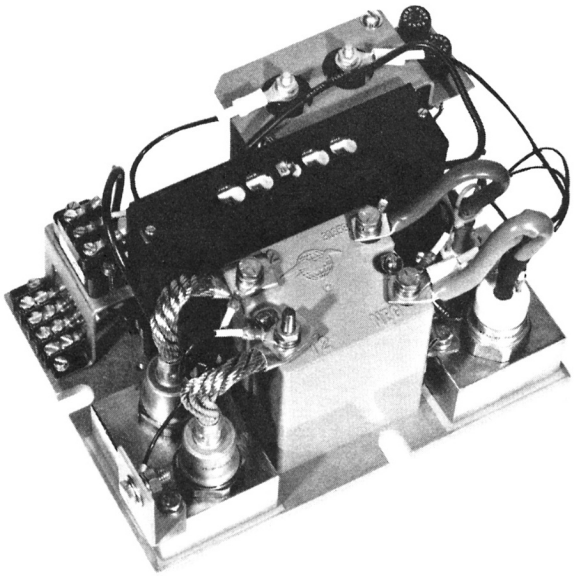
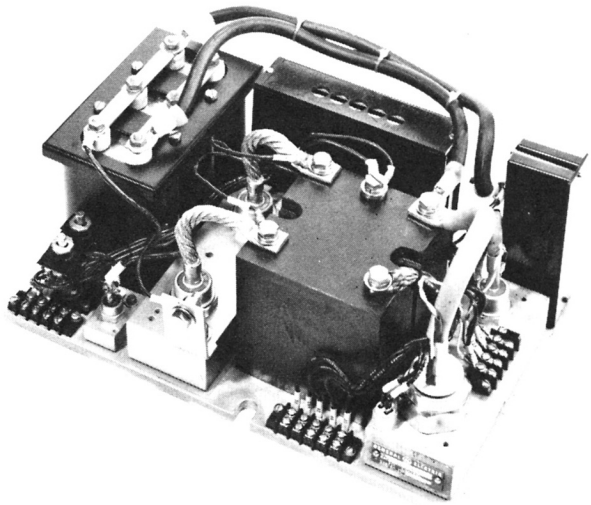
GENERAL ELECTRIC

C185 [M200]

C290 [M300]





PANEL REPLACEMENT PARTS LISTS & DIAGRAMS

AND TROUBLESHOOTING/ TUNE-UP INSTRUCTIONS

FSIP
FLIGHT SYSTEMS
INDUSTRIAL PRODUCTS
Website: www.fsindl.com
800-333-1194

 PRINTED IN USA REVISED DEC. 2002

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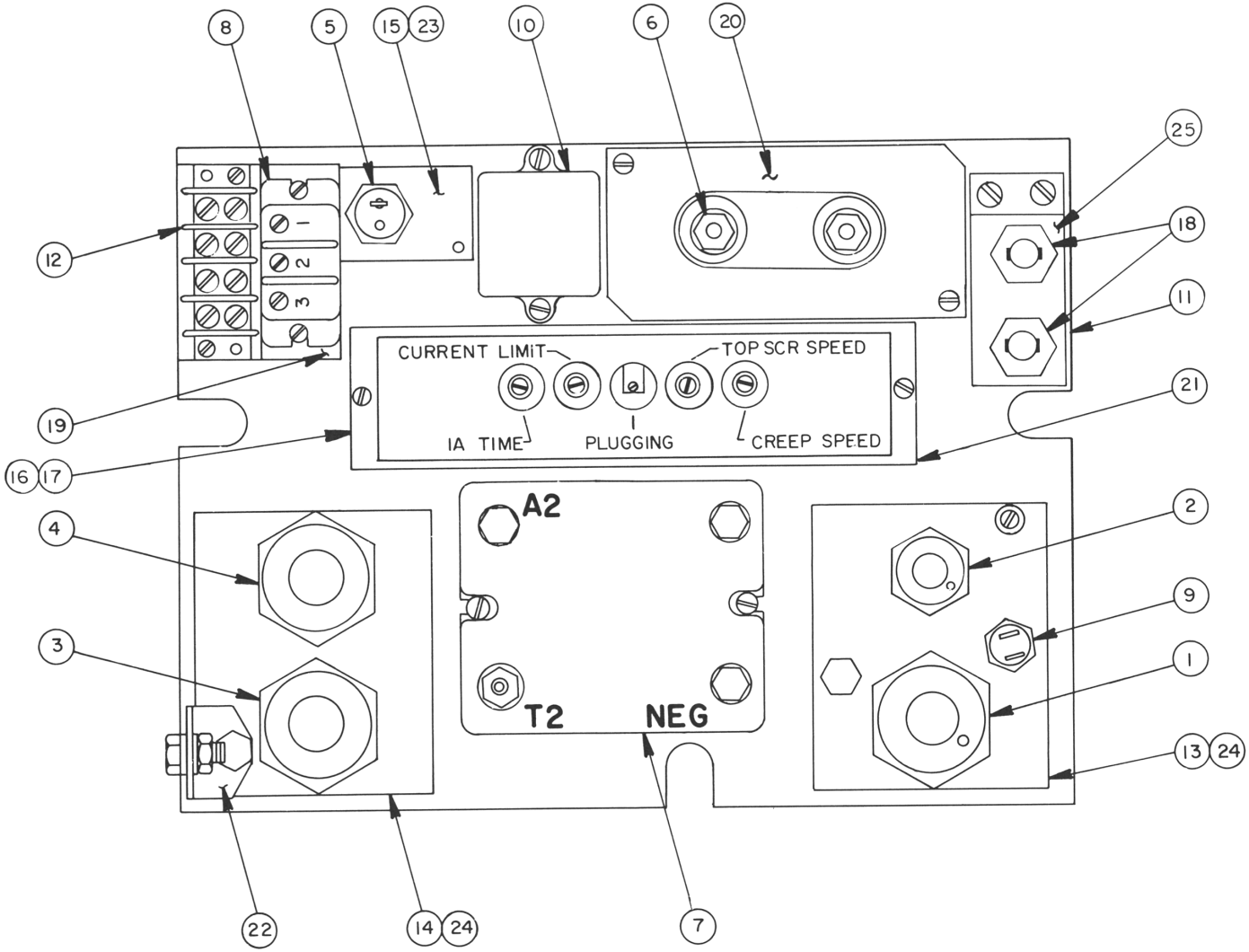


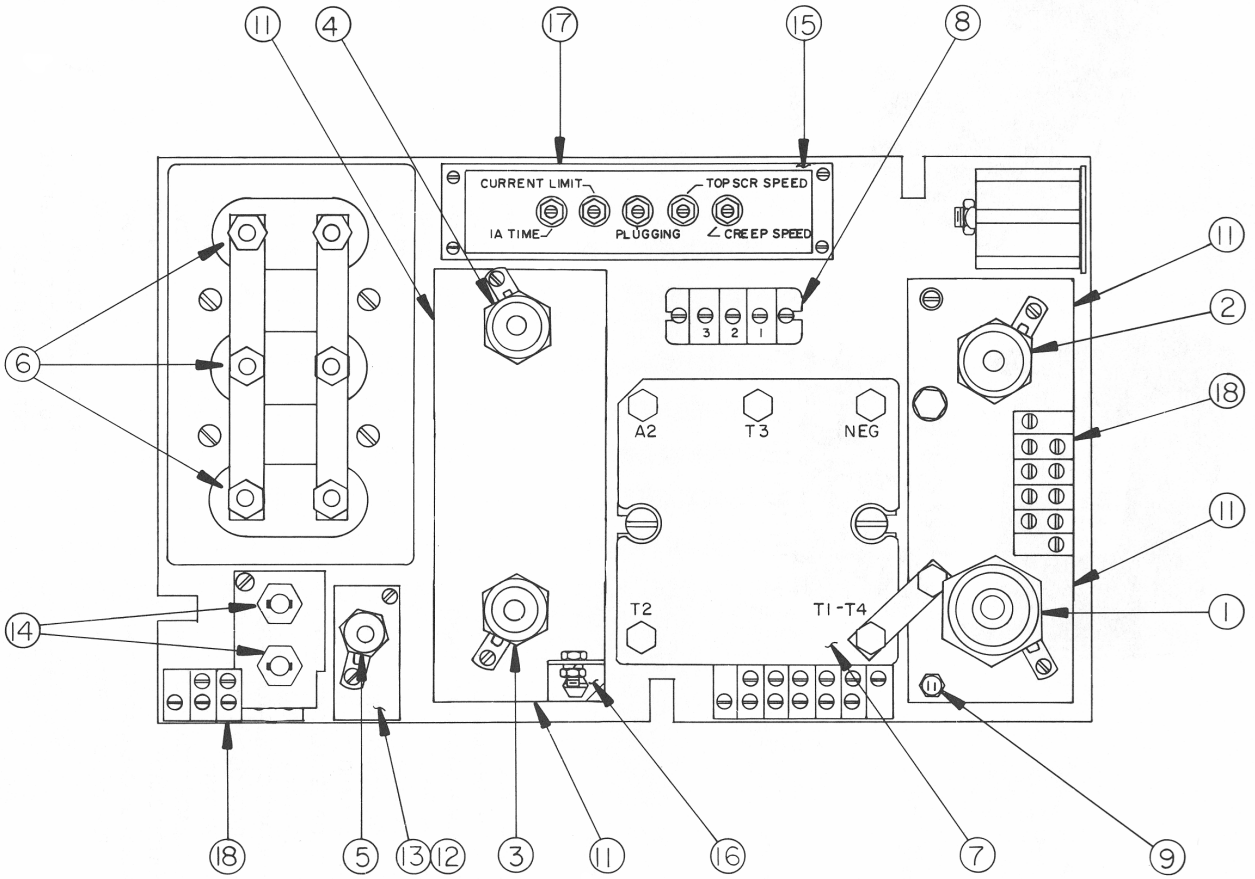
C185 (M200) SCR PANEL

C185 (M200) REPLACEMENT PARTS
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	FSIP
148B6203G46	116178	B27140-86	992936	80372	237587	4906480 74906480		5123673-04	8	Filter Block	21-6293-46
157B2744G1	235MAD1 GE-SCR141	B27140-76	895906	76318 78446 78466 80538	1144836 1199494 210669	4905330 74905330	333613	1297270-10 5118788-01	7	Transformer	34-2744-01
167A8468P4									12	Terminal Strip	38-T185-00
188A5137P1									20	Capacitor Bracket	43-5137-01
194A7582P1									22	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	144841 1198723 1199497 224138	4905335 74905335	333607	0793386-56 1291610-46 1295040 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
206A5981P5	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
205A5986G2	235MAC1 GE-SCR133	B27140-70	895911	76316 76566 78445	1144839 1199495	4905325 74905325	333611	12995040-80 1301450-03 5118768-01	10	Choke	32-5986-02
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 226MAW1 226MBC1 26121-26125 GE-SCR132 GE-SCR152	A27788-17 B27140-57	1802210 889404 895899 899404 995138 995665 995417 998526 999095	76317 79812	1199323 274092 278931	4905234 4910571 4910919 74905234 74910571 74910919	301773 377087 377231	1294980-39 1297270-08 1301450-04 5118778-01 5169178-02 5169178-03	6	Capacitor	33-9053-R

C185 (M200) REPLACEMENT PARTS
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	FSIP
205A7130P1									6	Capacitor	33-9053-FS
218A4038P2									18	Fuse Holder	29-F18500
218A9452P3									3&4	Diode	25-BF20-01
219A1561P1									25	Fuse Mounting Bracket	43-F185-00
245A2436P1				76323			354692		2	Diode	26-4840-05
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
68B997691G5			991421			4908226 74908226	354758	5170758-02	17	Receptacle	38-7691-05
7119R33							343131		16	Harness w/Receptacle	43-W185-00
IC4484A160									21	Oscillator Card	11-ACOM-00
IC4484A161									21	Oscillator Card	11-ACOM-00
IC4484A162									21	Oscillator Card	11-ACOM-00
IC4484A166									21	Oscillator Card	11-ACOM-00
IC4484A169									21	Oscillator Card	11-ACOM-00
IC4484A170									21	Oscillator Card	11-ACOM-00
IC4484A173									21	Oscillator Card	11-ACOM-00
IC4484A176									21	Oscillator Card	11-ACOM-00
IC4484A186									21	Oscillator Card	11-ACOM-00
IC4484A189									21	Oscillator Card	11-ACOM-00
IC4484A195	116175	B27140-47	896892	76320	1144085	4905252		1295040-67	21	Oscillator Card	11-ACOM-00
	GE-SCR146	B27140-81	990447		1199326	4906483		1299420-78	21	Oscillator Card	11-ACOM-00
	GE-SCR147 GE-SCR148 GE-SCR169		990448 931423 991424 992930 993180 993700 994100		1199496	74905252 74906483		5114098-01 5114098-03 5114098-06 5114098-09 5118808-01 5118808-09 5184688-09 5184688-17			
See Our P/N									13	Heatsink	44-H102-00
See Our P/N									14	Heatsink	44-H304-00
See Our P/N									15	Heatsink	44-H500-00
See Our P/N									19	Filter Mount	43-D185-00
See Our P/N									23	Insulator	43-N500-00
See Our P/N									24	Insulator	43-N123-40



C290 (M300) SCR PANEL

C290 (M300) 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	FSIP
148B6203G44			991986			4907261 74907261		5123673-05	8	Diode Block	21-6203-44
157B9651G1			991641		1199324	4905248 74905248	324438	1299420-49 5118788-02	7	Transformer	34-9651-01
167A8468P4									18	Terminal Strip	38-T185-00
194A7582P1									20	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									5	SCR	26-3J20-01
205A5981P17	GE-SCR153		1704432 961809 991429		1199329 223659 224136	4905255 74905255	342435 350362	1297270-95 1299420-79 5118818-07	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
205A678P2									1	SCR	26-JB50-01
205A678P3									1	SCR	26-JB50-01
205A7104G1	GE-SCR144 GE-SCR162	B27140-63	895904	76319	1144084 1199325 245404	4905251 74905251 5118798-02	333614	1297270-17 5118798-01	9	Thermal Protector	37-7104-01

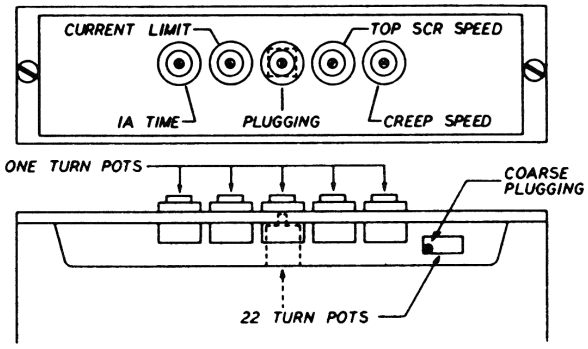
C290 (M300) REPLACEMENT PARTS LIST
Listed by GE part number in ascending order

General Electric	Baker	Barrett	Clark	Crown	Hyster	Kalmar AC (Allis Chalmers)	Towmotor/ Caterpillar	Yale	Ref. No.	Description	FSIP
205A7129P1	100018 106304 110923 226MAW1 226MBC1 26121-26125 GE-SCR132 GE-SCR152	A27788-17 B27140-57	1802210 889404 895899 899404 995138 995417 995665 998526 999095	76317 79812	1199323 274092 278931	4905234 4910571 4910919 74905234 74910571 74910919	301773 377087 377231	1294980-39 1297270-08 1301450-04 5118778-01 5169178-02 5169178-03	6	Capacitor	33-9053-FS
205A7130P1									6	Capacitor	33-9053-FS
218A4038P2									14	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
205A9053P2									6	Capacitor	33-9053-FS
68B997691G5			991421			4908226 74908226	654758	5170758-02	17	Receptacle	38-7691-05
IC4484A160									15	Card	11-AC0M-00
IC4484A161									15	Card	11-AC0M-00
IC4484A162									15	Card	11-AC0M-00
IC4484A166									15	Card	11-AC0M-00
IC4484A169									15	Card	11-AC0M-00
IC4484A170									15	Card	11-AC0M-00
IC4484A173									15	Card	11-AC0M-00
IC4484A176									15	Card	11-AC0M-00
IC4484A186									15	Card	11-AC0M-00
IC4484A189									15	Card	11-AC0M-00
IC4484A195	116175 GE-SRC146 GE-SRC147 GE-SRC148 GE-SRC169	B27140-47 B27140-81	895892 990447 990448 991423 991424 992930 993180 993700 994100	76320	1144085 1199326 1199496	4905252 4906483 74905252 74906483		1295040-67 1299420-78 5114098-01 5114098-03 5114098-06 5114098-09 5118808-01 5118808-09 5184688-09 5184688-17	15	Card	11-AC0M-00
See Our P/N									11	Insulator	43-N123-40
See Our P/N									12	Insulator	43-N500-00
See Our P/N									13	Heatsink	44-H500-00

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

C-185 (M-200)
C-290 (M-300)

PANELS



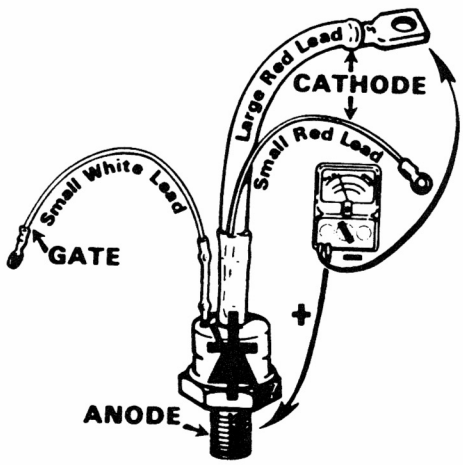
PRELIMINARY INFORMATION

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 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 wire 33 and the negative lead to wire 13.



B. Creep Speed Adjustment

1. Turn the Current Limit and Plugging potentiometers fully clockwise. This disables these functions to prevent any interaction during the speed adjustments. If the No. 1 card is equipped with a Coarse Plugging trimpot (accessible through the slot on the side of the card), turn it clockwise at this time.

   Note: The Plugging adjustment may be a square 22-turn trimpot. To disable, turn clockwise until the adjustment screw starts to drag or tick — or until it has been turned 22 times.
   Other than plugging, all controls are single-turn potentiometers. These should not be forced past their stopping point.

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. Remove wire 29 from the thermal protector on the panel. Install a jumper between this wire and negative at wire 13. Leave this jumper installed for Top Speed and Current Limit adjustments.
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 the table below.

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

TABLE I

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 with which it is to be used.

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 29 to wire 13 is installed. Block the 1A contactor 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	M200 (C185)			M300 (C290)		
	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 the jumper on wire 29, and the brake switch jumper. Also reconnect wire 29 to the Thermal Protector.

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 pulsing. 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 Adjustment**

1. Turn Plugging and Coarse Plugging potentiometers fully counterclockwise. At this point, the SCR panel will probably be completely disabled. Turn the Coarse Plugging adjustment clockwise until pulsing resumes and acceleration is normal. If this adjustment has been made critically enough. Plugging is now set for the least possible severity.

   Note: If your card uses 22-turn Plugging trimpot, a Coarse Plugging control is unnecessary. Make all adjustments from the 22-turn pot.
2. Plug the truck from top speed and adjust the Plugging control clockwise for the desired stopping distance. It may be necessary to touch up the Coarse Plugging pot if this stopping distance cannot be achieved.

AFTER THE TUNE-UP

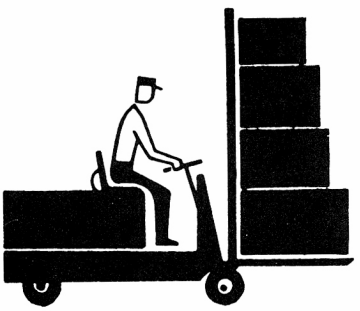
If you have trouble or do not understand the instructions, assistance is available to you at no charge by calling Flight Systems Technical Service.

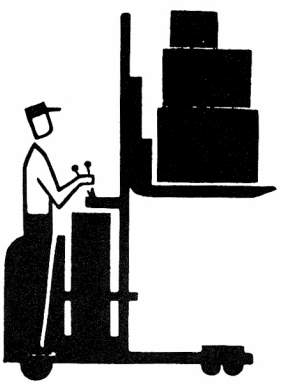
INSTRUCTIONS

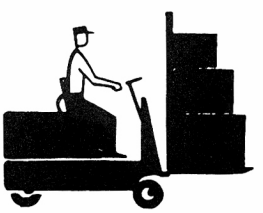
C-155—Model 100
C-185—Model 200
C-290—Model 300

IC 4483F

SCR CONTROL for ELECTRIC VEHICLES







CONTENTS

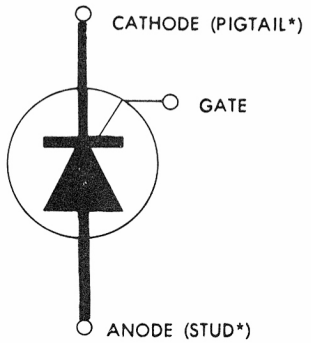
The information contained herein is intended to assist truck users and dealers in the servicing of SCR control furnished by the General Electric Company. It does not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation,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

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, 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.

PHOTOS OF CONTROL

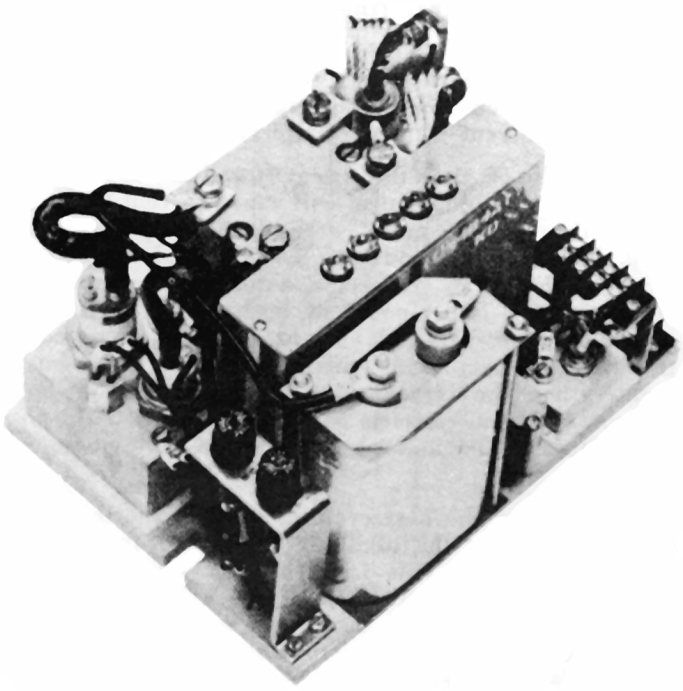


Figure 1

Typical SCR static panel.

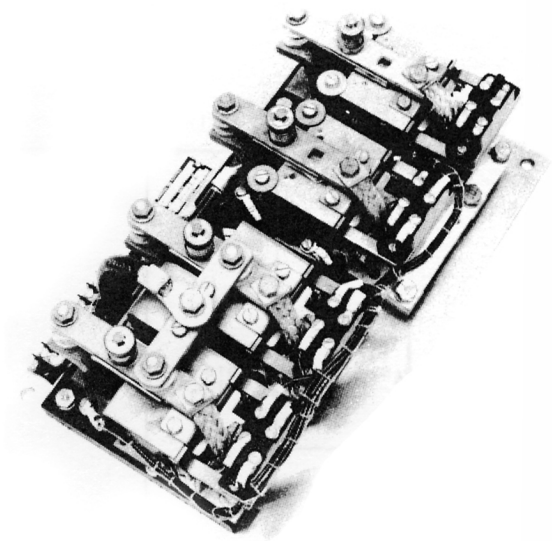


Figure 2

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

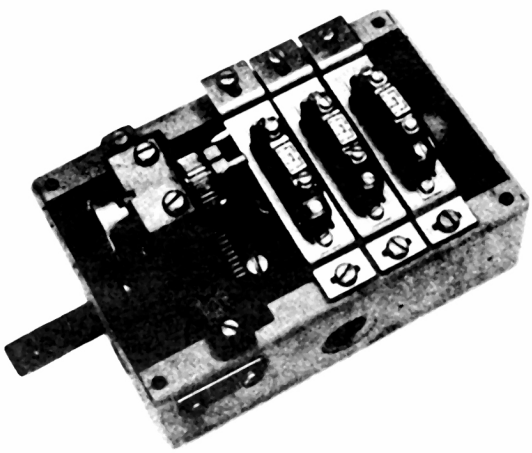
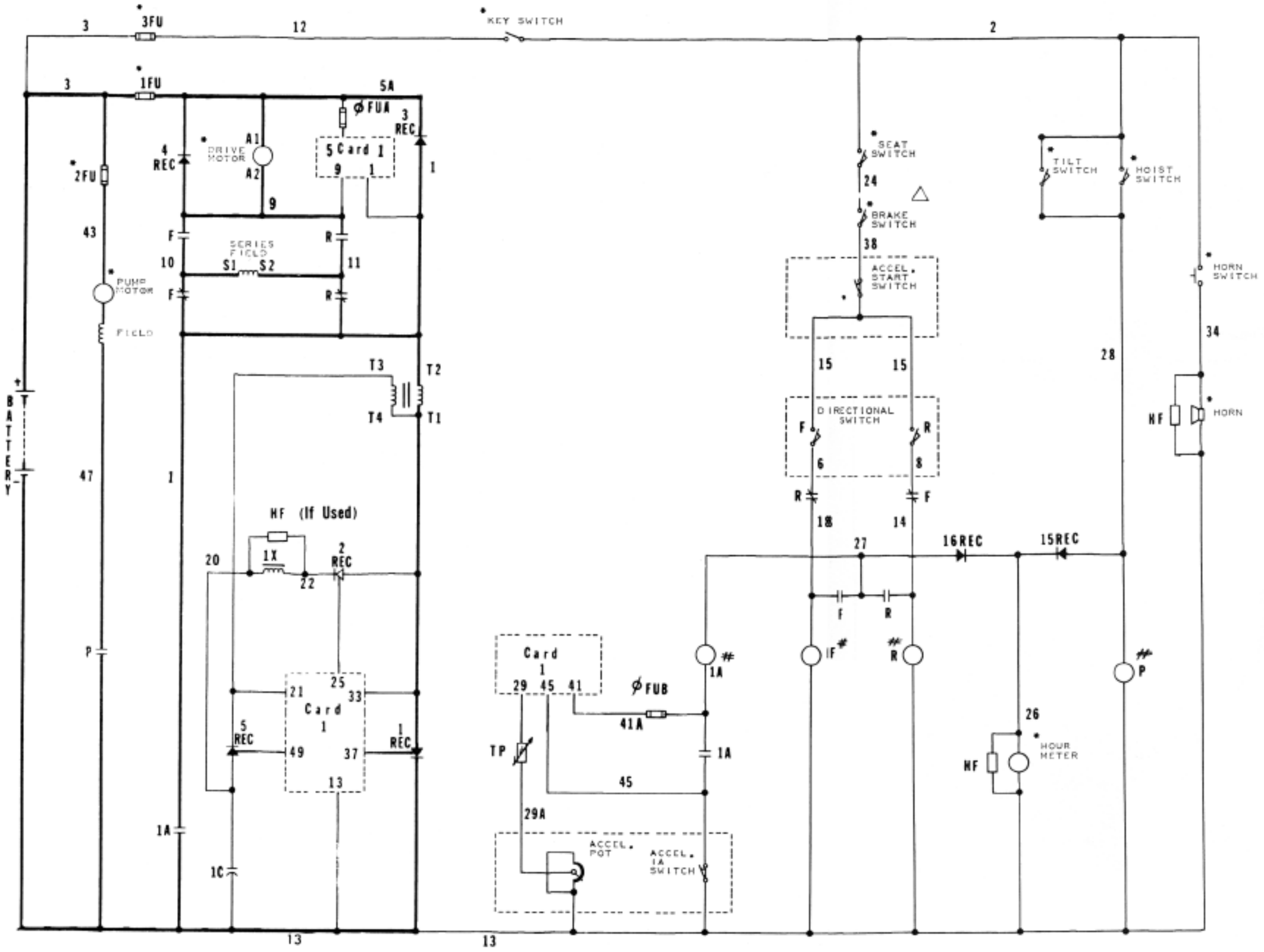


Figure 3

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



This diagram is typical and may not necessarily reflect all the details of every truck appplication. Refer to the diagram furnished with the vehicle. Wire numbers may be preceedeod with a "G" to distinguish GE numbers from truck manufacturer's wire numbers.

Figure 4—Typical elementary diagram, General Electric C-155/185/290) SCR control.

* Furnished by Truck Mfr.

HF Hash Filter

ø Fuses Required on U/L approved trucks.

Coils have integral filters, see page 12, paragraph 4 F.

△ N.C. Switch on sit down trucks. N.O. switch on stand up trucks.

CIRCUIT OPERATION

(See Figure 4)

The 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 an oscillator located in Card 1.

The oscillator section will oscillate only when it receives both positive power through the F or R interlock and a synchronizing control signal from the anode of 1 REC (wire 33). The oscillator output is fed from terminal 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, drives T3 below battery negative, causes current to flow from card 1 (wire 49) to the gate of 5 REC, turning 5 REC on. Current then flows from transformer secondary T4 through 1 REC, 1C, 5 REC and back to T3 charging 1C (wire 20) negative until the transformer saturates, reducing this current flow to zero, turning off 5 REC. The voltage of T3 then swings from negative to positive, causes current to flow from Card 1 (wire 25) to the gate to 2 REC, turning 2 REC on. 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.

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 of 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 70-90% 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.

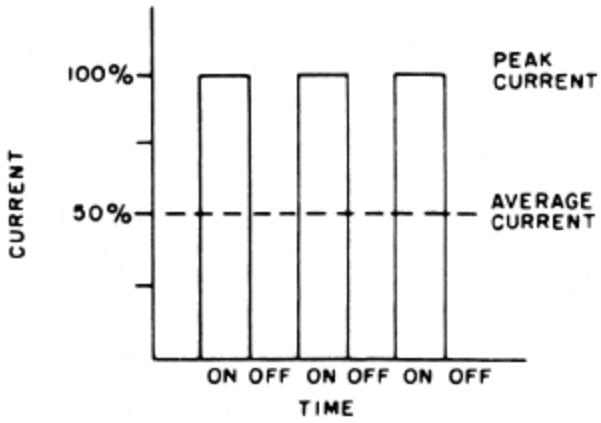


Figure 5—Battery Current

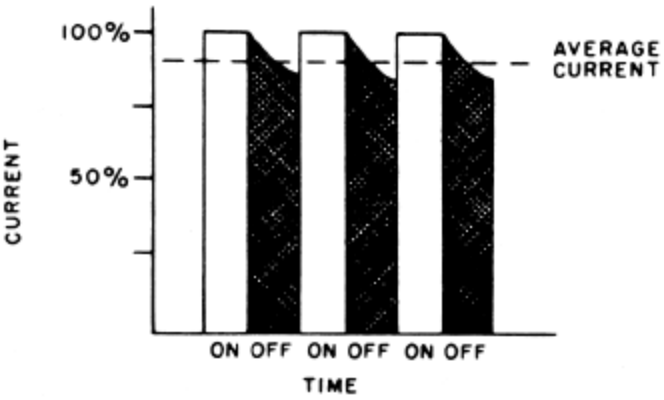


Figure 6—Motor Current

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 adjustable 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 buildup 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. A signal taken from 4 REC, when plugging current is present, is fed to Card 1 retarding the pulse frequency and provides a soft reverse stopping action. The distance or severity of the reversal is adjustable 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 adjustable 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 FAULT DETECTOR ..... (GEK-7940)

IC4484Y100D STATIC RETURN-TO-OFF CARD ..... (GEK-7941)

IC4484 FIELD-WEAKENING SYSTEM (GEK-8475)

IC3012BH ACCELERATOR MASTER SWITCH ..... (GEK-8073)

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 DON'TS 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 de-natured alcohol can be used to wash off the control and then blow completely dry with low pressure air or 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.

- 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.

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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 preceeded 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 for low specific gravity and connections for looseness or broken fittings.
1B.	Contactors do not pick up. Control volts present from positive to negative.	• (For these tests, if fault detector is used, disconnect wire 27 from fault detector terminal 3). • (See NOTE 1) Connect jumper from battery positive 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 battery positive move other end to wire 8 on F interlock or 6 on R interlock. Coils should pick up. This proves F and R 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 disconnected at SCR terminal board, check for control volts positive at SCR terminal board (wire 41) to negative (wire 13A). If there is zero volts at this point, check F or R normally open interlocks and 1A coil for continuity. • (See NOTE 1) With F or R picked up and wire 45 disconnected at SCR terminal board, check for control volts positive at 1 REC heat sink (wire 33) to negative (wire 13A). If there is zero volts at this point, check: F or R power tips, and continuity of wiring from battery positive to 1 REC heat sink. • Check FUB. NOTE 1: Drive wheels should be off the floor.

1C	(Continued)	• (See NOTE 1) With F or R picked up and wire 45 disconnected from SCR terminal board, measure approximately 3 volts from (wire 29) to negative (wire 13A) with accelerator pot near creep speed. Volts will drop to zero as accelerator is moved toward full speed. If readings are not correct, first place a jumper wire between wires 29 and 29A which bypasses the thermal protector. Depress the accelerator and check for the above voltage. If voltage readings are correct, replace thermal protector. If the above tests will produce no voltage change, place a jumper between wires 29A and 13A. 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 motor fails to operate, check card trimpot settings. • Check 1 REC for open circuit or open gate (See 4H). • Check card by replacement.
1D.	Contactors close, but very little power and high-pitch SCR hum.	• Check 2 REC for a shorted condition in the conducting direction (See 4H).
1E.	Contactors close. Very little or no power with low SCR hum, even when accelerator is in top SCR position.	• (See NOTE 1) Disconnect wire 9 from wire A2. Reapply power and if control operates normally, replace card. • (See NOTE 1) Check setting on card, creep speed and top speed. 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

	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 29A or shorted accelerator pot.
2B.	Contactors close. Full speed immediately with no audible hum.*	• Check for welded power tips on 1A contactor.
2C.	Contacts close. Full speed immediately with no audible hum.* Capacitor not charged.	• Check for open gate circuit to 5 REC (See 4H and 4Aa). • Check 5 REC for shorted condition (see 4H). • Check continuity of wiring from 1C to 5 REC and from 5 REC through T3, T4 to T1 and 1 REC wire 33. • Check capacitor 1C (See 4D). • Check 1 REC for short (See 4H).
2D.	Contactors close. Full speed immediately with no audible hum.* Capacitor Charged.	• Check for open 2 REC (See 4H). • Check for open gate in 2 REC (See 4H). • Check for open gate circuit to 2 REC (See 4Ab).

* If truck is equipped with a Fault Detector or Pulse Monitoring Trip and it fails to shut down the control on the above faults, check fault detector per GEK-7940 or GEK 28539 respectively.

Table 3

Misoperation of Special Features

	SYMPTOMS	WHAT TO DO
3A.	**Failure of 1A contactor to operate.**	● Check resistance of 1A coil. If resistance is much different from other contactor coils, replace coil. See GEH 3101 or GEH 3074A.
		● Drive wheels should be off the floor. Move negative jumper 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-8475
3C.	**Severe reversal.**	● Check settings of plugging trimpot on Card 1 (See 6Ad).
		● Check 4 REC (See 4G).
		● Check continuity of wires 5 and 9.
		● Check FUA (if used).
3D.	**Very soft reversal.**	● Check same as 3C.

Table 4

Checking Components

Before touching electrical components, disconnect the battery and discharge capacitor 1C.

4A CARD 1 (See Table 6 for tuneup of Card 1).

Items a) and b) are simple tests that can be performed with a volt-ohm meter. Remove card from panel by loosening two screws at bottom of box, pull box straight up to disengage from receptacle. Connection can be made to card pins with insulated clips.

a) 5 REC FIRING CIRCUIT:

VOM on RX100 scale. Connect VOM positive lead to pin 13, negative lead to pin 49, circuit should read 1700 to 2100 ohms. Reverse leads and read infinity.

b) 2 REC FIRING CIRCUIT:

VOM on RX100 scale. Connect VOM positive lead to pin 21, negative lead to pin 25; circuit should read 1170 to 1430 ohms. Reverse leads and read infinity.

c) 1A TIMER:

The 1A-timer section of Card 1 can be checked-out only when it is operating as part of a complete system. If 1A Timer does not appear to be operating properly and cannot be adjusted per Table 6Ae to obtain desired operations, remove Card 1 as directed above and replace with a card known to be good.

NOTE: The complete card (Card 1) can be checked out by the truck manufacturer by using a component tester available from the General Electric Co.

4B FIELD WEAKENING CARD (if used) GEK-8475.

4C FAULT DETECTOR (if used) GEK-7940.

PULSE MONITORING TRIP (if used) GEK-28539

4D CAPACITOR 1C

Disconnect battery and discharge capacitor. Remove 1 lead from 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 in green epoxy. For the varnish tape-wound type, a separate filter is required and will be mounted adjacent to the coil. The new green epoxy 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.

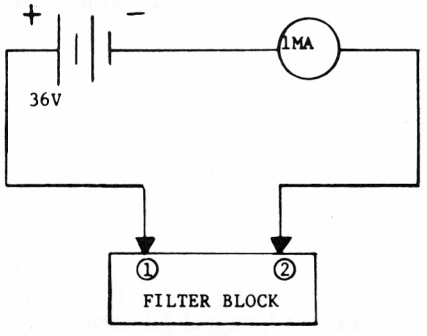


Figure 7

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 reassembling 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 non conducting 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. Remove card and box from panel and lay aside, this opens the gate circuits to all three devices. Disconnect pigtail of 1 and 2 REC or lead to terminal of 5 REC.

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.

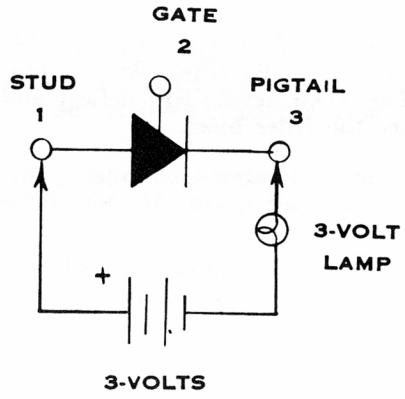


Figure 8

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. If SCR is shorted (Zero ohms), it must be replaced.

b) Measure resistance from gate lead (white lead) to pigtail and then from pigtail to gate lead. If resistance reads either zero ohms (shorted) or infinity ohms (open), replace the SCR.

When reassembling SCR's, refer to Table 5.

4I POTENTIOMETER IN ACCELERATOR

To check operation of the potentiometer, disconnect battery and disconnect wire 29A from thermal protector or SCR terminal board. Connect V OM from wire 29A to negative (13A) with scale set to RX 100. 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 reading of 10 to 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 because these adjustments are so designed that they do not interact when near their proper setting.

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. Remove wire 29 from the thermal protector and connect a jumper from wire 29 to negative (pigtail of 1 REC).

   NOTE: Be sure to insulate or wrap the jumper connection to wire 29 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 Amp	100
300 or 400 Amp	200
400 or 500 Amp	300

   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 (ie. a 500 amp rating to read 100 amps), 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 41). 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 on the ground check creep speed of truck as F or R contactor operates.

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 6Bd and read motor volts to see if it falls within values given in Table 6Bd.

Disconnect shunt, voltmeter, and jumper to wire 29, and reconnect wire 29 on the thermal protector.

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 6Bd and within the rating specified by the truck manufacturer.

NOTE: DO NOT STALL the motor for more than 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 29, and reconnect wire 29 on the thermal protector.

d) STATIC PLUGGING

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

NOTE: There may be a coarse trimpot adjustment on the card accessable from the slot on the side of the card box.

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 thru e.

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.) Adjust CREEP SPEED as desired.

d) 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 loaded level amperes with motor directly across the battery and motor fields connected the same as are used in the SCR control.

Typical Battery Current	SCR Model
45 - 50 Amps	100
75 - 80 Amps	200
120 - 130 Amps	300

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

		CURRENT LIMIT AMPS (MAXIMUM)		
Battery Volts	Motor Volts	C155 Model 100	C185 Model 200	C290 Model 300
12	7 - 9	100	200	300
18	13 - 15	100	200	300
24	17 - 20	100	200	300
36	25 - 32	100	200	300
48	34 - 43	*	185	300
72	50 - 65	NA	150	300

* Refer to vehicle manufacturer

e) CURRENT LIMIT

Turn the current limit trimpot fully counterclockwise. When the trimpot is fully counterclockwise, the card is designed so that the control may be cut off (no pulsing occurs).
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 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 to correct value, disconnect meter and reconnect wire 29 to the thermal protector.

f) 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 may cut off control operation no pulsing). This will give the longest distance for stopping. If pulsing of the control has stopped, turn plugging trimpot clockwise (clockwise rotation decreases stopping distance) until control just starts to pulse. Then turn the trimpot about 30 degrees more clockwise rotation and try truck for stopping distance. If stopping distance is too short or too long, continue to adjust trimpot until desired stopping distance is obtained.

If the desired stopping distance cannot be obtained, there may be a coarse trimpot adjustment on the card that is accessible from the slot on the side of the card box. This may be turned CW or CCW to give extended range to the normal plugging trimpot.

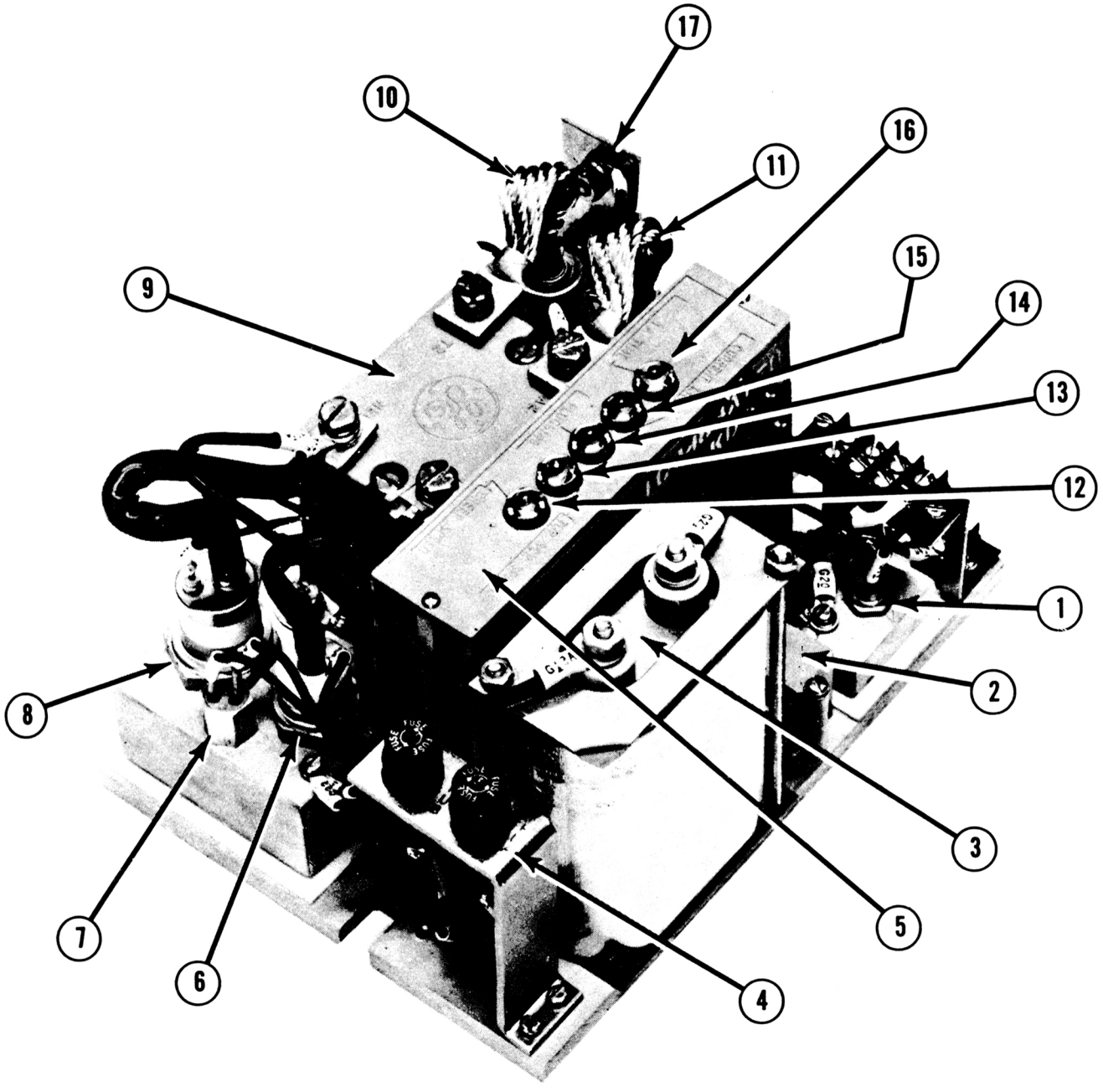
g) 1A TIMER

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.

After all the trimpots have been set, each should be sealed with a silicon rubber compound such as RTV (bath-tub sealer). This will discourage further adjusting by unauthorized personnel.

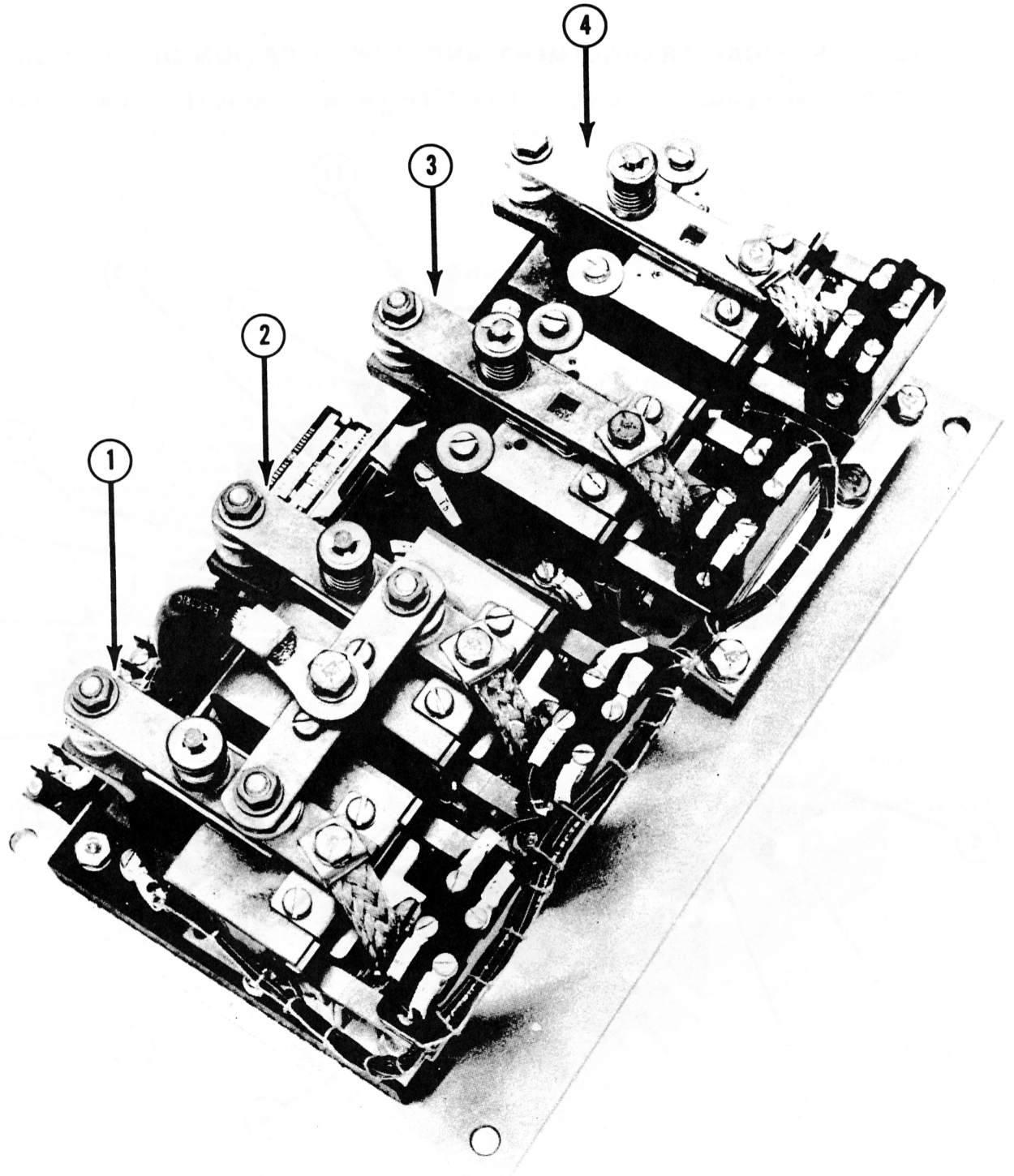
TYPICAL PHYSICAL ARRANGEMENT AND IDENTIFICATION OF COMPONENTS

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



(1) BLOCKING SCR (5 REC)
(2) CHOKE (1X)
(3) COMMUTATING CAPACITOR (1C)
(4) CONTROL CIRCUIT FUSES
(5) OSCILLATOR CARD (CARD 1)
(6) TURN-OFF SCR (2 REC)
(7) THERMAL PROTECTOR
(8) MAIN SCR (1 REC)
(9) PULSE TRANSFORMER (1T)
(10) FLY-BACK DIODE (3 REC)
(11) PLUGGING DIODE (4 REC)
(12) CREEP-SPEED ADJUSTMENT
(13) TOP-SPEED ADJUSTMENT
(14) STATIC-PLUGGING ADJUSTMENT
(15) CURRENT-LIMIT ADJUSTMENT
(16) 1A TIMER ADJUSTMENT
(17) PLUGGING SENSOR

Figure 9—Typical SCR Static Panel.



(1) FORWARD CONTACTOR (F)
(2) REVERSE CONTACTOR (R)
(3) BY-PASS CONTACTOR (1A)
(4) PUMP CONTACTOR (P)

Figure 10—Typical Magnetic Panel.

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