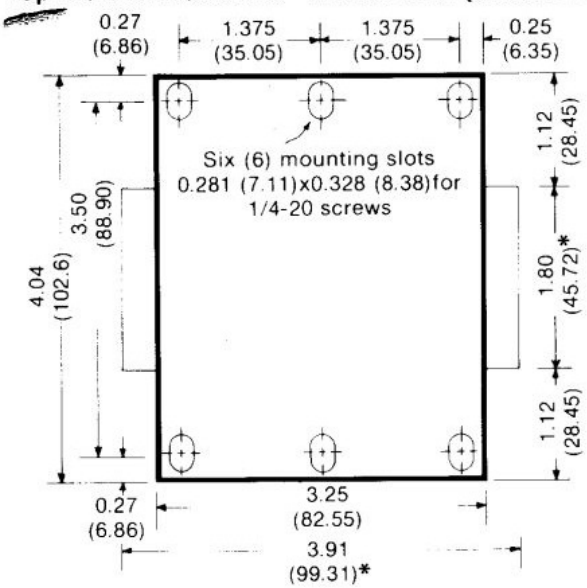
Available Power Terminal Forms	Coil Group Number arg #4	Volts (Intermittent)	Volts (Continuous)	Amperes
SINGLE-POLE NORMALLY OPEN				
 arg #3 Top View	205	24	...	1.65
	206		24	1.05
	207	36		1.53
	208	36/48	36	1.09
	210	...	48	.60
	212	72/80	72	.58
	214‡	36/48	36	1.11
	215‡	24	...	1.65
	216‡	36	...	1.57
	217‡	72/80	72	.58
SINGLE-POLE DOUBLE-THROW				
 arg #3 Top View	305	24	18	3.24
	306	30	24	2.33
	307	36	...	1.82
	308	36/48	...	1.89
	309	...	48	.94
	312	72/80	...	1.00
	314	...	36	1.08
	315	...	72	.57

‡ These coils have varistor spike suppression and therefore are not polarity sensitive. They cannot be used with EV-1 controls with oscillator cards A thru D. All other coils listed have diode and resistor suppression. Positive side terminals are marked with (+).

ϕ Bolted connection with spacer.

DIMENSIONS

Top view Dimensions Inches and (millimeters)



*Forms 710-712 (48-80 volts)

Type of Contactor	Catalog No.	Dimensions In. (mm)	
		Tip Button Diameter	Contactor Depth
Single pole, normally open	IC4482CTRA700	0.62	3.73 (94.74)
Single pole, double throw	IC4482CTRA701	.38	4.91 (124.71)
	IC4482CTRA702	.62	
Single pole, normally open	IC4482CTRA710	.62	3.73 (94.74)
Single pole, double throw	IC4482CTRA711	.38	4.91 (124.71)
	IC4482CTRA712	.62	

GENERAL ELECTRIC COMPANY, U.S.A.
INDUSTRIAL CONTROL DEPARTMENT

CHAPTER 3
APPLICATION INFORMATION FOR THE EV-10 SCR CONTROL

GEK-81453

INSTRUCTIONS

APPLICATION INFORMATION FOR THE EV-10* SCR CONTROL

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GENERAL ELECTRIC

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JANUARY, 1983

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CHAPTER 3
APPLICATION INFORMATION

SECTION 1
INTRODUCTION

APPLYING THE EV-10 TO YOUR VEHICLE

The SCR control is basically a switch that connects the motor directly across the battery at a very rapid rate for short time intervals. The ability of the SCR to control large currents with relatively low losses is derived from using the inductance of the motor for storing energy during the on time and releasing this energy during the off time to continue current flow through the motor and flyback diode.

A second interchange of energy exists between the inductive energy of the current in the battery cables and the capacitive energy of the commutating capacitor. Thus, the length and routing of the battery cables and any capacitance load connected across the battery has a marked effect on the positive capacitor voltage (overshoot voltage). Any significant change in total circuit ohms or motor inductance has an effect on the peak currents and capacitor volts.

MOTOR CONTROL EVALUATION

The motor control evaluation performed on a vehicle verifies that the SCR control is within ratings which, for the most part, cannot be verified with the normal volt and ampere meters. The control should be re-evaluated if the vehicle design is changed after the prototype evaluation in any of the following ways:

- Design changes of the battery (including ampere hour, size, voltage, resistance or routing), motor, cable resistances, or routing.
- The addition or removal of any capacitive load or filter of more than 10 MFD (unless the capacitor has a 15 ohm or greater series impedance).

The items which are verified during evaluation for a fully charged battery are as follows:

Item	Function of
First pulse - turn off time	Battery volts, motor inductance.
Stall capacitor volts and turn off time	Battery volts, cable inductance, circuit resistance, motor inductance, current limit setting.
Plug - arcing	Speed, motor design, plug setting.
Transient voltages	Peak currents, transient suppressors, etc.

DETERMINE THE SIZE OF THE SCR CONTROL

The size of the SCR control is determined by the duty cycle heating of the SCR and its ability to handle peak motor currents. The SCR size is selected in accordance with the full field, full load, level running current, 50% duty cycle rating, or the 1 hour rating of the motor (if significantly different). The ratio of on time/total time at stall must be within allowable limits. After an SCR has been selected, factors such as capacitor volts, turn off time, and the ability to accelerate gradually can be calculated.

The full field, full load, level running current is calculated as follows:

EQUATION NO. 1

$$I_B = \frac{W \times RF \times MPH \times 88 \times 746}{33{,}000 \times GE \times ME \times BE \times V_B}$$

where:

W = Full load gross weight in lbs.
RF = Rolling friction (0.02)*
MPH = Miles per hour in full field (bypass)
GE = Gear efficiency (0.90)*
ME = Motor efficiency (0.75 for 12 - 14 volts; 0.8 above 24 volts)*
BE = Battery efficiency (0.9)*
V_B = Battery open circuit volts

* Values shown are typical; exact values should be used if they are available.

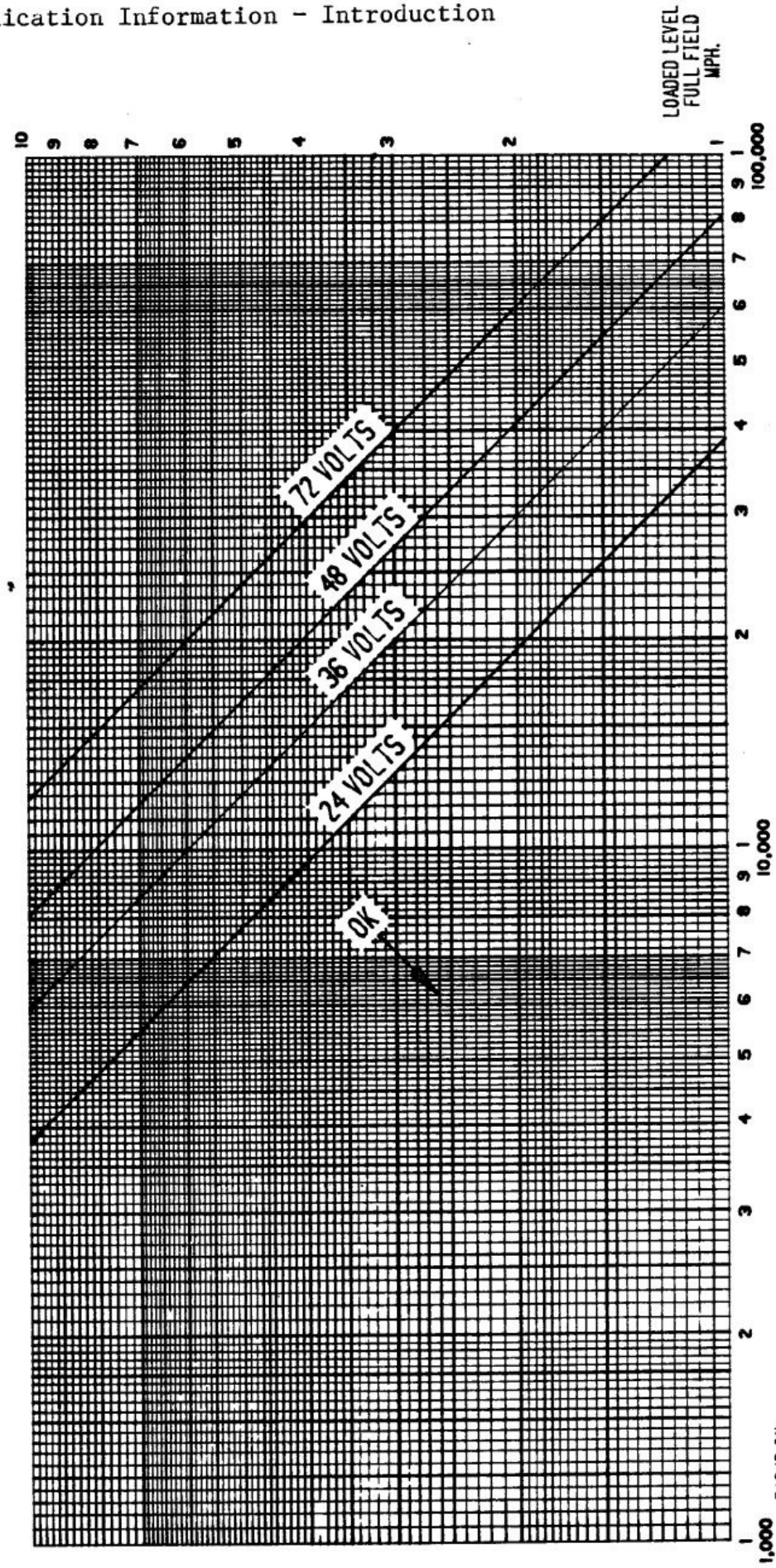


Figure 3.1.1
FULL LOAD RUNNING RATING

SELECT SIZE F, R and 1A CONTACTORS

Using Equation No. 1, shown on page 3-2, determine I_B. Refer to the contactor specification sheets and select F, R, and 1A contactors that have a 50% duty cycle maximum time or 20 minimum rating that is equal to or less than I_B. Next determine I_B:

EQUATION NO. 2

$$I_{1A} = V_B/(R_M + R_B + R_L)$$

where:

V_B = Battery volts
R_M = Resistance of the motor
R_B = Resistance of the battery
R_L = Resistance of the battery cables

I_{1A} is the stall motor current in 1A. Compare this current to the interruption rating of the 1A contactor. This rating must be equal to or greater than I_{1A}.

SELECT A PUMP CONTACTOR

To select a pump contactor, compare the top speed rpm, current, and stall currents to the carry and interruption ratings of the contactor (as in the selection of the F, R, and 1A contactors). The pump duty cycle will be considered to be approximately 30%, unless otherwise specified by the customer.

SELECT FILTERS

CAUTION

WHEN ADDING ELECTRICAL ACCESSORIES TO SCR CONTROLS, FILTERS ARE REQUIRED ON ALL INDUCTIVE TYPE LOADS THAT CREATE EXCESSIVE VOLTAGES OR RADIO FREQUENCY HASH WHEN INTERRUPTED (OR WHEN SUCH DEVICES AS HORNS ARE OPERATED). THE ABSENCE OF SUCH FILTERS WILL RESULT IN DAMAGE TO THE CONTROL.

The filters should limit the peak volts to 350 volts and should critically damp any oscillations. When opening the load circuit with a slow-acting switch, observe the volts across the load with an oscilloscope.

CAUTION

UNDER NO CONDITIONS SHOULD SUSTAINED OSCILLATIONS BE NOTED. THEIR APPEARANCE MAY RESULT IN DAMAGE TO THE CONTROL.

When adding an external unfiltered coil, these voltages should be obtainable using a diode block 148B6203G74.

The positive lead should come from the battery through a separate fuse. It can also come through the control fuse and keyswitch, if the currents are low enough. The negative lead should return to power negative.

Certain type loads can be connected to the F or R coil side of the directional switch through diodes such as the hourmeter diode, but the negative transient on these leads must be limited (-10 volts for a 24 - 48 volt card).

If the accessory is electronically constructed, use care to protect the accessory from the transients produced by the SCR control and sometimes to suppress radio frequency noise emanating from the accessory.

If a capacitive type line filter is needed to protect the electronic accessory, use a buffer (generally inductive) on the battery side of the capacitive type filter.

SELECT A DIRECTIONAL SWITCH

Select a directional switch for the steering post. Specify the number of switches (i.e., F, R, steer pump open in neutral) and the diameter of the post. (1.50 inch and 1.75 inch diameters are available.)

SELECT AN ACCELERATOR SWITCH

Select an accelerator switch. Specify shaft rotation, shaft length, conduit plate openings required, and wiring configurations. For a potentiometer type accelerator, specify mounting, extender thread type (inch or metric), and terminations for solid-state accelerator.

NOTE

1. If a truck is used for freezer operation, specify and order a separate 10 watt resistor (calculate ohms for 5 watts dissipation) to heat the directional switch and a 20 watt resistor (calculate ohms for 10 watts dissipation) to heat the accelerator switch (potentiometer type only).

2. When installing the control in the vehicle, add silicone grease (Dow Corning No. 342 or equivalent) between the SCR control base and vehicle frame. This provides a seal to prevent corrosion and increases the heat transferred to the vehicle frame. The vehicle frame must be free of burrs and relatively flat.

SECTION 2
REQUIRED APPLICATION DATA

In order to assure the correct application of an Electric Vehicle Control system, the following application data from the customer is required:

- A set of data sheets and motor speed torque curves for each truck.
- A sheet summarizing families of trucks should also spell out any differences between trucks within one family; i.e., motors, options, wiring, gear ratio, etc.
- A listing of the range of ampere hours of the batteries that will be installed.

Based on an analysis of the data received, General Electric will do the following:

1. Make suggestions.
2. Confirm the control application.
3. Request the loan of a motor if necessary.
4. Provide field engineering services, if required, to check over the installation of a prototype control. In most cases, the prototype control will be shipped directly to the customer's factory for installation on the vehicle with which the equipment will be used.
5. Provide assistance in testing the prototype control, if required. Upon completion of these tests, it is recommended that both the customer and General Electric review the results to ensure that the proper control has been selected for the truck and anticipated duty cycle.
6. In unusual circumstances, General Electric may ask the customer to provide a truck with motors and a battery for final evaluation of the control application. In such cases, General Electric will install the control unit in the truck and perform preliminary tests to confirm the application.

APPLICATION INFORMATION FORM

CUSTOMER _____ DATE _____

REQUISITION NUMBER _____ VEHICLE MODEL _____

ADMINISTRATIVE DATA

Vehicle Model Number _____

Is this a new truck model? YES ☐ NO ☐

What is required?

	YES	NO		YES	NO
SCR Panel:	☐	☐	Contactor Panel:	☐	☐
Accelerator Switch:	☐	☐	Directional Switch:	☐	☐

If this is to be a replacement for earlier GE controls, what equipment is being replaced? (Be specific, list catalog nos.)

SCR Panel: _____

Contactor Panel: _____

Accelerator Switch: _____

PACKAGING DATA

Is the SCR going to be mounted against a truck frame? YES [_] NO [_]

Surface and Thickness Dimensions: _____

If "NO", specify method of mounting and provisions for cooling:

_____

_____

_____

APPLICATION DATA

Contactor Panel Requirements: (Customer preference for size)

Forward/Reverse: [_] 75 amps [_] 100 amps [_] 150 amps

Forward/Reverse/1A(Bypass): [_] 75 amps [_] 100 amps [_] 150 amps

List special requirements: (i.e. hour meter feed and filters, dual motor, duty cycle, ambient temperature, environmental conditions, etc.)

_____

_____

CABLE DATA

Cables from battery to control:

Size: _____

Length: _____

Cables from motor to control:

Size: _____

Length: _____

MOTOR DATA

NOTE

If General Electric motors are to be used, attach copies of the computer runs and omit the data requested below. For other motors, include as much information as is available on speed, torque, and current curves.

Traction Motor(s) - Manufacturer and Model _____

Armature Ohms, 25°C/Hot: _____/_____

Saturated Motor Inductance, Millihenries: _____

Field Ohms, 25°C/Hot: _____/_____

Brush Drop Volts: _____at_____amps

If field weakening is required, state the ratio of field amperes to armature amperes: _____

Battery: Open Circuit Volts: _____ Type: _____

Ampere Hours: _____ Hours of Discharge: _____

Vehicle: Weight, No Load: _____ Weight, Full Load: _____

Speed, Full Load: _____ Rolling Friction: _____

Gear Efficiency: _____ Gear Ratio: _____

Rolling Radius: _____

Acceleration Required: Distance: _____ Seconds: _____

Maximum Ramp: Percent: _____ Distance: _____

Speed: _____

SECTION 3
EVALUATION BY THE OEM OR GENERAL ELECTRIC

After the control has been installed, a prototype evaluation is performed to ensure the correct application and conformance to specifications.

DISCONNECT THE BATTERY

Disconnect all current drain from the battery, except for the motor and the control (i.e., steer pump blocked out).

RECORD PERTINENT DATA

1. Record all motor nameplate data.
2. Check for a freshly charged battery (measure specific gravity).
3. Record battery volts and other customer data on the Evaluation Report in Section 4 of this chapter.

CURRENT LIMIT (C/L)

1. Check the maximum battery current limit as preset by the factory.
2. With a current shunt placed in the battery circuit, stall the motor with the 1A tips blocked.
3. Measure and record this current reading. This current is the maximum allowable setting to keep the current within the rating of 1 REC.
4. With the motor stalled, 1A tips blocked, and current limit preset for minimum, measure and record capacitor volts at stall.
5. Repeat this procedure for the current limit maximum (the value recorded in Step 3).

CURRENT LIMIT (C/L) (Continued)

6. Reduce the current limit until the capacitor voltage falls within the above rating, if the capacitor voltage at maximum current exceeds 200 volts and one of the following is met:

    a. If the battery voltage is 72 or 160 volts.
    b. If the battery voltage is 48 volts or less.

    This current limit is now the maximum allowed; measure and record.

7. Install a battery shunt and motor non-inductive shunt in the circuit.

8. Stall the truck to measure and record the values for battery current, motor current, and scope trace (for minimum and maximum settings).

9. Calculate the percent on from the scope trace for minimum and maximum current limit settings.

10. Reset the current limit to the level preset by the factory.

1 REC TURN OFF TIME

Measure 1 REC turn off time at stall and first pulse.

SPIKE VOLTAGES

At stall measure and record the maximum spike voltage on each rectifier.

RUNNING

1. If desired, participate with the customer in running full load and no load tests.

2. Record mph, motor current, battery current, and the ability to accelerate gradually (rampability) in each mode (SCR and 1A mode).

PLUGGING

Check plugging current at desired stopping distance. Plugging current must not exceed 480 amps for 1 second or 330 amps for 10 seconds.

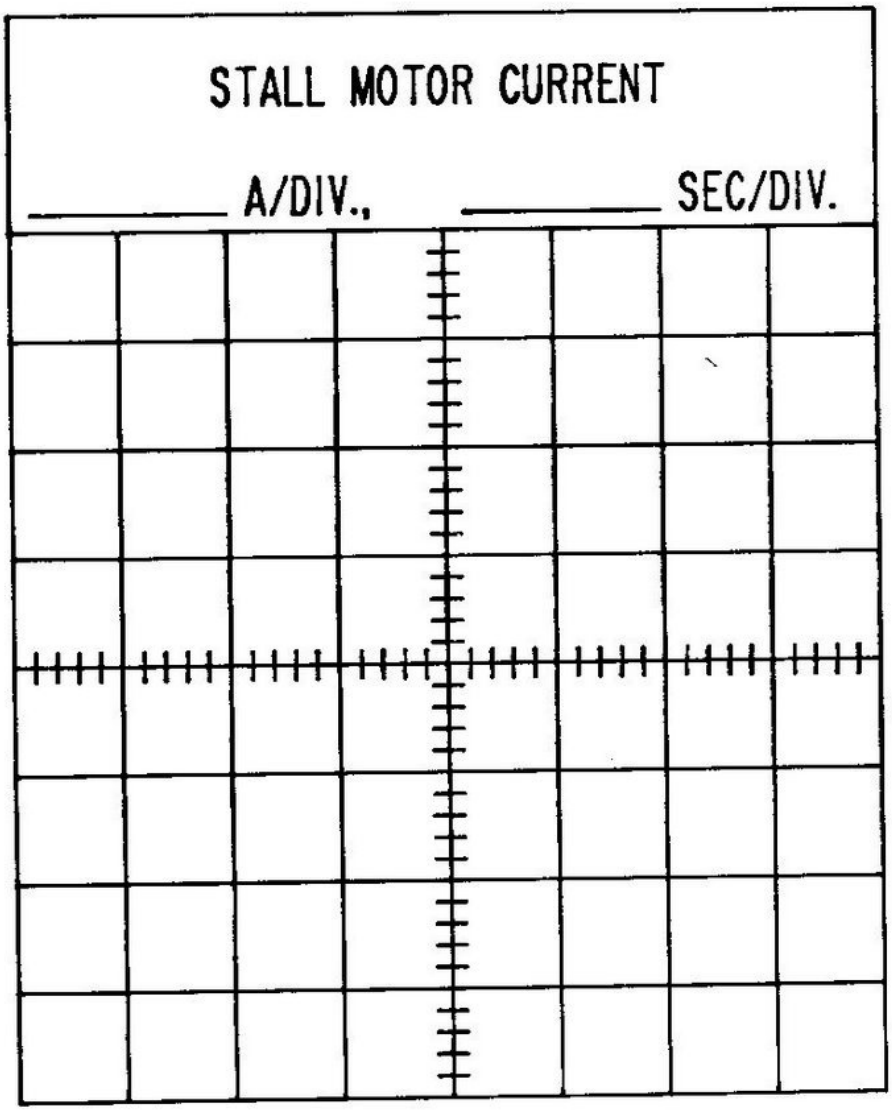
SECTION 4
EV-10 EVALUATION REPORT

EV-10 EVALUATION REPORT

FUNCTION	CONDITION	VALUE		
CURRENT LIMIT (STALL)	BATTERY AMPS			
	MOTOR AMPS			
PERCENT ON TIME	STALL			
TOP SCR	BLOCK 1A PERCENT ON TIME			
1 R E C TURNOFF TIME	STALL			
	FIRST PULSE			
CAPACITOR VOLTS (STALL)	+ OVERSHOOT			
	- COMM. VOLTS			
1 R E C VOLTS	STALL	+		
		-		
2 R E C VOLTS	STALL	+		
		-		
5 R E C VOLTS	STALL	+		
		-		
3 R E C VOLTS	STALL			
4 R E C VOLTS	STALL			
		AMPS	FEET TO STOP	
PLUG FROM 1A RUNNING	NO LOAD (AMPS)			
	FULL LOAD (AMPS)			
SCR RUN	NO LOAD	MPH	^1M	^1B
	FULL LOAD	MPH	^1M	^1B
1A RUN	NO LOAD	MPH	^1M	
	FULL LOAD	MPH	^1M	
FW RUN	NO LOAD	MPH	^1M	
	FULL LOAD	MPH	^1M	

NOTE
PLUG CURRENT SHOULD NOT EXCEED:
300 AMPS, FOR 1 SECOND.
250 AMPS, FOR 10 SECONDS.

EV-10 EVALUATION REPORT - Continued



EV-10 EVALUATION REPORT - Continued

CUSTOMER-		
TRUCK-		
SCR CAT.-		
MAG. CAT.-		
MOTOR		
BATT. VOLTS	NL	STALL
A. H. BATT.-		
SPECIFIC GRAVITY-		
GROSS WEIGHT-		
EMPTY WEIGHT-		
DATE-		
NAME-		
COMMENTS-		

GEK-83455

INSTRUCTIONS

INSTALLATION AND INITIAL ADJUSTMENTS OF THE EV-10* SCR CONTROL

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JANUARY, 1983

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CHAPTER 4
INSTALLATION AND INITIAL ADJUSTMENTS

SECTION 1
INSTALLATION OF THE PROTOTYPE

INSTALLATION PROCEDURE

Use the following steps as a guideline for the initial installation of the prototype control:

1. Mount the SCR panel on a truck surface which is free from rust, paint, dirt, and weld splatter. The truck surface should be as smooth as possible.

2. Lightly coat the surface between the SCR panel base and the truck frame with a non-conducting silicone grease, such as GE No. 642 or Dow Corning Nos. 340 or 342. This will assist in heat transfer and also prevent corrosion after the controls are mounted and wired.

3. Check that the wiring between the control and the vehicle is correct. (Refer to Figures 4.1.1, 4.1.2, and 4.1.3.)

4. Jack the drive wheels up off the front.

5. Install a current shunt in the battery circuit.

6. Plug in the battery and operate the vehicle in both directions.

7. While running the vehicle at low speed, manually close the 1A contactor with an electrically insulated tool. The control should shut off.

8. Release 1A and reset the control by turning the keyswitch off for 1 second or longer.

9. Block the 1A contactor.

10. Apply the brakes to stall the motor and move the accelerator to the top speed position. Measure and record the current level. If the current limit trimpot has not been readjusted from the factory setting, this current reading is the maximum allowable for this vehicle and must not be increased.

11. Place a current shunt in the motor circuit after plugging in the battery.

12. Jack down the vehicle.

13. Load up the vehicle to equal its gross weight.

14. Run the vehicle up to top speed in 1A and plug to a stop. Readjust the plug trimpot to obtain the desired stopping distance.

15. Measure the motor current while plugging and record the highest current reading during the plug cycle. Increase the stopping distance if the plug current stays above 480 amps for 1 second or 330 amps for 10 seconds by turning the plug trimpot counterclockwise (CCW).

16. Unplug the battery and remove the current shunt.

17. Reconnect the motor cable.

SECTION 2
CUSTOMER WIRING DIAGRAMS

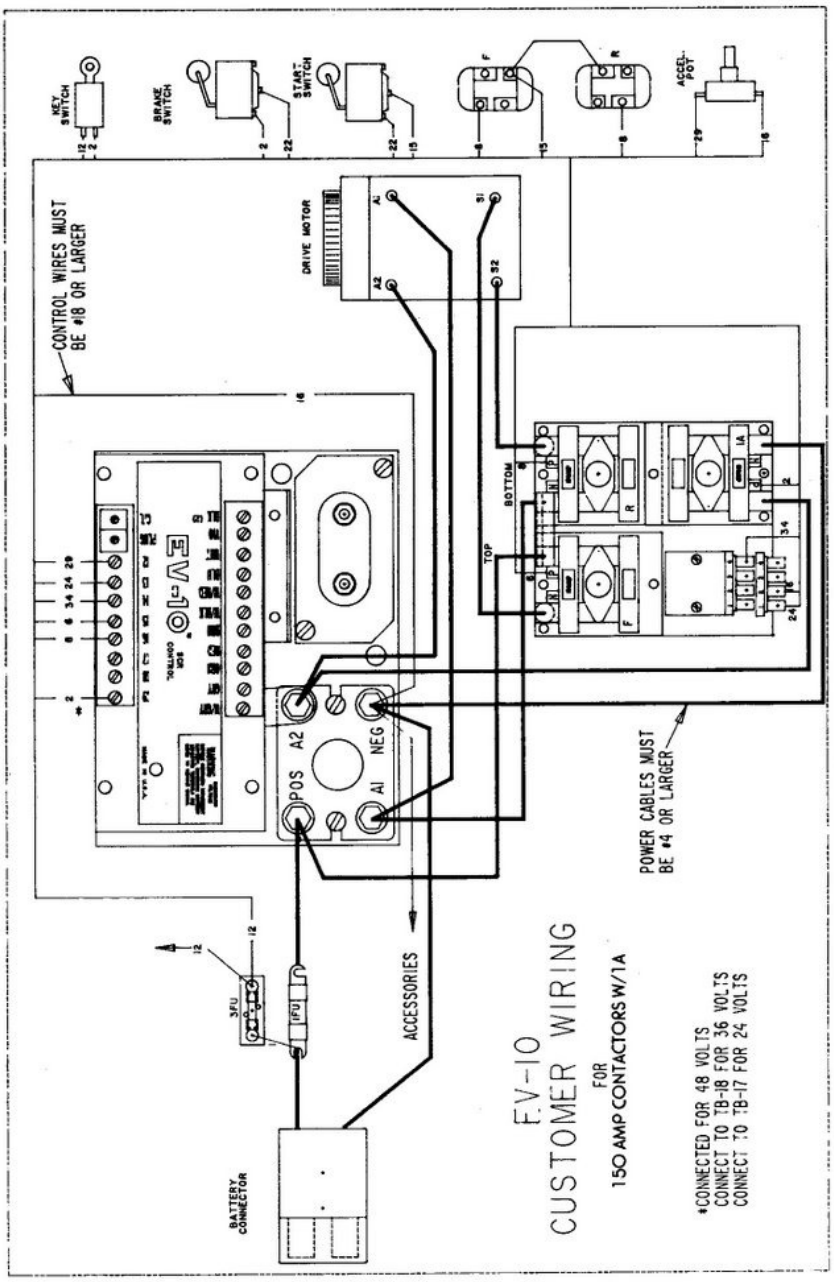

Figure 4.2.1
150 AMP WIRING

Ref. 91.TMP.23

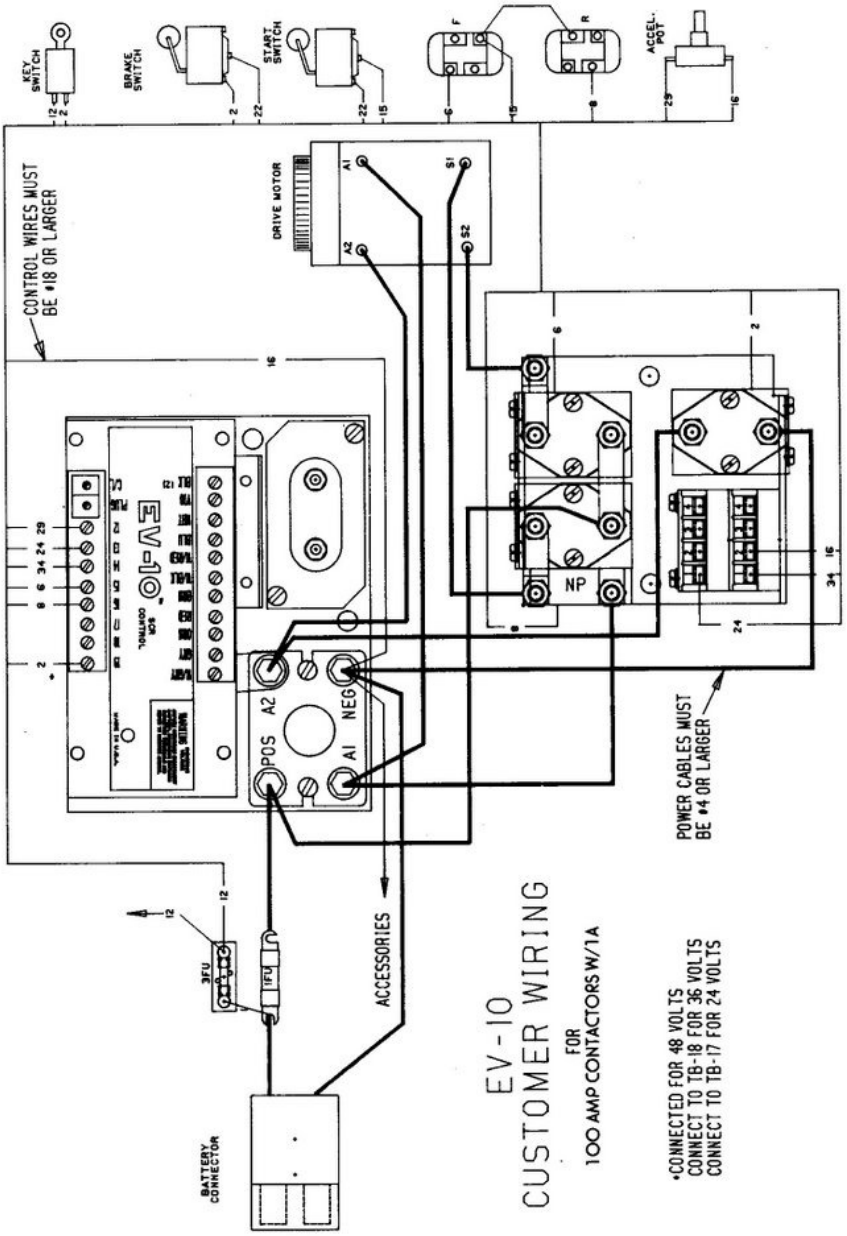

Figure 4.2.2
100 AMP WIRING

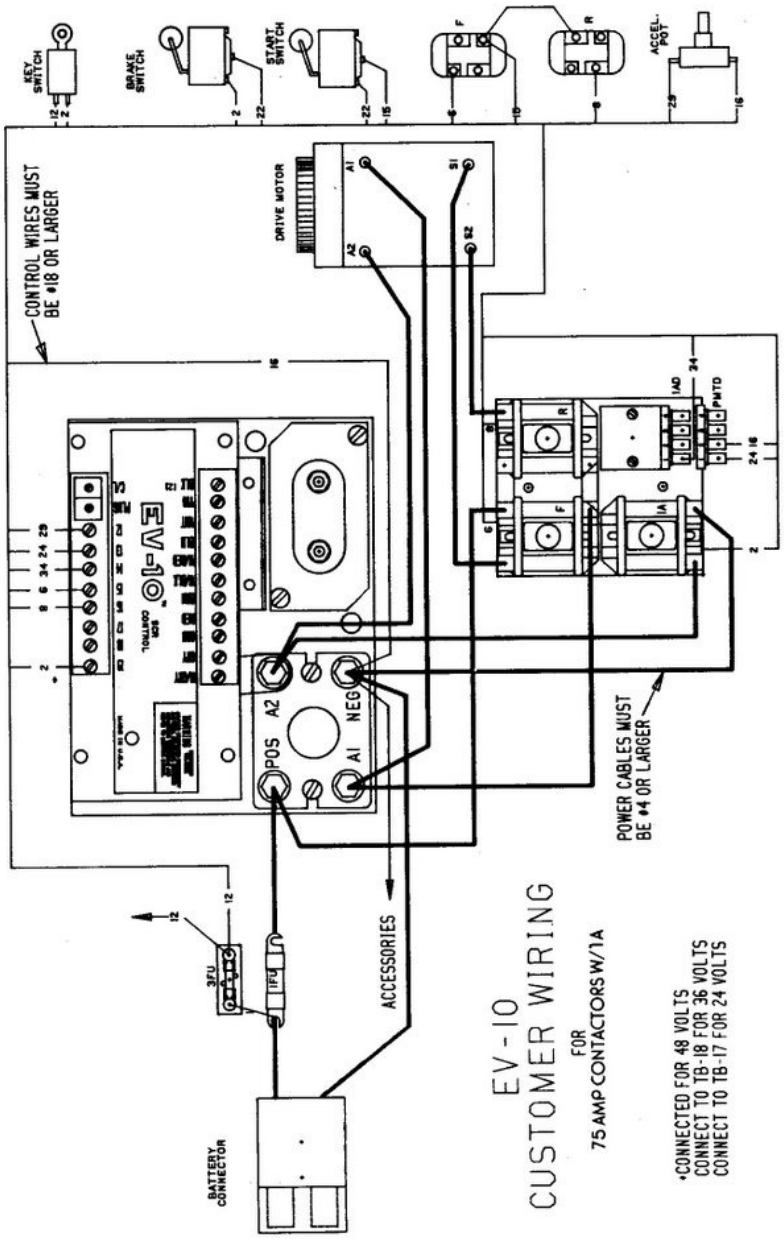

Figure 4.2.3
75 AMP WIRING

GEK-83454

INSTRUCTIONS

MAINTENANCE AND TROUBLESHOOTING FOR THE EV-10* SCR CONTROL

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JANUARY, 1983

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CHAPTER 5
MAINTENANCE AND TROUBLESHOOTING

SECTION 1
GENERAL MAINTENANCE INSTRUCTIONS

The SCR control, like all electrical apparatus, does have some thermal losses. The semiconductor junctions have finite temperature limits above which these devices may be damaged. For these reasons, normal maintenance should guard against any action which exposes the components to excessive heat, such as steam cleaning, or which reduces the heat dissipating ability of the control, such as restricting air flow.

The following DO'S and DON'TS should be observed:

1. Advise the truck manufacturer of any controls that will be used in ambients of 100°F (40°) or over.

2. Use filters on all external components having inductive coils. Refer to the vehicle manufacturer for specifications.

3. Do not steam-clean the control. In dusty areas, use low pressure air to blow off the control. In oily or greasy areas, use a mild solution of detergent, denatured alcohol, or Freon TF degreaser to wash off the control; then blow it completely dry with low pressure air.

4. Mount the SCR panel against the frame of the truck. The truck frame, acting as an additional heat sink, will give improved truck performance by keeping the SCR control package cooler. Add Silicone Grease (Dow Corning No. 342 or equivalent) between the SCR Control base and the vehicle frame.

5. Keep the terminal boards and other exposed SCR control parts free of dirt and paint which might change the effective resistance between points.

CAUTION

THE TRUCK SHOULD NOT BE PLUGGED IN WHEN IT IS JACKED UP AND THE DRIVE WHEELS ARE IN A FREE-WHEELING POSITION. THIS CAN CREATE EXCESSIVE VOLTAGES THAT CAN BE HARMFUL TO THE CONTROL.

SECTION 2
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

HOW TO USE THE DIAGNOSTIC DIAGRAM

DIAGRAMS ARRANGED BY FAILURE

The diagrams are arranged by failure modes. These modes are described in oval-shaped boxes at the top of each page.

FIND YOUR SYMPTOM AND FOLLOW THE ARROWS

Find the symptom that describes your vehicle's failure mode and proceed to the next step following the arrow.

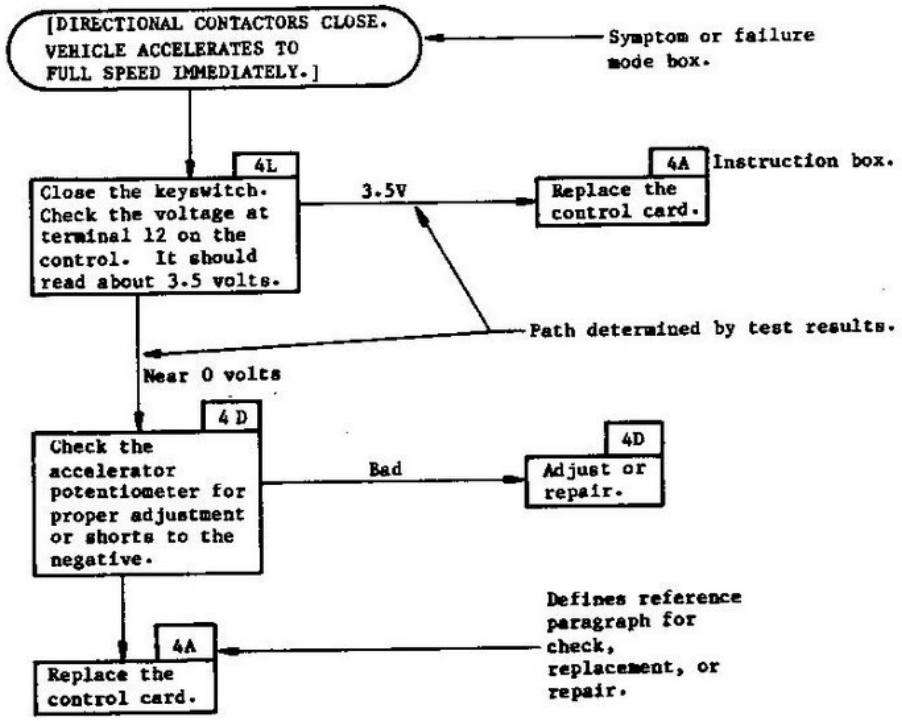
FOLLOW THE INSTRUCTIONS

Follow the instruction described in the box and proceed to the next box along the arrow path which coincides with the result of your action.

NOTE

The numbers and letters (i.e., 4A) enclosed in small boxes in the upper right corner of some instruction boxes correspond to a particular segment in Section 4, Checking Components. Please refer to that segment for more detailed instructions.

EXAMPLE


[DIRECTIONAL CONTACTORS CLOSE. VEHICLE ACCELERATES TO FULL SPEED IMMEDIATELY.]
Symptom or failure mode box.
4L
Close the keyswitch. Check the voltage at terminal 12 on the control. It should read about 3.5 volts.
3.5V
4A
Replace the control card.
Instruction box.
Path determined by test results.
Near 0 volts
4 D
Check the accelerator potentiometer for proper adjustment or shorts to the negative.
Bad
4D
Adjust or repair.
Defines reference paragraph for check, replacement, or repair.
4A
Replace the control card.

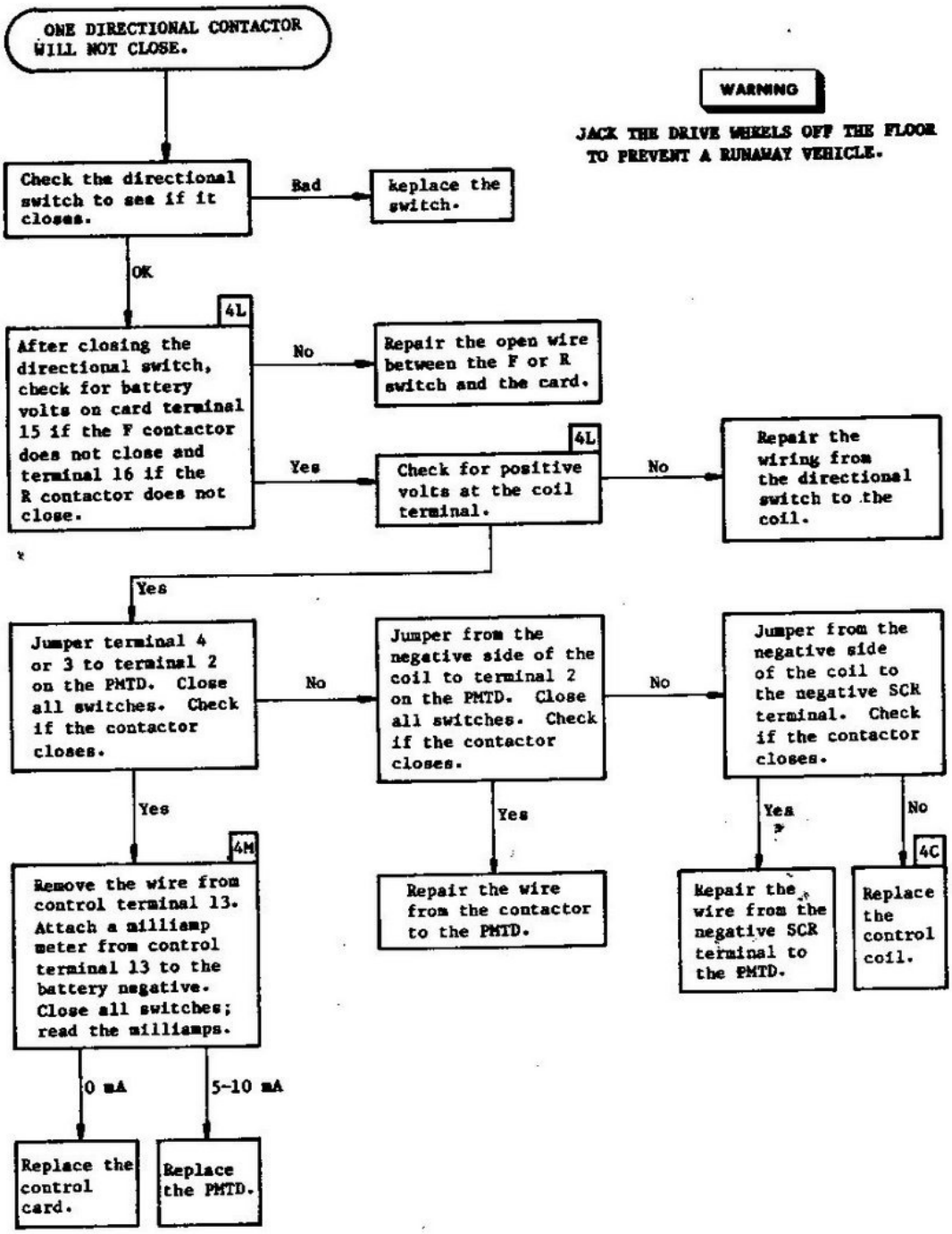


Figure 5.2.1, Sheet 1
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

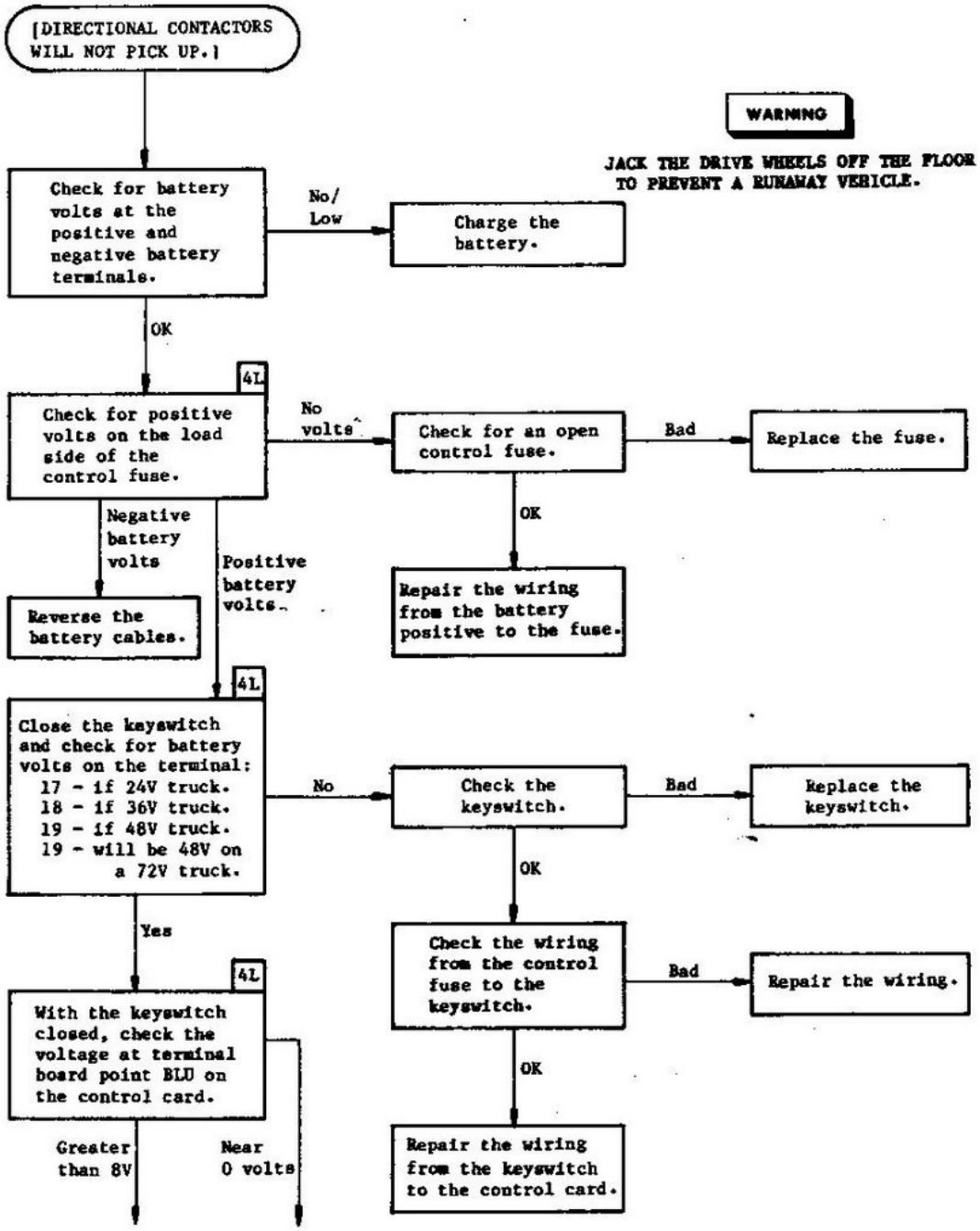


Figure 5.2.1, Sheet 2
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

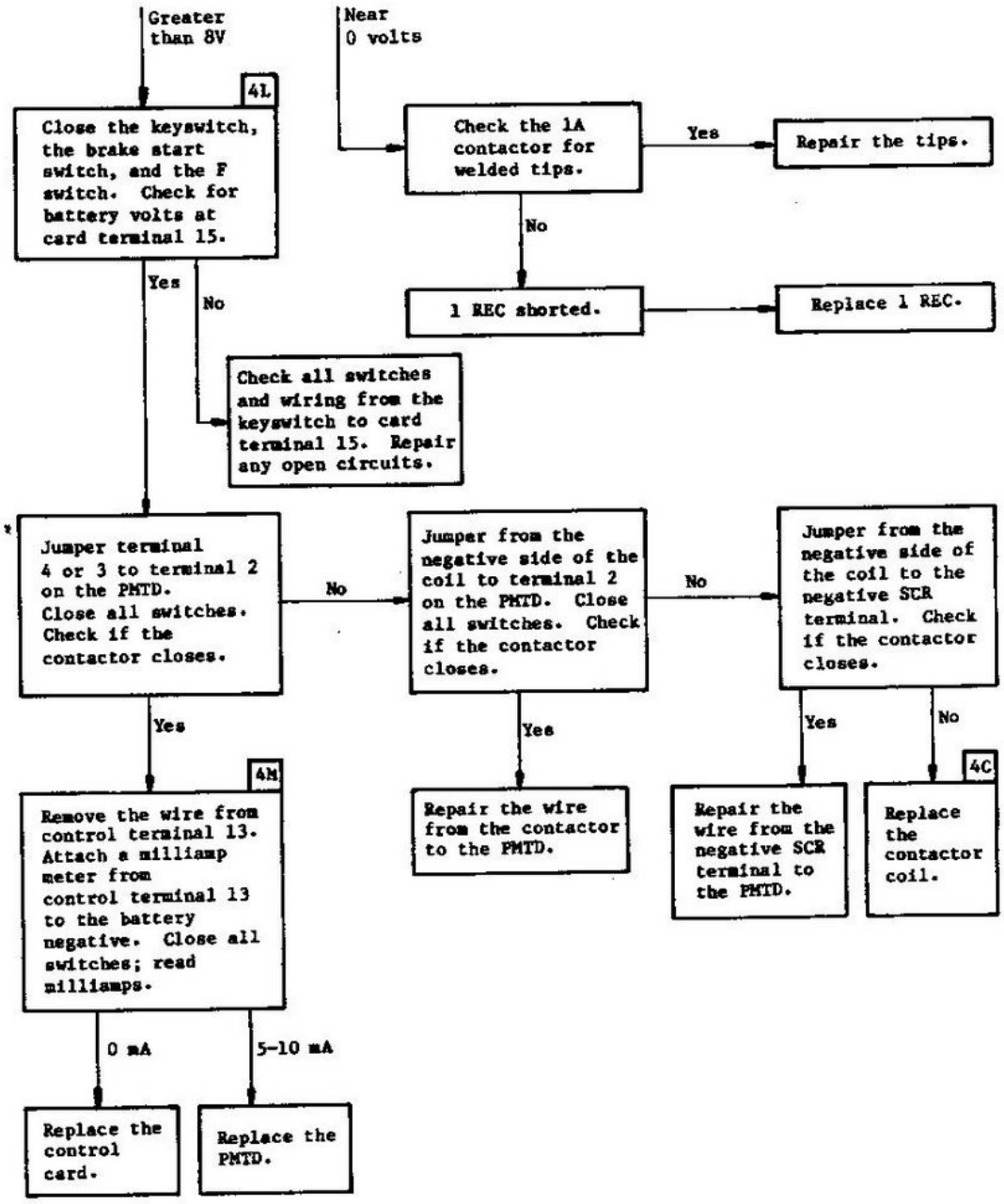


Figure 5.2.1, Sheet 3
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

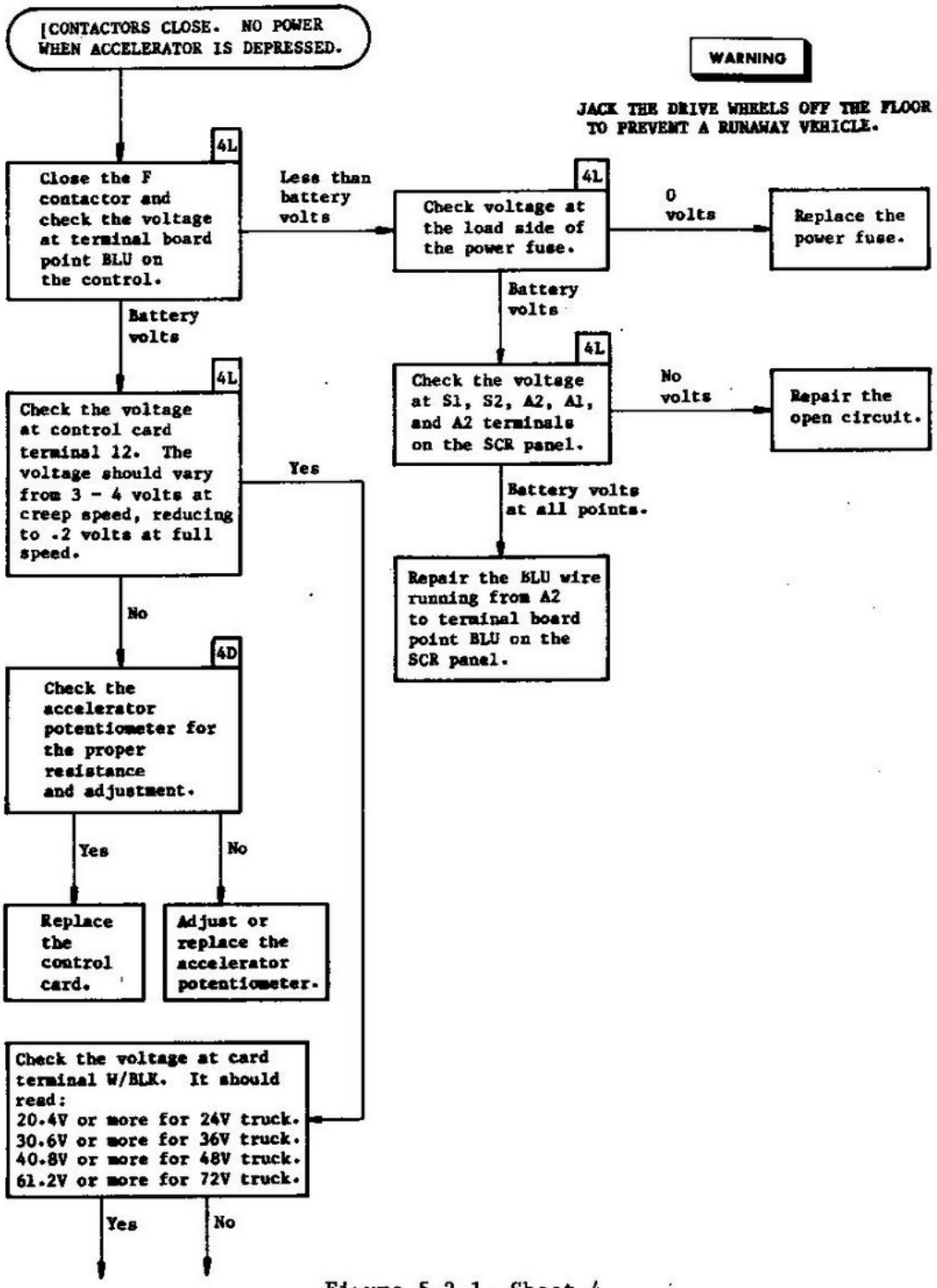


Figure 5.2.1, Sheet 4
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

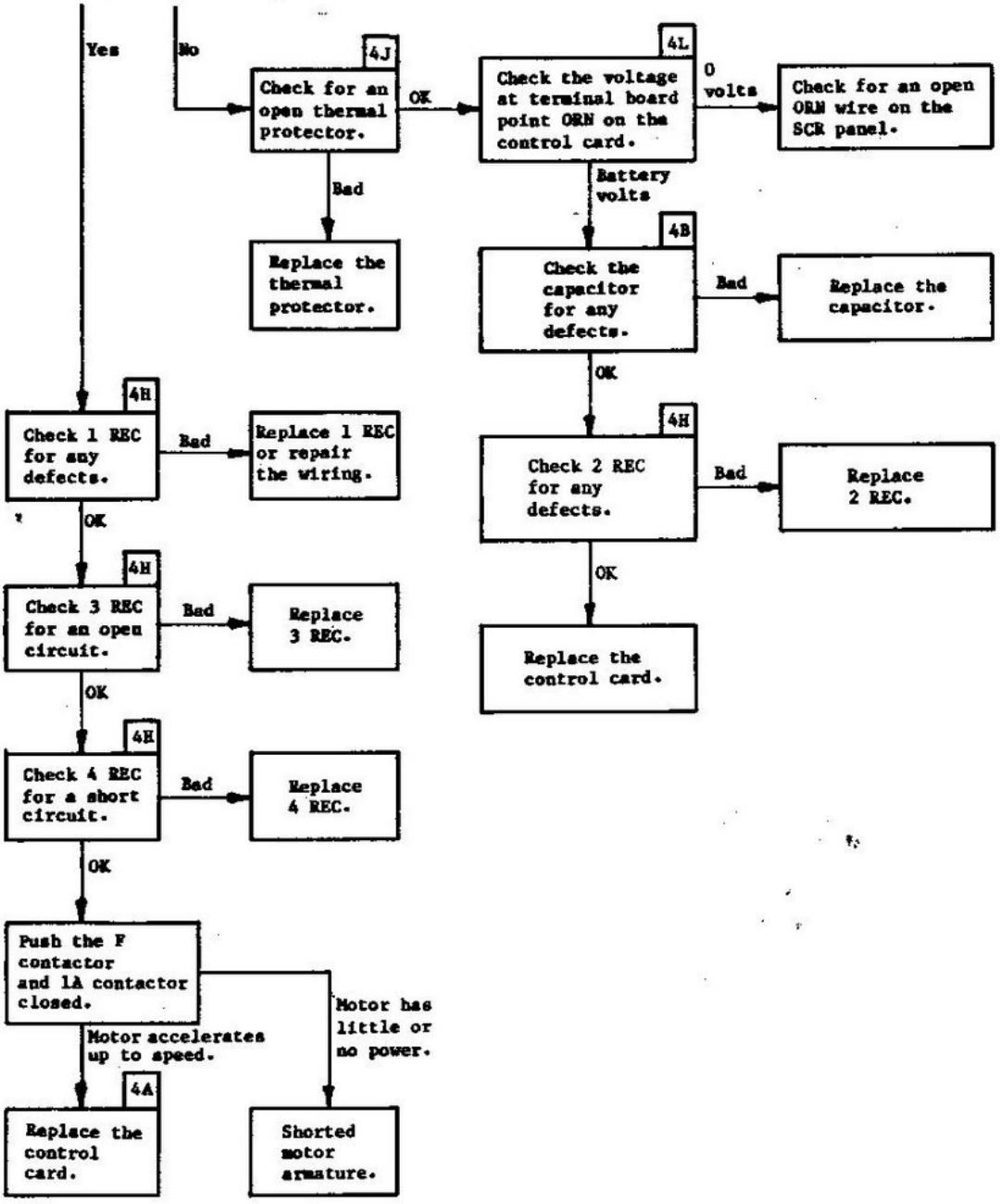
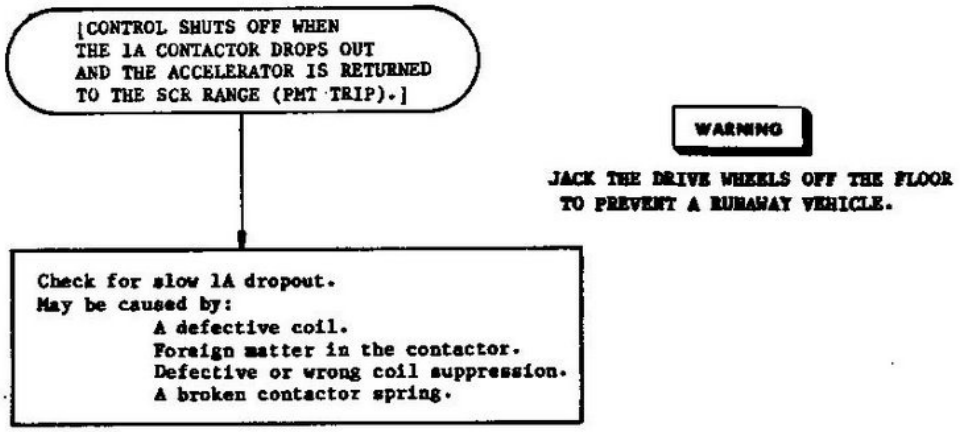


Figure 5.2.1, Sheet 5
TROUBLESHOOTING DIAGNOSTIC DIAGRAM



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TROUBLESHOOTING DIAGNOSTIC DIAGRAM

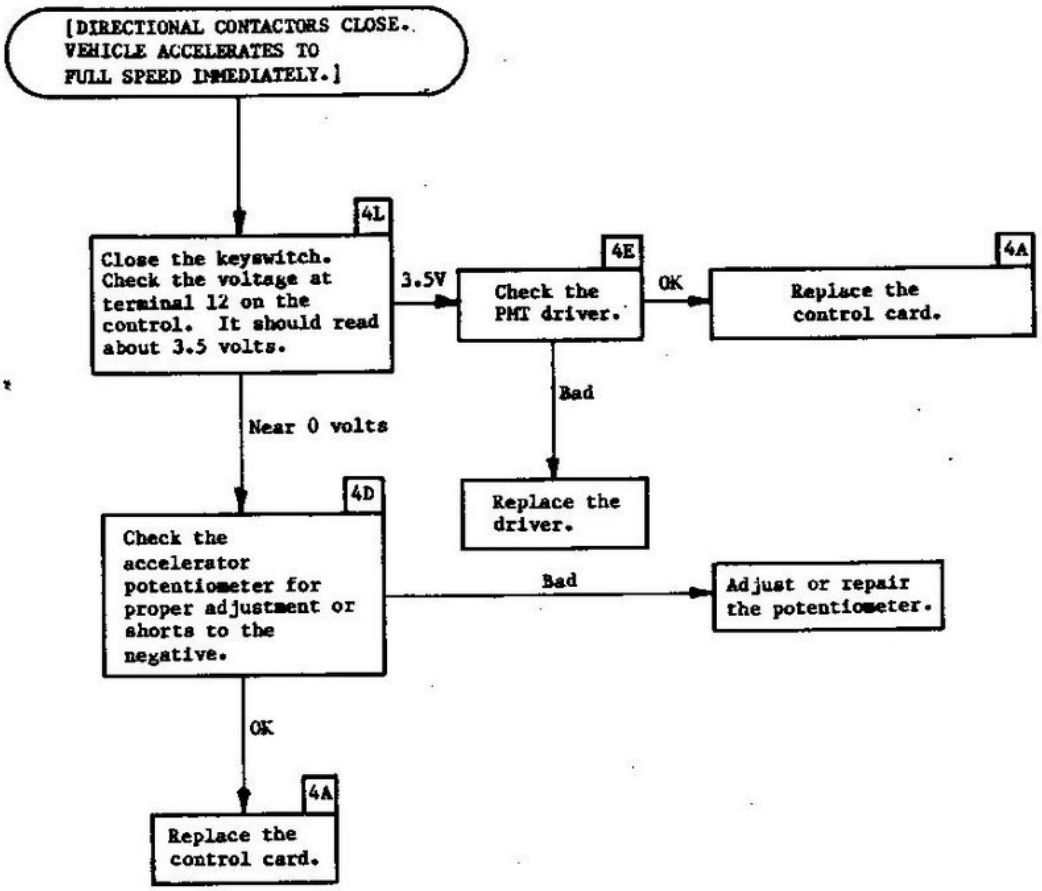


Figure 5.2.1, Sheet 7
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

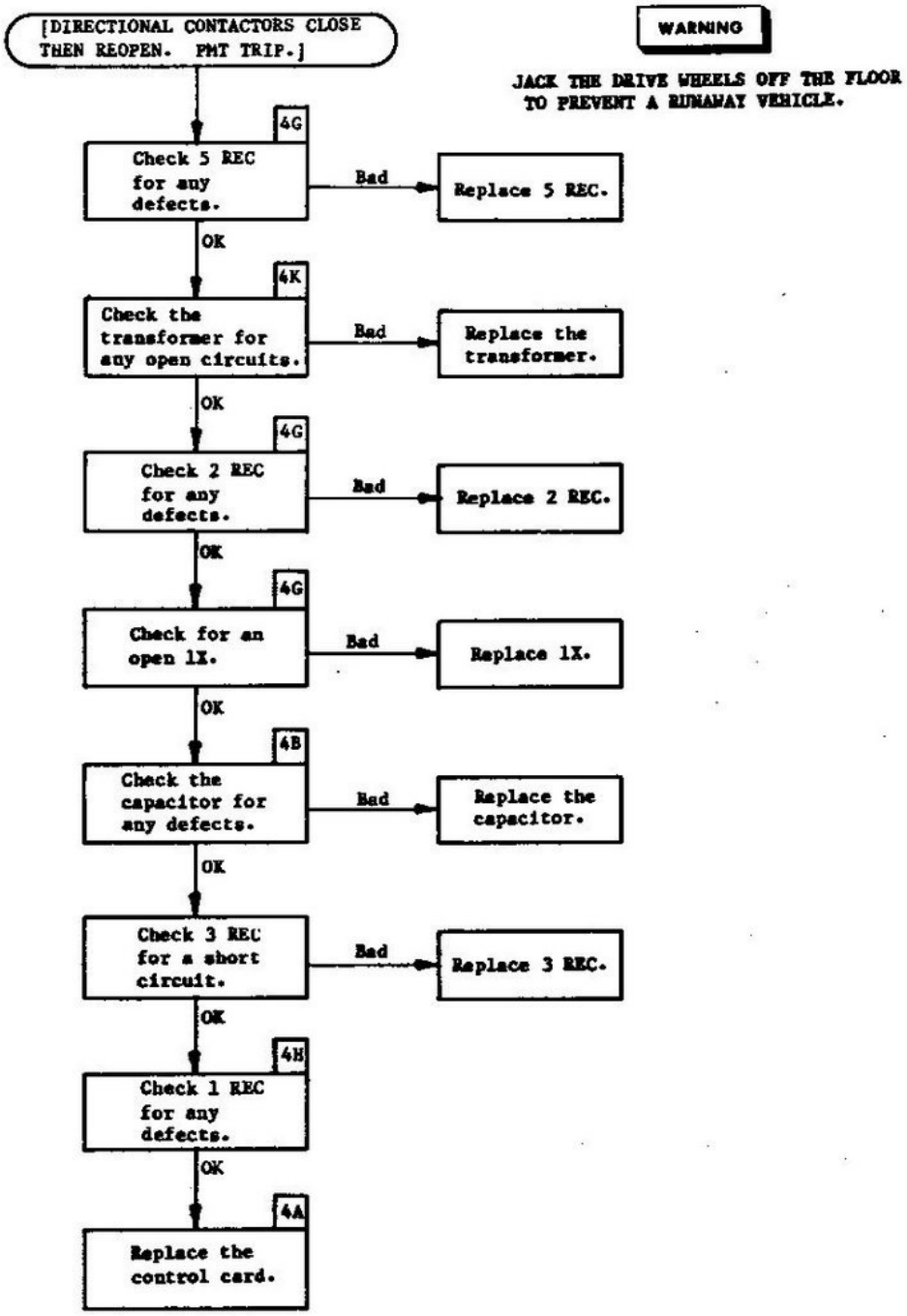


Figure 5.2.1, Sheet 8
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

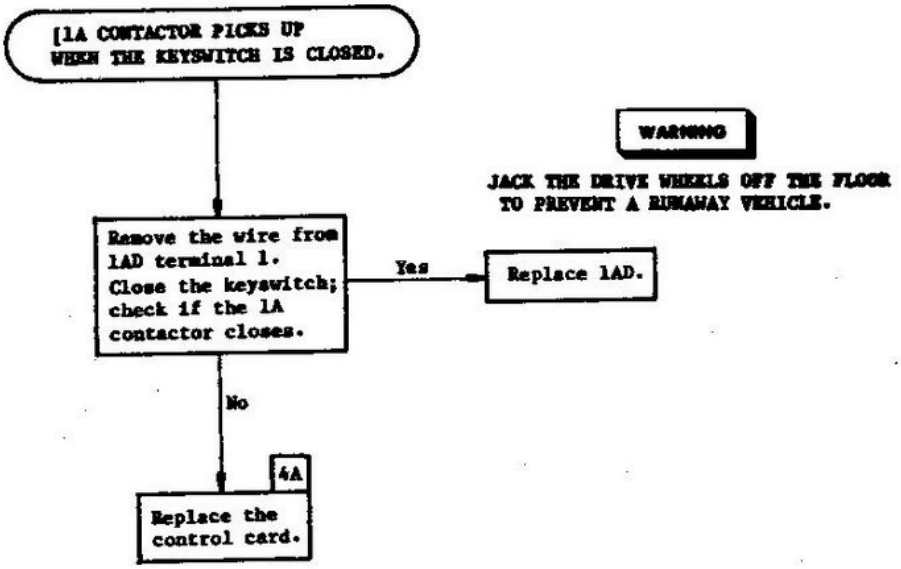


Figure 5.2.1, Sheet 9
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

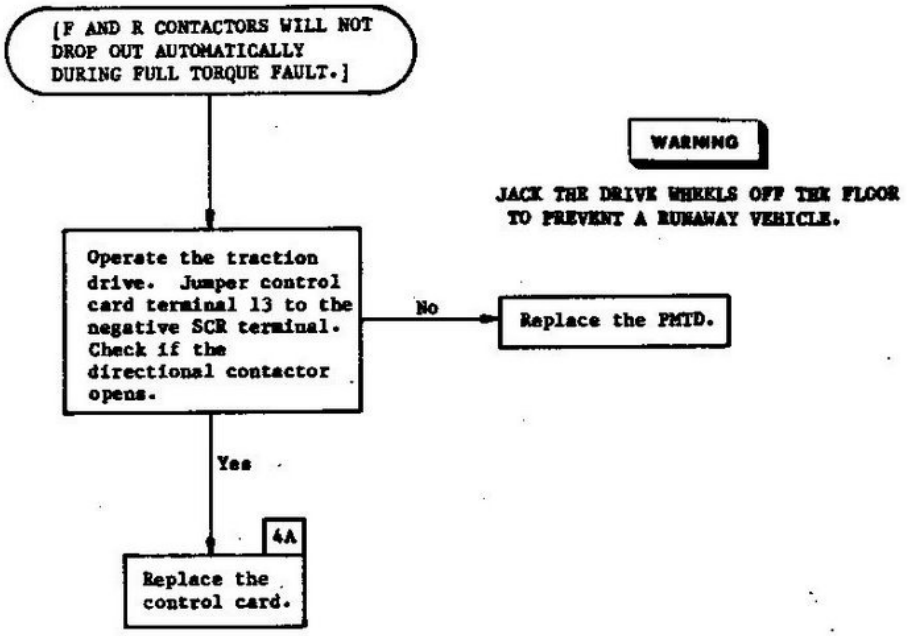


Figure 5.2.1, Sheet 10
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

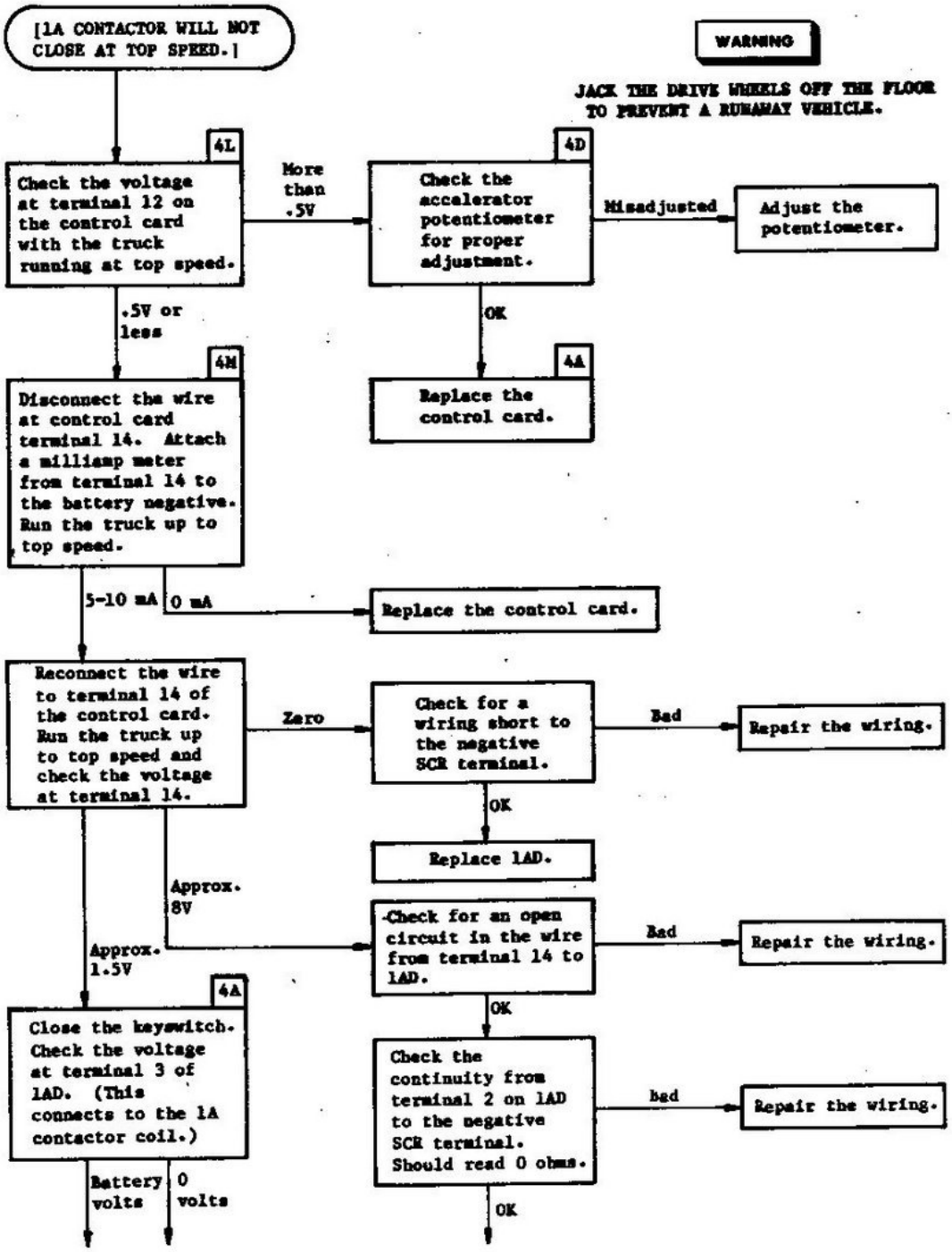


Figure 5.2.1, Sheet 11
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

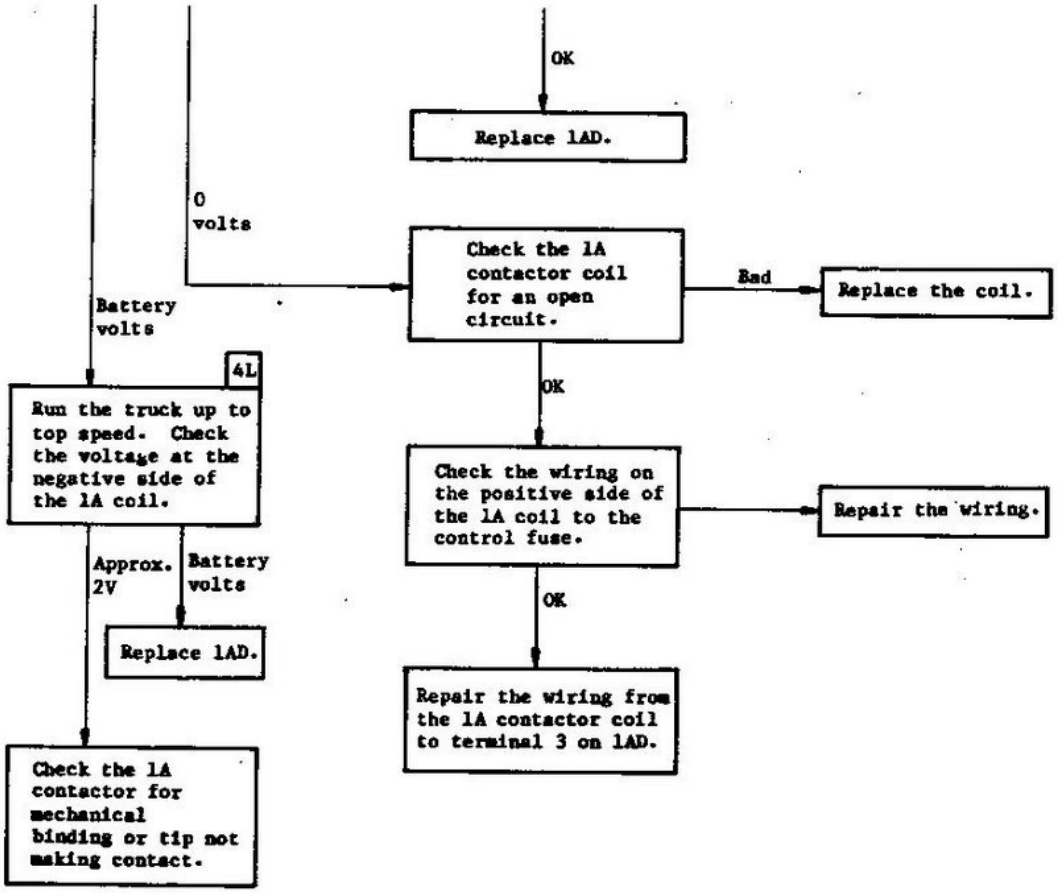


Figure 5.2.1, Sheet 12
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

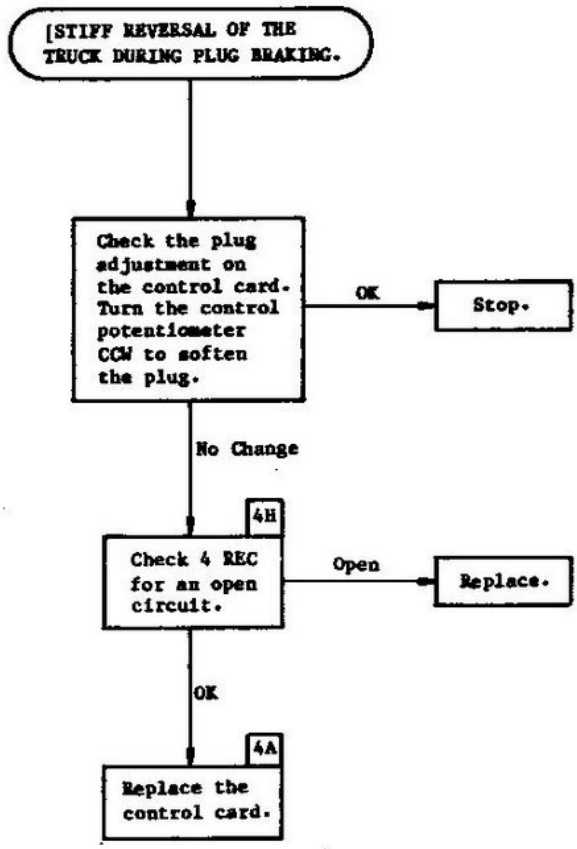


Figure 5.2.1, Sheet 13
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

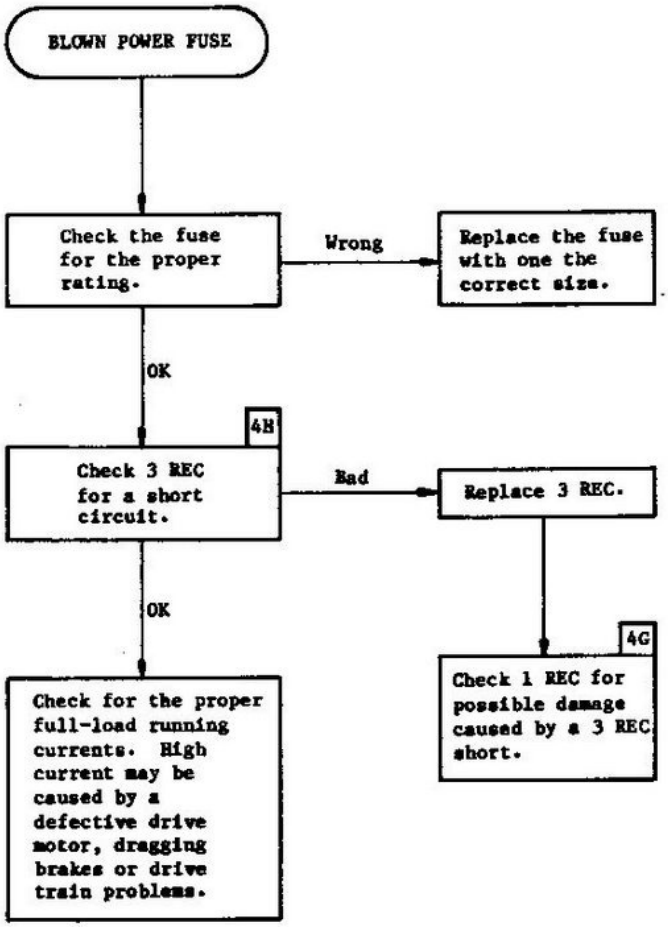


Figure 5.2.1, Sheet 14
TROUBLESHOOTING DIAGNOSTIC DIAGRAM

SECTION 3
DESCRIPTION OF OSCILLATOR CARD INPUTS AND OUTPUTS

INPUTS

Table 5.3.1
OSCILLATOR CARD INPUTS

COLOR	FUNCTION
W/GRN	Plugging input
GRY	Thermal protector input
ORN	Battery volts reference
RED	Gate drive for 5 REC
BRN	Gate loading for 5 REC
W/BLK	Gate loading for 2 REC & capacitor volts
W/RED	Gate drive for 2 REC
BLU	PMT/current limit sense input
WHT	Gate drive for 1 REC
VIO	Gate loading for 1 REC
BLK (2)	Negative card input - 1 wire from negative on transformer and 1 wire from thermal protector.

OUTPUTS

Table 5.3.2
OSCILLATOR CARD OUTPUTS

TERMINAL NUMBER	FUNCTION
19	Battery positive input for 48 volt vehicle
18	Battery positive input for 36 volt vehicle
17	Battery positive input for 24 volt vehicle
16	Reverse directional switch input
15	Forward directional switch input
14	Signal for 1A driver
13	Signal for PMTD or F/R driver
12	Accelerator potentiometer input

SECTION 4
CHECKING COMPONENTS

This section provides step-by-step instructions for checking the components. These instructions include meter readings from the Volt-Ohm-Meter, with the desired reading indicated at the end of that particular step.

MAIN SCR CONTROL CARD (4A)

The troubleshooting diagnostics check all outside devices and eliminate them as the source of the problem. If that does not resolve the problem, then the card must be faulty.

INSTRUCTIONS FOR REMOVAL OF THE CONTROL CARD

WARNING

TO AVOID DAMAGE TO THE CARD, DO NOT REMOVE THE SCR CONTROL CARD FROM ITS METAL TOP AND BOTTOM.

1. Remove all wires from the outside terminal board on the control card.

2. Remove all wires from the inside terminal board on the control card.

3. Remove the 2 screws attaching the control card bottom to the stand-up bracket (near the capacitor).

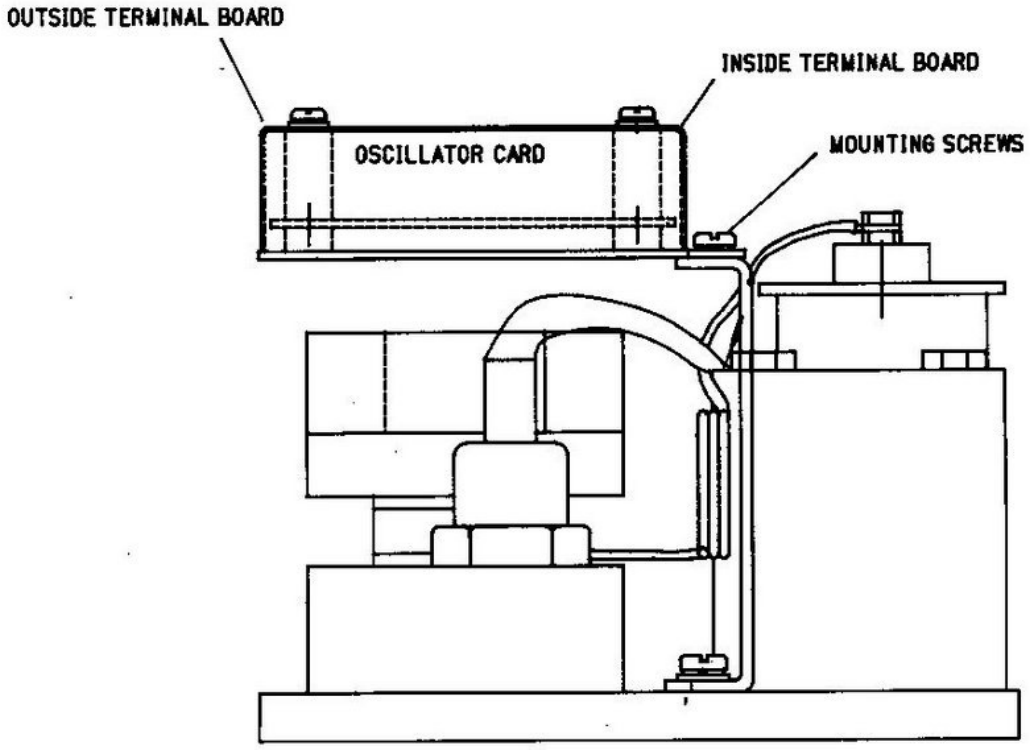


Figure 5.4.1
SCR CONTROL CARD

Ref. 91.TMP.26

CAPACITOR 1C (4B)

WARNING

TO AVOID ELECTRICAL SHOCK OR A RUNAWAY VEHICLE, DISCONNECT THE BATTERY AND DISCHARGE THE CAPACITOR BEFORE DOING ANY TESTING.

USING A VOLT-OHM-METER (VOM) SET TO THE R X 10,000 SCALE:

1. Remove the wires from one of the terminals of the capacitor.
2. Connect the leads from the VOM across the capacitor terminals. The meter should swing to 0 ohms, then gradually swing to above 100,000 ohms.
3. Reverse the leads of the VOM. The meter should swing to 0 ohms, then gradually swing to above 100,000 ohms.
4. Check the resistance from one of the capacitor terminals to its case. Meter reading: 50,000 ohms or more.

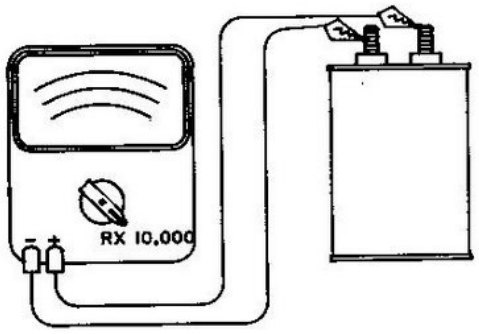


Figure 5.4.2
CAPACITOR CHECK

Ref. 91.TMP.27

CONTACTORS F, R, 1A, and P (4C)

For 150 and 300 amp contactors, refer to GEH-4469 located in Section 7 of this chapter.

For 75 amp contactors, refer to GEH-3099A located in Section 7 of this chapter.

POTENTIOMETER IN ACCELERATOR (4D)

1. Disconnect the battery.

2. Remove the wire from terminal board point 12.

3. Connect a Volt-Ohm-Meter from the wire at terminal board point 12 to the negative on the transformer with the scale set to R X 100.

4. Set the accelerator at creep speed.
   Meter reading: 4800 to 6000 ohms.

5. Move the accelerator to top speed.
   Meter reading: 200 ohms or less.

6. Move the negative VOM lead to the truck frame.
   Meter reading: 1,000,000 ohms or more.

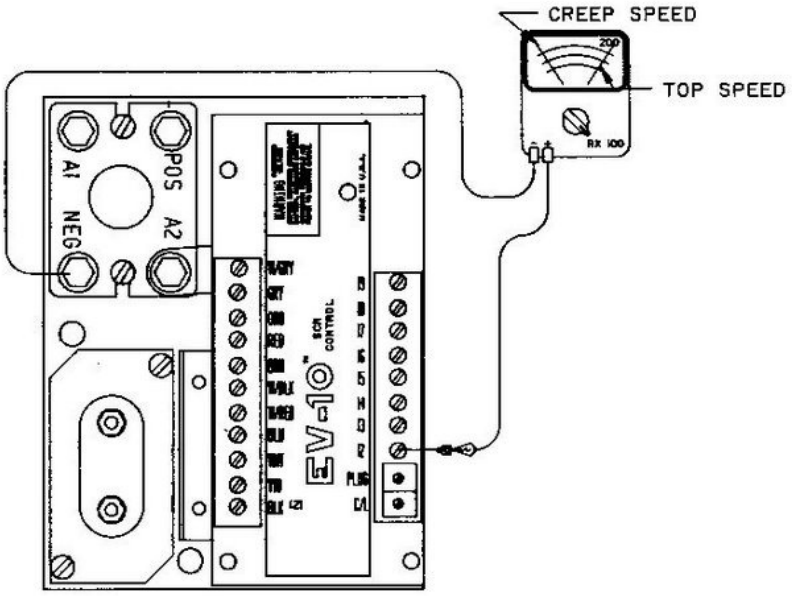


Figure 5.4.3
ACCELERATOR POTENTIOMETER CHECK

Ref. 91.TMP.28

DRIVER MODULE (4E)

Resistor = 8200 ohms 2 watts for 72 volts.
= 4700 ohms 2 watts for 24/36/48 volts.

USING A VOM SET TO THE 50V DC SCALE:

(For 24/36/48V, use a VOM set to a 100V dc scale.)

1. Disconnect the leads.
2. Connect the resistor, coil and switch to terminals 1 and 3 as shown.
3. Connect the battery negative to terminal 2 and the battery positive to the junction of the switch and the resistor.
4. Connect the negative lead of the VOM to terminal 2 and the positive lead of the VOM to terminal 3. Read the battery voltage on the VOM.
5. Close the switch. The VOM meter reading should drop to 2V or less.
6. Move the resistor and the positive meter lead from terminal 3 to terminal 4.
7. Repeat the same test.

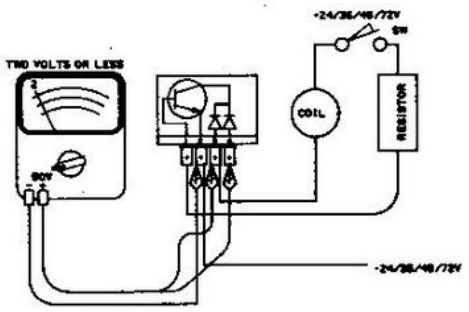


Figure 5.4.4
DRIVER MODULE CHECK

Ref. 91.TMP.29

HOURMETER MODULE (4F)

USING A VOM SET TO THE R X 1 SCALE:

1. Disconnect the lead from terminal 4.

2. Connect the positive lead of the VOM to terminal 3 and the negative lead of the VOM to terminal 4.
   Meter reading: less than 20 ohms.

3. Move the positive lead to terminal 2.
   Meter reading: less than 20 ohms.

4. Move the positive lead to terminal 1.
   Meter reading: less than 20 ohms.

SWITCH THE VOM TO THE R X 10,000 SCALE:

5. Connect the negative lead of the VOM to terminal 3 and the positive lead to terminal 4.
   Meter reading: 50,000 ohms or more.

6. Move the negative lead to terminal 2.
   Meter reading: 50,000 ohms or more.

7. Move the negative lead to terminal 1.
   Meter reading: 50,000 ohms or more.

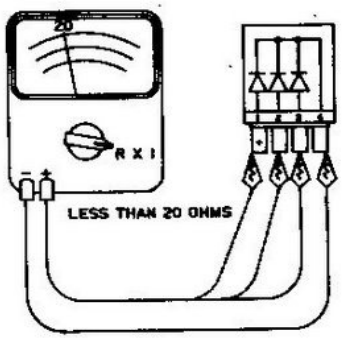


Figure 5.4.5
HOURMETER MODULE CHECK

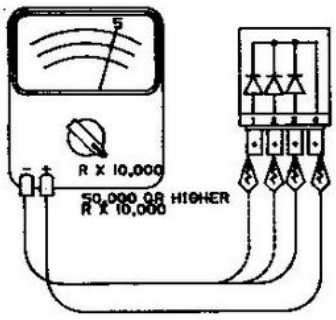


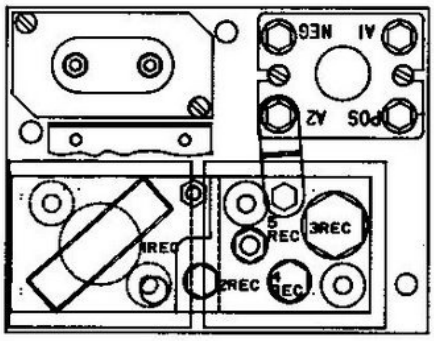
Figure 5.4.6
HOURMETER MODULE CHECK

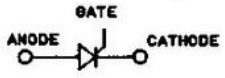
Ref. 91.TMP.30
Ref. 91.TMP.31

SCR (1 REC, 2 REC, 5 REC) (4G)

WARNING

TO AVOID ELECTRICAL SHOCK OR A RUNAWAY VEHICLE, DISCONNECT THE BATTERY AND DISCHARGE THE CAPACITOR BEFORE DOING ANY TESTING.





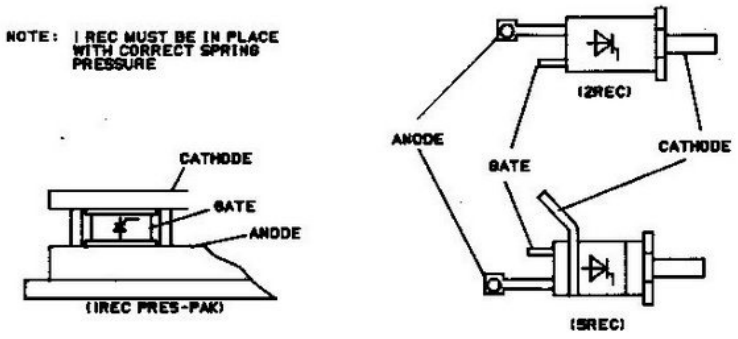


Figure 5.4.7
SCR LOCATIONS

Ref. 91.TMP.32

1 REC

USING A 6V TEST LIGHT, AS SHOWN:

1. Disconnect the WHT wire from the card.

2. Connect the negative lead of the test light to terminal board point VIO (cathode).

3. Connect the positive lead of the test light to terminal board point BLU (anode). If the light comes on, 1 REC has shorted. If the light does not come on, continue testing.

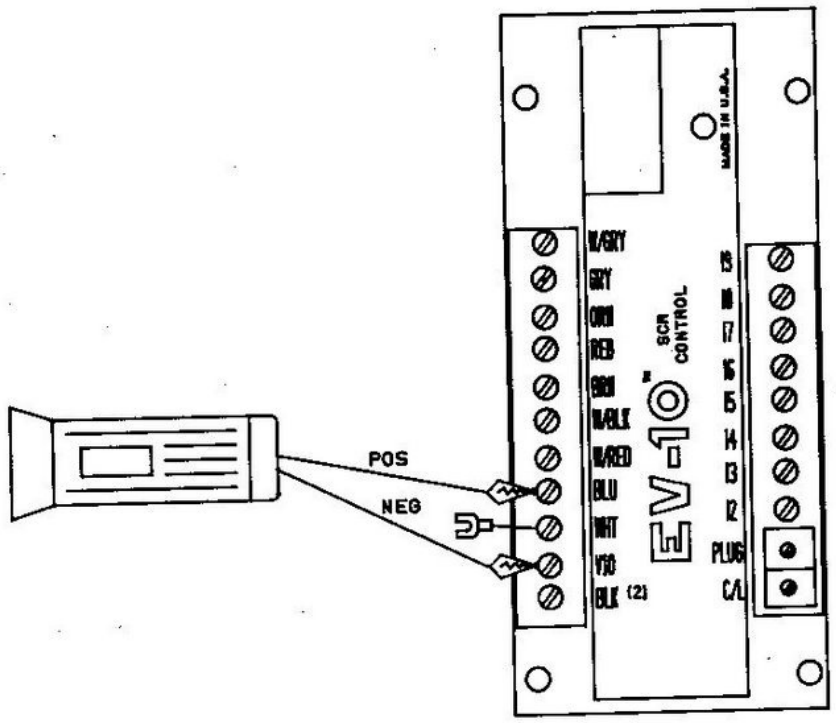


Figure 5.4.8
1 REC TEST LIGHT CHECK

1 REC (Continued)

4. Touch the WHT (gate) wire to terminal board point BLU. The light should come on. If it does not, 1 REC is open.

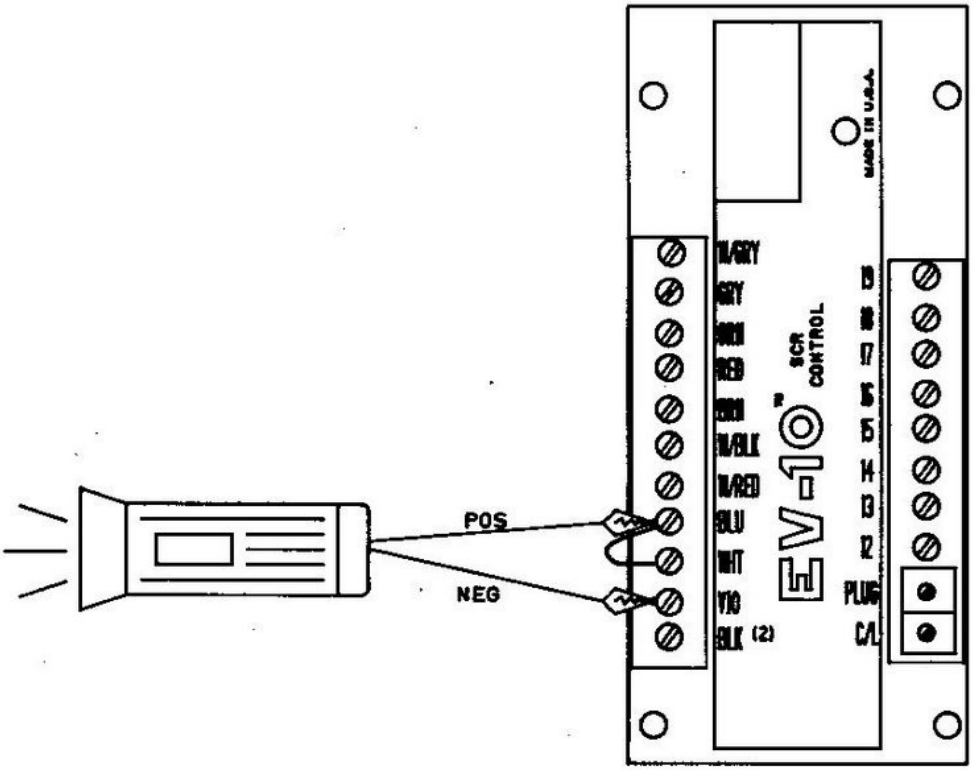


Figure 5.4.9
1 REC TEST LIGHT CHECK

Ref. 91.TMP.34

1 REC (Continued)

USING A VOM SET TO THE R X 1 SCALE:

1. Disconnect the BLU wire from terminal board point BLU.
2. Disconnect the WHT wire from terminal board point WHT.
3. Connect the negative lead of the VOM to the WHT wire (gate).
4. Connect the positive lead of the VOM to terminal board point VIO (cathode). Replace 1 REC if the reading is either zero or infinity.
5. Reverse the meter leads and check again. Replace 1 REC if the reading is zero or infinity.

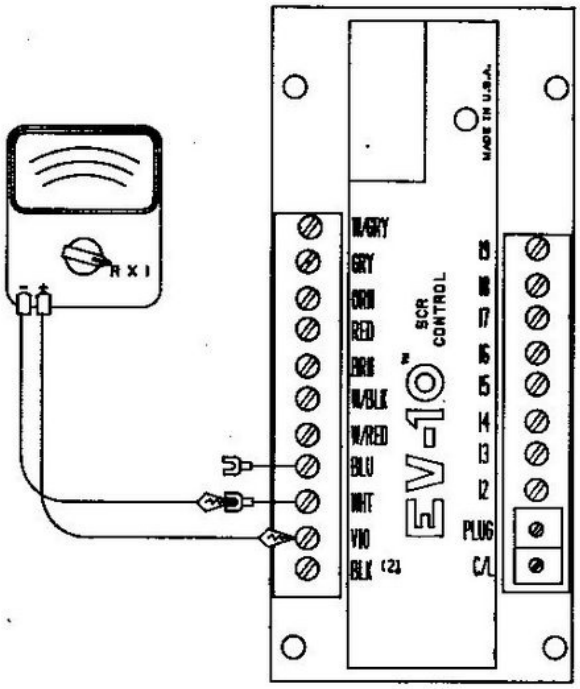


Figure 5.4.10
1 REC VOM CHECK

Ref. 91.TMP.35

1 REC (Continued)

SWITCH THE VOM TO THE R X 100 SCALE:

6. Connect the negative lead of the VOM to the BLU wire (anode).

7. Connect the positive lead of the VOM to terminal board point VIO (cathode). Replace 1 REC if the meter reads zero.

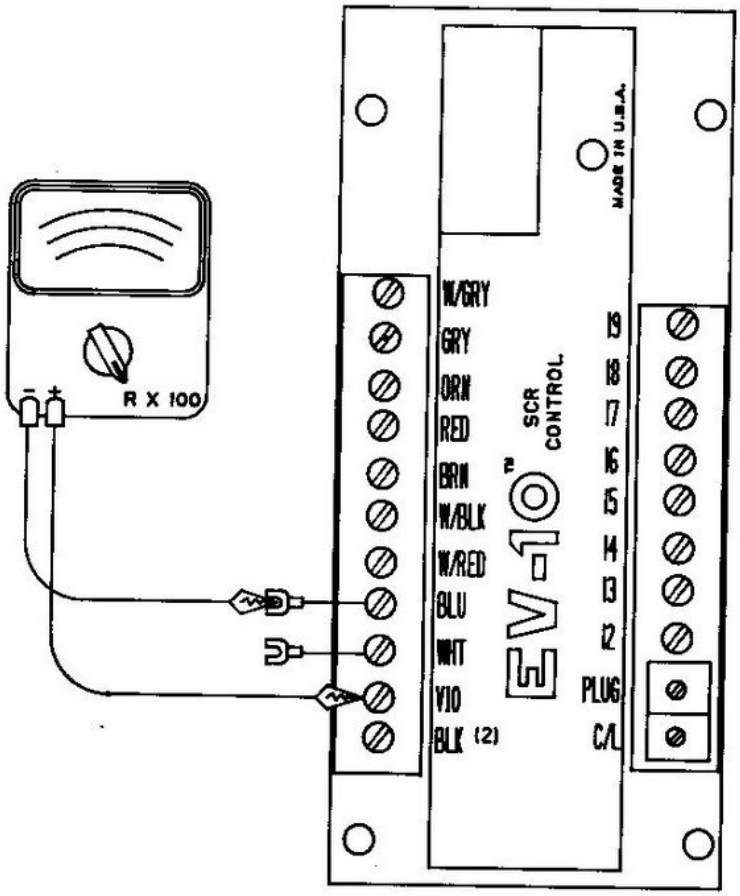


Figure 5.4.11
1 REC VOM CHECK

Ref. 91.TMP.36

2 REC

USING A 6V TEST LIGHT, AS SHOWN:

1. Disconnect the W/RED wire from the card.

2. Connect the negative lead of the test light to terminal board point W/BLK (cathode).

3. Connect the positive lead of the test light to terminal board point BLU (anode). If the light comes on, 1 REC has shorted. If the light does not come on, continue testing.

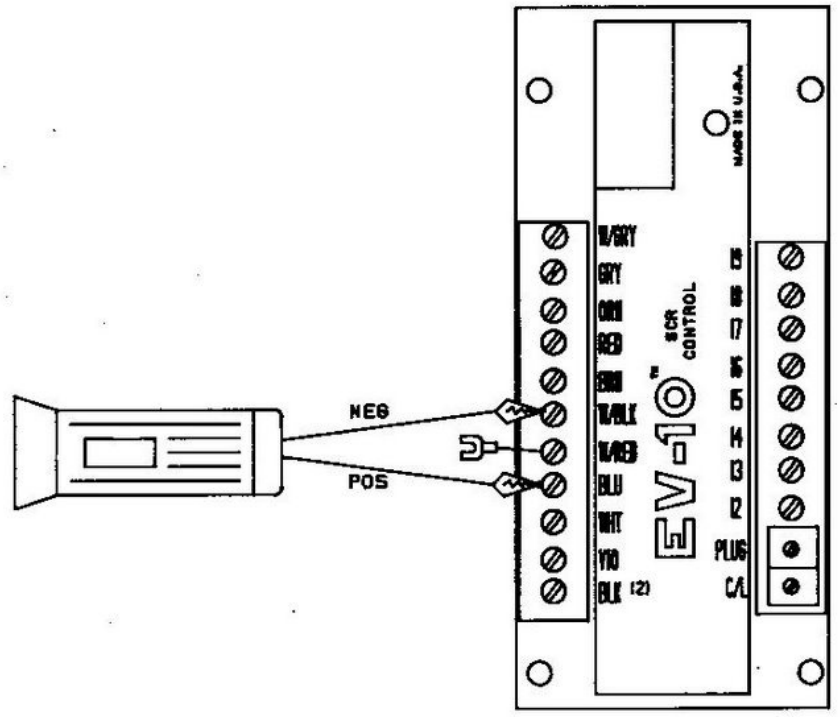


Figure 5.4.12
2 REC TEST LIGHT CHECK

Ref. 91.TMP.37

2 REC (Continued)

4. Touch the W/RED (gate) wire to terminal board point BLU. The light should come on and stay on when the W/RED wire is removed; if not, 2 REC is open.

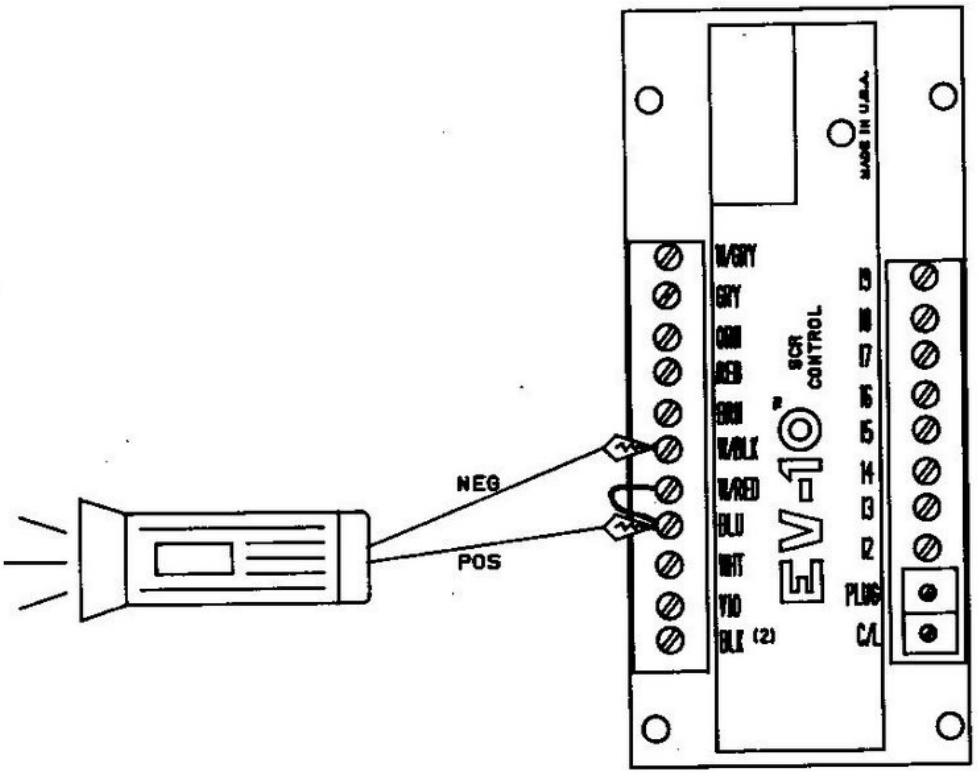


Figure 5.4.13
2 REC TEST LIGHT CHECK

Ref. 91.TMP.38

2 REC (Continued)

USING A VOM SET TO THE R X 1 SCALE:

1. Disconnect the BLU wire from terminal board point BLU.
2. Disconnect the W/RED wire from terminal board point W/RED.
3. Connect the negative lead of the VOM to the W/RED wire (gate).
4. Connect the positive lead of the VOM to terminal board point W/BLK (cathode). Replace 2 REC if the reading is either zero or infinity.
5. Reverse the meter leads and check again. Replace 1 REC if the reading is zero or infinity.

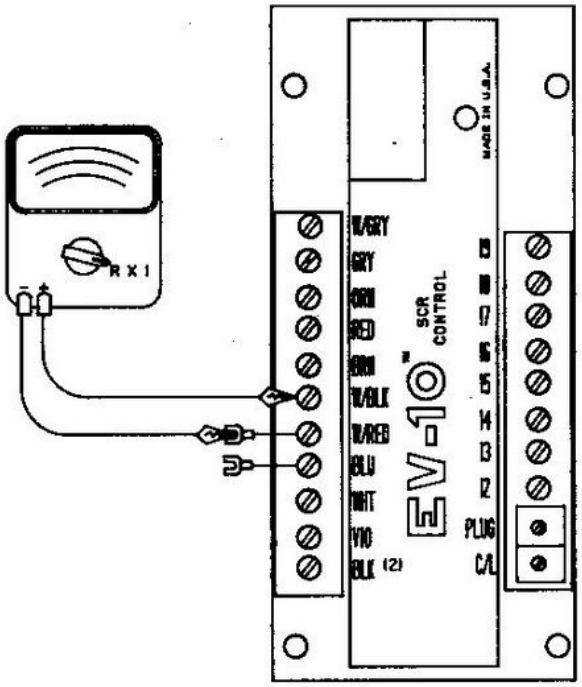


Figure 5.4.14
2 REC VOM CHECK

Ref. 91.TMP.39

2 REC (Continued)

SWITCH THE VOM TO THE R X 100 SCALE:

6. Connect the negative lead of the VOM to the BLU wire (anode).

7. Connect the positive lead of the VOM to terminal board point W/BLK (cathode). Replace 2 REC if the meter reads zero.

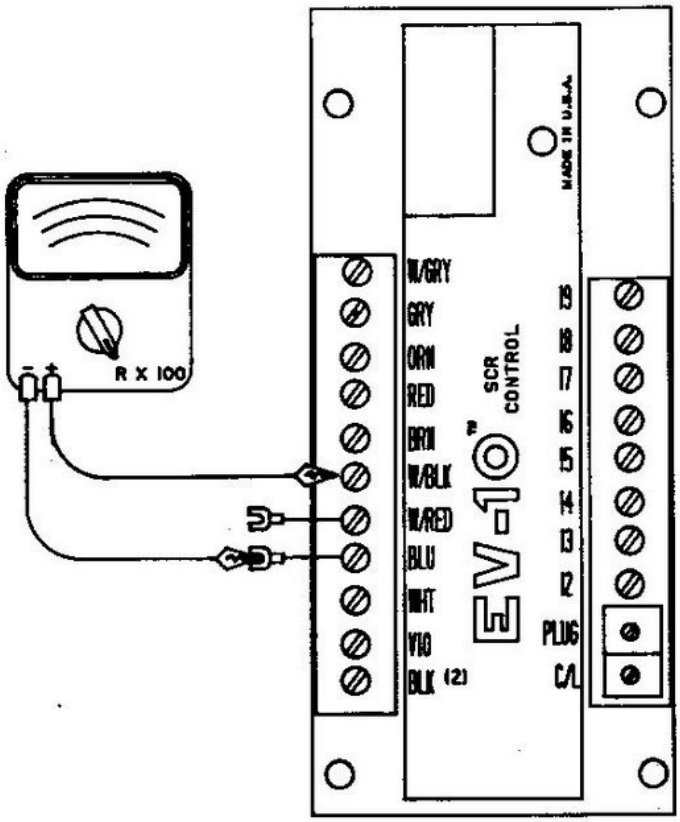


Figure 5.4.15
2 REC VOM CHECK

Ref. 91.TMP.40

5 REC

USING A 6V TEST LIGHT, AS SHOWN:

1. Disconnect the RED wire from the card.
2. Connect the negative lead of the test light to terminal board point BRN (cathode).
3. Connect the positive lead of the test light to terminal board point W/BLK (anode). If the light comes on, 1 REC has shorted. If the light does not come on, continue testing.

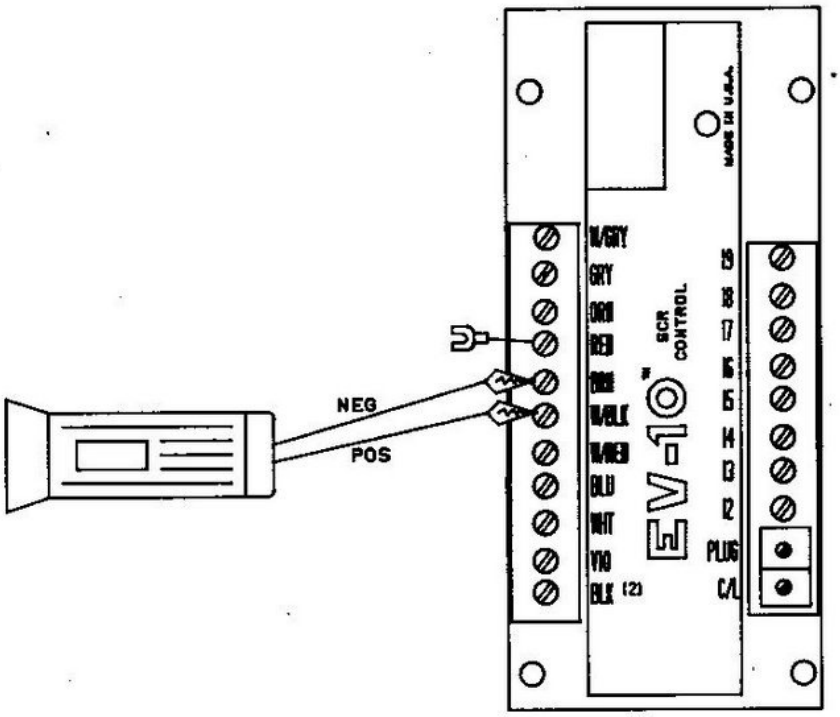


Figure 5.4.16
5 REC TEST LIGHT CHECK

Ref. 91.TMP.41

5 REC (Continued)

4. Touch the RED (gate) wire to terminal board point W/BLK. The light should come on and stay on when the RED wire is removed; if not, 5 REC is open.

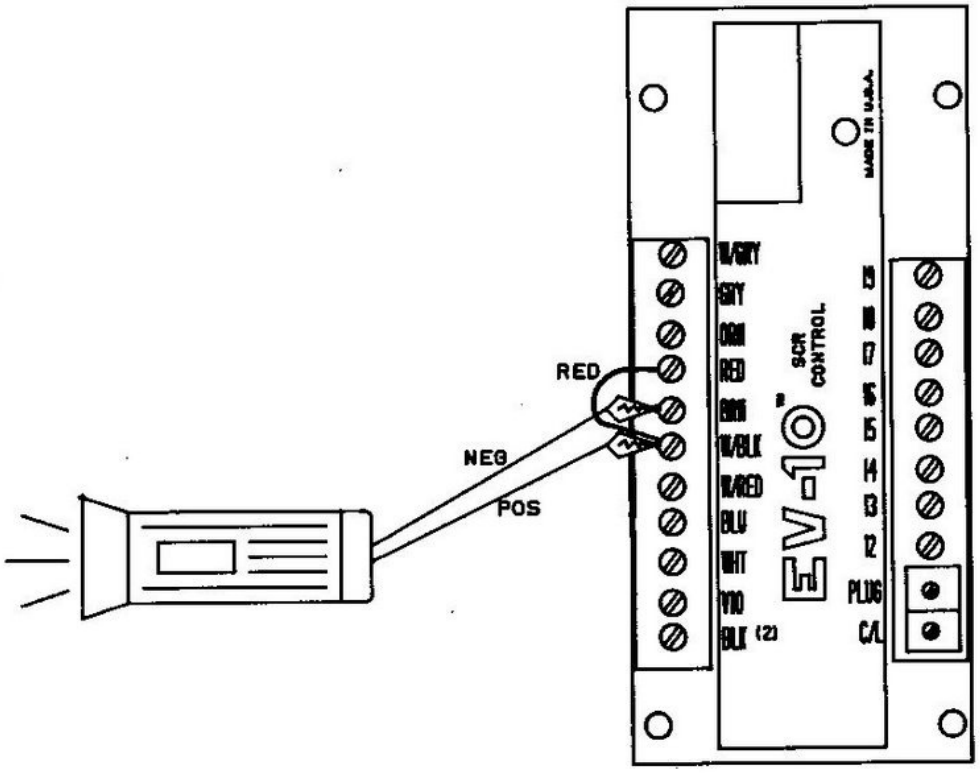


Figure 5.4.17
5 REC TEST LIGHT CHECK

Ref. 91.TMP.42

5 REC (Continued)

USING A VOM SET TO THE R X 1 SCALE:

1. Disconnect the W/BLK wire from terminal board point W/BLK (anode).
2. Disconnect the BRN wire from terminal board point BRN.
3. Connect the negative lead of the VOM to the BRN wire (cathode).
4. Connect the positive lead of the VOM to terminal board point RED (gate). Replace 5 REC if the reading is either zero or infinity.
5. Reverse the meter leads and check again. Replace 5 REC if the reading is zero or infinity.

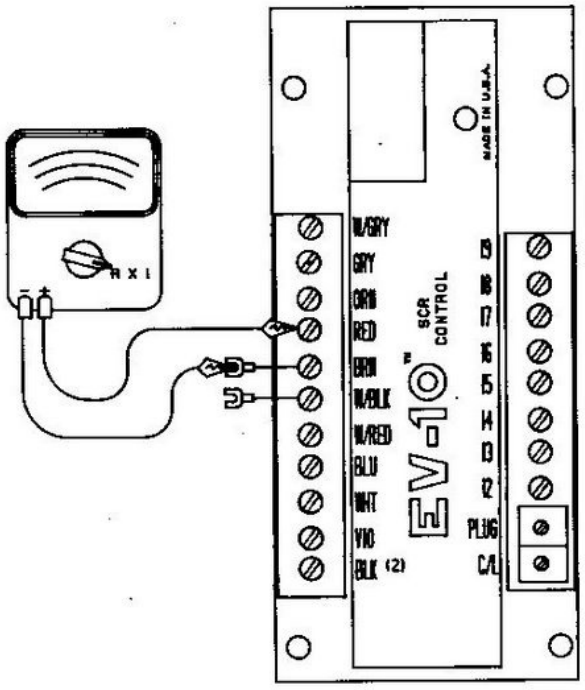


Figure 5.4.18
5 REC VOM CHECK

Ref. 91.TMP.43

5 REC (Continued)

SWITCH THE VOM TO THE R X 100 SCALE:

6. Connect the negative lead of the VOM to the W/BLK wire (anode).

7. Connect the positive lead of the VOM to the BRN wire (cathode). Replace 5 REC if the meter reads zero.

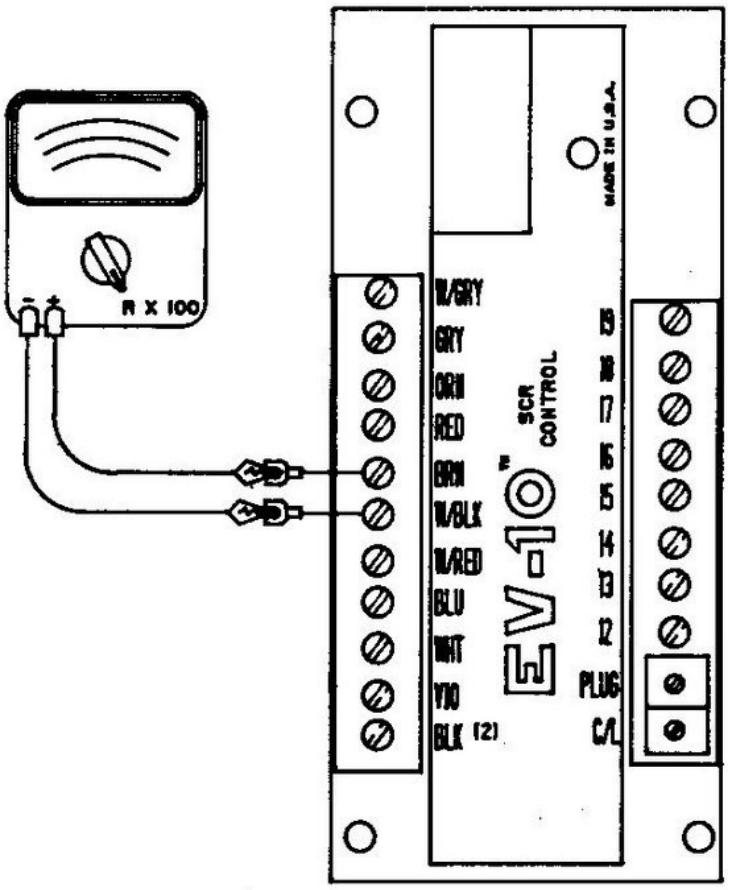


Figure 5.4.19
5 REC VOM CHECK

Ref. 91.TMP.44

RECTIFIERS (3 AND 4 REC) (4H)

WARNING

TO AVOID ELECTRICAL SHOCK OR A RUNAWAY VEHICLE, WHEN CHECKING DIODES, DISCONNECT THE BATTERY AND DISCHARGE THE CAPACITOR 1C.

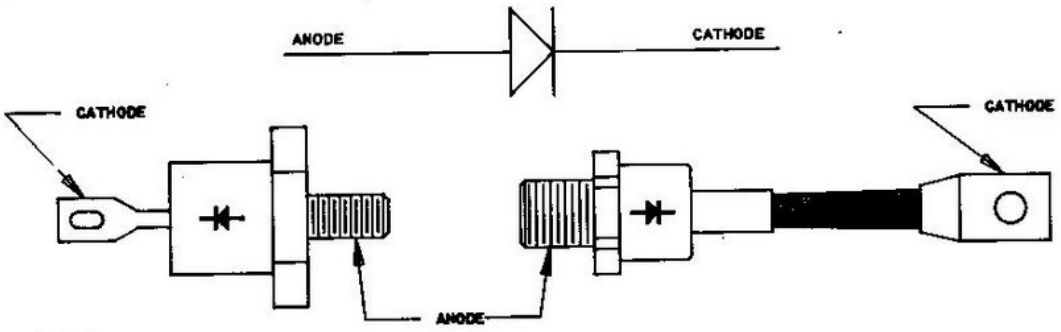


Figure 5.4.20
DIODE DESCRIPTION

Ref. 91.TMP.45

RECTIFIERS (3 AND 4 REC) (Continued)

USING A CONTINUITY TEST LIGHT:

1. Disconnect the cathode end from the panel wiring.
2. Connect the negative lead of the test light to the anode.
3. Connect the positive lead of the test light to the cathode. If the light comes on, the REC has shorted. If the light does not come on, continue testing.

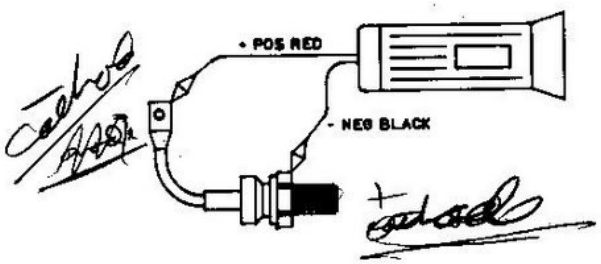


Figure 5.4.21
3 AND 4 REC TEST LIGHT CHECK

USING A CONTINUITY TEST LIGHT (Continued):

4. Connect the negative lead of the test light to the cathode.
5. Connect the positive lead of the test light to the anode. The light should normally come on. If it comes on, the test is concluded using a continuity light. If it does not come on, the diode is open.

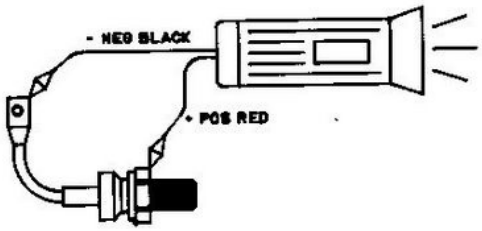


Figure 5.4.22
3 AND 4 REC TEST LIGHT CHECK

Ref. 91.TMP.46
Ref. 91.TMP.47

RECTIFIERS (3 AND 4 REC) (Continued)

USING A VOLT-OHM-METER (VOM) SET TO THE R X 10,000 SCALE:

1. Disconnect the VOM.
2. Connect the positive lead of the VOM to the cathode.
3. Connect the negative lead of the VOM to the anode.
   Meter reading: 50,000 ohms or more.

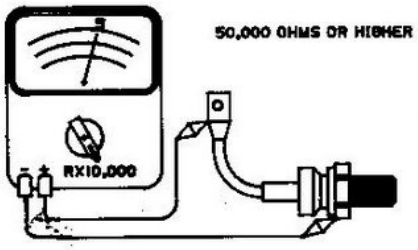


Figure 5.4.23
3 AND 4 REC VOM CHECK

USING A VOLT-OHM-METER (VOM) SET TO THE R X 10,000 SCALE (Continued):

SWITCH THE VOM TO THE R X 1 SCALE:

4. Connect the positive lead of the VOM to the anode.
5. Connect the negative lead of the VOM to the cathode.
   Meter reading: 7 to 12 ohms.

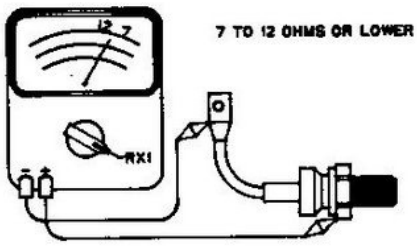


Figure 5.4.24
3 AND 4 REC VOM CHECK

Ref. 91.TMP.48
Ref. 91.TMP.49

THERMAL PROTECTOR (TP) (4J)

USING A VOLT-OHM-METER (VOM) SET TO THE R X 100 SCALE:

1. Disconnect the GRY wire from terminal board point GRY.

2. Connect the leads of the VOM to the GRY wire and to terminal board point BLK as shown in Figure 5.4.25. The resistance should be less than 200 ohms when at normal temperature.

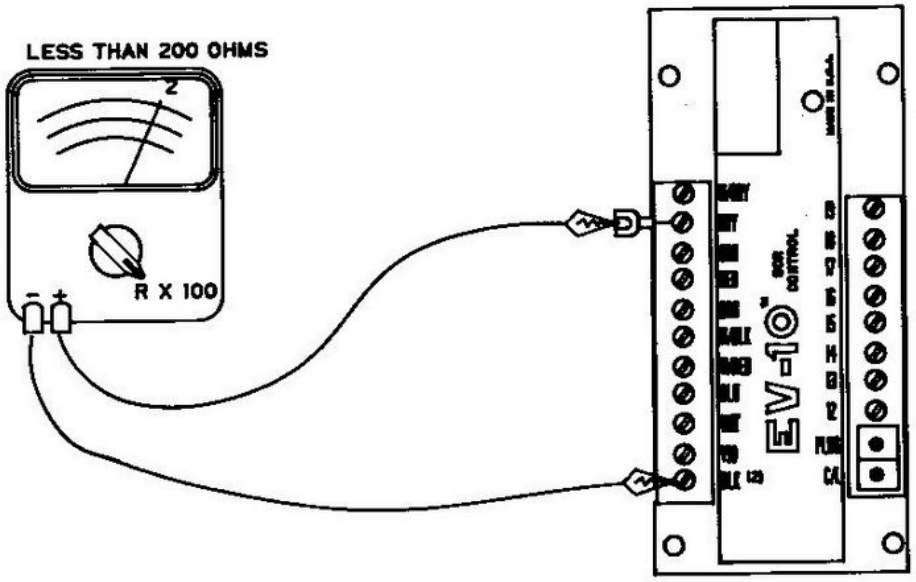


Figure 5.4.25
THERMAL PROTECTOR CHECK

Ref. 91.TMP.50

TRANSFORMER (4K)

USING A VOM SET TO THE R X 1 SCALE:

1. Connect the leads of the VOM to the negative (transformer) and 1C.
   Meter reading: less than 2 ohms.

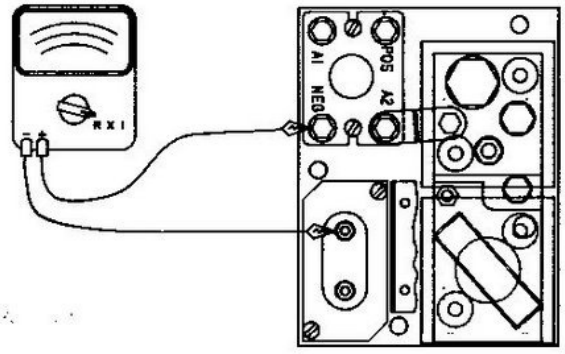


Figure 5.4.26
TRANSFORMER CHECK

2. Connect the leads of the VOM to A2 (transformer) and terminal board point BRN.
   Meter reading: less than 2 ohms.

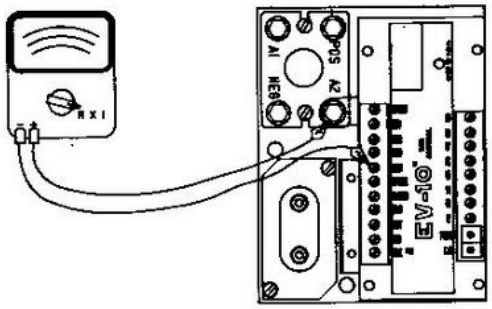


Figure 5.4.27
TRANSFORMER CHECK

Ref. 91.TMP.51
Ref. 91.TMP.52

VOLTAGE CHECK (4L)

USING A VOM SET TO THE DC VOLTAGE SCALE:

1. Set the VOM equal to or greater than the anticipted voltage.
2. Connect the black negative head of the VOM to the SCR negative.
3. Connect the red positive lead of the VOM to the point described in the Troubleshooting Diagnostic Diagram.
4. Read the voltage.

MILLIAMP CHECK (4M)

USING A VOM SET TO THE 10 MA. SCALE:

1. Connect the black negative lead of the VOM to the SCR negative.
2. Disconnect the wire from the point described in the Troubleshooting Diagnostic Diagram.
3. Connect the red positive lead to the point indicated.
4. Read the milliamps.

SECTION 5
REPLACEMENT OF COMPONENTS

NOTE

The use of a heat transfer grease such as GE Versilube G-350-M or its equivalent is recommended.

REPLACEMENT OF THE 1 REC MODULE

1. Remove the 1 REC gate wire (WHT) from the inside card terminal board.
2. Remove the wires from the outside card terminal board.
3. Remove the two card mounting screws and rotate the card over the capacitor and the transformer.
4. Unplug the two thermal protector wires.
5. Disconnect the T2-strap from the top heat sink.
6. Remove the spring assembly by first removing its mounting bolts.
7. Clean both heat sinks with a clean rag and isopropyl alcohol.
8. Apply a light coat of heat transfer grease to both ends of the 1 REC Press-Pak.
9. Install and torque the heat sink/spring assembly according to the torquing instructions that follow.
10. Reconnect the thermal protector, strap (T2), card, and card wires.

TORQUING INSTRUCTIONS

MOUNTING PROCEDURE

1. Apply Silicon Grease (Dow No. 44) to both sides of the SCR.
2. Locate the SCR in place with the pin on the large heat sink.
3. With the anode down, place the upper heat sink on top with the clamp in position. (See Figure 5.5.1.)

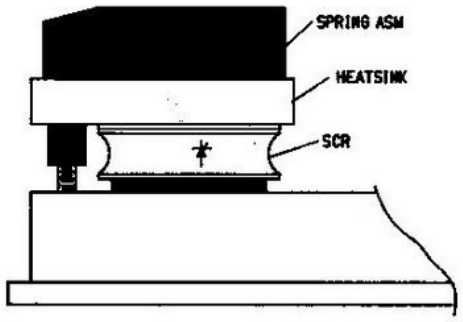


Figure 5.5.1
MOUNTING PROCEDURE

4. Tighten the bolts evenly until they are finger tight. Then tighten each bolt 1/4 turn using a 7/16 socket wrench on the bolt heads.
5. Place the force indicator gauge firmly against the springs, as shown on the outline drawing, so that both ends and the middle are in solid contact with the springs. The edges of the gauge will then indicate the spring deflection or force. Correct mounting force is indicated when the proper edges coincide.

Ref. 91.TMP.53

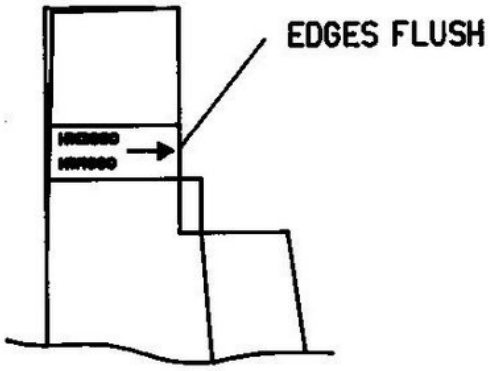


Figure 5.5.2
CORRECT TORQUING FORCE

6. If the mounting force indicated is less than rated force, tighten the bolts alternately 1/4 turn at a time until the points coincide. (See Figure 5.5.3.)

7. If excessive force is indicated, loosen the bolts and start over. Never try to adjust spring force by backing off the bolts. Spring friction will produce false readings.

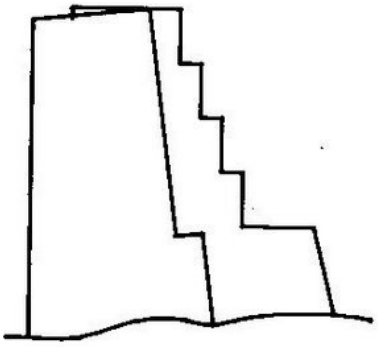


Figure 5.5.3
LESS THAN RATED FORCE

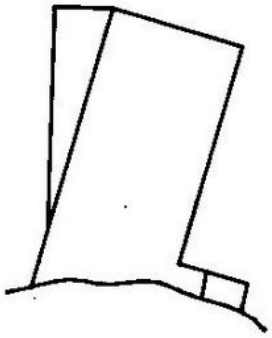


Figure 5.5.4
EXCESSIVE FORCE

Ref. 91.TMP.54
Ref. 91.TMP.55
Ref. 91.TMP.56

CALIBRATE THE FORCE GAUGE

If you suspect the force gauge is out of calibration due to wear or damage, check it on a flat surface, as indicated in Figure 5.5.5.

NOTE

If the edges are not flush within ±.010, calibrate the gauge by filing the bottom contact points.

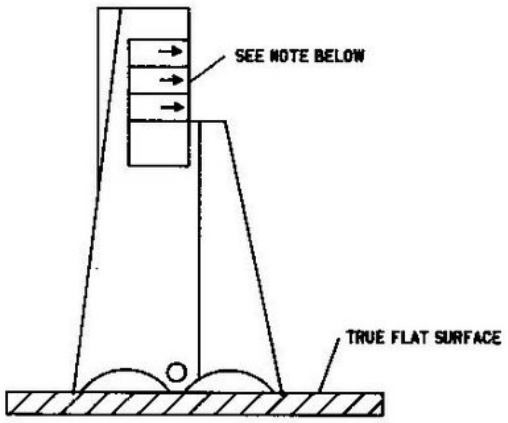


Figure 5.5.5
FORCE GAUGE

Ref. 91.TMP.57

REPLACEMENT OF THE CAPACITOR

1. Remove the nuts from the capacitor connections and remove the wires.
2. Remove the two mounting screws and bracket.
3. Reverse this procedure to install a new capacitor.

REPLACEMENT OF THE TRANSFORMER/CHOKE

1. Disconnect all transformer leads.
2. Remove the two mounting screws and lift the transformer free.
3. Reverse this procedure to reassemble.

REPLACEMENT OF THE CONTROL CARD

1. The panels are factory-adjusted for a particular motor and truck and should not need adjustment when used with this motor and truck.

NOTE

If the panels are used to control motors or trucks for which they were not factory-adjusted, the settings may be out of optimum adjustment to the extent that they do interact.

2. Clockwise (CW) rotation increases the function being adjusted.
3. Connect the shunt, the millivoltmeter, and the voltmeter to measure the battery current and motor voltage.
   a. Connect the shunt and the millivoltmeter between battery negative and 1 REC (or between the truck receptacle and the battery plug).
   b. Connect the voltmeter between battery positive and T2 on the SCR panel.
4. Jack up the truck so that the drive wheels are free to rotate. If a brake interlock is used, jumper it out so that power and the brakes can be applied at the same time.

5. Equipment required:

   a. 50 millivolt dc shunt.

NOTE

The shunt rating must be greater than the current to be measured. Best results are obtained when the reading is between half and full scale on the meter. If a shunt of too high a rating is used (i.e., a 500 amp rating to read 100 amps), the meter will be hard to read and the accuracy of the reading will be poor.

6. Check that the ohms in the accelerator potentiometer are less than 200 ohms in the top SCR range.

* 7. Check the card settings:

   a. Check the current limit by first moving the accelerator until either the F or R contactor operates. Do not move the accelerator to the point where 1A picks up. Apply the brakes until the wheels come to a standstill (the wheels must not be turning) and read the current to see if it falls below the maximum rating of 170 amps and within the rating specified by the truck manufacturer.

WARNING

Do not stall the motor for more than 30 seconds at a time. Allow time for the motor to cool between stalls. To avoid personal injury or a runaway vehicle, do not operate the motor at high speeds or plug the motor with the wheels jacked up.

   b. With the truck on the ground, plug the truck from top speed. If the stopping distance is not as desired, adjust the plugging trimpot.

8. Tuneup Procedure.

   a. Turn the plugging trimpot fully clockwise to prevent any interaction when setting the current limit trimpot.

   b. Turn the current limit trimpot fully counterclockwise.

   c. Check to be sure the plugging trimpot is turned fully clockwise.

   d. Depress the accelerator until F or R operate, but not the 1A contactor.

   e. Apply the brakes until the wheels come to a standstill and remain at a standstill.

   f. Slowly turn the current limit trimpot in a clockwise direction until the current reaches 170 amps, or as specified by the truck manufacturer.

NOTE

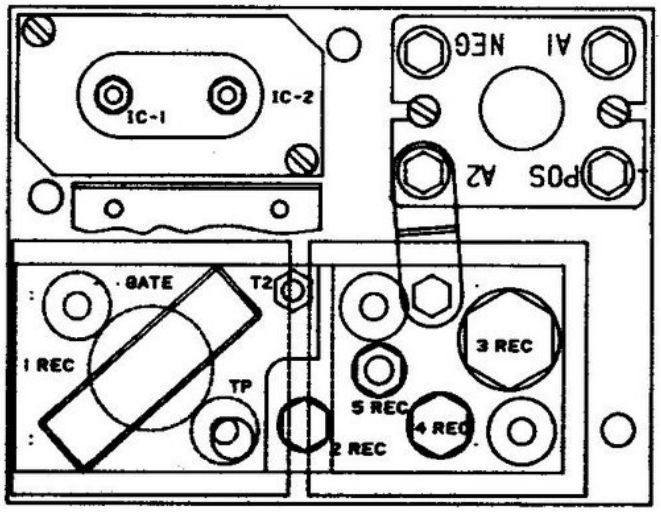
Since these controls are used on a variety of types and sizes of trucks for various applications, it is common for the truck manufacturer to set the current limit at some value below this maximum. For this reason, it is recommended that you obtain the actual current limit setting for your particular truck from the truck manufacturer.

WARNING

Do not stall the motor for more than 30 seconds at a time. Allow time for the motor to cool between stalls. To avoid personal injury or a runaway vehicle, do not operate the motor at high speeds or plug the motor with the wheels jacked up.

g. To adjust the static plugging, the truck should be in its normal running condition and on the ground. Turn the plugging trimpot fully counterclockwise. This will give the longest distance for stopping.

h. Turn the trimpot clockwise to increase the stopping distance. If the stopping distance is too short or too long, continue to adjust the trimpot until the desired stopping distance is obtained.



WIRE NO	COLOR SIZE	FROM	TO	WIRE DESCRIPTION
	GRY/#22	CARD GRY	TP (EITHER)	TWISTED PAIRS
	BLK #22	CARD BLK	TP (EITHER)	
	VIO #22	CARD VIO	IREC HS-T2	259A9500 P10 TWISTED PAIRS
	WHT/#22	CARD WHT	IREC GATE	
	BLU/#22	CARD BLU	HS-A2	259A9500 P6
	WHT/RED/#22	CARD W/RED	2REC GATE	259A9500 P12 TWISTED PAIRS
	WHT/BLK/#22	CARD W/BLK	2REC-C	259A9500 P11
	BLK/#22	CARD BLK	IC-2	259A9500 P2
	WHT/GRN/#22	CARD W/GRN	4REC-C	259A9500 P13
	ORN/#22	CARD ORN	TRANS-POS	259A9500 P8
	BRN/#22	CARD BRN	5REC-C	259A9500 P7 TWISTED PAIRS
	RED/#22	CARD RED	5REC GATE	259A9500 P3
5 CHOKE 25 16	BLK #8	4 REC-C 2 REC-C	TRANS-AI IC-1	68A7541P8BK49
	BLK #12	5 REC-A	IC-1	68A7541P12BK19
	BLK #10	IC-2	1 REC-T2	68A7541P10BK19
	WIRE STRAP	TRANS-T3 TRANS-T2	5 REC-C 1 REC-T2	

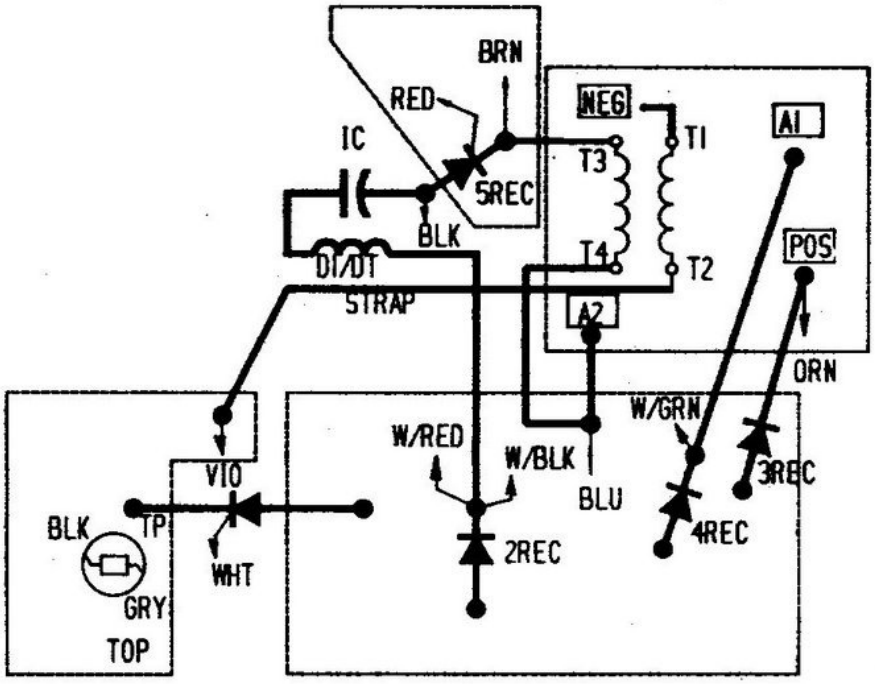


Figure 5.5.6
PLACEMENT OF COMPONENTS

SECTION 6
CONTACTORS

INSTRUCTIONS

150- AND 300-AMPERE ELECTRIC-VEHICLE CONTROL CONTACTORS

IC4482-CTR A700, A800 SERIES

Before any adjustments, servicing, parts replacement or any other act is performed requiring physical contact with the electrical working components or wiring of this equipment, DISCONNECT THE BATTERY, DISCHARGE CAPACITOR(S), AND JACK WHEELS OFF FLOOR.

DESCRIPTION

GENERAL

These d-c contactors are designed for low-voltage, intermittent-duty operation such as found in battery truck service.

PURPOSE OF INSTRUCTIONS

The purpose of these instructions is to instruct the user on proper care and maintenance to obtain satisfactory service from these devices. The manufacturer of the electric vehicle has tested and applied these contactors according to the requirements of his vehicle. No modifications or changes should be made in the layout, physical arrangement or electrical connections without his permission.

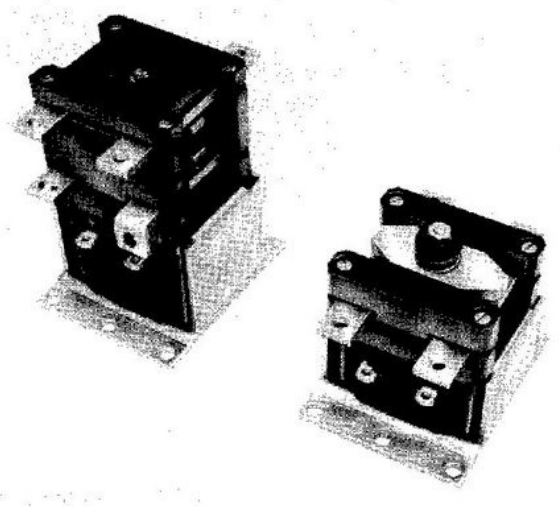


Fig. 1. Right - Single-pole, single-throw type (one normally open contact)
Left - Single-pole, double-throw type (one normally open and one normally closed contact)

MOUNTING

These contactors are designed to mount on a vertical surface or on a horizontal surface.

DISASSEMBLY AND ASSEMBLY

Two main categories of these contactors are available. The single-pole normally open types, and the single-pole double-throw types which have one normally open and one normally closed contact (Fig. 1). The assembly and disassembly of these devices will be covered individually.

Single-pole, Double-throw Type (One Normally Open and One Normally Closed Contact)

DISASSEMBLY

(Refer to Fig. 2, page 2 for exploded view and parts index).

1. Remove all electrical connections and remove the contactor from the vehicle for easier servicing.

2. Loosen the four long bolts in each corner, remove the top contact retainer, and the long bolts.

3. Remove the two top stationary normally closed contacts.

4. Remove the two contact spacers.

5. Remove the two bottom stationary contacts.

6. Remove armature and movable-contact assembly.

7. Remove magnet frame and coil from base.

8. Loosen and remove the 10-32 nut from the armature and movable-contact assembly using a 3/8-inch socket or nut driver. Note the order in which the parts are removed from the stud.

The information contained herein is intended to assist truck users and dealers in the servicing of control furnished by the General Electric Company. It does not purport to cover all details or variations in equipment or provide for every possible contingency to be met in connection with installation, operation or maintenance.

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the truck manufacturer through his normal service channels, not directly to General Electric Company.

PARTS INDEX

1. Long bolt with #8 lock washer
2. Top contact retainer
3. Top stationary contact
4. Contact spacer
5. Bottom stationary contact
6. Armature and movable-contact assembly
   a. 10-32 nut
   b. No. 10 lock washer
   c. No. 10 flat washer
   d. Movable-contact carrier
   e. Shim
   f. Movable contact
   g. Spring cup (snaps into 6f)
   h. Contact spring
   i. Bottom stationary-contact support
   j. Armature
   k. Spiral return spring
7. Magnet frame
8. Coil
9. Base
10. Bus connector

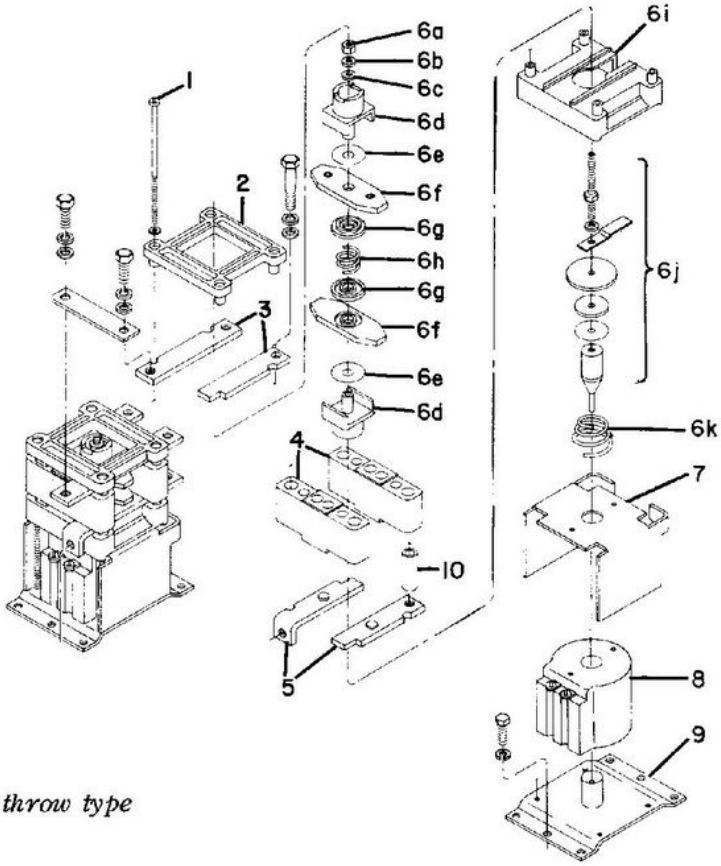


Fig. 2. Assembly of single-pole, double-throw type

PARTS INDEX

1. Long bolt with #8 lock washer
2. Contact spacer
3. Stationary contacts
4. Armature and movable-contact assembly
   a. 10-32 nut
   b. No. 10 lock washer
   c. No. 10 flat washer
   d. Contact spring retainer
   e. Contact spring
   f. Movable contact
   g. Shim
   h. Movable-contact carrier
   i. Stationary-contact support
   j. Armature
   k. Spiral return spring
5. Magnet frame
6. Coil
7. Base

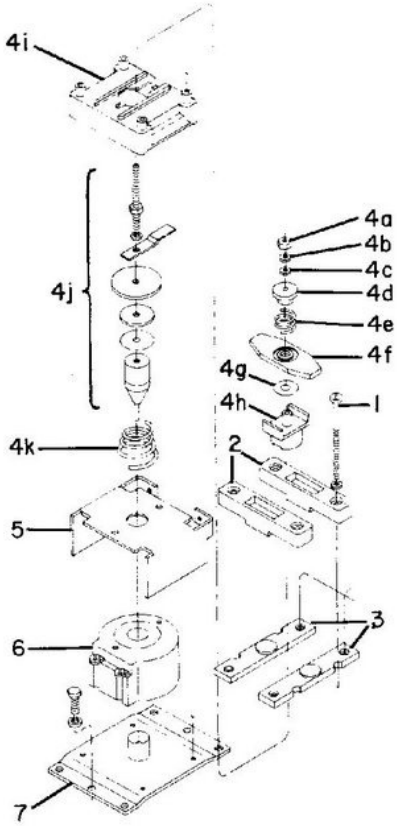
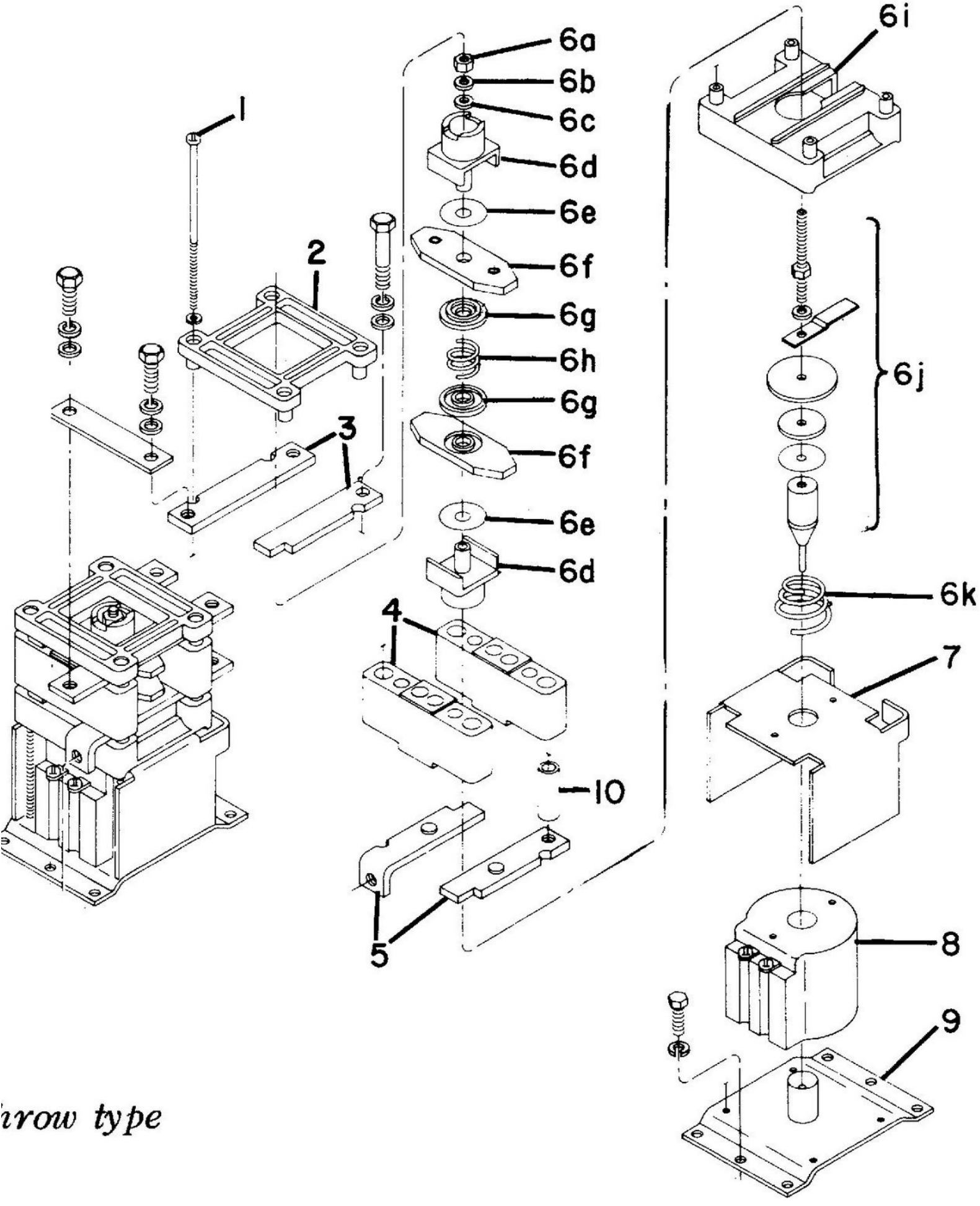


Fig. 3. Assembly of single-pole, single-throw type



hrow type

Maintenance And Inspection Of Parts

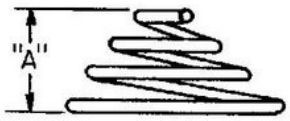
CONTACTS

Contacts must be replaced before they have worn through contact button to the base copper material.

SPIRAL RETURN SPRING

The free length should be between the limits shown in the table and should be replaced if it shows signs of corrosion.

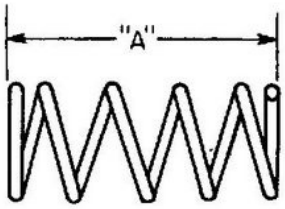
Contactor	Free Length "A" In inches (mm)
700, 710	0.73 to 0.79 (18.5 to 20.1)
701, 711, 712, 801, 702, 802, 811, 812	0.67 to 0.73 (17.3 to 18.5)
800, 810	0.80 to 1.00 (20.3 to 25.5)



CONTACT SPRING

The free length should be between the limits shown in the table and should be replaced if it shows signs of having been overheated or of corrosion.

Contactor	Free Length "A" In inches (mm)
700, 701, 711, 712, 801, 702, 802, 811, 812	0.38 to 0.40 (9.6 to 10)
800, 810	0.37 to 0.39 (9.4 to 9.9)



COILS

CAUTION: *The coils have voltage suppression cast integral with the coil. If a test voltage is applied in the wrong direction or if the coil is connected backwards, permanent damage may result. Observe the polarity mark on the coil during maintenance.*

If the contactor fails to operate, measure the voltage being applied to the coil terminals. The coils on the contactor have been designed to actuate the contactor on reduced battery voltage and with approximately three volts drop in the electronic circuit so that all contactors should operate at or below 65 percent of rated battery voltage. Replace the coil if the contactor does not operate to the full stroke on 65-percent voltage or if the coil shows signs of being overheated.

RENEWAL PARTS

Only factory specified parts should be used. These parts should be obtained from the truck manufacturer through his normal service channels.

AUXILIARY CONTACTS

Auxiliary contacts or electrical interlocks are available for the contactors as shown mounted on the contactor in Fig. 5. The auxiliary contact block is operated by de-energizing the contactor. Figures 6 and 7, page 4, illustrate the operations.

To obtain proper operation of the contact block, the gap between the auxiliary contact operator and the button on the contact block should be as shown in Fig. 7. This gap can be obtained by loosening the adjustment screws and moving the interlock support. The slots in the support permit this adjustment. The screws should be retightened to 14 to 18 inch-pounds torque (1.6 to 2.0 Newton meters).

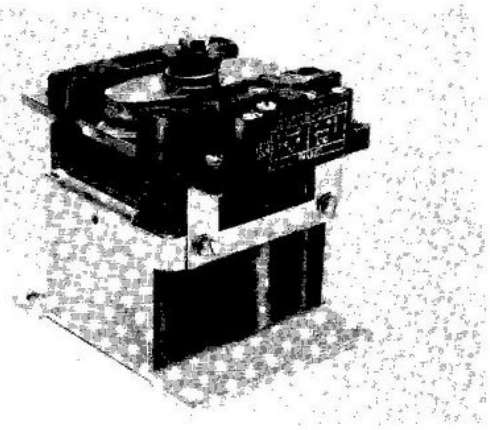


Fig. 5. Contactor with an auxiliary contact

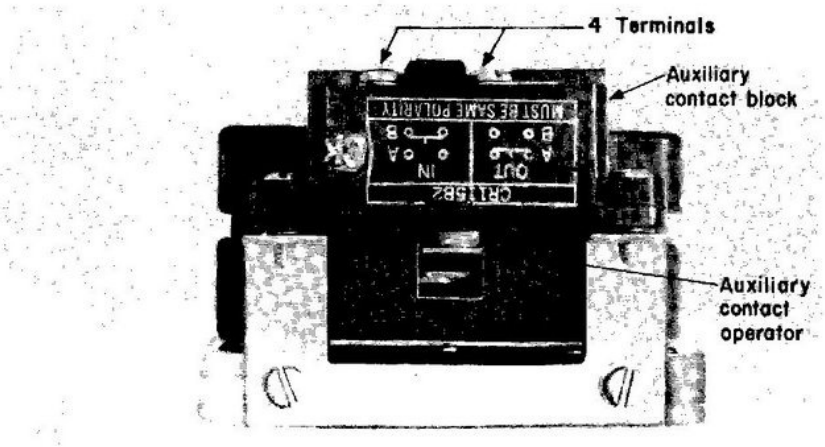


Fig. 6. Auxiliary contact shown in the operated position by the de-energized contactor

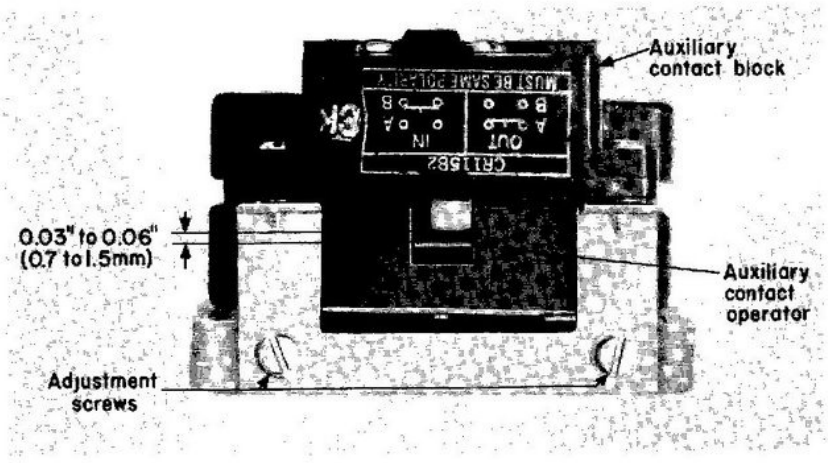


Fig. 7. Auxiliary contact shown in the normal position by the energized contactor

ASSEMBLY

(Refer to Fig. 2, page 2 for exploded view and parts index).

Before assembly, all parts should be cleaned, inspected for wear and replaced if required. Assembly is performed in reverse order from disassembly with the following precautions required:

1. Force the small end of the spiral spring over the small diameter on the armature assembly. See Fig. 4, page 3.

2. Reassemble the armature parts 6a to 6k and tighten the 10-32 nut to 14 to 18 inch-pounds torque (1.6 to 2.0 Newton meters).

3. Locate the projections on the magnet frame in the indentations on top of the coil with frame oriented as in Fig. 2.

4. Add the armature and moveable-contact assembly.

5. Properly seat the stationary contacts in the slots of the molded stationary contact support and add the two contact spacers.

6. Add the two top stationary contacts and top contact retainer. Insert bus connector before proceeding to Step 7.

7. Tighten the four long bolts in a uniform manner using a diagonal tightening sequence. Tighten the bolts with 14 to 18 inch-pounds torque (1.6 to 2.0 Newton meters).

DISASSEMBLY AND ASSEMBLY

Single-pole, Single-throw Type (One Normally Open Contact)

DISASSEMBLY

(Refer to Fig. 3, page 2 for exploded view and parts index).

1. Remove all electrical connections and remove the contactor from the vehicle for easier servicing.

2. Loosen the four long bolts in each corner and remove the two contact spacers.

3. Remove the two stationary contacts.

4. Remove armature and movable-contact assembly.

5. Remove magnet frame and coil from the base.

6. Loosen and remove the 10-32 nut from the armature and movable contact assembly using a 3/8-inch socket or nut driver. Note the order in which the parts are removed from the stud. See Fig. 3, page 2.

ASSEMBLY

(Refer to Fig. 3, page 2 for exploded view and parts index).

Before assembly all parts should be cleaned and inspected for wear and replaced if required. The assembly is performed in the reverse order from the disassembly with the following precautions required:

1. Force the small end of the spiral spring over the small diameter on the armature assembly. See Fig. 4, page 3.

2. Reassemble the armature parts 4a to 4k and tighten the 10-32 nut to 14 to 18 inch-pounds torque (1.6 to 2.0 Newton meters).

3. Locate the projections on the magnet frame in the indentations on top of the coil with frame oriented as in Fig. 3.

4. Add the armature and moveable-contact assembly.

5. Properly seat the stationary contacts in the slots of the molded stationary-contact support and add the two contact spacers.

6. Tighten the four long bolts with 14 to 18 inch-pounds torque (1.6 to 2.0 Newton meters).

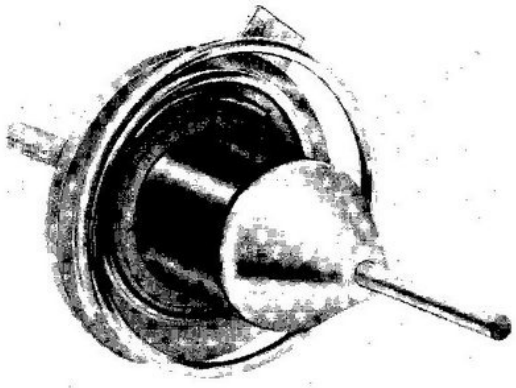


Fig. 4. Spiral spring attached to small diameter on cone head

75-AMPERE ELECTRIC-VEHICLE CONTROL CONTACTORS

IC2800-M601, -M610, -M611

Before any adjustments, servicing, parts replacement or any other act is performed requiring physical contact with the electrical working components or wiring of this equipment, the POWER SUPPLY MUST BE DISCONNECTED.

GENERAL

These d-c contactors are designed for 36-volt maximum, intermittent-duty operation, such as found in battery-powered lift trucks and golf-cart services. The shunt-operating coils are rated for 50-percent time-on intermittent duty. The contactors are self-contained units suitable for mounting on the vertical surfaces of either metal or insulated bases. All terminals and mounting holes are accessible from the front of the device.

TABLE I

IDENTIFICATION

Nomenclature IC2800	Power Circuits
-M601	1-NC
-M610	1-NO
-M611	1-NO – 1-NC (DPDT)

TABLE II

CURRENT RATINGS OF POWER CONTACTS

Amperes	Duty Cycle Percent Time-on	Maximum Time-on
50	100*	Continuous*
75	50	5 Minutes
250	5	30 Seconds
500†	2	5 Seconds

* For continuous applications, the operating coil must be de-rated or a holding resistor must be inserted in series with the operating coil.

† The maximum interrupting rating of these contactors is 300 amperes at 36 volts with an inductive load such as a motor.

ARCING CLEARANCES

During installation, it is important that certain minimum clearance be maintained between the contactor and other surrounding components. See Fig. 3.

CONNECTIONS

As a rule, the normally open power connections and the coil terminal connections are at the top of the contactor, with the normally closed power connections at the bottom. (See Figs. 1 and 2). Certain special forms have other configurations. A quick visual check can be made as shown in Fig. 2.

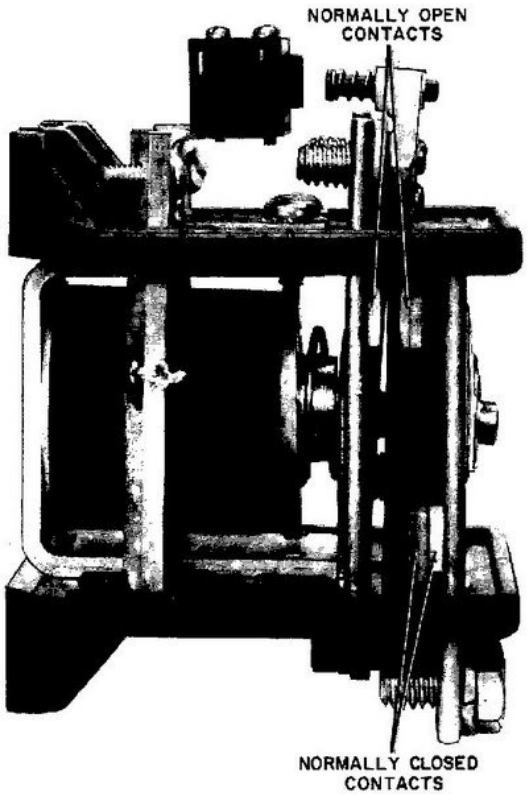


Fig. 1. IC2800-M611 contactor for electric-vehicle applications.

Forms of the IC2800-M611 (DPDT) are available with a tie between one of the normally open stationary contacts and one of the normally closed

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

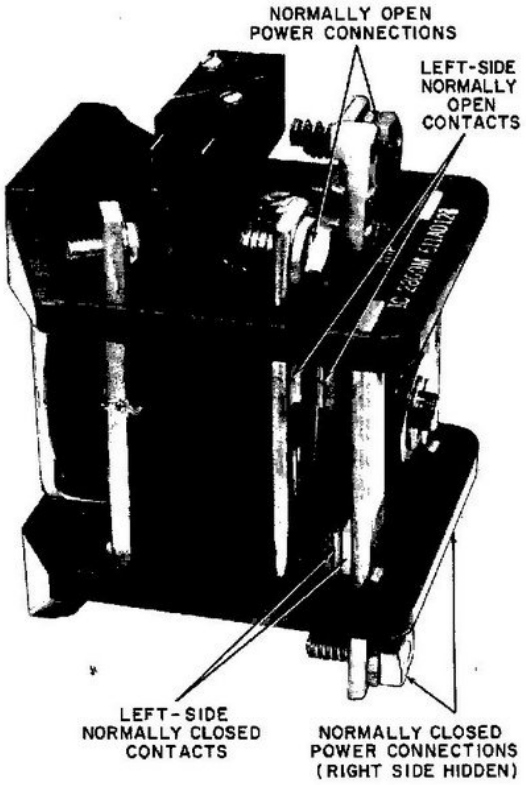


Fig. 2. IC2800-M611 contactor with CR1070C143C3 interlock.

stationary contacts. This tie or common connection is available either on the left or the right side of the contactor. A typical application of these contactors is as a reversing pair.

The power connections are 1/4 - 20 screws which should be tightened to 45 to 60 inch-pounds (5.1 to 6.8 newton meters [N·m]). It is recommended that this tightening be done with a screw driver, spin tight, or a socket on a shaft extension. If a wrench is used, take care that the head or body of the wrench does not come in contact with the molded side plate (see Fig. 4). That is, do not use the molded side plate as a pivot point.

VOLTAGE SPIKE SUPPRESSION

When these contactors are used in conjunction with static control, it is often necessary to suppress the voltage spike which results when coil current is interrupted. This is done to prevent damage to static components such as silicon controlled rectifiers, transistors, etc.

Use only those voltage spike suppressors which are factory specified and supplied by the truck manufacturer.

When connecting the suppressors across the coil, polarity must be maintained in accordance with Fig. 5.

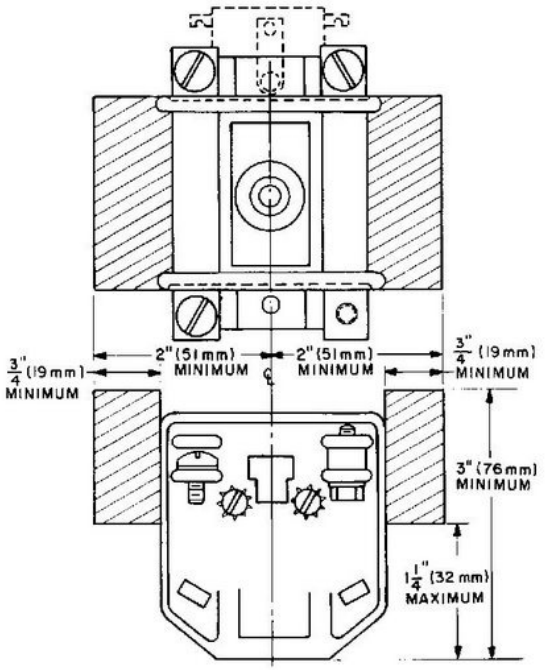


Fig. 3. Installation clearances. For proper operation the shaded area should be free of any obstructions.

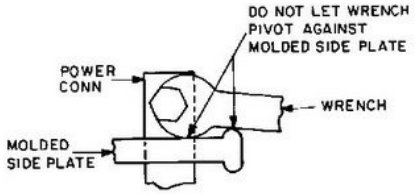


Fig. 4. Proper use of a wrench when tightening power contacts.

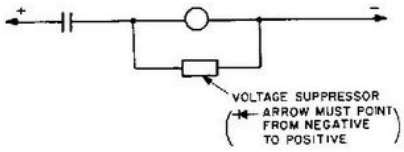


Fig. 5. Polarity maintenance.

MAINTENANCE AND ADJUSTMENTS

The following information is intended to assist during periods of normal maintenance and to provide checks to determine if the contactors are in proper operating condition.

As these devices are adjusted, inspected, and tested at the factory, they should not normally require further adjustments. However, any time a part has been replaced, the following checks should be made.

POWER CONTACTS

In normal operation, the contacts will become blackened, discolored, and roughened. This will not interfere with proper operation and cleaning is not necessary. The contacts should be replaced before the silver-alloy contact facing is completely eroded through to the backing material, or before the wipe is reduced to zero. The silver alloy may transfer from one contact and cause buildup on the mating contact. This can be expected under certain conditions and does not require contact dressing or filing. When replacing only one contact of a mating pair, remove any high peaks or beads of material on the contact that is not replaced.

POWER CONTACTS ADJUSTMENTS

With the contactor mounted or held in its normal operating position (see Fig. 3), check the contact wipes and gaps. These checks are most easily made with small rods or drills of a diameter equal to the dimensions given below. These contactors are double break (two sets of contacts per circuit) and the gaps must be measured on both sets of contacts.

Normally open gap – 0.050 inches (1.27 mm) minimum each side

Normally closed gap – 0.050 inches (1.27 mm) minimum each side

Normally open wipe – 0.040 inches (1.0 mm) minimum

Normally closed wipe – no check

NOTE: *The normally open wipe measurement given is with new contacts and will decrease as the contacts wear.*

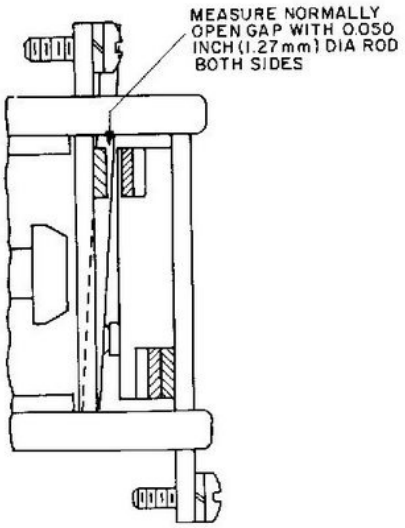


Fig. 6. Contactor in de-energized position.

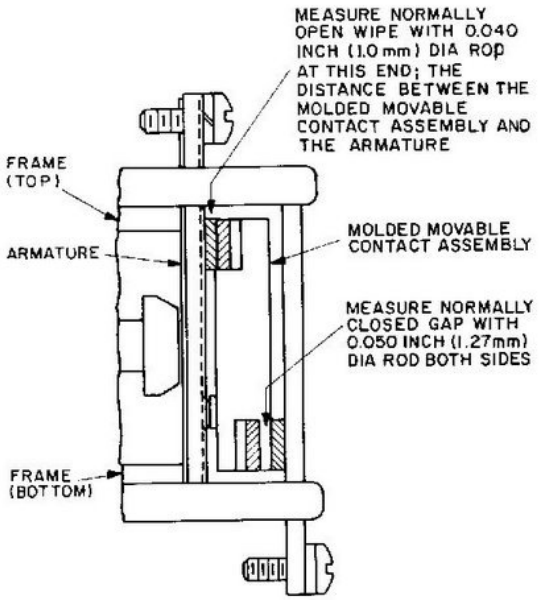


Fig. 7. Contactor in energized position with armature firmly seated against the frame at top and bottom.

Figures 6 and 7 show de-energized and energized positions, and where to measure.

The only means of adjusting to obtain these measurements is by moving the side plates in or out on the frame. If adjustment is necessary, make sure that the side plates are relatively square with respect to each other and with the U-frame. Recheck the electrical interlock adjustments and, if necessary, re-adjust per the section on Electrical Interlocks in this instruction publication.

REPLACEMENT OF PARTS

It is necessary to disassemble these devices in order to replace any part except the electrical interlock or its operator. For this reason, you may find it to your advantage to replace the entire contactor whenever a complete set of contacts or a new coil is needed. However, if you desire to replace a part, use the following procedures:

1. Disconnect the contactor and remove it from the vehicle.

2. To replace the coil, first unsolder the coil leads from the coil terminal strips; then remove the screws which fasten the molded side plates to the frame.

3. Now, slide the frame and coil out from between the molded side plates. If the core does not have a head, it is now possible to remove the coil without disassembling the core and the frame. If

the core does have a head, you must remove the screw which holds the core to the frame. It may be necessary to hold the core with a pair of pliers.

4. Replace the coil, and reassemble the core to the frame. Be sure the special conical lockwasher is in place and that the screw is tightened.

5. Slide the frame and coil assembly back between the molded side plates with the armature spring positioned as shown in Fig. 8.

6. Replace the screws in the side plates, making sure the stationary contacts and the coil terminal strips are positioned in their respective slots in the side plates.

7. Check the power contact gaps and wipes per the Power Contact Adjustments section of this instruction publication. Also, check the electrical interlock and, if necessary, readjust per the section on Electrical Interlock Adjustments in this instruction publication. Make sure the armature spring is properly seated as shown in Fig. 8.

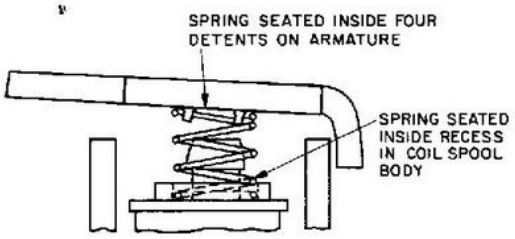


Fig. 8. Outline drawing of armature spring.

8. The side plates can be moved by the amount the holes are larger than the screws. Try to align the side plates as squarely as possible with the frame.

9. To replace a worn contact or set of contacts, first disconnect the contactor and remove it from the vehicle.

a. Remove the bottom molded side plate. Note that by leaving the top molded side plate attached to the frame, the normally open contact adjustments and the electrical interlock adjustments will not be changed.

b. Replace the worn contacts and reassemble the contactor, taking care that the stationary contact strips, the coil terminal strips, and the armature tongues are all properly positioned in their respective slots in the side plates. Make sure the armature spring is positioned as shown in Fig. 8.

c. Check the contact gaps and wipes and the electrical interlock adjustments and if necessary, re-adjust per the applicable sections in this instruction publication.

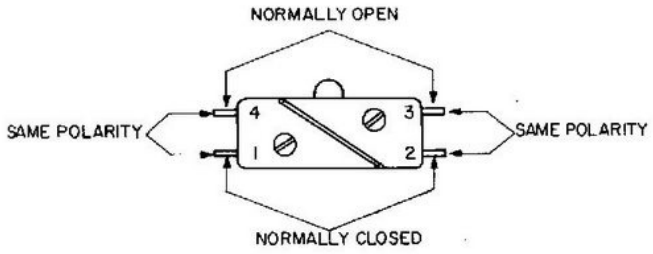


Fig. 9. CR1070C143C3 interlock connections.

ELECTRICAL INTERLOCKS

An auxiliary snap-action electrical interlock can be mounted on most forms of these contactors (see Fig. 1). This electrical interlock has one normally open pole and one normally closed pole. It must be adjusted to operate in the following manner.

1. With a 0.010-inch (0.25 mm) thick shim or rod between the armature and the U-frame at the top, the interlock must operate when the coil is energized or when the armature is manually operated.

2. With an 0.030-inch (0.76 mm) thick shim or rod, using the same procedure, the interlock should not operate. The interlock mounting bracket has slotted mounting holes and can be moved in or out to obtain these requirements. If it is necessary to do this, recheck the contact adjustments per this instruction publication.

TABLE III

INTERLOCK RATINGS (RECOMMENDED)

Voltage Inductive	Current-Amperes	
	Make and Break	Carry
6	10.0	10
12	6.0	10
18	4.0	10
24	3.5	10
30	3.0	10
36	2.5	10

Ordinarily, any one circuit will control two of the coils used in these contactors. Coils may be connected either in series or parallel.

RENEWAL PARTS

When ordering renewal parts, address the nearest General Electric Company sales office, specify the quantity required, and give the catalog number or describe the required parts in detail. Give the complete nameplate rating of the equipment.

EV-1* SCR CONTROL
ACCELERATOR SWITCH
IC4485ACC1

Before any adjustments, servicing, parts replacement or any other act is performed requiring physical contact with the electrical working components or wiring of this equipment, JACK WHEELS OFF FLOOR, DISCONNECT THE BATTERY AND DISCHARGE CAPACITOR(S).

DESCRIPTION

The IC4485ACC1 is a family of accelerator master switches that may be either foot-operated through a pedal and linkage system or hand-operated by a suitable handle arrangement. This master switch offers a wide variety of options so that it may be customized to fit the user requirements. The master switch contains a switchette which closes at the beginning of travel to energize the control circuit, a switchette at the end of travel to bypass the control for maximum speed and torque, and a unique unidirectional potentiometer to vary the speed in between. The potentiometer is controlled by mechanical linkage to turn in only one direction so that it is independent of handle movement. This feature simplifies the setting of the potentiometer to provide consistent performance in both directions.

A single molded cam is used for the foot-operated CW and CCW forms. Direction of rotation can be changed in the field by changing the position of the start switchette and relocating the OFF-position stop.

A different molded cam is used for the hand-operated forms.

INSTALLATION

A conduit plate can be located on either side. The four mounting holes are symmetrical relative to the shaft; only three need be used.

When an external linkage is used, a separate external return spring is required. Any external linkage that can be operated forcibly should also have an external mechanical stop.

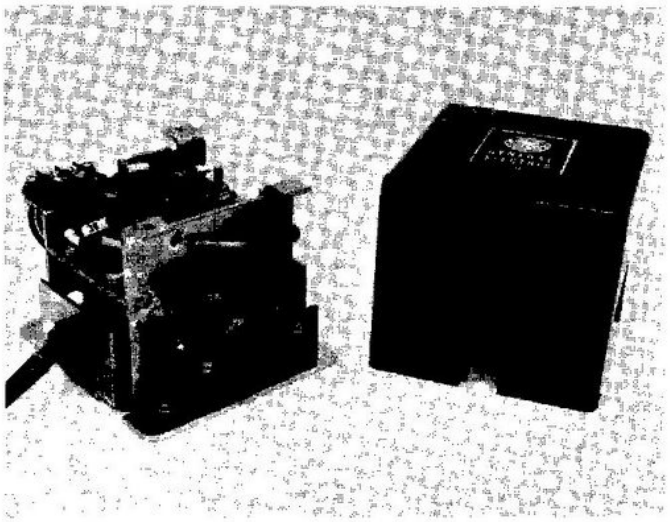


Fig. 1. IC4485ACC1 master switch with cover removed

TABLE 1

CURRENT RATING OF SWITCHETTES

Voltage Inductive	Current-Amperes	
	Make and Break	Carry
6	10.0	10
12	6.0	10
18	4.0	10
24	3.5	10
30	3.0	10
36	2.5	10
48	2.0	10
72	1.0	10

The ratings in Table 1 are for single circuits (i.e., normally open contact only). Voltages above 72 require capacitor-type filters, in accordance with factory recommendations.

MAINTENANCE

Oil-less bearings are used on both ends of the main operating shaft and thus eliminate the need for any lubrication of the switch.

* Trademark of General Electric Company

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

SWITCHETTE ADJUSTMENT

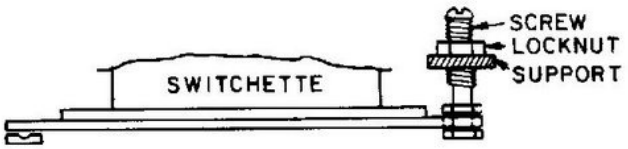


Fig. 2. Switchette adjustment, view from shaft end

Unlock locknut (see Fig. 2) and turn screw CW to make the normally open switchette close at less travel. The start switch should close at 5 to 8 degrees and reset at a minimum of 1-degree travel from the OFF position. The 1A switch should close at 26 to 29 degrees and reset at a minimum of 22 degrees travel from the OFF position. Total travel is 30 degrees.

POTENTIOMETER ADJUSTMENT

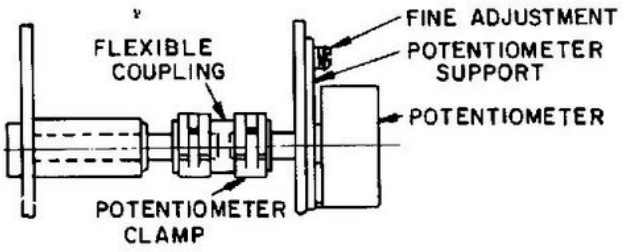


Fig. 3. Potentiometer and clamps

To remove the potentiometer, remove the wires from the terminal board, loosen the clamps on the flexible coupling with duck-bill pliers, and move both clamps to the left (see Fig. 3). Remove the potentiometer and its support by removing the two "fine-adjustment" screws. Retain the potentiometer support.

To replace, mount the new potentiometer on the support, locating the tab in the hole of the support, and secure with the lockwasher and nut. With an ohmmeter on the potentiometer terminals (R x 100 scale), turn the shaft clockwise until the point where the resistance starts to reduce below the level (4800- to 6000-ohm) portion of the curve (see Fig. 4). This corresponds to the START position.

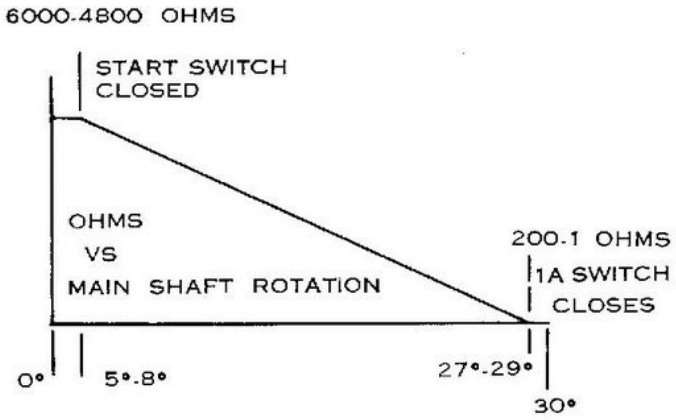


Fig. 4. Potentiometer resistance curve

With the potentiometer clamp moved to the left and the master switch in the START position, line up the potentiometer shaft with the flexible coupling and center the fine-adjustment slots with the fine-adjustment tapped holes. Push the potentiometer until the support is against the frame. Assemble, but do not tighten, the fine-adjustment screws. Release the coupling clamp with duck-bill pliers and slide the clamp into position.

Rotate the master switch shaft until the START switchette operates (a slight click at about 7 degrees). The ohmmeter should be 4800 to 6000 ohms. Continue rotating the shaft until the 1A switchette operates (a slight click at about 28 degrees). The ohmmeter should be less than 200 ohms and remain above 1 ohm, when the shaft is rotated fully.

If the ohms are too low when the start switch closes, loosen the fine-adjustment screws and rotate the potentiometer support CCW.

If the ohms are too high when the 1A switch closes, loosen the fine-adjustment screws and rotate the potentiometer support CW.

If the fine adjustment is not enough to bring the resistance values within limits, return the master switch to the OFF position, release the potentiometer clamp with duck-bill pliers, and turn the potentiometer shaft with needle-nose pliers a slight amount. (Clockwise from shaft end of potentiometer to reduce ohms.) Recheck resistances at START and 1A and use fine adjustment as described previously if necessary.

Check that coupling clamps are in position and the fine-adjustment screws are tight.

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FIELD MODIFICATION OF FOOT-OPERATED SWITCH

If the direction of rotation of a foot-operated switch needs to be changed, the location of the OFF-position stop, the switchette and the cam must be changed. (See Figs. 5 and 6 and Table 2.)

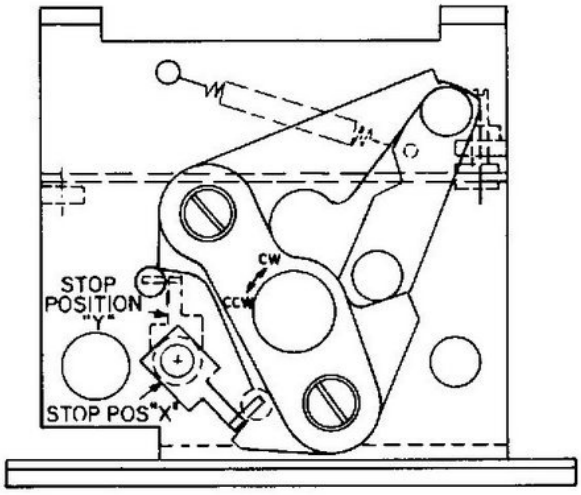

Fig. 5. OFF-position stop

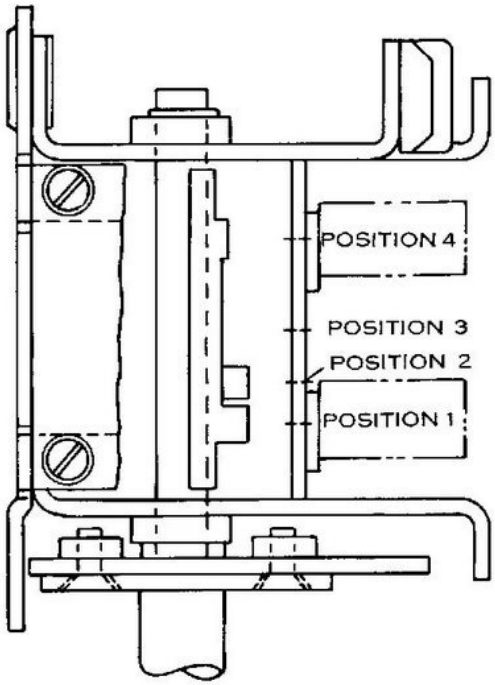

Fig. 6. Switchette position

TABLE 2

OFF-POSITION STOP AND SWITCHETTE POSITION

Switch Rotation	Switchette Position (See Fig. 6)		Stop Position (See Fig. 5)	Use Cam
	Start	1A		
CW	2	4	Y	194B8333P1
CCW	3	4	X	171B3172P1
CW and CCW	1 and 3	4	Stop not used	171B3172P1

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