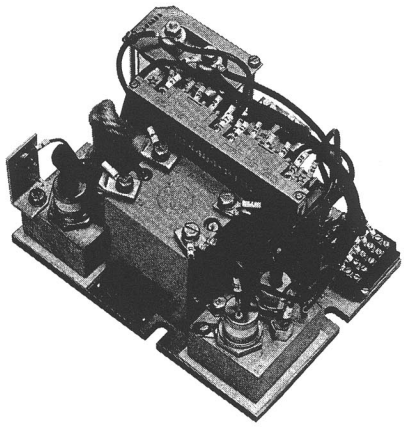
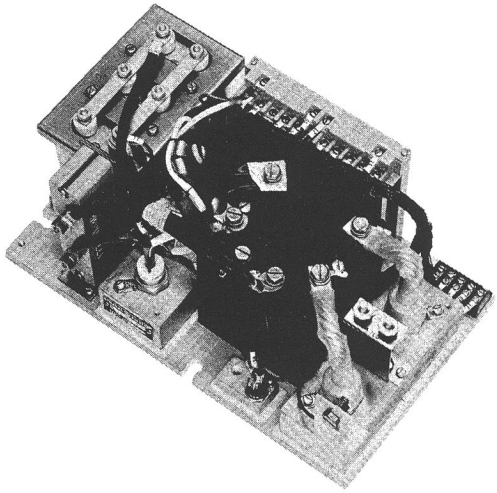
GENERAL ELECTRIC

M210 M310





PANEL REPLACEMENT PARTS LISTS & DIAGRAMS

AND TROUBLESHOOTING/ TUNE-UP INSTRUCTIONS

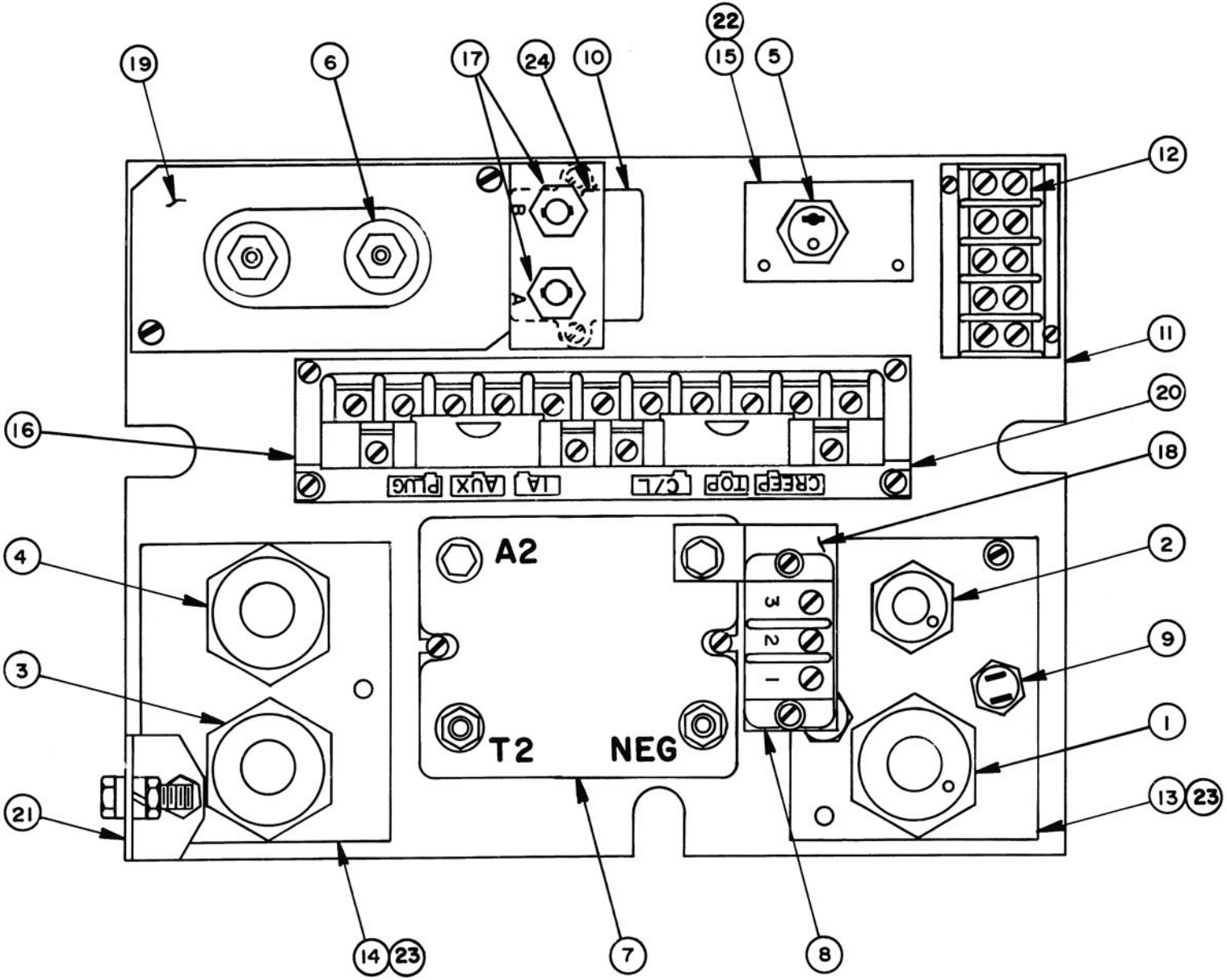
FSIP

FLIGHT SYSTEMS
INDUSTRIAL PRODUCTS
Website: www.fsip.biz

PARTS PRICING/ORDER INFORMATION: 800-333-1194

PRINTED IN USA

REVISED JUNE 2003



M210 SCR PANEL

M210 REPLACEMENT PARTS LIST

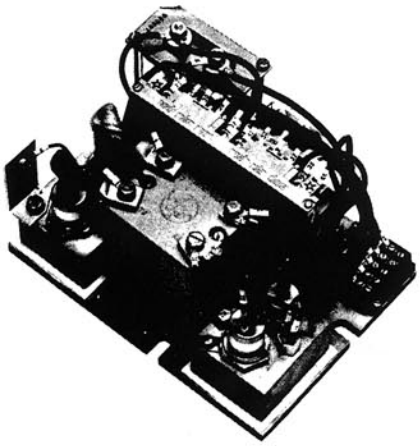
Listed by GE part number in ascending order

General Electric	Baker	Barrett	Clark	Crown	Hyster	Kalmar AC (Allis Chalmers)	Towmotor/ Caterpillar	Yale	Ref. No.	Description	Flight Systems
148B6203G59	108723		994979	80372	228903		354693 354709		8	Diode Block	21-6203-59
157B2744G4	79024-102-1		995037		245442		333670 347820		7	Transformer	34-2744-04
194A7582P1									21	B + Power Bracket	43-S120-00
205A5963G6									11	Baseplate	43-B120-FS
205A5981P1	230MAG1 230MBB1 230MBN1 27909-35150 GE-SCR117 GE-SCR142	B27140-46	1802189 2305209 895902 897219	76322	1144841 1198723 1199497 224138	4905335 74905335	333607	0793386-56 1291610-46 1295040-68 5118818-01	1	SCR	26-9730-01
205A5981P3	230MAT1 GE-SCR157 GE-SCR158	B27140-55	2305708 2305809 895908 897222 980775 994977	80491	1144844 1198980 1199034 1199328 1199500 249366	4905254 4907076 74905254 74907076	333609 354707	0970901-CD 1294980-35 1297270-26 5100528-06 5118818-06	3&4	Diode	25-BF20-01
205A5981P5	106300 230MAX1 230MBL1 GE-SCR100 GE-SCR155	B27140-56	2305909 895909 897217 995661 996215	76324 76569	1144845 1198996 1199501 224137	4905337 74905337	333610	0793386-64 1293380-18 1297270-28 1301450-10 1301450-12 5118818-04	5	SCR	26-1F10-01
205A5981P10									5	SCR	26-1F10-01
205A5981P11									5	SCR	26-1F10-01
205A5981P13									3&4	Diode	25-BF20-01
205A5981P14									5	SCR	26-1F10-01
205A5981P18									5	SCR	26-1F10-01
205A5986G7	108730		995038	80537	210668				10	Choke	32-5986-07
205A7104G1	GE-SCR144 GE-SCR162	B27140-63	895904	76319	1144084 1199325 245404	4905251 74905251	333614	1297270-17 5118798-01 5118798-02	9	Thermal Protector	37-7104-01
205A7109P1									1	SCR	26-9730-01
205A7129P1	100018 106304 110923 26121-26125 226MAW1 226MBC1 GE-SCR132 GE-SCR152	A27788-17 B27140-57	1802210 889404 899404 995138 995417 995665 998526 999095	76317 79812	1199323 274092	4905234 4910571 4910919 74905234 74910571 74910919	301773 377087	1294980-39 1297270-08 1301450-04 5118778-01 5169178-02 5169178-03	6	Capacitor	33-9053-FS
205A7130P1									6	Capacitor	33-9053-FS
218A4038P2									17	Fuse Holder	29-F185-00
218A9452P3									3&4	Diode	25-BF20-01
245A2436P1				76323			354692		2	SCR	26-4B40-05

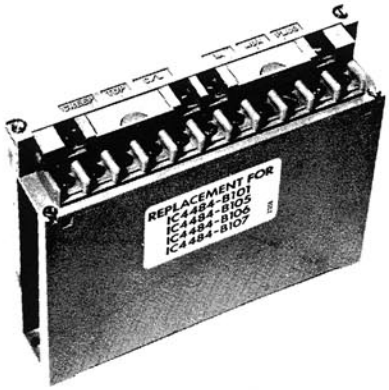
General Electric	Baker	Barrett	Clark	Crown	Hyster	Kalmar AC (Allis Chalmers)	Towmotor/ Caterpillar	Yale	Ref. No.	Description	Flight Systems
245A2487P1									3&4	Diode	25-BF20-01
259A5523P1									6	Capacitor	33-9053-FS
259A5523P2									6	Capacitor	33-9053-FS
259A9053P1									6	Capacitor	33-9053-FS
259A9053P2									6	Capacitor	33-9053-FS
IC4484B101									20	Card	12-B101-00
IC4484B105									20	Card	12-B101-00
IC4484B106									20	Card	12-B101-00
IC4484B107	108726 79024-108-1		994555	78458	205600 244761 251214		343828 347819 358744		20	Card	12-B107-00
See Our P/N			993703						12	Terminal Strip	38-T210-00
See Our P/N									13	Heatsink (1)	44-H102-00
See Our P/N									14	Heatsink (2)	44-H304-00
See Our P/N									15	Heatsink (5)	44-H500-00
See Our P/N								1297270-19	16	Harness	43-W210-00
See Our P/N									18	Filter Mount Bracket	43-D210-00
See Our P/N									19	Cap Mounting Bracket	43-C210-00
See Our P/N									22	Insulator	43-N500-00
See Our P/N									23	Insulator	43-N123-40
See Our P/N									24	Fuse Mounting Bracket	43-F210-00

FLIGHT SYSTEMS REBUILDING SERVICES

FOR "B" SERIES CARDS AND PANELS



Model 210 Panel

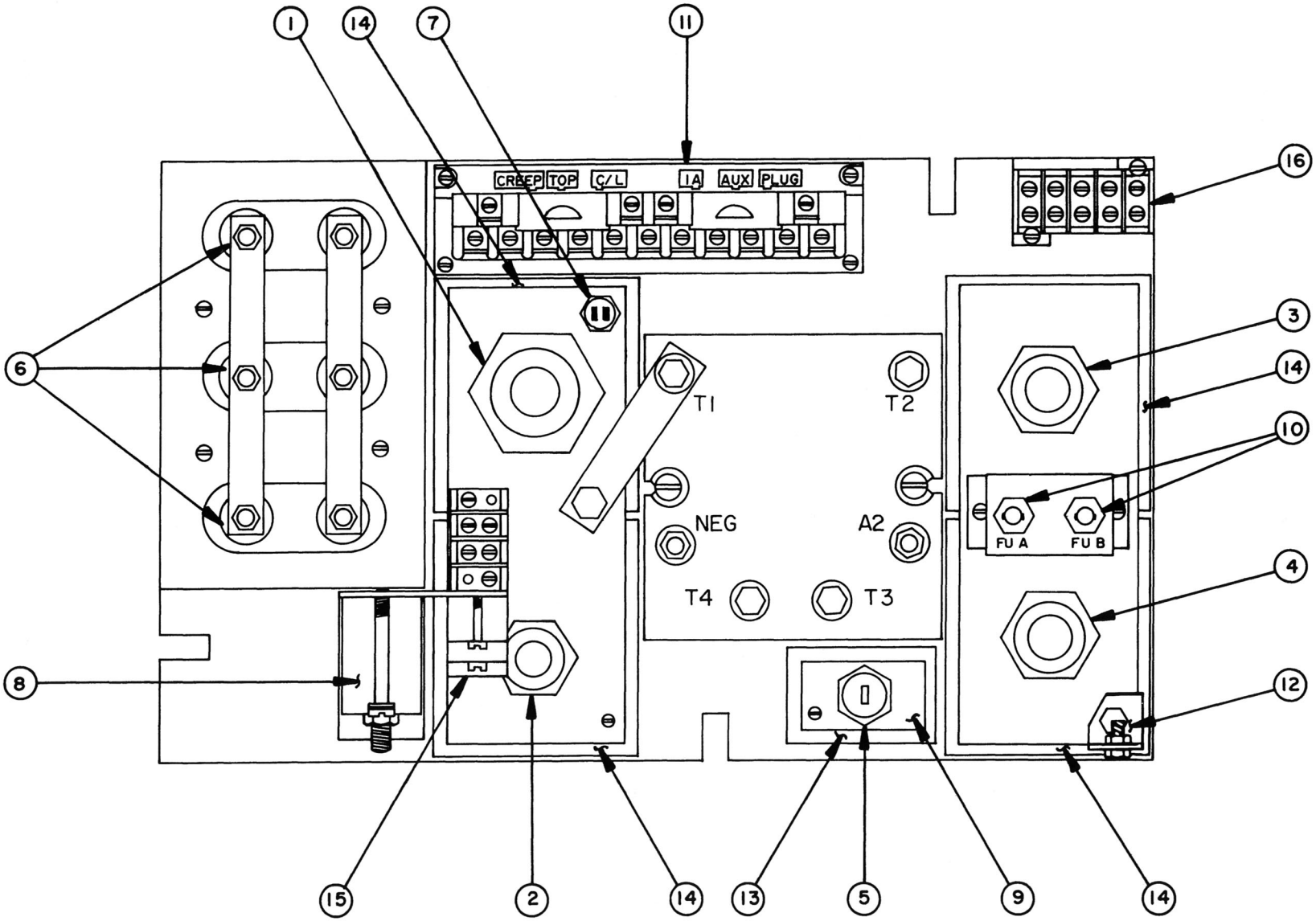


Main Oscillator Card

Model 310 Panel

OEM P/N	FUNCTION	VOLTAGE
IC4484:		
B100	HIGH VOLTAGE OSCILLATOR CARD	72-80V
B101	STANDARD OSCILLATOR CARD	24-48V
B102	OSCILLATOR CARD W/O 1A	24-48V
B103	DUAL MOTOR OSCILLATOR CARD	24-48V
B105	OSCILLATOR CARD	24-48V
B106	OSCILLATOR CARD	24-48V
B107	OSCILLATOR CARD	24-48V
B109	OSCILLATOR CARD	24-48V
B110	OSCILLATOR CARD W/O 1A	96-112V
B111	OSCILLATOR CARD W/O 1A	72-80V
COMPLETE M210 PANEL		REPAIR & RETEST
		FULL DISMANTLE & REBUILD
COMPLETE M310 PANEL		REPAIR & RETEST
		FULL DISMANTLE & REBUILD

- New Cases and covers are FREE with each " B " Series control card repair (if needed).
- Rebuilt cards and panels can be purchased on an exchange or outright basis depending upon core availability.
- One year warranty on all repair services & rebuilt items.



M310 SCR PANEL

M310 REPLACEMENT PARTS LIST

Listed by GE part number in ascending order

General Electric	Baker	Barrett	Clark	Crown	Hyster	Kalmar AC (Allis Chalmers)	Towmotor/ Caterpillar	Yale	Ref. No.	Description	Flight Systems
139B8723P1	GE-SCR165		980776 994552		1199322 205541 224140	4905229 74905229	341568 350360	1297270-62 1299420-48 5118768-02	8	Choke	32-8019-01
148B6203G59	108723		994979		228903		354693 354709		15	Diode Block	21-6203-59
149B2795G1									8	Choke	32-8019-01
157B8019G1									8	Choke	32-8019-01
177B2033G1									8	Choke	32-8019-01
194A7582P1									12	B+ Power Bracket	43-S120-00
205A5981P2	230MAF1 230MBA1 230MBE1 230MBM1 230MBW1 GE-SCR119 GE-SCR143 GE-SCR164	B27140-58	2305509 895905 897218 899401 899417 980777 994099 994976 996216	76326	1144842 1198720 1199327 1199498 211820 249367	4905253 4905336 4907078 74905253 74905336 74907078	333608 342434 354708	0793386-55 1293380-08 1295040-69 1297270-64 1297270-83 1297270-86 1297270-89 5118818-02 5118818-05 5118818-14	2	SCR	26-4B40-01
205A5981P3	230MAT1 GE-SCR157 GE-SCR158	B27140-55	2305708 2305809 895908 897222 980775 994977	80491	1144844 1198980 1199034 1199328 1199500 249366	4905254 4907076 74905254 74907076	333609 354707	0970901-CD 1294980-35 1297270-26 5100528-06 5118818-06	3&4	Diode	25-BF20-01
205A5981P7									2	SCR	26-4B40-01
205A5981P8									2	SCR	26-4B40-01
205A5981P9									2	SCR	26-4B40-01
205A5981P13									3&4	Diode	25-BF20-01
205A5981P15									2	SCR	26-4B40-01
205A5981P16	GE-SCR153		1704432 961809 991429		1199329 223659 224136	4905255 74905255	342435 350362	1297270-95 1299420-79 5118818-07	5	SCR	26-3J20-01
205A5981P17									5	SCR	26-3J20-01
205A5981P19									5	SCR	26-3J20-01
205A6787P1	GE-SCR163		899400 899941		1199330 205559 205599	4905256 74905256	342436	1294980-34 1297270-63 1297270-90 5118818-08 5118818-11	1	SCR	26-JB50-01
205A6787P2									1	SCR	26-JB50-01
205A6787P3									1	SCR	26-JB50-01
205A7104G1	GE-SCR144 GE-SCR162	B27140-63	895904	76319	1144084 1199325 245404	4905251 74905251	333614	1297270-17 5118798-01 5118798-02	7	Thermal Protector	37-7104-01
205A7129P1	100018 106304 110923 226MAW1	A27788-17 B27140-57	1802210 889404 895899 899404	76317 79812	1199323 274092 278931	4905234 4910571 4910919 74905234	301773 377087 377231	1294980-39 1297270-08 1301450-04 5118778-01	6	Capacitor	33-9053-FS

General Electric	Baker	Barrett	Clark	Crown	Hyster	Kalmar AC (Allis Chalmers)	Towmotor/ Caterpillar	Yale	Ref. No.	Description	Flight Systems
	226MBC1 26121-26125 GE-SCR132 GE-SCR152		995138 995417 995655 998526 999095			74910571 74910919		5169178-02 5169178-03			
205A7130P1									6	Capacitor	33-9053-FS
218A4038P2									10	Fuse Holder	29-F185-00
218A9452P1									1	SCR	26-JB50-01
218A9452P3									3&4	Diode	25-BF20-01
218A9452P4									2	SCR	26-4B40-01
245A2486P1									2	SCR	26-4B40-01
245A2487P1									3&4	Diode	25-BF20-01
259A5523P1									6	Capacitor	33-9053-FS
259A5523P2									6	Capacitor	33-9053-FS
259A9053P1									6	Capacitor	33-9053-FS
259A9053P2									6	Capacitor	33-9053-FS
IC4484B101	108726 79024-108-1		994555	78458	205600 244761 251214		343828 347819 358744		11	Card	12-B101-00
IC4484B105									11	Card	12-B101-00
IC4484B106									11	Card	12-B101-00
IC4484B107									11	Card	12-B107-00
SEE OUR P/N									9	Heatsink (5 Rec)	44-H500-00
SEE OUR P/N									13	Insulator	43-N500-00
SEE OUR P/N									14	Insulator	43-N123-40
SEE OUR P/N									16	Terminal Strip	38-T210-00

GEK-28897B

OPERATING & MAINTENANCE

INSTRUCTIONS

Model 110
Model 210
Model 310

IC 4483F

SCR CONTROL for ELECTRIC VEHICLES

CONTENTS

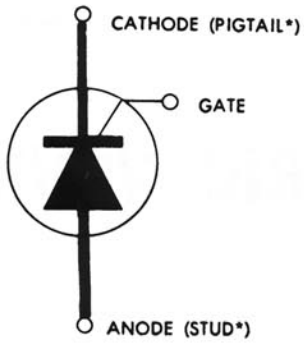
The information contained herein is intended to assist truck users and dealers in the servicing of SCR control furnished by the General Electric Company. It does not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance.

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

GENERAL ELECTRIC

WHAT IS AN SCR?

Since the heart of the control is a silicon controlled rectifier (SCR), a general understanding of the characteristics of the device will be helpful. The SCR is a semi-conductor rectifier used as a latching switch; i.e., it may assume either a conducting or nonconducting state (On or Off).



The SCR can be turned on by a momentary application of control current to the gate. To turn it off, it is necessary in addition to removing the turn-on signal from the gate, either to remove all power from the SCR or to apply momentary reverse voltage between cathode and anode.

* Typical of SCR as used in GE control for electric vehicles.

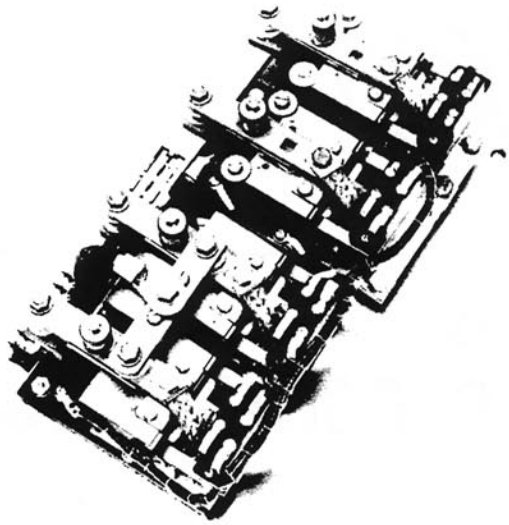


Fig. 2. Typical magnetic panel consisting of forward, reverse, bypass, and pump contactors

PHOTOS OF CONTROL

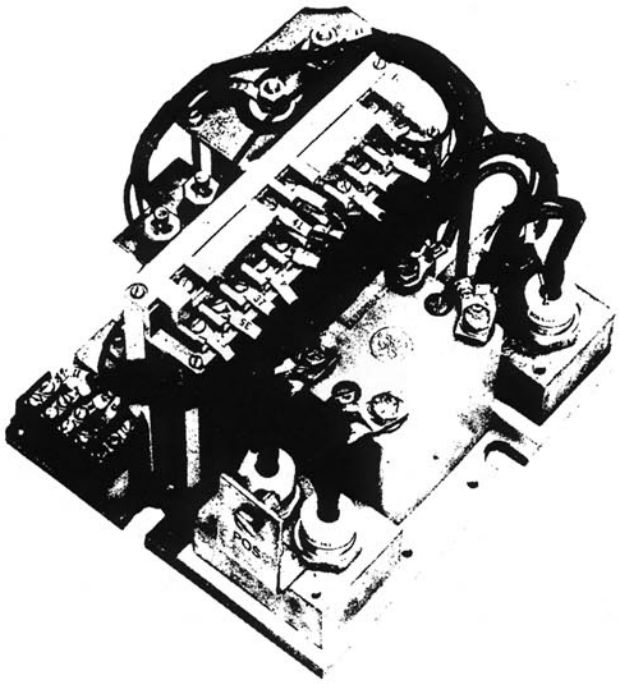


Fig. 1. Typical SCR static panel

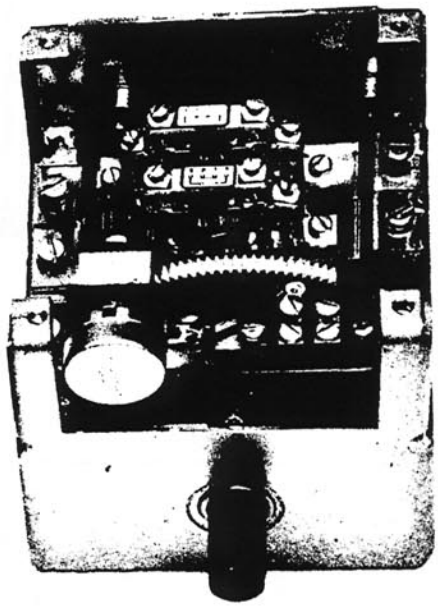
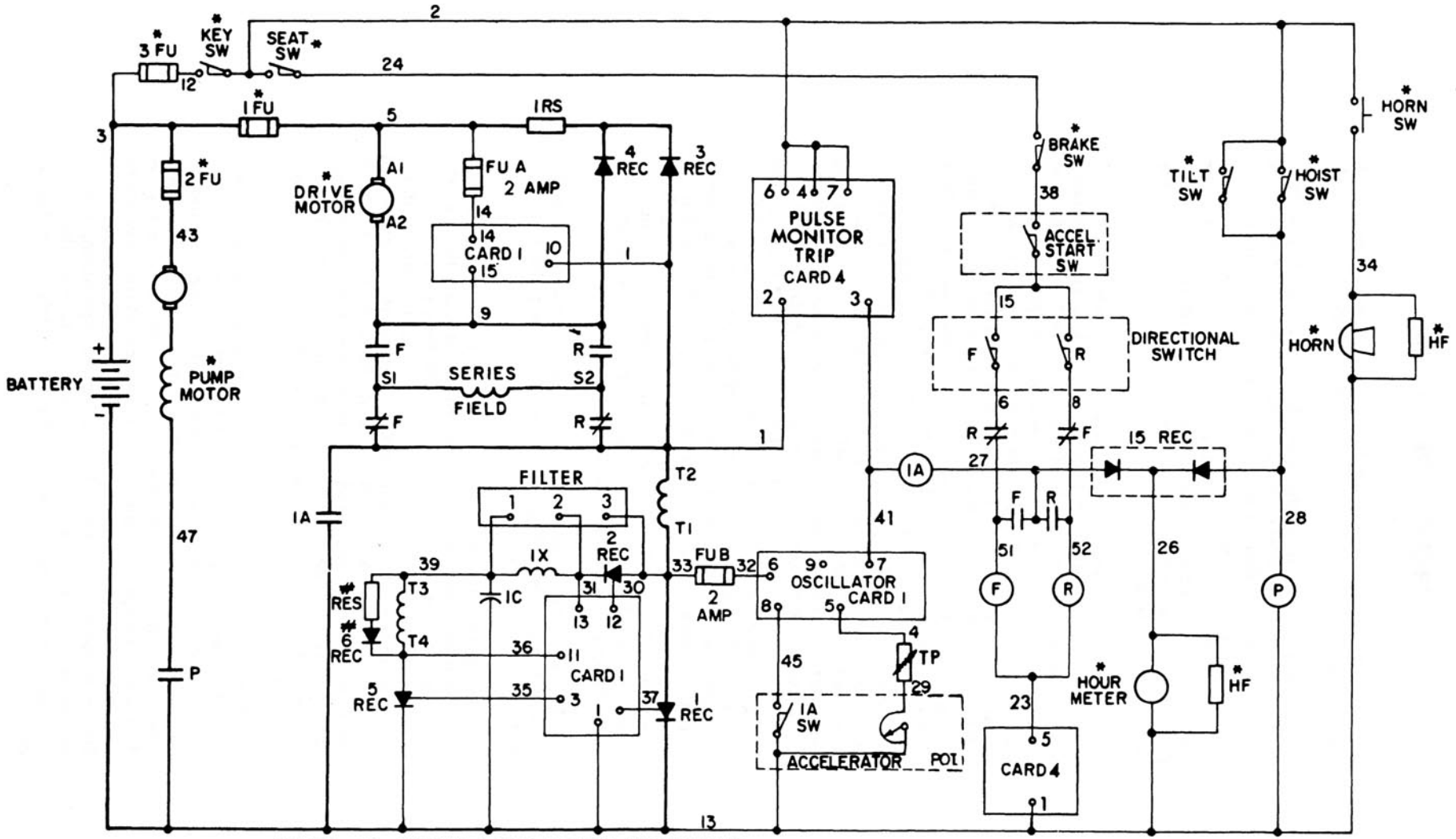


Fig. 3. Typical foot-operated accelerator switch with cover removed showing speed control potentiometer and control interlocks

ELEMENTARY DIAGRAM



NOTE: A) BROKEN LINES DENOTE ACCESSORIES.
B) * DENOTES CUSTOMER'S ITEMS.
C) # USED ON 72 VOLTS.

Fig. 4. Typical elementary diagram, General Electric Model 110/210/310 SCR control

CIRCUIT OPERATION

(See Figure 4)

Connecting the battery applies voltage positive to wire 5, negative to wire 13. Capacitor 1C charges through wire 31.

The control circuit is energized by closing the key switch, the seat switch, the brake switch, and moving the forward or reverse lever to either position and then depressing the accelerator closing the accelerator start switch. The F or R contactor coil is now energized, applying power to the drive motor circuit. Positive control power is fed through F or R interlock to wire 27, through the 1A coil to wire 41 to the oscillator card terminal 7.

The oscillator section will oscillate only when it receives positive power through the F or R interlock, a synchronizing control signal from the anode of 1 REC (wire 33, term 6), and the capacitor is charged. The oscillator output is fed from wire 37 to the gate of 1 REC, the main SCR. This is the gate signal which will switch 1 REC to the conducting state. When 1 REC is conducting, current flow is from battery positive through 1 FU, drive motor T2-T1, 1 REC, and back to battery negative. The initial rising d-c current through T2-T1 induces a voltage from T4 to T3, and drives T4 positive. An oscillator in the card fires 5 REC by applying a gate pulse out of Term. 3 (wire 35), and 5 REC assumes a conducting state. Current then flows from T4 through 5 REC, 1C and back to T3 charging the capacitor negative until the transformer saturates, reducing the current flow to zero. When the current drops to zero, 5 REC shuts off. When the transformer saturates 2 REC is fired by a gate pulse out of terminal 12 (wire 30) turning 2 REC on. When 2 REC conducts, capacitor 1C discharges around the circuit composed of 1C, 1 REC, 2 REC and 1X. This discharge current opposes the battery current through 1 REC so that the resultant current is zero. With reverse voltage across 1 REC (the main SCR), 1 REC is turned off. Current continues to flow in the 2 REC, 1C, and battery loop until the capacitor is fully charged. 2 REC then turns off.

This explanation has been for one complete cycle, or pulse, of circuit operation. Figure 5 illustrates the pulsing of current from the battery.

During the off time the energy stored in the motor, by virtue of its inductance, will cause current to circulate through the motor around the loop formed by 3 REC, thus providing what is called "flyback current." Figure 6 shows the nature of the motor current which is composed by both battery current and the inductive flyback current. It should be noted that the average motor current measured will be greater than the average battery current. The SCR control, in effect, converts battery current at battery volts into a higher motor current and a lower motor volts.

The time for the next cycle to start is determined by the time that the oscillator section of the card takes to oscillate. This frequency of oscillation is controlled by the potentiometer in the accelerator. Slow speed is obtained by having maximum ohms in the potentiometer. As the resistance in the pot decreases, the speed of the motor increases. With level operation, the SCR circuit is capable of delivering approximately 70- to 90-percent speed. For full-speed operation, the 1A contactor is closed to apply full battery voltage to the motor. 1A coil is energized by closing the 1A switchette in the accelerator.

CARD 1

- CURRENT LIMIT – The current-limit section of Card 1 provides protection to the motor and control by limiting currents during acceleration and stall. This circuit is sensitive to load current and overrides the oscillator under heavy loads so as to limit the pulse frequency (thus the average current) to a value based on the maximum rating of 1 REC. Because of the flyback current through 3 REC, the motor current usually runs 2 to 3 times this current-limit value. The CURRENT LIMIT is adjustable by means of a trimpot on Card 1.

- OSCILLATOR – The oscillator section of the card has two adjustable modes and one fixed feature. With the accelerator pot at maximum resistance, the CREEP SPEED can be adjusted with a trimpot on the card. With the accelerator pot at minimum resistance, the TOP SCR SPEED is set by means of a trimpot on the card. The fixed feature is controlled acceleration. When the accelerator is set for maximum speed and the directional switch is closed, the controlled acceleration provides a gradual buiid-up of pulses, thus giving a smooth acceleration to top SCR speed. This feature also provides a smooth reacceleration during a plugging reversal of direction.

- PLUGGING – Slowdown is accomplished when reversing by providing a small amount of retarding torque for deceleration. If the truck is moving and the direction lever is moved from forward to reverse, the motor field is reversed. During the 1 REC off time the motor armature, driven by the inertia of the truck, acts as a generator. This generated current passes through 4 REC and the resistor 1 RS. A signal taken across 4 REC and 1 RS is fed to Card 1 to control the field current and provide a soft stopping action. The distance or severity of the reversal is set by means of a PLUGGING trimpot on the card.

- 1A TIMER – A time-delay pickup of 1A is provided by a circuit in Card 1. This allows the truck to accelerate through the SCR range before 1A picks up even if the accelerator 1A switch is closed immediately. This time delay is set by means of a 1A TIME trimpot on Card 1. An additional feature of the timer circuit is that 1A is rendered inoperative any time plugging is in process.

1A CONTACTOR (By-pass contactor around the SCR control) – The 1A contactor is used to provide top truck speed, torque, and efficiency when called for. The 1A contactor is picked up when the accelerator is moved to its extreme end of travel.

THERMAL PROTECTOR – A thermal protector (TP) is mounted on the heat sink between 1 REC and 2 REC. This is a temperature sensitive device which increases resistance with an increase in temperature. During the normal operating range, the thermal protector has a resistance of approximately 50 ohms. If the temperature of the 1 REC heat sink exceeds 80 C, the resistance of the thermal protector increases. Being in series with the accelerator potentiometer, this increased resistance decreases the speed of the truck. The truck will operate at a reduced speed until the temperature reaches a safe value, then full SCR power will be available.

Other functions and equipment available with SCR control for electric vehicles and their instruction references are:

IC4484 PULSE MONITOR TRIP .... (GEK-28898)
IC4484 FIELD-WEAKENING SYSTEM (GEK-28899)
IC4484 AUXILIARY PLUGGING
CONTROL (FREQUENCY) ..... (GEK-28900)
IC3012BH ACCELERATOR MASTER
SWITCH ..... (GEK-8073)

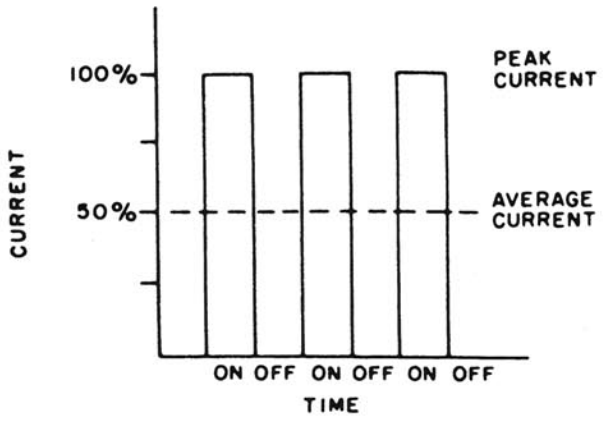


Fig. 5. Battery current

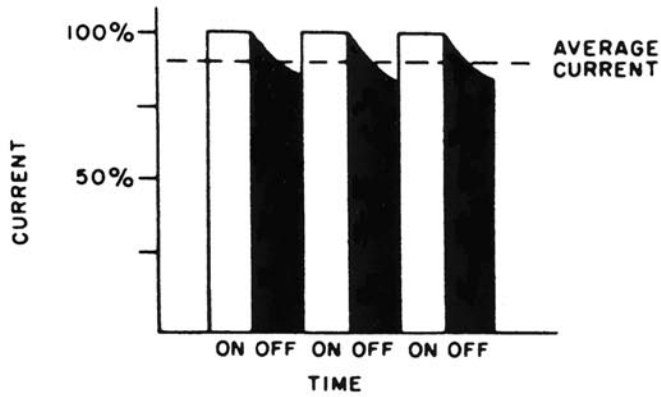


Fig. 6. Motor current

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 will expose the components to excessive heat, such as steam cleaning; or which will reduce the heat dissipating ability of the control, such as restricting air flow.

The following DO'S and DONT'S should be observed:

- Any controls that will be used in altitudes of 5000 feet or over and in ambients of 100 F (40 C) or over should be brought to the attention of the truck manufacturer.
- All external components having inductive coils must be filtered. Refer to vehicle manufacturer for specifications.
- The control should not be steam cleaned. In dusty areas, use low pressure air to blow off the control. In oily or greasy areas, a mild solution of detergent or denatured alcohol can be used to wash off the control and then blow completely dry with low pressure air. The control can also be cleaned with Freon TF* degreaser.
- For the SCR panel to be most effective, it must be mounted 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. The use of a heat transfer grease (such as Dow Corning #340) is recommended.
- Terminal boards and other exposed SCR control parts should be kept free of dirt and paint which might change the effective resistance between points.
- The truck should not be plugged when the truck 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.

* Registered trademark of the E. I. duPont de Nemours & Company

TROUBLE-SHOOTING INSTRUCTIONS

The pulsing of the main SCR is too fast for conventional instruments to measure. When the control is functioning properly, a low hum can be heard.

Malfunctions of the SCR will generally fall into one of two categories. They are either no power (Table 1) or full power (Table 2), when operating in the SCR control range.

These simple and easy-to-follow tables outline the various symptoms and the corrective action to be taken.

The same device designations have been maintained on different controls but the wire numbers may vary. Refer to the elementary and wiring diagram for your specific control. The wire numbers shown on the elementary diagram will have identical numbers on the corresponding wiring diagrams for a specific truck, but these numbers may be different from the numbers referenced in this publication. Wire numbers may be preceded with a "G" to distinguish GE numbers from truck manufacturer's wires.

Before proceeding, visually check for loose wiring, maladjusted linkage to accelerator switch, signs of overheating of components, etc. Before touching electrical components, disconnect the battery and discharge capacitor 1C. Reconnect the battery as needed for the specific check.

Tools and test equipment required are: 36-volt test battery, 3-volt battery, 3-volt lamp (or BRIGHT STAR No. 1618CT circuit continuity tester), clip leads, volt-ohm meter (20,000 ohms per volt) and general hand tools.

TABLE 1

Failures Which Cause No Motor Torque With SCR Control

SYMPTOMS	WHAT TO DO
1A. Contactors do not pick up. No control voltage from positive to negative.	• Check power fuses. • Check battery connector. • Check battery for low specific gravity and connections for looseness or broken fittings.
1B. Contactors do not pick up. Control volts present from positive to negative and of correct polarity.	• For these tests, if Pulse Monitor Trip is used, connect a jumper from point 5 (wire 23) to point 1 (wire 13) on the card. • (See NOTE 1) Connect jumper from control positive (load side of control fuse) to positive side of F or R coil. If device does not pick up, check coil for continuity. Also jumper negative to opposite terminal to check for opens in negative connections. • (See NOTE 1) With jumper on control positive move other end to wire 8 on F interlock or 6 on R interlock. Coils should pick up. This proves F and R normally closed electrical interlocks. • (See NOTE 1) Using jumper continue to check remaining components in circuit such as directional switch, brake switch, seat switch and key switch by moving end of jumper to positive side of each of these devices.
1C. Contactors close. No power and no SCR hum with accelerator in SCR range.	• (See NOTE 1) With F or R picked up and wire 45 at point 8 disconnected at SCR terminal board, check for control volts at SCR terminal board, positive (wire 41) to negative (wire 13). If voltage is zero at this point, check F or R (normally open interlocks) and 1A coil for continuity. If polarity is reversed, check battery connections. • (See NOTE 1) With F or R picked up and wire 45 at point 8 disconnected at SCR terminal board, check for control volts positive at point 6 (wire 32) to negative (wire 13). If there is zero volts at this point, check: FUB, F or R power tips, and continuity of wiring and motor from battery positive to 1 REC heat sink.

NOTE 1: *Drive wheels should be off the floor.*

TABLE 1

Failures Which Cause No Motor Torque With SCR Control

SYMPTOMS	WHAT TO DO
1A. Contactors do not pick up. No control voltage from positive to negative.	• Check power fuses. • Check battery connector. • Check battery for low specific gravity and connections for looseness or broken fittings.
1B. Contactors do not pick up. Control volts present from positive to negative and of correct polarity.	• For these tests, if Pulse Monitor Trip is used, connect a jumper from point 5 (wire 23) to point 1 (wire 13) on the card. • (See NOTE 1) Connect jumper from control positive (load side of control fuse) to positive side of F or R coil. If device does not pick up, check coil for continuity. Also jumper negative to opposite terminal to check for opens in negative connections. • (See NOTE 1) With jumper on control positive move other end to wire 8 on F interlock or 6 on R interlock. Coils should pick up. This proves F and R normally closed electrical interlocks. • (See NOTE 1) Using jumper continue to check remaining components in circuit such as directional switch, brake switch, seat switch and key switch by moving end of jumper to positive side of each of these devices.
1C. Contactors close. No power and no SCR hum with accelerator in SCR range.	• (See NOTE 1) With F or R picked up and wire 45 at point 8 disconnected at SCR terminal board, check for control volts at SCR terminal board, positive (wire 41) to negative (wire 13). If voltage is zero at this point, check F or R (normally open interlocks) and 1A coil for continuity. If polarity is reversed, check battery connections. • (See NOTE 1) With F or R picked up and wire 45 at point 8 disconnected at SCR terminal board, check for control volts positive at point 6 (wire 32) to negative (wire 13). If there is zero volts at this point, check: FUB, F or R power tips, and continuity of wiring and motor from battery positive to 1 REC heat sink. *NOTE* 1: *Drive wheels should be off the floor.*

SYMPTOMS	WHAT TO DO
1C. (Continued)	• (See NOTE 1) Check 1C capacitor volts point 13 (wire 31) to negative (wire 13). Must be over 1/2 battery volts to pulse. If near zero, check 1C and 5 REC for shorted condition (see 4H).
	• (See NOTE 1) With F or R picked up and wire 45 disconnected from SCR terminal board, measure approximately 6 volts from (wire 4) to negative (wire 13) with accelerator pot near creep speed. Volts will drop to near zero as accelerator is moved toward full speed. If readings are not correct, check thermal protector (see 4J).
	• If the above tests will produce no voltage change, place a jumper between wires 4 and 13. This bypasses the accelerator and the truck should now run at top SCR speed. If top speed is obtained, check accelerator pot per Table 4I. If control fails to operate, turn creep speed trim pot clockwise. If volts from terminal 15 to 14 are not zero, check wiring. If volts from terminal 9 to 1 are not zero, remove wire from terminal 9 and recheck. If still not zero replace card.
1D. Contactors close, but very little power, and barely audible SCR hum.	• Check 1 REC for an open condition in the conducting direction (see 4H).
1E. Contactors close. Very little or no power with slow SCR pulsing, even when accelerator is in top SCR position.	• (See NOTE 1) Check for battery volts from terminal 14 to 1, and zero volts from terminal 14 to 15. Check volts from terminal 9 to 1. If more than one volt, replace card.
	• (See NOTE 1) Check creep speed setting on card. Also if current limit is full counterclockwise speed will be slow.
1F. Contactors close. Very little power with a normal SCR hum.	• Check 3 REC for open condition (see 4G). If 3 REC is found to be open, check 1, 2, and 5 REC for proper operation.
	• Check 4 REC for short (see 4G).

NOTE 1: *Drive wheels should be off the floor.*

TABLE 2

Failures Which Cause Full Motor Torque With SCR Control

WARNING: Drive wheels should be off the floor.

SYMPTOMS	WHAT TO DO
2A. Contactors close. Full SCR speed immediately with audible hum.	● Check potentiometer for proper resistance (see 4I). ● Check for grounds in wires 29 and 4 or shorted accelerator pot. ● Check creep speed setting on card.
2B. Contactors close. Full speed immediately with no audible hum.*	● Check for welded power tips on 1A contactor. ● Check for open gate in 5 REC (see 4H). ● Check 5 REC for open condition (see 4H). ● Check continuity of wiring from 2 REC cathode thru IX, to 1C thru T3, T4 to 5 REC anode, and 5 REC cathode to 1 REC cathode. ● Check capacitor 1C (see 4H). ● Check 1 REC for short (see 4H). ● Check for open 2 REC (see 4H). ● Check for open gate in 2 REC (see 4H). ● Check 2 REC for shorted condition in the conducting direction (see 4H).

* If truck is equipped with a Pulse Monitoring Trip and it fails to shut down the control on the above faults, check Pulse Monitoring Trip per GEK-28898.

TABLE 3

Misoperation Of Special Features

SYMPTOMS	WHAT TO DO
3A. SCR control operates but the 1A contactor fails to operate.	• Check resistance of 1A coil. If resistance is much different from other contactor coils, replace coil. (see GEH-3101 or GEH-3074.) • (See NOTE 1) Jumper negative to SCR terminal board (wire 45). 1A should pick up after approximately 1 second delay. This checks the timer section of Card 1. • If the two above tests check good, then check 1A switch in accelerator for proper operation.
3B. Failures in FW circuit.	• See GEK-28899.
3C. Severe reversal, or too soft reversal.	• Check settings of plugging trimpot on Card 1 (see 6Ad). • Check 4 REC (see 4G). • Check continuity of wires 5 and 9.
3D. Severe plug at beginning and end of plug.	• See Table 6 Bg.

NOTE 1: *Drive wheels should be off the floor.*

NOTE 2: *When the auxiliary plugging control card is used.*

TABLE 4

Checking Components

WARNING: BEFORE TOUCHING ELECTRICAL COMPONENTS, DISCONNECT THE BATTERY AND DISCHARGE CAPACITOR 1C.

4A. CARD 1

Cannot be tested with a VOM. Card should be considered operative until all checks under Table 1 or 2 have been performed depending upon symptoms. If checks in Table 1 or 2 do not result in location of defective parts, change Card 1.

4B. FIELD WEAKENING CARD (if used)

See GEK-28899.

4C. PULSE MONITOR TRIP (if used)

See GEK-28898.

4D. CAPACITOR 1C

Disconnect battery and discharge capacitor. Disconnect leads to one side of capacitor. Measure ohms through the capacitor using the RX10, 000 scale. Meter should read zero ohms and then swing to above 100, 000 ohms. Replace capacitor if above reading is not obtained.

4E. CONTACTORS F, R, 1A, FW AND P

a) 100-ampere contactors (see GEH-3101)

b) 200-ampere contactors (see GEH-3074)

NOTE: Control is arranged so that F and R do not normally break current. Contactor 1A drops out ahead of F or R.

4F. CONTACTOR COIL AND ACCESSORY FILTER

(7, 8, 9, and 12 REC)

On some magnetic panels, the contactor coils will either be varnish tape-wound or encapsulated. For the varnish tape-wound type, a separate filter is required and will be mounted adjacent to the coil. The encapsulated coil contains the necessary filtering and is not visible from the exterior of the device.

a) Separate Filter (Typical Cat. No. 148B6203G14)

These are varistors and should be checked as follows: Disconnect battery and discharge capacitor 1C. Disconnect the leads to the filter block. Connect a 36-volt d-c test battery in series with the varistor and a volt-ohm meter set on the 1ma. scale as shown in Figure 7. If the varistor is good, there will be a noticeable deflection of the meter needle when the leads are touched to the filter block terminals. If no deflection is obtained, replace the filter block.

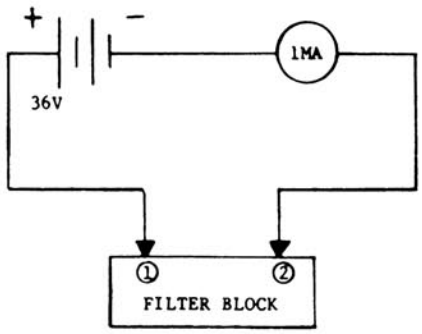


Fig. 7

b) Integral Coil Filter

When this filter fails, it will be evident by a severe cracking of the coils in the vicinity of the coil terminals.

4G. RECTIFIERS

When checking diodes, disconnect battery and discharge capacitor 1C to prevent burning out the ohmmeter. When replacing rectifiers, refer to Table 5.

3 and 4 REC: Disconnect pigtail. 3 and 4 REC are diodes with about 7 to 12 ohms in the conducting direction (+ ▶| −) measured on the RX1 scale, and 50,000 ohms or higher, in the nonconducting direction (− ▶| +) measured on the RX10,000 scale.

15 and 16 REC: Disconnect one lead. Check same as 3 and 4 REC above.

4H. SCR'S (1 REC, 2 REC, 5 REC)

These are silicon control rectifiers. Before checking, disconnect battery and discharge capacitor 1C. Disconnect pigtail of 1 and 2 REC or the negative lead to terminal of 5 REC. Disconnect gate leads of SCR's at the card terminal board.

To check an SCR, it is necessary to have a 3-volt battery and a 3-volt lamp. (A test flashlight such as a BRIGHT STAR No. 1618CT circuit continuity tester is excellent for this test.)

Connect the plus lead to the stud (1), connect negative lead to the pigtail (3) as shown in Figure 8.

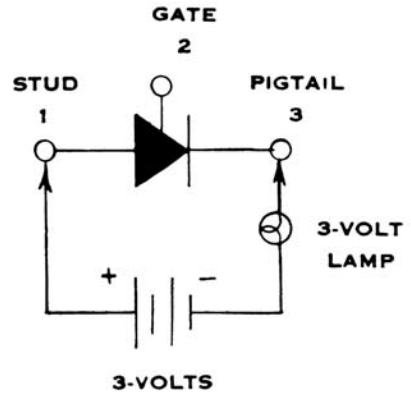


Fig. 8

a) The lamp should not light. If the lamp does light, the SCR is shorted and must be replaced.

b) If check (a) was satisfactory, test the SCR for its ability to be turned on by the gate. Touch gate (point 2) to point 1. If gate is operative, the lamp should come on and must remain on when the gate is removed.

c) If lamp cannot be lit under step (b) the SCR is open and must be replaced.

NOTE: If you do not have a test light to check the SCR's as described above, they may be checked for shorts or opens by use of the VOM.

a) Measure resistance from stud to pigtail (RX100 scale). If SCR is shorted (less than 100 ohms), it must be replaced.

b) Measure resistance from gate lead (white lead) to pigtail and then from pigtail to gate lead (RX1 scale). If resistance reads either less than 5 ohms (shorted) or more than 50,000 ohms (open), replace the SCR.

c) If available, try in known good control.

When reassembling SCR's, refer to Table 5.

4I. POTENTIOMETER IN ACCELERATOR

To check operation of the potentiometer, disconnect battery and disconnect wire 29 from thermal protector or SCR terminal board. Connect VOM from wire 29 to negative 13 with scale set to RX100. With accelerator in creep-speed position, the ohm reading should be 3,500 to 6,600 ohms; with accelerator in top-speed position, reading should be 200 ohms or less. If these readings are not obtained, loosen pinion gear clamp and adjust rotation of pot shaft relative to accelerator shaft or replace.

With wires disconnected as above, check for resistance of 1 megohm or higher from pot wires to truck frame.

For additional information, refer to GEK-8073.

4J. THERMAL PROTECTOR (TP)

Remove both connections from TP and with a VOM read approximately 10-50 ohms terminal to terminal, if heat sink is at room temperature. Set VOM to highest ohm scale and check pins to heat sink, reading should be infinity.

4K. FILTER BLOCK (HF)

To check, disconnect all wires from filter block. With VOM on RX10,000 scale, touch the leads to the filter terminals to charge the filter. After a few seconds, reverse the meter leads and touch the filter terminals. The VOM needle will deflect and return to infinity. If this capacitor action is not observed, replace the filter block.

TABLE 5

Replacement Of Semiconductors

When replacing semiconductors such as 1, 2, 3, 4 and 5 REC, it is not necessary to torque these devices to a specific value. However, the device should be screwed into the heat sink and tightened to a snug fit.

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

TABLE 6

Tuneup For New Or Mistuned Card 1

IMPORTANT NOTES

1. Panels are factory adjusted for a particular motor and truck and should not need adjustment when used with this motor and truck. However, checks and/or touchup adjustments may be made per Table 6A.

2. The TOP SCR SPEED setting is a factory made and sealed setting! Under normal conditions, this setting should not be touched.

   If setting is required, the complete tuneup procedure, Table 6B, must be followed.

3. 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 and the complete tuneup procedure, Table 6B, must be followed.

4. All adjustments are such that CW rotation increases function being adjusted.

5. Connect the shunt, the millivoltmeter and the voltmeter to measure battery current and motor volts. Connect the shunt and millivoltmeter between battery negative and 1 REC (or between truck receptacle and battery plug). Connect voltmeter between battery positive and T2 on the SCR panel. Connect a jumper from wire 4 (terminal 5 of Card 1) to negative (pigtail of 1 REC).

   NOTE: Be sure to insulate or wrap the jumper connection to wire 4 to prevent accidental contact of this point to the truck frame. If this point touches the truck frame, it will damage the control card.

   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 brakes can be applied at the same time.

6. Equipment required:

   50-millivolt d-c shunt*

   50-millivolt d-c meter (d'Arsonval movement)

   50-volt d-c meter (d'Arsonval movement) (250 volt scale needed for 72V)

   Battery with equal or greater ampere-hour capacity than used on truck, charged to 1250 or higher specific gravity.

*Typical Shunt Ratings	SCR Model
200 amperes	110
300 or 400 amperes	210
400 or 500 amperes	310

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

7. Check that the ohms in accelerator potentiometer are less than 200 ohms in top SCR range (see Table 4I). Refer to Figure 3 for potentiometer locations.

TABLE 6A

Checking Of Card Settings

Checks and/or minor touchup adjustments can be made without following complete tuneups as given in Table 6B.

a) CREEP SPEED

With truck jacked up, apply brakes (refer to Note 5, Table 6). Measure motor volts from positive (wire 5) to T2 (wire 1) as F or R contactor closes. Volts should be per Table 6Be. Increasing creep speed increases stiffness at the end of a plug and stiffens controlled acceleration.

b) TOP SCR SPEED

Refer to Note 5, Table 6.

Check TOP SCR SPEED by first moving the accelerator until the F or R contactor operate. Do not move accelerator to the point where 1A picks up.

Apply brakes until battery current reads per the value as given in Table 6Be and read motor volts to see if it falls within values given in Table 6Be.

Disconnect shunt, voltmeter, and jumper to wire 4.

c) CURRENT LIMIT

Refer to Note 5, Table 6.

Check CURRENT LIMIT by first moving the accelerator until the F or R contactor operate. Do not move accelerator to the point where 1A picks up.

Apply brakes until wheels come to a STANDSTILL (the wheels must not be turning) and read current to see if it falls below the maximum rating given in Table 6Be and within the rating specified by the truck manufacturer.

NOTE: DO NOT STALL the motor for more than 5 *to* 10 *seconds at a time. Allow time for motor cooling between stalls. Do not operate motor at high speeds or plug the motor with wheels jacked up.*

Disconnect shunt, voltmeter, and jumper to wire 4.

d) STATIC PLUGGING

With truck on the ground, plug truck from top speed. If stopping distance is not as desired, adjust plugging trimpot. If plug is too stiff near end of plug, see table 6Bg.

e) 1A TIMER

With truck on the ground check operation on a full acceleration. If 1A contactor picks up too early or if truck is sluggish, adjust trimpot to obtain desired operations.

TABLE 6B

Tuneup Procedure

COMPLETE ALL STEPS a through f.

a) Turn CURRENT-LIMIT trimpot fully clockwise.

b) Turn PLUGGING trimpot fully clockwise. (Steps a and b prevent any interaction when setting the speed adjustment.)

c) Turn AUXILIARY trimpot fully counterclockwise.

d) CREEP SPEED

Refer to Table 6Aa.

e) TOP SCR SPEED

Refer to Note 5, Table 6.

Check TOP SCR SPEED by first moving the accelerator until the F or R contactor operate. Do not move accelerator to the point where 1A picks up.

Apply the brakes until battery current is about 70 to 80 percent of the full-field loaded level amperes.

Typical Battery Current	SCR Model
45 - 50 amperes	110
75 - 80 amperes	210
120 - 130 amperes	310

Adjust the TOP SCR SPEED trimpot until the voltmeter reads motor volts as indicated below:

Battery Volts	Creep Speed Motor Volts	Top Speed Motor Volts	CURRENT LIMIT AMPERES (MAXIMUM)		
			Model 110	Model 210	Model 310
12	0.4 - 0.6	7 - 9	100	200	300
18	0.6 - 0.9	13 - 15	100	200	300
24	0.8 - 1.2	17 - 20	100	200	300
36	1.2 - 1.8	25 - 31	100	200	300
48	1.6 - 2.4	34 - 41	100	185	300
72	2.4 - 3.6	50 - 61	NA	150	300

f) CURRENT LIMIT

Turn the current limit trimpot fully counterclockwise.
Check to be sure the plugging trimpot is turned fully clockwise.
Depress the accelerator until F or R operate but not the 1A contactor.
Apply the brakes until the wheels come to a standstill and remain at a standstill.
Slowly turn the CURRENT LIMIT TRIMPOT in a clockwise direction until the current reaches a value as shown in the above table, or as specified by the truck manufacturer.

NOTE: The current limit values as given in the table above represent the typical maximum values that we suggest for each control when operated on a given voltage and these values must not be exceeded.

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 the maximum. For this reason it is recommended that you obtain the actual current limit setting for your particular truck from the truck manufacturer.

NOTE: DO NOT STALL the motor for more than 5 *to* 10 *seconds at a time. Allow time for motor cooling between stalls. Do not operate motor at high speeds or plug the motor with wheels jacked up.*

After setting the correct value, disconnect meter and remove jumper from wire 4.

g) STATIC PLUGGING

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. Adjust trimpot until desired stopping distance is obtained.

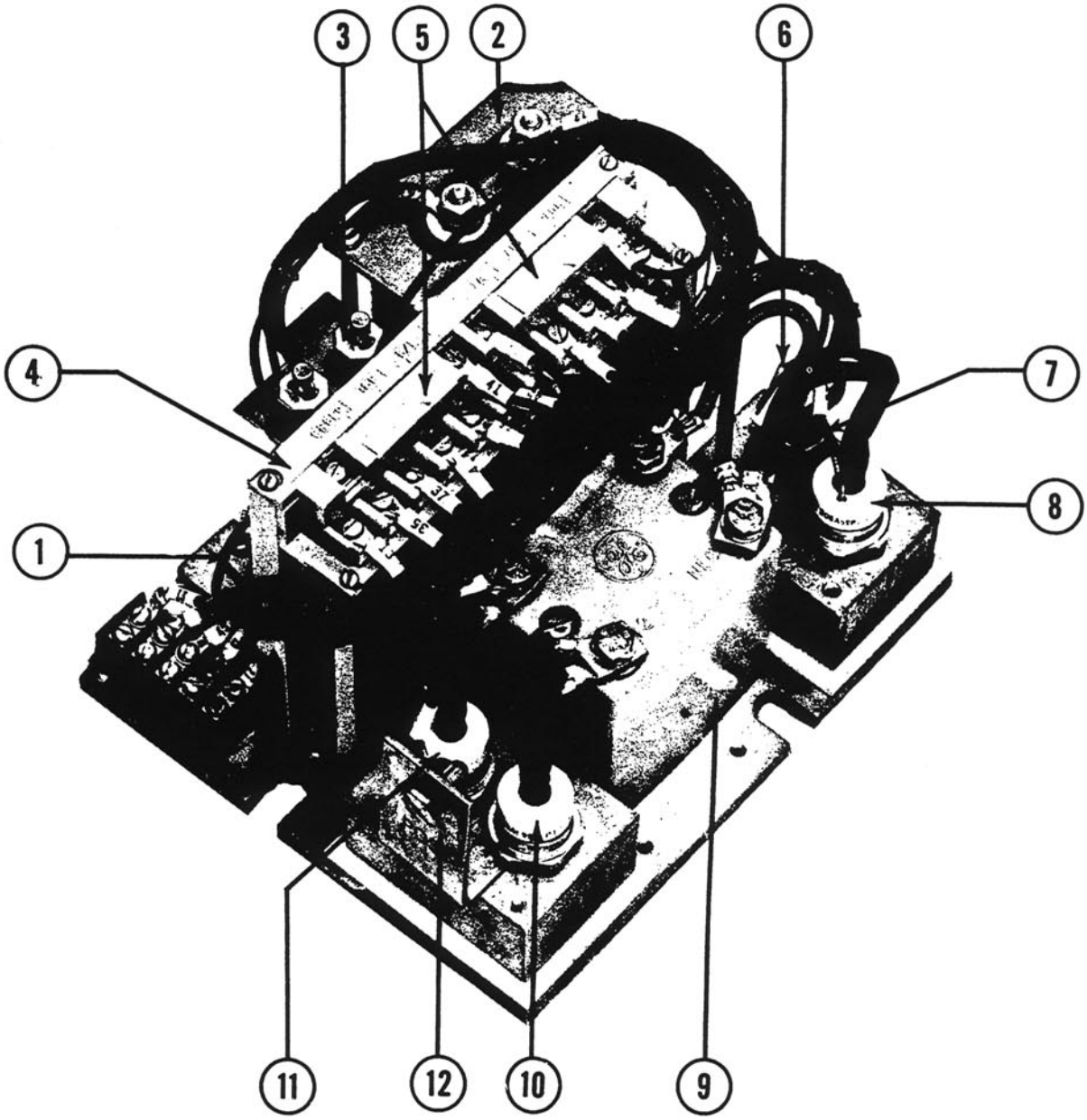
When using the plug trimpot to adjust to the desired stopping distance, if the truck develops too much torque near the end of the plug, the plug trimpot (RH6) may be turned CCW to obtain the desired torque near the end of the plug, and the aux. trimpot (RH5) turned CW as needed to regain the desired plugging distance.

h) 1A TIMER

The 1A TIMER is factory set at approximately 1 second on all models.
Check truck performance. If the 1A contactor picks up too early, resulting in jerky operation, turn the 1A Timer trimpot CW to increase time delay, to a value that provides desired operation.

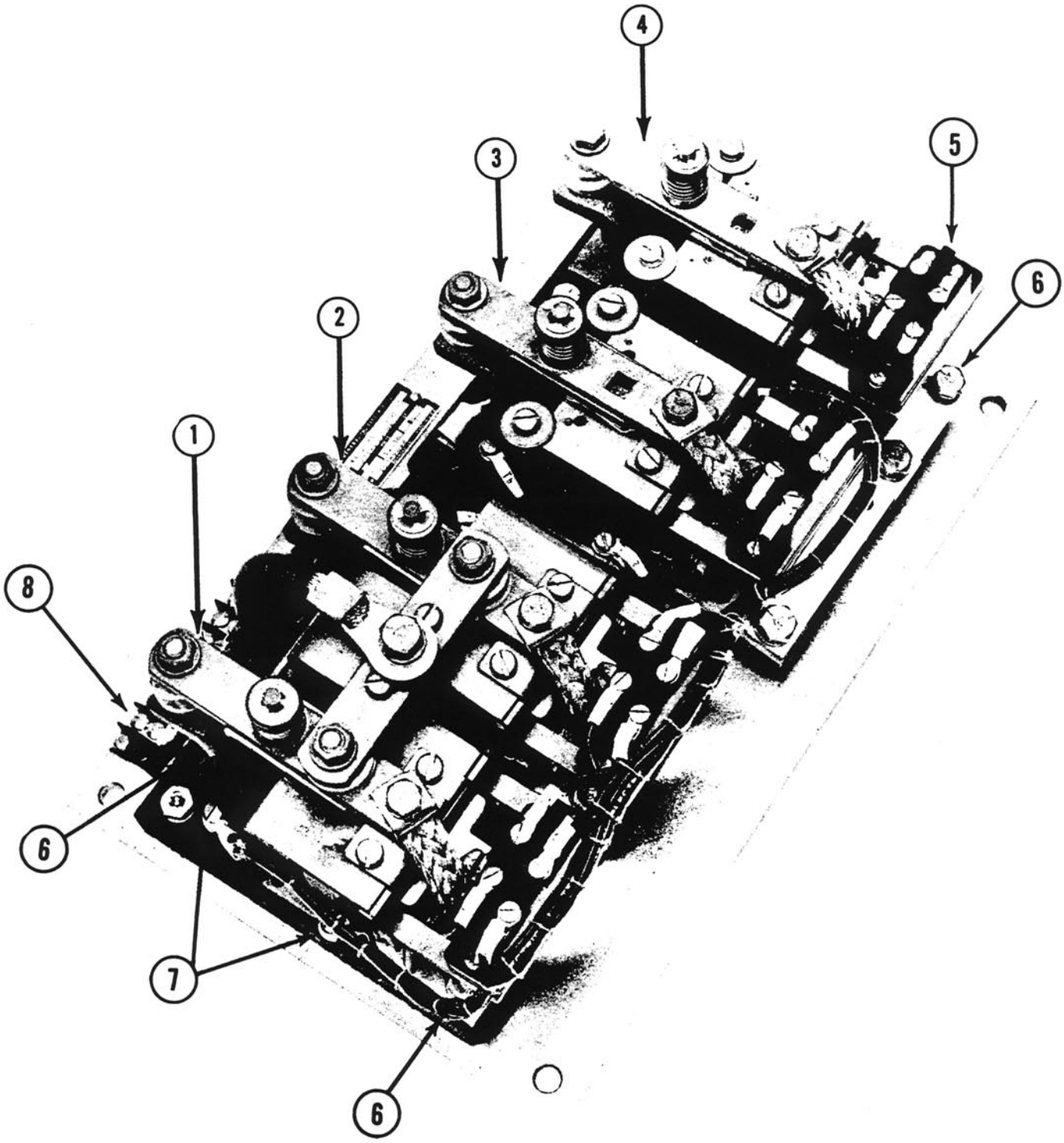
TYPICAL PHYSICAL ARRANGEMENT AND IDENTIFICATION OF COMPONENTS

(Refer to wiring diagram furnished with truck for precise arrangement of components.)



(1) CHARGING SCR (5 REC)
(2) COMMUTATING CAPACITOR (1C)
(3) CONTROL CIRCUIT FUSES
(4) OSCILLATOR CARD
(5) OSCILLATOR CARD ADJUSTMENTS
(6) TURN-OFF SCR (2 REC)
(7) THERMAL PROTECTOR
(8) MAIN SCR (1 REC)
(9) PULSE TRANSFORMER
(10) FLY-BACK DIODE (3 REC)
(11) PLUGGING DIODE (4 REC)
(12) PLUGGING SENSOR

Fig. 9. Typical SCR static panel



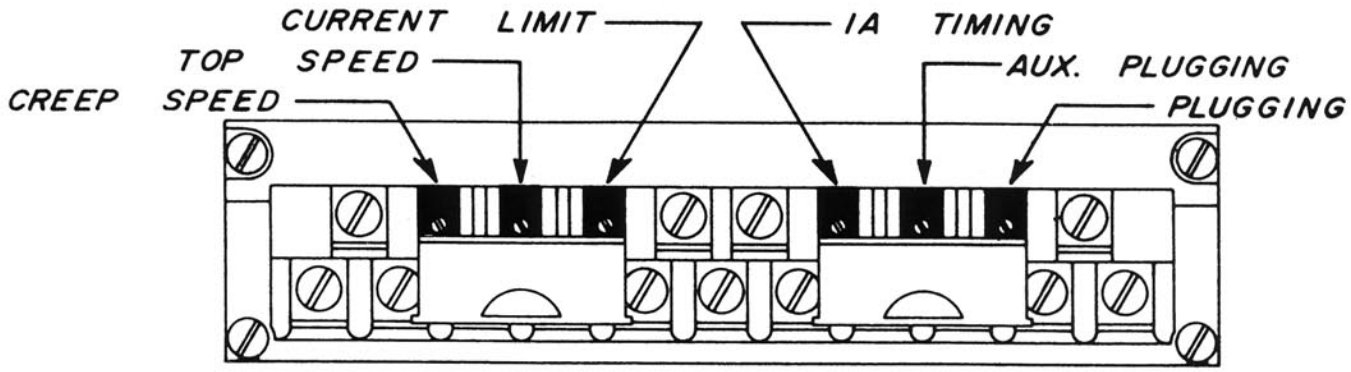
(1) FORWARD CONTACTOR (F)
(2) REVERSE CONTACTOR (R)
(3) BY-PASS CONTACTOR (1A)
(4) PUMP CONTACTOR (P)
(5) INTERLOCK SWITCHETTES
(6) CUSTOMER POWER CONNECTIONS
(7) COIL TERMINALS
(8) CUSTOMER CONTROL CONNECTIONS

Fig. 10 Typical SCR magnetic panel

NUMBER ONE CARD TUNE-UP PROCEDURE FOR GENERAL ELECTRIC "B" SERIES

M-210, M-310

PANELS



CARDS COVERED BY THIS PROCEDURE

IC4484B100	B103	B106
B101	B105	B107

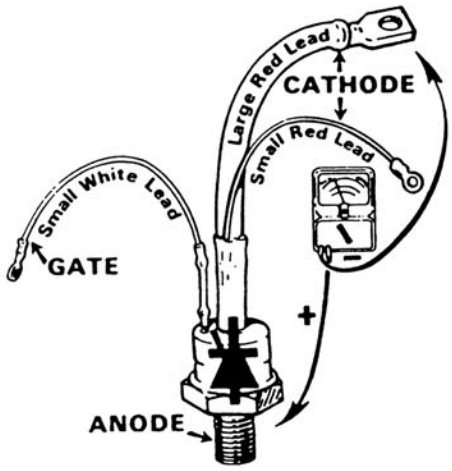
PRELIMINARY INFORMATION

If a control card is sufficiently out of tune, it may be impossible to adjust one function of the card until some other function is correct. When installing a new or rebuilt No. 1 Card, it is best to assume that the card is completely mistuned and follow this procedure in sequence. Only after all functions are operating properly is it safe to "touch-up" an individual adjustment without going through the entire procedure.

TUNE-UP PROCEDURE

A. Preparing the Truck

1. Block the drive wheels up off the ground.
2. Defeat the seat switch and brake mechanism. The simplest way to do this, usually, is to tie down the seat.
3. All of the voltages required in this procedure may be read by monitoring the anode of 1 Rec. This may be accomplished by probing the SCR as illustrated below, or by connecting the positive lead of the voltmeter to card terminal 6 and the negative lead to terminal 1.



B. Creep Speed Adjustment

1. Turn the Current Limit and Plugging potentiometers fully clockwise, and the Auxiliary Plugging pot fully counterclockwise. This disables these functions to prevent any interaction during the speed adjustments.

   Note: All adjustments are 22-turn potentiometers. To adjust fully in either direction, turn until the adjustment screw starts to drag or tick – or until it has been turned 22 times.

2. Depress the accelerator to the point where the initial switch just closes. When the Creep potentiometer is at its extreme counterclockwise position, the motor will not run – although the SCR panel will be pulsing. As the control is turned clockwise, motor speed will pick up. The meter reading will decrease from battery voltage to less than half of battery voltage. Set Creep at approximately the value shown in Table 1 below. This setting will be optimized when the truck is on the ground.

C. Top Speed Adjustment

1. Short the speed potentiometer by installing a jumper between terminal 5 of the card and negative at terminal 1. This may also be accomplished by removing wire 4 from the thermal protector and touching it to negative at the cathode of 1 Rec.
2. Depress the accelerator until the initial switch just closes. The truck will quickly accelerate into top speed. As the Top Speed adjustment is turned counterclockwise, the meter reading will start to increase. Set Top Speed according to Table 1 below. Leave the jumper installed for Current Limiting Adjustments.

BATTERY VOLTAGE	CREEP VOLTAGE	TOP SPEED VOLTAGE
12	10	2
24	22.5	2.5
36	34	4
48	45	5.5
72	68	8

TABLE 1

D. Current Limiting Adjustment

1. Equipment

   To adjust current limiting, a reliable, accurate D.C. ammeter is required. The shunt type is preferred because of its higher inherent accuracy and freedom from errors caused by steel and nearby wires. Although the clamp-on type is more convenient, it is less accurate and somewhat harder to read due to its non-linear scale. With either type, make sure it is suited for pulsating D.C. measurement and is in good condition. Check it against a standard or another ammeter that is known to be accurate, if possible. Never use a clip-on type ammeter designed for A.C. only. A 0-500/1000 amp. range is suitable for all of the controls covered in these instructions. Suitable test leads are required for the shunt type ammeter.

2. Procedure

   Since these controls are used on a variety of truck applications, it is recommended that you obtain the actual current limit setting for your particular truck make and model from the manufacturer. (The current limit value based on the motor ratings usually results in a lower setting than the maximum listed for the panel.) Also, determine if the current limit value specified is for motor armature current, or battery current. It should be noted that the relationship between motor current and battery current is highly dependent on motor characteristics. There is also some variation between the card setting from one truck to another, even the same model. Therefore, every control card should be final adjusted on the truck it is to be used on.

   The battery should be charged to at least 1200 S.G. Make sure drive wheels are clear of the floor. Make sure the jumper from wire 4 to negative is intact. Block the 1A contractor with an insulating material. Jumper the brake switch (if equipped). If manufacturer's specifications are not available, use the table below as a guide.

   IMPORTANT: If the ammeter is connected at the battery plug, you are measuring battery current. If connected in series with the armature, you are measuring armature current.

CURRENT LIMIT SETTINGS IN AMPERES

NOMINAL BATTERY VOLTAGE	M210			M310		
	MAXIMUM BATTERY	TYPICAL BATTERY	TYPICAL ARMATURE	MAXIMUM BATTERY	TYPICAL BATTERY	TYPICAL ARMATURE
12	200	170-180	340-360	300	255-270	510-540
24	200	170-180	340-360	300	255-270	510-540
36	200	170-180	340-360	300	255-270	510-540
48	185	155-165	310-330	300	255-270	510-540
72	150	125-135	250-270	300	255-270	510-540

USE THE **TYPICAL** VALUES GIVEN ABOVE AS A GUIDE. **DO NOT EXCEED THE MAXIMUM VALUES.**

Start with the Current Limit trimpot fully counterclockwise (minimum current) – Depress the accelerator to close the initial switch and apply the brakes until the wheels come to a standstill and remain at a standstill. Slowly turn the Current Limit trimpot in a clockwise direction until the current being read reaches the value shown for your specific truck.

IMPORTANT: Do not stall the drive motor for more than 30 seconds at a time and be sure to allow time between stalls for the motor to cool, (approximately 2 minutes). Disconnect the shunt, meter, and brake switch jumper. Remove the jumper from wire 4 to negative.

E. 1A Timer Adjustment

Depress the accelerator fully, activating the final switch. Note the time delay until the bypass contactor activates. This delay can be adjusted from nearly zero to three or four seconds. Set for approximately one second. This time may need to be increased when the truck is on the ground.

F. Creep and 1A Touch-up

1. Restore the truck to its normal operating condition. Leave access to the No. 1 Card adjustments.
2. Accelerate the truck until it is rolling freely on the level. Then back off the accelerator to the point where the initial switch is just about to open. The truck should be capable of coming to a complete stop while the SCR panel is still puls-

ing. Only a slight depression of the accelerator should be necessary to get the truck moving. Adjust the Creep Speed potentiometer as necessary to achieve this.

3. Accelerate the truck into bypass. If the truck jerks when the 1A contactor picks up, increase the 1A time until this transition is smooth.

G. Plugging and Auxiliary Plugging Adjustment

Note: If the truck is equipped with an Auxiliary Plugging Card (B700 or B701), the following instructions will not apply. Consult the instructions for the card used.

1. Adjust the Plugging control fully counterclockwise. The Auxiliary Plugging control should already be counterclockwise. Plugging is now set for the least possible severity. Plug the truck from top speed and adjust the Plugging potentiometer clockwise until the desired stopping distance is achieved.
2. If the truck begins to develop too much torque near the end of the plug, return the Plugging control counterclockwise until this torque is acceptable. Now adjust the Auxiliary Plugging control clockwise until the desired stopping distance is obtained.

AFTER THE TUNE-UP

If you have trouble or do not understand the instructions, assistance is available to you at no charge by calling Flight Systems Technical Service.

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