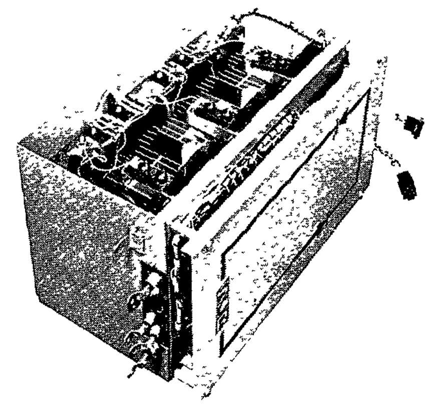
INSTRUCTIONS

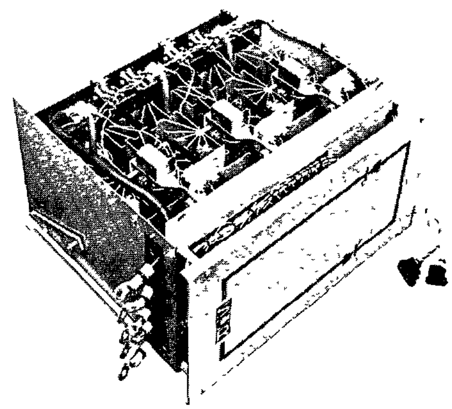
GEK-11015A

SCR CONVERSION MODULES
FOR
SILCON VI* SCR DRIVES

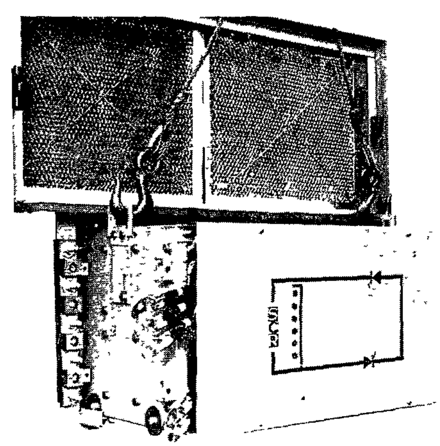
OPERATION – TROUBLE SHOOTING – REPAIR



SMALL



MEDIUM



LARGE

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

GENERAL ELECTRIC

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WARNING

HIGH VOLTAGE. ELECTRIC SHOCK CAN CAUSE SERIOUS OR FATAL INJURY. WHETHER THE AC VOLTAGE SUPPLY IS GROUNDED OR NOT, HIGH VOLTAGES TO GROUND WILL BE PRESENT AT MANY POINTS WITHIN THE SCR DRIVE. EXTREME CARE MUST BE EXERCISED IN THE SELECTION AND USE OF TEST INSTRUMENTS.

OPERATORS SHOULD NOT STAND ON GROUNDED SURFACES OR BE IN CONTACT WITH GROUND WHEN APPLYING TEST INSTRUMENTS TO TEST POINTS. TEST INSTRUMENTS SHOULD NOT HAVE CHASSIS GROUNDED WHILE TESTS ARE BEING MADE. THUS THEIR CHASSIS WILL BE AT A HIGH VOLTAGE WITH RESPECT TO GROUND DURING TESTING. EXTREME CARE SHOULD BE TAKEN WHILE ATTEMPTING TO ADJUST, TROUBLESHOOT OR MAINTAIN ANY DRIVE SYSTEM DESCRIBED HEREIN.

INSTRUCTIONS

GEK-11015A
ERRATA SHEET
NUMBER ONE

SCR CONVERSION MODULES
FOR
SILCON VI* SCR DRIVES

OPERATION **TROUBLE SHOOTING** **REPAIR**

ERRATA SHEET: Affects GEK-11015A, Page 4

This errata sheet should be attached inside the front cover of GEK-11015A, and retained as a part of this book.

The instruction book text should be changed in accordance with information contained in this errata sheet. Revised areas of the text are indicated by a star (★).

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★ Wording added, changed, or deleted.

TROUBLE SHOOTING - Page 4

Under "Checking for Malfunctions" add:

★ "NOTE: When using an oscilloscope without a differential amplifier to check the operation of the pulse transformer card, the common (chassis) lead of the oscilloscope should be connected only to the F or C terminals. Connecting the oscilloscope common lead to any other point(s) on this card may cause improper operation of the drive by permitting firing of SCRs at incorrect times."

SPEED VARIATOR DEPARTMENT

GENERAL ELECTRIC

ERIE, PENNSYLVANIA

SCR CONVERSION MODULES
FOR
SILCON VI* SCR DRIVES

INTRODUCTION

The SCR conversion module is the power building block in the SCR conversion assembly. It converts three phase A-C power into adjustable voltage D-C power. The voltage is controlled by means of gate pulse signals fed from the driver module. The SCR conversion module consists of the power conversion circuit, protective components and circuitry, firing circuitry, and feedback circuitry, all mounted together in one package.

The power conversion circuit is a three phase, full wave bridge, each of its six legs containing a silicon controlled rectifier (SCR). This arrangement can furnish unidirectional current, and can control the voltage output in either polarity as long as output current is drawn; that is, it can power a D-C motor in both the first and fourth quadrants. When two of these modules are connected back-to-back, they can power a D-C motor through all four quadrants.

The SCR conversion module is packaged in three different physical sizes, according to the current rating required. These packages are all of draw-out construction to facilitate maintenance. The power connections are flexible cables for terminal board termination, while the control leads are terminated by two plug-in connectors.

RATINGS AND SPECIFICATIONS

1. A-C Power Input

(a) Voltage—three phase;
low voltage—230 volts +10%, —5%;
high voltage—460 volts +10%, —5%

(b) Frequency—60 or 50 cps

2. D-C Power Output

(a) Voltage—controllable over the following maximum ranges at —5% A-C voltage:

Conversion Type	Controllable D-C Voltage Range	
	Motoring	Regenerating
Low Voltage	0 to 285 volts	0 to 250 volts
High Voltage	0 to 570 volts	0 to 500 volts

(b) Current—depending on cooling, overload requirements and ambient temperature, the conversion module rating is matched to the D-C motor rating.

3. Control Input

(a) Gate pulses—six gate pulses spaced 60 degrees apart, each capable of being phase shifted over a range of 150 electrical degrees; each pulse to be at least 15 volts in magnitude (at 15 milliamps loading) and be at least 10 microseconds, but no more than 50 microseconds, in width.

(b) Power supply—+20 volts D-C for operation of gate pulse amplifying circuitry.

4. Control Output

(a) Voltage feedback—0 to ±10 volts D-C for rated operating voltage range.

(b) Current feedback—0 to +5 volts D-C for rated operating current range.

(c) Thermostat interlock—normally closed interlock which opens for excessive SCR heat sink temperature.

PRINCIPLES OF OPERATION

It will be helpful in understanding the following theory of operation to refer to the SCR conversion module elementary diagrams. A copy of the diagram, which applies to the specific drive furnished, will be found in the diagram section.

SCR POWER CONVERSION

The function of converting A-C power to adjustable voltage D-C power is performed by silicon controlled rectifiers (SCR's). The SCR is a semiconductor device which can block voltage in both directions, but is capable of conducting current in one direction when "fired" by a proper gate signal. With reverse voltage applied, the SCR behaves the same as a diode rectifier. With forward voltage applied, the SCR will block current until it is switched into the conducting state by means of a gate signal. The SCR will remain in the conducting state even after gate signal is removed, as long as forward current is maintained. Controlling the instant in time, relative to the A-C voltage wave, when the gate signal is applied to the SCR controls the amount of D-C voltage and current that is furnished to the load.

The SCR conversion module uses six SCR's connected together to form a three phase, full wave bridge. Each SCR is mounted on a separate aluminum heat sink. The heat sink transmits the heat produced inside the SCR to the surrounding air. Convection cooling is adequate for the smaller conversion modules, however the larger ratings require forced cooling to achieve their optimum power ratings.

The operation of the three phase SCR bridge in converting A-C power to adjustable voltage D-C power is best explained by referring to Figures 1 through 6. These figures show the A-C voltage and D-C voltage wave shapes into and out of the SCR bridge, plus the voltage wave shape across each SCR. The first three figures show control of the SCR bridge in the motoring mode; that is, with positive voltage output and positive current output, or first quadrant operation. The last two figures show control of the SCR bridge in the regenerative mode; that is, with negative voltage output and positive current output, or fourth quadrant operation. The voltage wave shapes shown in these figures are all based on loaded operation. This means that for the regenerative cases, the load must be capable of delivering power (that is, both voltage and current) to the SCR conversion bridge.

Figure 1 shows the voltage wave shapes for the zero degree phase back condition, or full advance. This is not a normal operating condition since it is the absolute maximum output voltage obtainable. It is shown to provide a starting point to understanding SCR operation. To obtain this operating condition each SCR must be fired as soon as forward voltage appears across it. The operation is therefore the same as if the bridge consisted of diode rectifiers.

Figure 2 shows the effects of delaying the SCR firing 30 degrees in time with respect to the zero phase back condition. Note that the average voltage level has decreased.

Figure 3 shows the voltage wave shapes for the 60 degree phase back condition. The D-C voltage wave varies from almost the peak value to zero, six times a cycle. This would produce high peak to average D-C current in the D-C motor armature if it were not for the smoothing effect of armature inductance. (See Figure 18 in the "Trouble Shooting" section.)

Figure 4 shows the 90 degree phase back condition under sufficient load to keep current continuous. Notice that the average voltage is actually zero. This would be motor stall condition if the IR drop voltage were neglected. Since current, and therefore IR drop, can only have positive values, the motor CEMF would have to be slightly negative in practice to obtain zero terminal voltage, loaded operating condition.

Figure 5 shows the voltage wave shapes for the 120 degree phase back condition. This is a regenerative operating condition since the D-C voltage is negative and the D-C current is positive. This condition is obtained when motor rotation has been reversed by action of the motor load. The SCR drive is holding back by means of positive current, and therefore positive torque, to oppose the negative speed and voltage.

Figure 6 shows the 150 degree phase back condition, which is the maximum allowable phase retard. The current must be switched (commutated) from one A-C supply line to the next while correct polarity voltage still exists to turn off the first SCR. If the SCR firing is retarded to the 180 degree phase back condition, there is no commutating voltage available to turn off the preceding SCR, and a plugging condition will result. Therefore a 30 degree margin for SCR commutation is reserved.

PROTECTIVE COMPONENTS

The protective components described below are all included in the SCR conversion module to protect the SCR's.

Thyrectors are connected across the A-C supply lines to suppress voltage transients. They are special selenium rectifiers which break down momentarily to limit voltage transients to a safe value. After absorbing the energy of the transient, they reform themselves.

Series resistor-capacitor networks are also connected across the A-C supply lines, and across the D-C output, to suppress voltage transients. Additional R-C networks are connected across each SCR, both to suppress voltage transients and to limit the rate of rise of voltage (DV/DT) across the SCR. If the DV/DT applied to the SCR in the forward direction exceeds a certain value, the SCR could be turned on.

Chokes are placed in the SCR bridge to limit the rate of rise of voltage (DV/DT) applied to each SCR and also the rate of rise of current (DI/DT) through the SCR when it switches on. If the DI/DT through the SCR at turn-on exceeds a certain value, the cell may be destroyed. The combination of chokes and R-C circuits across the SCR's limit both DV/DT and DI/DT to well within safe operating limits. The chokes (reactors) also act with the R-C circuits and thyrectors to limit A-C line voltage transients to safe limits. When SCR conversion modules are operated in parallel, these chokes also provide for load sharing between conversion modules.

A thermostat mounted on an SCR heat sink monitors heat sink temperature. This protects against high ambient temperatures, loss of cooling air or excessive overloading of the SCR conversion module. Operation of this thermostat shuts down the drive through the monitor card in the driver.

Leg fuses are included in those large SCR conversion modules which are used in drives whose rating requires parallel modules. The function of each leg fuse is to isolate the SCR in that leg from the rest of the power conversion circuit in the event an SCR fails. This isolates the fault and allows the rest of the power circuit to continue operating. Indicating lights are connected across the SCR's on these modules to detect a failure. The light indicates during normal operation but goes out if the cell fails and/or the leg fuse blows.

SCR FIRING CIRCUITRY

The function of the firing circuitry in the SCR conversion module is to amplify the gate pulse signals from the driver and to electrically isolate the driver from the SCR's. This isolation function is achieved by means of pulse transformers which isolate the SCR gate leads (which are at A-C line potential) from the gate pulse circuitry. Amplification is achieved by single stage transistor amplifiers feeding the pulse transformers. This use of gate pulse signal amplification in each SCR conversion module enables a single set of gate pulse generator cards (in the driver) to control several paralleled SCR conversion modules. All of the SCR firing circuitry is contained on a printed circuit card which is mounted in the SCR conversion module.

FEEDBACK CIRCUITRY

The feedback circuitry includes both current feedback and voltage feedback elements. The voltage feedback circuit is a simple resistor bridge which reduces the rated output voltage of the SCR conversion module to a value of 10 volts for feedback to the driver. There are two resistor bridge ratios used; a 25 to 1 voltage reduction for 250 volt conversion modules and a 57 to 1 voltage reduction for 500/550 volt conversion modules. The voltage feedback is taken from terminals V1 and V2 (as shown on the SCR conversion module elementary diagram). This symmetrical circuit allows cross connection of the voltage feedbacks at the driver when using back to back SCR conversion modules.

The current feedback circuitry consists of three A-C current transformers plus rectifiers and loading circuitry. The current transformers are mounted on the incoming A-C supply lines of the SCR conversion module. The output of each current transformer is rectified and the three rectified outputs are summed together. This rectification and summation of the three A-C line currents produces a current signal of the same wave shape and having a constant ratio of magnitude to the D-C output current of the SCR conversion module. The current signal is changed into a voltage signal by means of a selected value of loading resistance. The correct loading resistor is chosen, depending on the drive rated current, by means of the XA to XD taps. The correct loading produces about a 5 volt current feedback signal at rated drive current. Diode D803 produces a .6 volt output at very low currents to operate the lockout circuits in the reversing driver. Diode D804 is used only when SCR conversion modules are paralleled, to prevent the operation of one SCR conversion module from affecting another when the current feedbacks are summed in the signal distribution assembly. With these diodes in the circuit, if any one conversion module is overloaded it will be the determining current feedback to the driver. All of the current feedback circuitry is contained on a printed circuit card mounted in the SCR conversion module.

OPERATION AND ADJUSTMENTS

The SCR conversion module is ready for operation as soon as the five power leads are connected to the terminal board on the supporting rack and the two control cables are plugged into the receptacle on the supporting rack. The A-C power leads must be connected to the correct terminals as labeled to maintain correct phase sequence. The two control cables cannot be plugged into the wrong receptacles or be plugged in upside down.

CURRENT FEEDBACK LOADING SELECTOR

The only adjustment in the SCR conversion module is the selection of the correct loading resistor on the current feedback card. The table on the SCR conversion module elementary diagram gives the correct tap (XA to XD) to use for the specific drive horsepower rating. These taps are fast-on connectors on the current feedback card, the movable jumper being plugged into one of them to select the correct loading resistance. This selection has been made at the factory and should not be changed unless a change in protective current feedback or instantaneous overcurrent trip range is desired which cannot be taken care of by adjustments in the driver.

TROUBLE SHOOTING

GENERAL APPROACH

When incorrect operation is first noticed, it is often possible to reduce the overall servicing time by studying the symptoms in order to localize the trouble. A good understanding of the functional operation, as explained in the "Principles of Operation" section, will be very helpful in isolating the problem. A systematic check of voltage wave shapes and comparison of them with the correct readings, as given later in this section, should reveal the source of many malfunctions.

The use of a good quality oscilloscope is required to properly trouble shoot this equipment.

WARNING

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The use of an oscilloscope with a differential amplifier will result in much greater safety to operating personnel, since the oscilloscope chassis may then be grounded. However, much greater care in the selection of probes and leads and in the adjustment of the oscilloscope must be used to produce accurate readings. The D-C balance and the voltage gain calibration of each channel must be accurately adjusted to obtain common mode voltage rejection. When properly adjusted, good results can be obtained with the differential amplifier connected oscilloscope for most readings. However, unless the common mode voltage rejection is perfect, it may be difficult to obtain accurate readings of low voltages such as SCR gate signals.

No matter which oscilloscope connection is used, voltage attenuating probes will be required for most readings. The probes should be adjusted for correct frequency compensation using the voltage calibrator as a square wave standard. The vertical gain and the sweep speed should also be calibrated to allow interpretation of observations.

CHECKING FOR MALFUNCTIONS

1. **Missing output voltage and current pulses causing unbalanced wave shape**

   (a) Check for firing pulses at input to pulse transformer card (terminals D1 and F1, D2 and F2, etc.) and at output of card to SCR's (terminals 1G and 1C, 2G and 2C, etc.), and compare with those given in Figures 20 and 21 of the voltage wave shape check list. If no input is present, check the pulse train outputs of the driver gate pulse generators (see GEK 11016A). If input is OK but no output is present, pulse transformer card must be defective and should be replaced.

   (b) Check SCR's to see if one of them is open or will not fire. Use the test circuit and follow the instructions under "Checking SCR's" in this section.

2. **Cannot obtain any output voltage or current**

   (a) Check for firing pulses at input to pulse transformer card (terminals D1 and F1, D2 and F2, etc.) and at output of card to SCR's (terminals 1G and 1C, 2G and 2C, etc.) If no input is present, check the pulse train outputs of the driver gate pulse generators (see GEK 11016A) and the cable connections between the driver and SCR conversion module. If inputs are OK but no outputs are present, check 20 volt power supply to pulse transformer card terminals A and B. If no voltage is present, check power supply output at driver and cable connections in between. If 20 volts is present at terminals A and B, pulse transformer card must be defective and should be replaced.

(b) Check for A-C power at incoming leads of SCR conversion module.

3. One large output voltage and current pulse which cannot be turned off and causes unbalanced wave shape

(a) Check for one SCR not being able to hold off forward voltage. Disconnect the pulse train cable (ICA or 3CA) from the SCR conversion module and apply A-C power. Connect oscilloscope across each SCR, one at a time (T1—P1, T2 — P1, T1 — P3, P2 — T1, P2 — T2 and P2 — T3), and check voltage wave shape across SCR in the forward direction. Observe for SCR firing, or the voltage being lower across one SCR in the forward direction than the others. Also check SCR's with multimeter for excessive leakage as explained under "Checking SCR's" in this section. If a defective SCR is suspected, it should be replaced and the module rechecked.

(b) Check gate pulse generator balance (see driver trouble shooting notes in GEK 11016A).

4. SCR conversion module trips out A-C breaker when energized

(a) Check for shorted SCR (see instructions under "Checking SCR's" in this section).

(b) Check for loose power connections or shorted bus bar. Use multimeter selected to read ohms to check for shorts.

5. SCR indicating light on large SCR conversion module not lit

(a) Check for shorted SCR (see instructions under "Checking SCR's" in this section). Also check for blown leg fuse on paralleled modules by reading resistance between terminal T1 and test point R1, T2 and R2, etc. with A-C power off. Unless zero resistance is observed, fuse is blown and should be replaced. See instructions in "Repair and Replacement" section of this instruction for replacement of defective SCR's and blown leg fuses.

6. Paralleled SCR conversion modules not sharing current

(a) Check for firing pulses into and out of pulse transformer card, for a defective SCR, or for presence of A-C power at module terminals. See instructions under malfunctions number 1, 2 and 3 above.

(b) Check for shorted SCR's and blown leg fuses per instruction under malfunction number 5 above.

7. No current feedback signal or distorted current feedback signal

(a) Check current feedback signal at test points A1 and A2, and compare with those given in Figures 18 and 19 of the voltage wave shape check list. If missing or distorted, check output of current transformers at terminals J1 and J2, J3 and J4, and J5 and J6 on the current feedback card, and compare wave shapes with those given in Figures 16 and 17.

If the current transformer outputs are all OK, but some of the pulses are missing at card output terminals A1 and A2, the current feedback card is defective and should be replaced. If the output of one of the current transformers is missing or distorted, the current transformer may be defective. Before removing the conversion module to replace the suspected current transformer, try to check the D-C current on the oscilloscope across a shunt to determine if a defective SCR or blown leg fuse is causing the trouble.

8. No voltage feedback signal

(a) Check voltage feedback signal at test points V1 and V2 and compare with wave shapes given in Figures 8 and 9, and with wave shape measured across P1 and P2 power terminals. If no signal across V1 and V2, check resistors and continuity of RES12, RES13, and RES14 circuit.

9. Thermostat open, or trips often

(a) If thermostat trips, shut off A-C power immediately and carefully feel SCR heat sinks. If all heat sinks are too hot to hold, check for air flow obstruction and for correct fan air flow (if forced cooled). If only a few heat sinks are hot, check for unbalanced operation (see malfunctions number 1, 3 and 6 above). If none of the heat sinks seem excessively hot, the thermostat may be defective. There are three different thermostats used depending on conversion module (175°F, 195°F and 205°F). Refer to the renewal parts list for correct rating.

10. Erratic operation with motor load

(a) Check for correct phase sequence; should be 1-2-3 for input power terminals T1, T2, and T3. Also check for correct SCR firing order: 2SCR, 4SCR, 3SCR, 5SCR, 1SCR, 6SCR, 2SCR, 4SCR, etc.

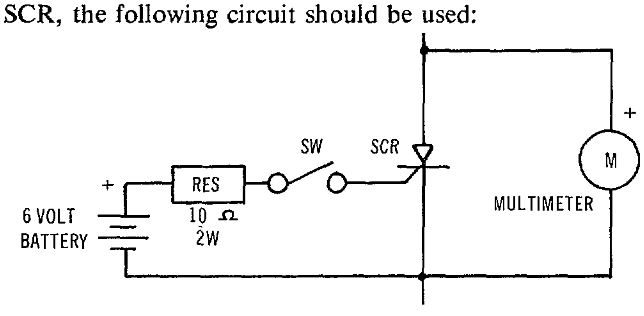
(b) Check for excessive DV/DT spikes across SCR's and wide voltage notches in A-C voltage wave. If a number of large SCR drives are operating off of the same A-C supply, line filtering may be necessary. Consult the General Electric Co.

CHECKING SCR's

Disconnect the A-C power and make sure the D-C armature loop contactor is open. Using a multi-meter selected to read ohms on the times—1K scale, check the forward and reverse resistance of each individual SCR cell. This is done by reading across power terminals T1 and P1, T2 and P1, T3 and P1, P2 and T1, P2 and T2, and P2 and T3. If the conversion module contains fuses for paralleling duty, test points R1, R2, R3 etc. should be used instead of terminals T1, T2 and T3. (See conversion module elementary diagram.) Good or faulty SCR's will give the following typical readings:

SCR Description	Forward Reading	Reverse Reading
Good SCR	100K to Infinity	100K to Infinity
Shorted SCR	Zero	Zero
Inoperative SCR	1 to 2K	100K to Infinity
Open SCR	100K to Infinity	100K to Infinity

Since an open SCR will give about the same resistance reading as a good SCR, another method must be used to find this type of fault. It should be pointed out however, that practically all cells fail by shorting and very few by opening. If an open SCR is suspected, or if it is desired to check the switching operation of an SCR, the following circuit should be used:



The multimeter is selected to read ohms on the 1K scale, and is connected to read the forward resistance of the SCR. When switch SW is closed, the forward resistance of a good SCR will change from a high value (100K to infinity) to a low value (1 to 10K). When the switch is opened, a good SCR will revert to its high forward resistance or blocking state. A faulty SCR will not switch, remaining in either an open or a conducting state.

If any SCR's are suspected of being faulty from the above resistance checks, the SCR conversion module should be removed from the case. See instructions in the "Repair and Replacement" section of this instruction. After the SCR pigtail (cathode) and gate leads have been disconnected, recheck the forward and reverse resistances before replacing the SCR heat sink assembly. This should be done before an SCR is definitely classified as damaged or faulty, since a fault in another SCR or another part of the circuitry can produce a faulty reading from a good SCR before it is disconnected from the circuit.

VOLTAGE WAVE SHAPE CHECK LIST

Voltage Wave Shape	Fig. No.
A-C voltage input, under load	7
D-C voltage output, motoring, under load	8
D-C voltage output, motoring, no load	9
D-C voltage output, regenerating, under load	10
D-C voltage output, regenerating, no load	11
SCR cell voltage, motoring, under load	12
SCR cell voltage, motoring, no load	13
SCR cell voltage, regenerating, under load	14
SCR cell voltage, regenerating, no load	15
A-C current, full load	16
A-C current, no load	17
D-C current, full load	18
D-C current, no load	19
Firing pulse train input (to card)	20
Firing pulse train across SCR gate	21

The firing order, and applicable pulse train order, is 2SCR, 4SCR, 3SCR, 5SCR, 1SCR, 6SCR, 2SCR, 4SCR, etc.

Also refer to the D-C and SCR voltage wave shapes given in "Principles of Operation" section as Figures 1 through 6. These diagrams do not show firing notches but are otherwise similar to actual readings.

REPAIR AND REPLACEMENT

SMALL CONVERSION MODULE (Figure 22)

1. Removal of module from case

(a) Remove the front cover from the module by removing 4 screws.

(b) Disconnect the 5 power leads.

(c) Unplug the 2 control harnesses at the right side of the case.

(d) Remove the 2 screws holding the module in its supporting frame.

(e) Pull the module slowly out of its frame.

(f) Place the module on a work bench in the same orientation it was in the case.

2. Replacement of SCR cell-sink assembly

Front Sinks

(a) The 3 front sinks are removed by sliding them out of the top side. First, unbolt the pigtail (cathode) of the cell to be removed, lift off the small white wire held by this same bolt.

(b) Disconnect the gate (white) and the control cathode (red) leads at the 2 pull-off tab connections. Pull or pry on the tab connector itself, and not on the wire.

(c) Note the bus bar which connects the sink to the choke. Loosen but do not remove the bolt at the choke end of the bus bar.

(d) Loosen the bolt at the other end of the bus bar and remove the bus bar. The bus bar ends are slotted.

(e) Slide out the heat sink, cell, bus bar assembly.

(f) Remove the short bus bar from the sink.

(g) Fasten the bus bar to the new cell-sink assembly.

(h) Slide the sink into the module.

(i) Place the bus bar into position and bolt it to the heat sink bus bar.

(j) Tighten the bolt at the other end of the bus bar.

(k) Connect the gate (white) lead to the terminal marked "G" and the control cathode lead (red) to "C".

(l) Fasten the pigtail (cathode) and the small white wire.

Rear Sinks

(m) The 3 rear sinks are removed by sliding them out of the bottom side. Turn the module so that it rests on its top. However, if the left rear sink is to be removed, disconnect the 2 wires S1 and S2 (tab connections) from the thermal switch on this sink before turning this module on its top. These wires are accessible from the top.

(n) With the module resting on its top, unbolt the pigtail of the cell-sink assembly to be removed.

(o) Disconnect the gate and control cathode leads.

(p) Loosen but do not remove the 3 nuts on the studs of the single bus bar which connects the 3 sinks together.

(q) Lift this bus bar carefully and place it on top of the front 3 sinks. Note the wires still attached to it.

(r) Loosen 2 nuts and remove the retaining strip which holds the 3 sinks in place.

(s) Slide out the heat sink and cell assembly.

(t) Remove the short bus bar from the sink and fasten it to the new sink.

(u) If the old sink has a thermal switch, remove the switch and fasten it to the new sink.

(v) Slide the new sink into the module until it bottoms against the insulating bar.

(w) Fasten the retaining strip tight against the sinks.

(x) Put the bus bar in place. The bus bar should go next to the sink bus bar. The small wire terminals should be next to the washers. Tighten the 3 nuts.

(y) Connect the gate lead (white) to terminal "G" and the cathode control lead (red) to "C".

(z) Fasten the pigtail.

(z1) Turn the module over and connect the 2 leads to the thermal switch. (Left rear sink only).

3. Re-installing module in case

(a) Slide the module into the case on the guide rails.

(b) Fasten the 2 screws holding the module in place.

(c) Plug in the 2 control harnesses. The plugs are different sizes and are keyed to permit only the proper connections.

(d) Fasten the 5 power leads.

(e) Install the front cover with 4 screws.

4. Re-placement of SCR cell on heat sink (not recommended)

(a) Remove the cell nut, lock washer and flat washer. Note the position of the cell hex body and pigtail with respect to the sink before removing the nut.

(b) Lift out the cell.

(c) Wipe the sink surfaces clean at the cell mounting hole. Remove any burrs that would prevent proper seating of the cell. Do not wire brush or sand the mounting surface.

(d) Apply Burndy Penetrox "A" Electrical Joint Compound on the sink surface where the cell will mount.

(e) Install the cell, flat washer, lock washer, and nut. Line up the cell hex body and pigtail as before.

(f) Tighten the cell nut with a torque wrench.
5/16" diam. stud=50 in.-lb.
1/2 " diam. stud=150 in.-lb.
1/4 " diam. stud=30 in.-lb.

Caution:
Excessive torque can fracture the cell crystal. Wipe off excess joint compound.

MEDIUM CONVERSION MODULE (Figure 23)

1. Removal of module from case

(a) Remove the front cover from the module by removing 4 screws.

(b) Disconnect the 5 power leads.

(c) Unplug the 2 control harnesses at the right side of the case.

(d) Remove the 2 screws holding the module in the case.

(e) Pull the module out slowly on its guide rails until it is stopped by the safety catches on either side of the module, as shown in photograph (Figure 24).

(f) Release both catches simultaneously by pressing down, then pull the module out completely. **Caution:** The module weighs 70 lb.

(g) Place the module on a work bench in the same orientation it was in the case.

2. Replacement of SCR cell-sink assembly

Front sinks

(a) The 3 front sinks are removed by sliding them out of the top side. First, unbolt the pigtail (cathode) of the cell to be removed, lift off the small white wire held by this same bolt.

(b) Disconnect the gate (white) and the control cathode (red) leads at the 2 pull-off tab connections. Pull or pry on the tab connector itself, and not on the wire.

(c) Note the bus bar which connects the sink to the choke. Loosen but do not remove the bolt at the choke end of the bus bar. The bar is slotted and will slide off the bolt.

(d) Slide out the heat sink, cell, and bus bar assembly. The resistor-capacitor network fastened to the bus bar will come out also. See photograph (Figure 25).

(e) Remove the bus bar from the sink.

(f) Fasten the bus bar to the new cell-sink assembly.

(g) Slide the sink into the module. The slotted end of the bus bar should go between the choke terminal and the support angle.

(h) Tighten the bolt at the slotted end of the bus bar.

(i) Connect the gate (white) lead to the terminal marked "G" and the control cathode lead (red) to "C".

(j) Fasten the pigtail (cathode) and the small white wire.

Rear sinks

(k) The 3 rear sinks are removed by sliding them out of the bottom side. Turn the module so that it rests on its top. However, if the left rear sink is to be removed, disconnect the 2 wires S1 and S2 (tab connections) from the thermal switch on this sink before turning this module on its top. These wires are accessable from the top.

(l) With the module resting on its top, unbolt the pigtail of the cell-sink assembly to be removed.

(m) Disconnect the gate and control cathode leads.

(n) Loosen but do not remove the 3 nuts on the studs of the single bus bar which connects the 3 sinks together.

(o) Lift this bus bar carefully and place it on top of the front 3 sinks. Note the wires still attached to it.

(p) Loosen 2 nuts and remove the retaining strip which holds the 3 sinks in place.

(q) Slide out the heat sink and cell assembly.

(r) Remove the short bus bar from the sink and fasten it to the new sink.

(s) If the old sink has a thermal switch, remove the switch and fasten it to the new sink.

(t) Slide the new sink into the module until it bottoms against the insulating bar.

(u) Fasten the retaining strip tight against the sinks.

(v) Put the bus bar in place. The bus bar should go next to the sink bus bar. The small wire terminals should be next to the washers. Tighten the 3 nuts.

(w) Connect the gate lead (white) to terminal "G" and the cathode control lead (red) to "C".

(x) Fasten the pigtail.

(y) Turn the module over and connect the 2 leads to the thermal switch. (Left rear sink only).

3. Re-installing module in case

(a) Slide the module into the case on the guide rails. Lift the safety catches, if necessary, to make entry easier.

(b) Fasten the 2 screws holding the module in place.

(c) Plug in the 2 control harnesses. The plugs are different sizes and are keyed to permit only the proper connections.

(d) Fasten the 5 power leads.

(e) Install the front cover with 4 screws.

4. Re-placement of SCR cell on heat sink (not recommended)

(a) Remove the cell nut, star washer and flat washer. Note the position of the cell hex body and pigtail with respect to the sink before removing the nut.

(b) Lift out the cell.

(c) Wipe the sink surfaces clean at the cell mounting hole. Remove any burrs that would prevent proper seating of the cell. Do not wire brush or sand the mounting surface.

(d) Apply Burndy Penetrox "A" Electrical Joint Compound on the sink surface where the cell will mount.

(e) Install the cell, flat washer, star washer, and nut. Line up the cell hex body and pigtail as before.

(f) Tighten the cell nut with a torque wrench.
¾″ diam. stud = 300 in.-lb.
½″ diam. stud = 150 in.-lb.

Caution:
Excessive torque can fracture the cell crystal. Wipe off excess joint compound.

LARGE CONVERSION MODULE (Figure 26)

1. Removal of module from case

(a) Remove the front cover from the module by removing 4 screws.

(b) Disconnect the 5 power leads.

(c) Unplug the 2 control wire harnesses at the right side of the case.

(d) Remove the 4 screws holding the module in the case.

(e) Pull module out slowly on its wheels. Support the front end when the front wheels leave the rails, stop pulling and lower it until the module supports itself again. Lift again and pull very slowly until lifting plates on sides are exposed. **Caution:** The module weighs 220 lb.

(f) Connect a crane hoist or equivalent to the 2 retractable lifting plates on the module sides. Raise the module until it is level, then slide it out the rest of the way. See photograph (Figure 26).

(g) Place the module on a work table in the same orientation it was in the case.

2. Replacement of SCR cell-sink assembly

(a) Refer to the descriptive photographs as necessary.

(b) Unplug the 3 control wire harnesses exposed by the cover removal. Two are located at upper left and one at lower right.

(c) Unbolt the power connections to the front portion of the module. Work from the top of the module. These consist of 2 double cable connections at the fuses (if used) near the front sinks, and one bus bar link on the left side. See photograph for power connections (Figure 27).

(d) Remove the 4 nuts at the extreme corners of the front and lift off the front sub-assembly. The 3 front sinks, the 3 leg fuses (if used), and the suppression panel make up the front sub-assembly. See photograph (Figure 28).

(e) Place the front sub-assembly on a work bench face down so the heat sinks are up. Use care not to damage any components on the front.

(f) To remove the desired cell-sink assembly, disconnect the cell gate lead and shield lead at the 2 pull-off tab connections. Pull or pry on the tab connector itself, and not on the wire.

(g) If the sink has a thermal switch mounted on it, disconnect the two wires to the switch.

(h) Unbolt the cell pigtail from the bus bar. Note the 2 small wires held by this same bolt.

(i) Remove the 2 bolts holding the sink to the bus bar.

(j) Remove the 2 bolts holding the opposite end of the sink, and lift out the sink. See photograph (Figure 29). The resistor-capacitor network attached to the sink will come out with the sink. Remove the RC network.

(k) Install RC network on new sink. If the old sink had a thermal switch, remove the switch from the old sink and fasten it on the new sink before installing the sink.

(l) Fasten the sink in place with the 4 bolts. Start all bolts before tightening any.

(m) Fasten the cell pigtail and the 2 small wires. The pigtail terminal goes next to the bus bar.

(n) Connect the cell gate lead (center conductor) to the "G" tab terminal and the shield lead (outer conductor) to the "C" tab terminal.

(o) Fasten the front sub-assembly to the module with the 4 corner nuts.

(p) Fasten the 3 power connections.

(q) Plug in the 3 control wire harnesses.

3. Re-installing module in case

(a) Lift the module, using a crane hoist or equivalent, up even with the guide rails in the case.

(b) Slide the module in as far as the hoist cable will permit.

(c) Remove the hoist cable and push the module in.

(d) Fasten the 4 bolts holding the module in place.

(e) Plug in the 2 control wire harnesses. The plugs are of different size and are keyed, so they will go together only the proper way.

(f) Re-connect the 5 power leads.

(g) Fasten on the front cover.

4. Replacement of leg fuse

It is not necessary to disassemble the module to replace only the leg fuses. The front fuses can replaced by sliding the module out of the case about half way to gain access from the topside. The rear fuses require that the module be removed completely from the case to gain access from the bottom.

An alternate method for replacing the rear fuses does not require that the module be removed completely from the case. Instead, the module is pulled about half way out of the case, and the front half of the module then is disconnected and removed. This exposes the rear fuses, which can then be changed out.

To disconnect the front half of the module, follow the procedure given under 2 (a), (b), (c), (d) on the preceding page.

To replace a fuse, remove the 2 bolts holding the fuse in place, remove the fuse, replace with a good one, and fasten with the two bolts.

If a leg fuse is to be replaced along with a sink assembly, it can be done at the same time the sink is replaced.

5. Replacement of SCR cell on heat sink (not recommended)

(a) Remove the cell nut, and flat washer. Note the position of the cell hex body and pigtail with respect to the sink before removing the nut. Hex sides are parallel to the sink sides.

(b) Lift out the cell.

(c) Wipe the sink surfaces clean at the cell mounting hole. Remove any burrs that would prevent proper seating of the cell. Do not wire brush or sand the mounting surface.

(d) Apply Burndy Penetrox "A" Electrical Joint Compound on the sink surface where the cell will mount.

(e) Install the cell, flat washer, and nut. Line up the cell hex body and pigtail as before.

(f) Tighten the cell nut with a torque wrench to 300 inch-lb. (¾" diam. stud).

Caution:

Excessive torque can fracture the cell crystal. Wipe off the excess joint compound.

0° FIRING ANGLE

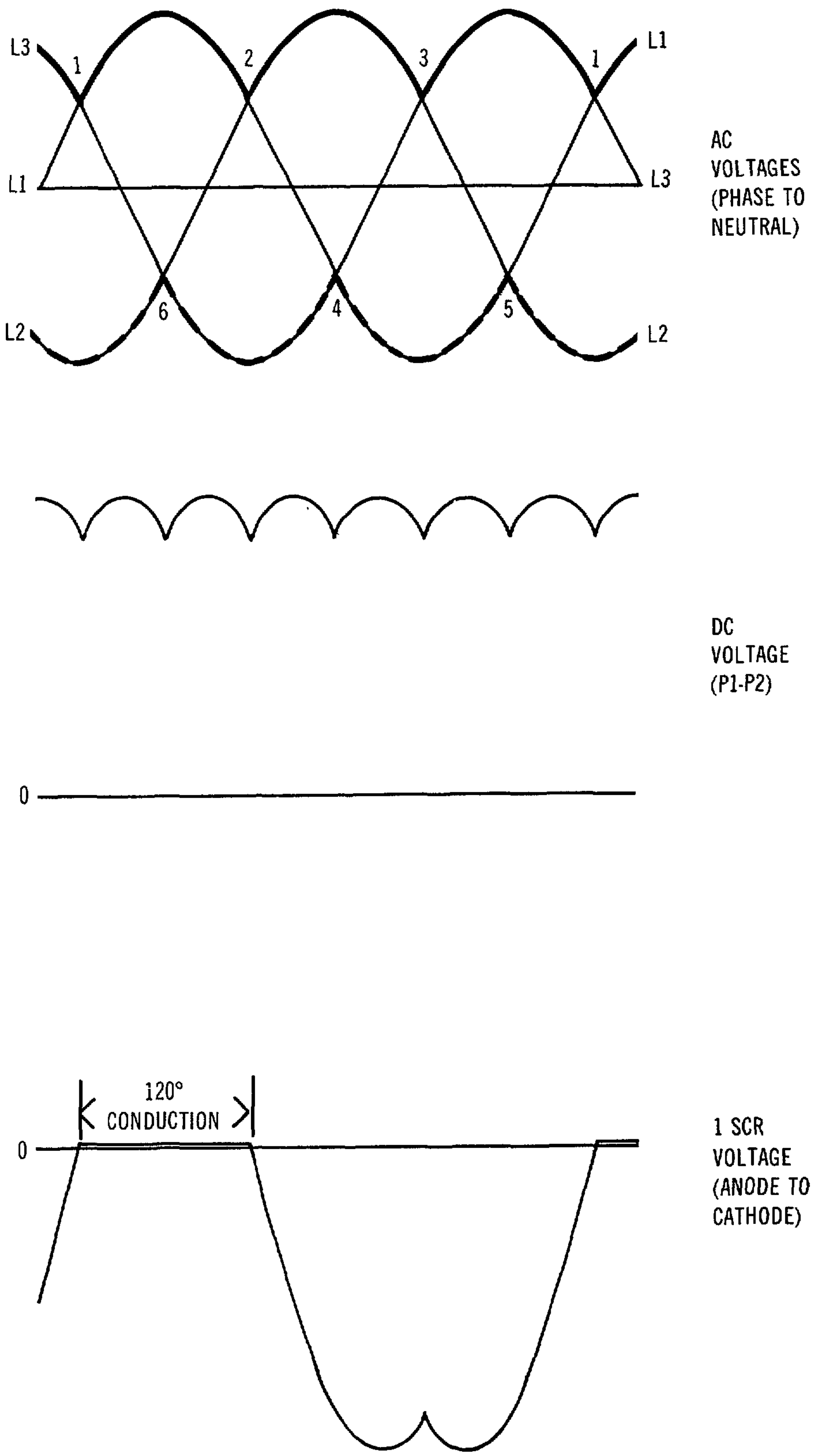


FIGURE 1

30° FIRING ANGLE

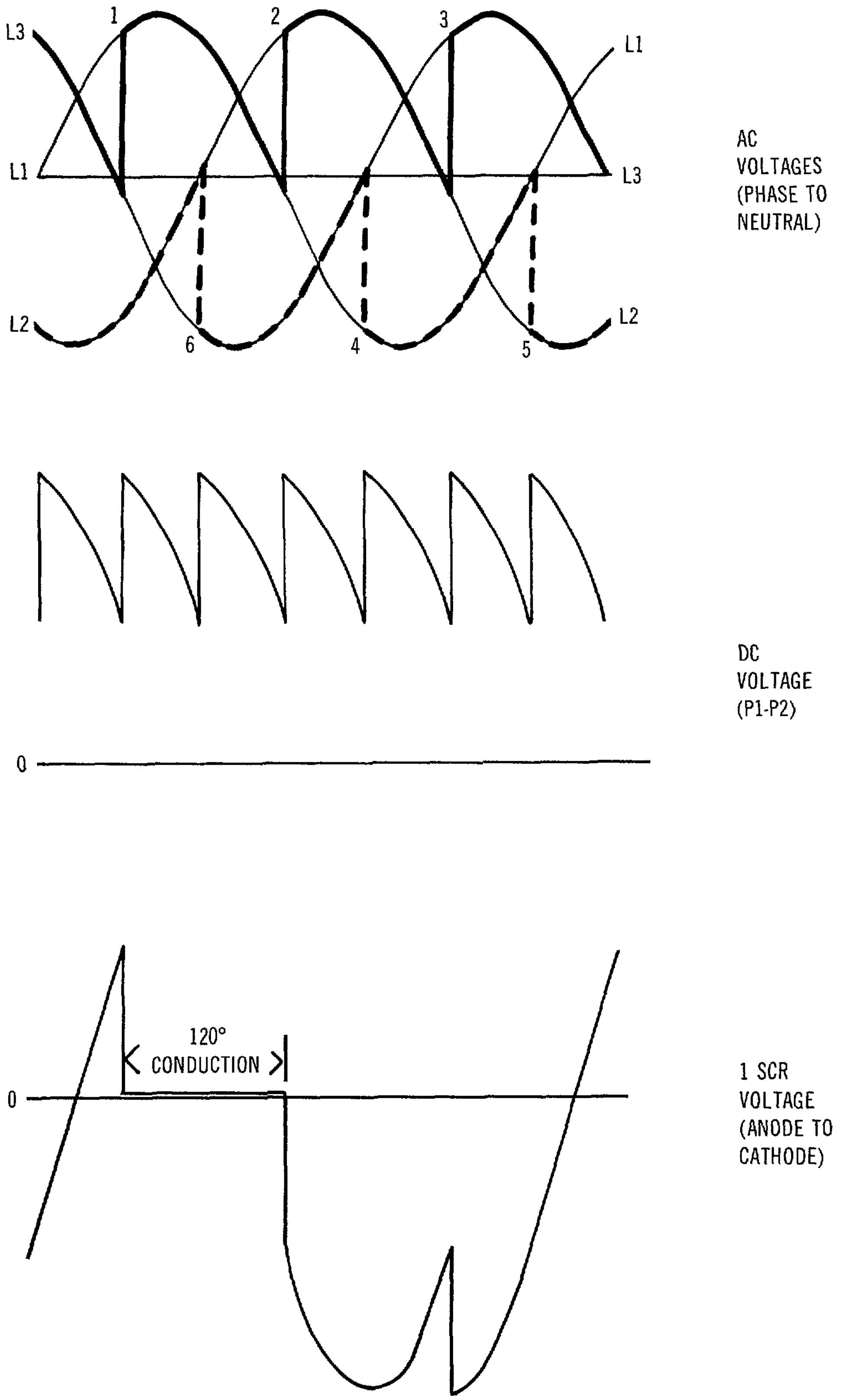


FIGURE 2

60° FIRING ANGLE

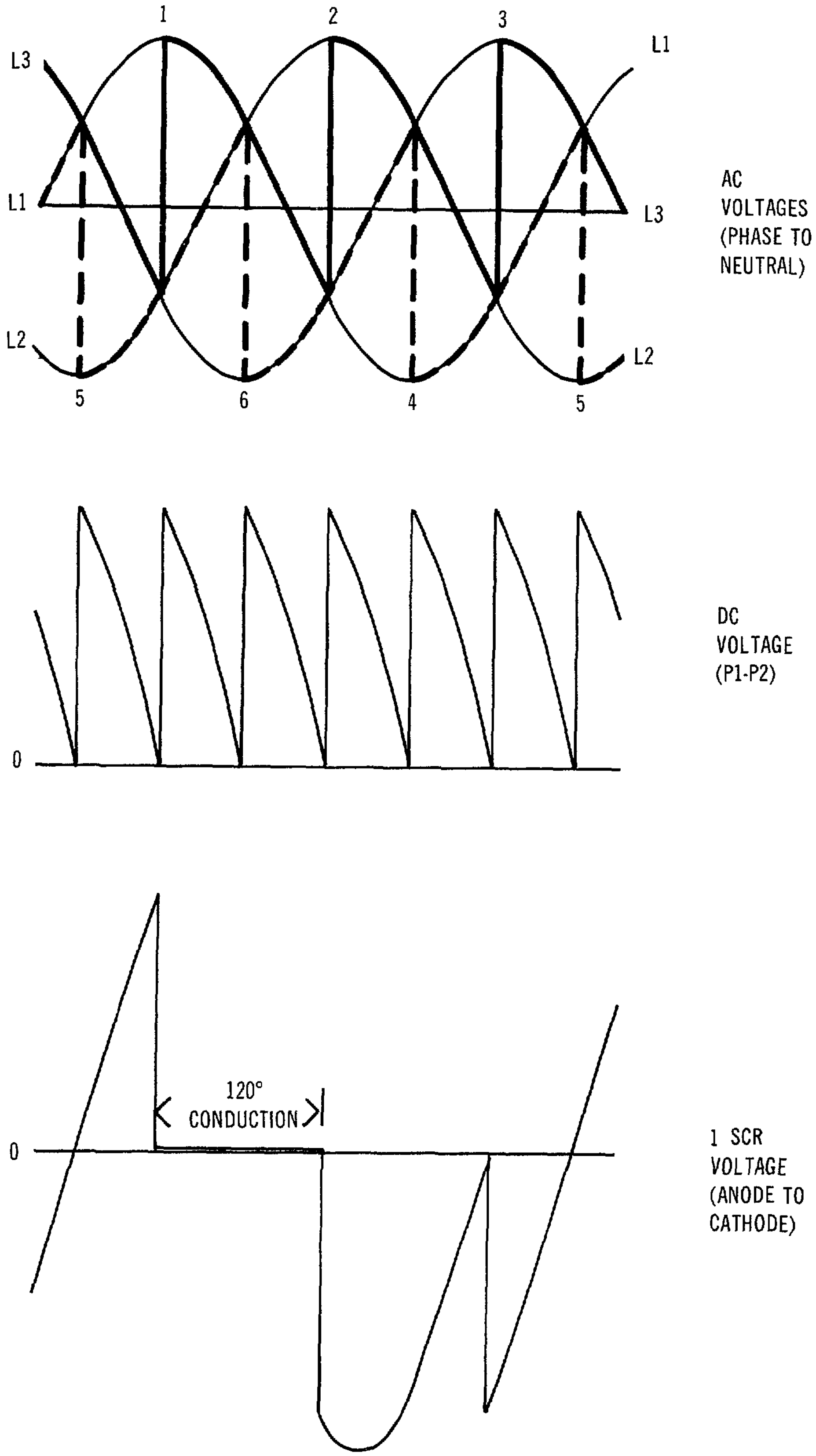


FIGURE 3

90° FIRING ANGLE

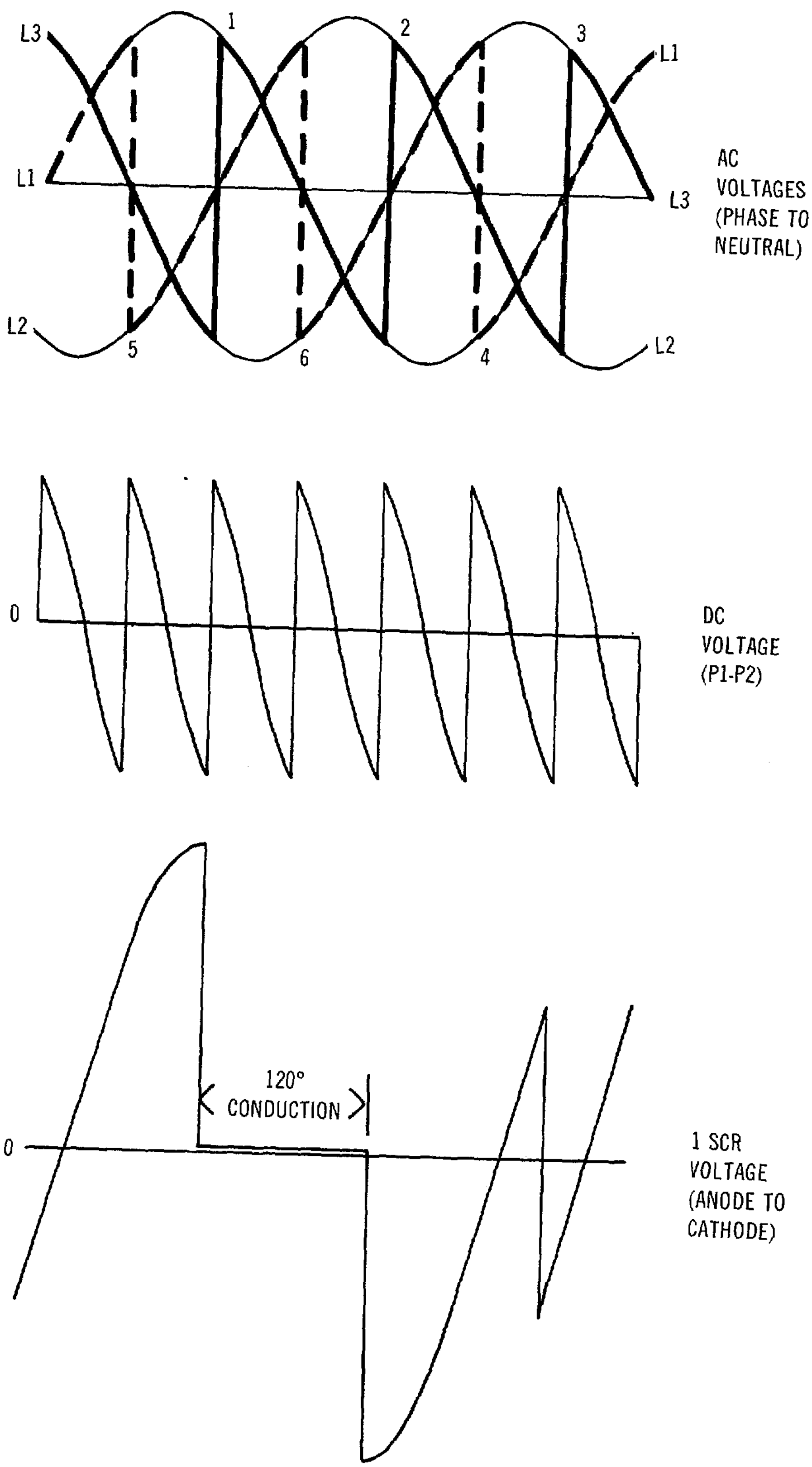


FIGURE 4

120° FIRING ANGLE

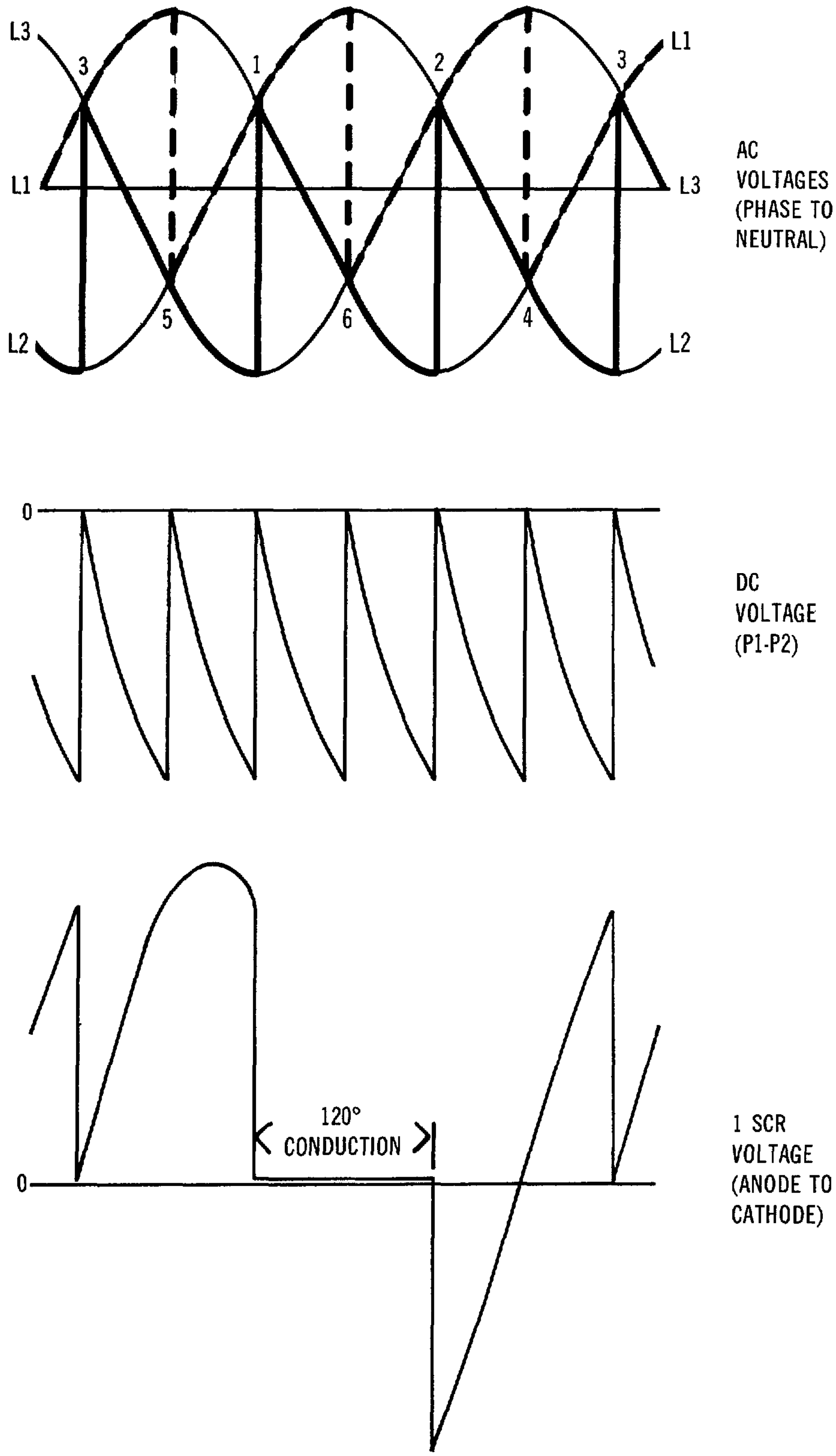


FIGURE 5

150° FIRING ANGLE

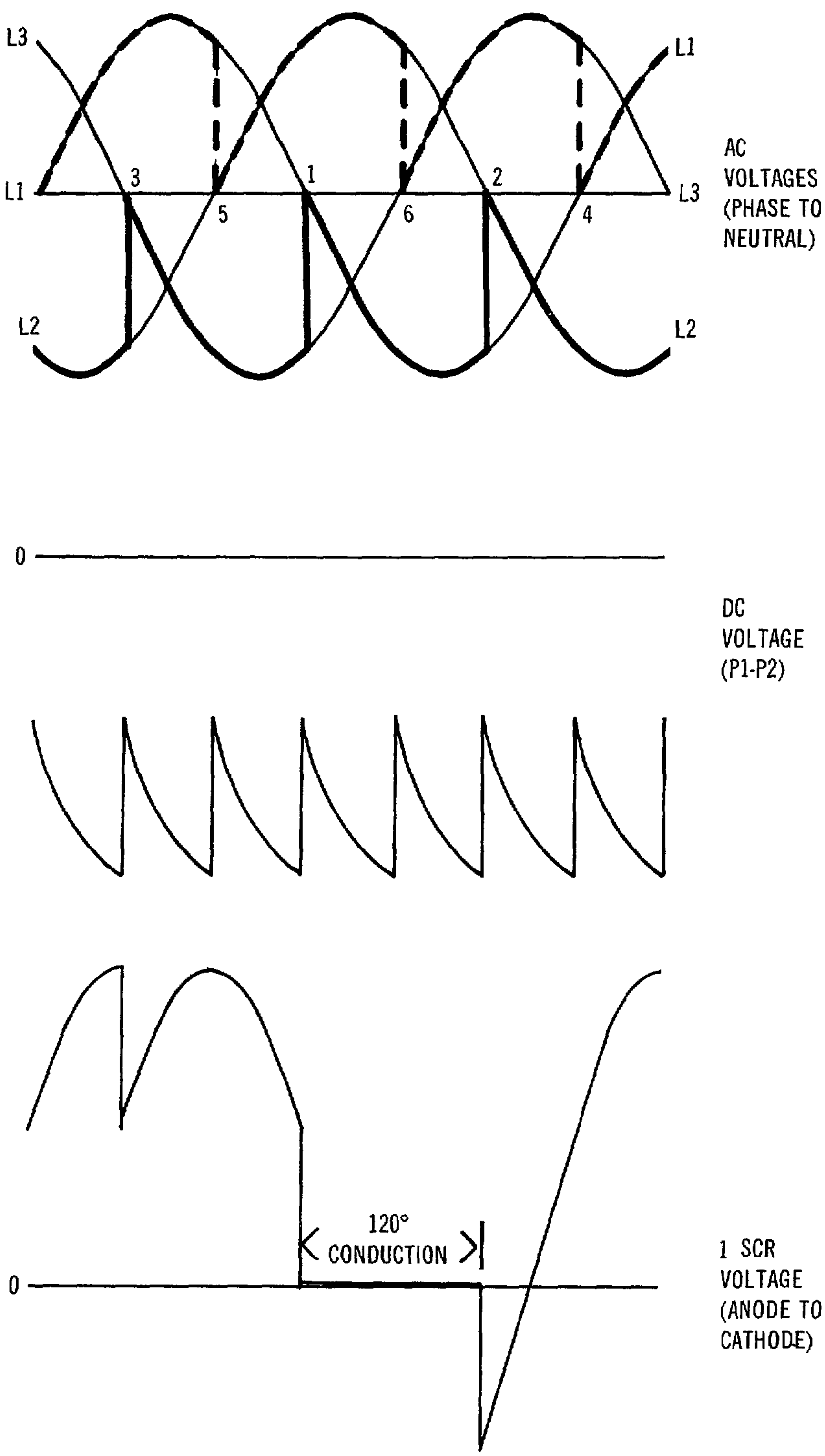


FIGURE 6

AC VOLTAGE INPUT (UNDER LOAD)

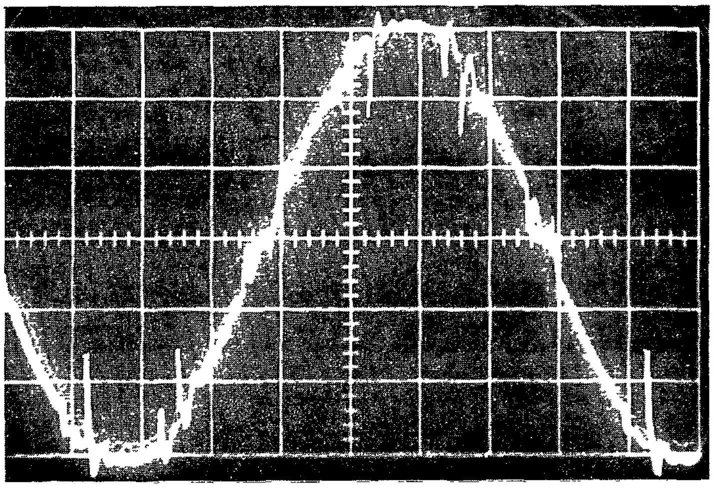


FIGURE 7

CALIB.

VERT.
100 VOLTS/CM

HORIZ.
2 MS/CM

DC VOLTAGE OUTPUT (MOTORING, UNDER LOAD)

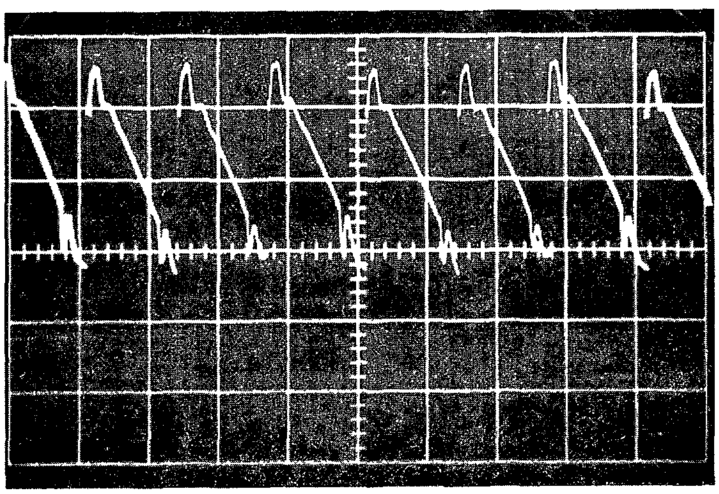


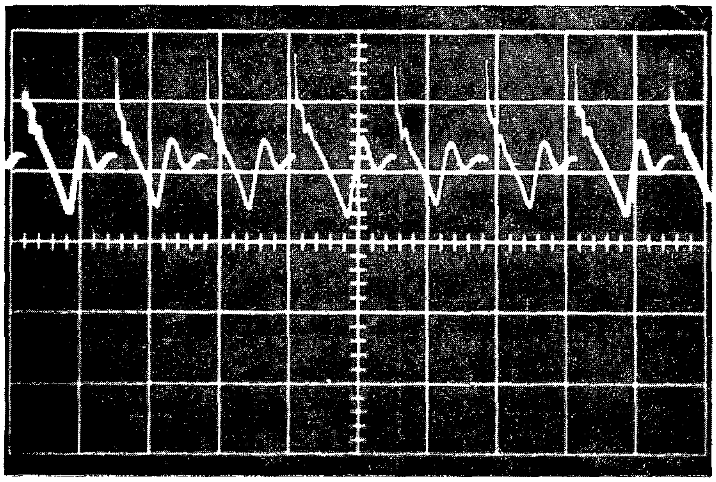
FIGURE 8

CALIB.

VERT.
100 VOLTS/CM

HORIZ.
2 MS/CM

DC VOLTAGE OUTPUT (MOTORING, NO LOAD)



— 0

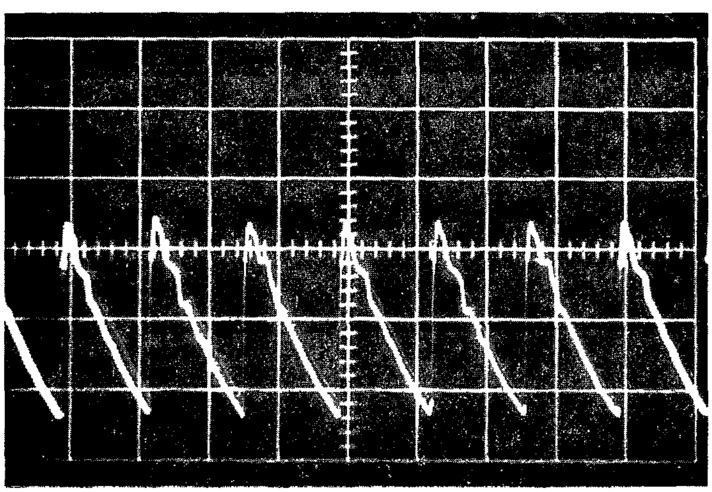
CALIB.

VERT.
100 VOLTS/CM

HORIZ.
2 MS/CM

FIGURE 9

DC VOLTAGE OUTPUT (REGENERATING, UNDER LOAD)



— 0

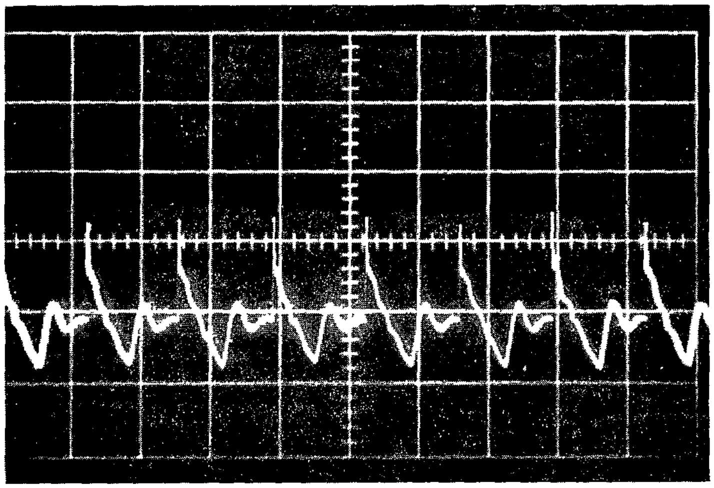
CALIB.

VERT.
100 VOLTS/CM

HORIZ.
2 MS/CM

FIGURE 10

DC VOLTAGE OUTPUT (REGENERATING, NO LOAD)



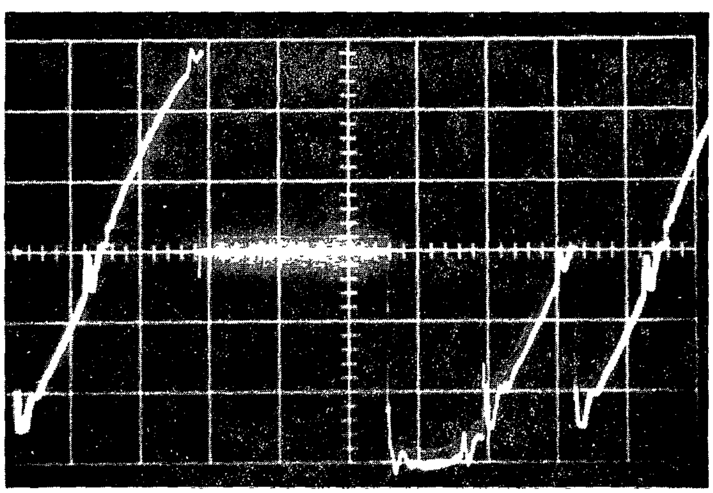
CALIB.

VERT.
100 VOLTS/CM

HORIZ.
2 MS/CM

FIGURE 11

SCR CELL VOLTAGE (MOTORING, UNDER LOAD)



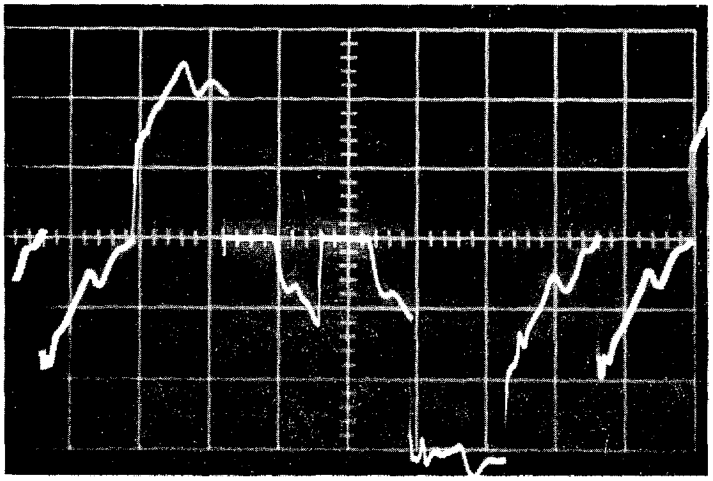
CALIB.

VERT.
100 VOLTS/CM

HORIZ.
2 MS/CM

FIGURE 12

SCR CELL VOLTAGE (MOTORING, NO LOAD)



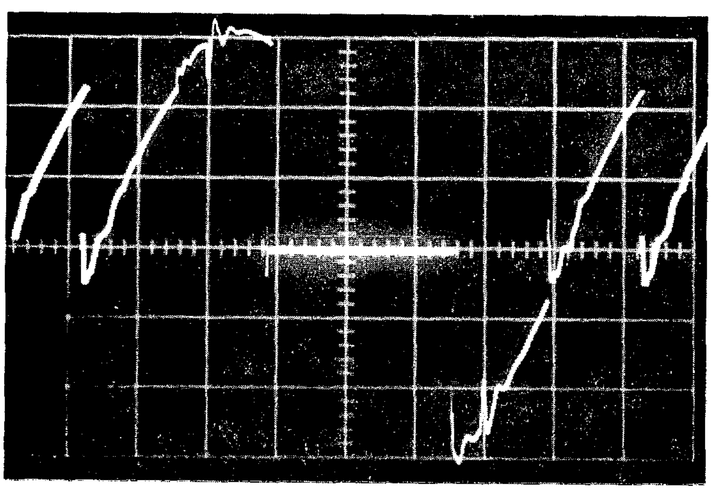
CALIB.

VERT.
100 VOLTS/CM

HORIZ.
2 MS/CM

FIGURE 13

SCR CELL VOLTAGE (REGENERATING, UNDER LOAD)



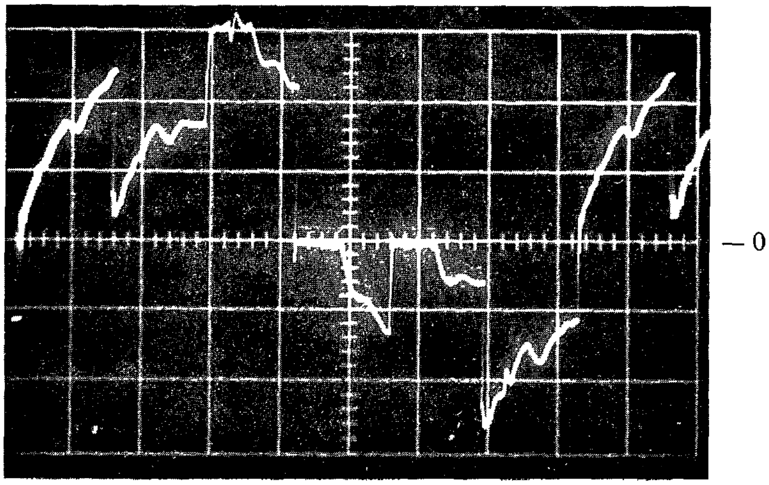
CALIB.

VERT.
100 VOLTS/CM

HORIZ.
2 MS/CM

FIGURE 14

SCR CELL VOLTAGE (REGENERATING, NO LOAD)



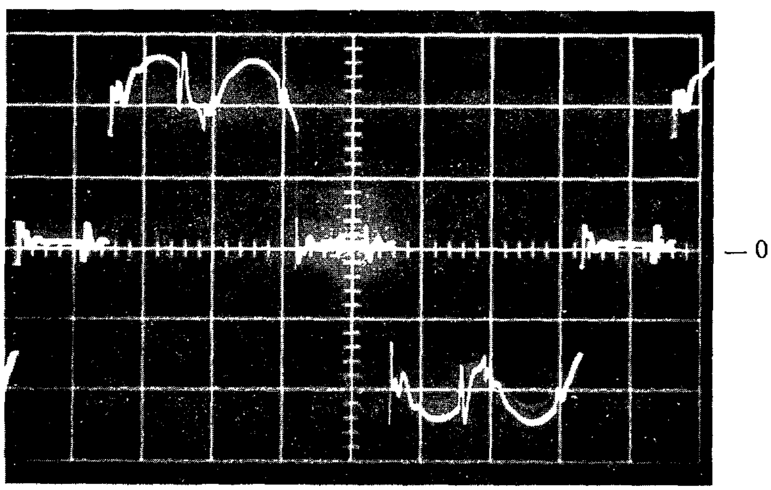
CALIB.

VERT.
100 VOLTS/CM

HORIZ.
2 MS/CM

FIGURE 15

AC CURRENT (FULL LOAD)

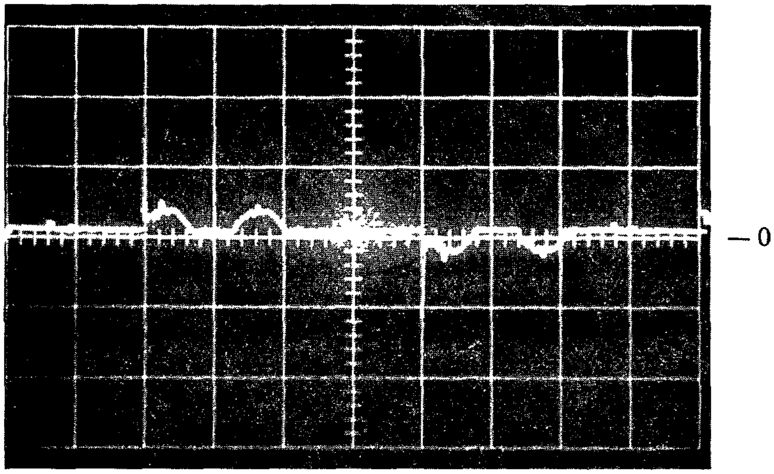


CALIB.

HORIZ.
2 MS/CM

FIGURE 16

AC CURRENT (NO LOAD)

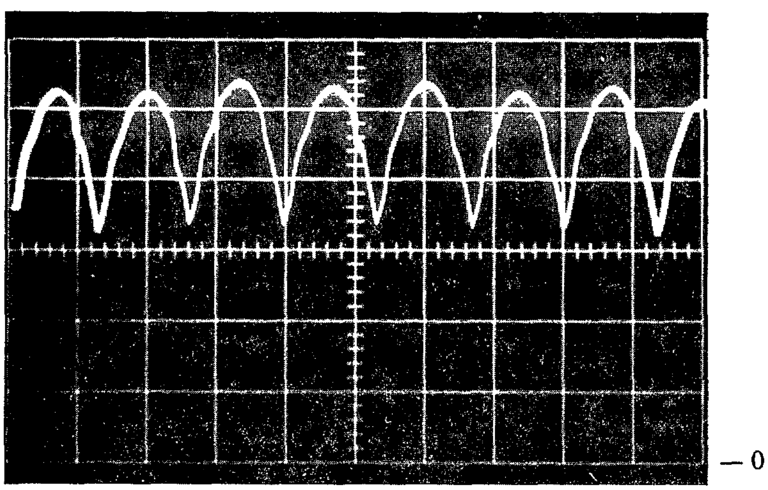


CALIB.

HORIZ.
2 MS/CM

FIGURE 17

DC CURRENT (FULL LOAD)

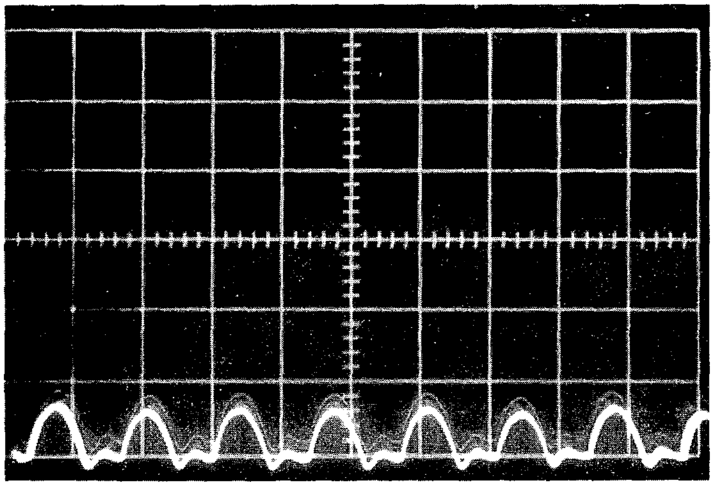


CALIB.

HORIZ.
2 MS/CM

FIGURE 18

DC CURRENT (NO LOAD)



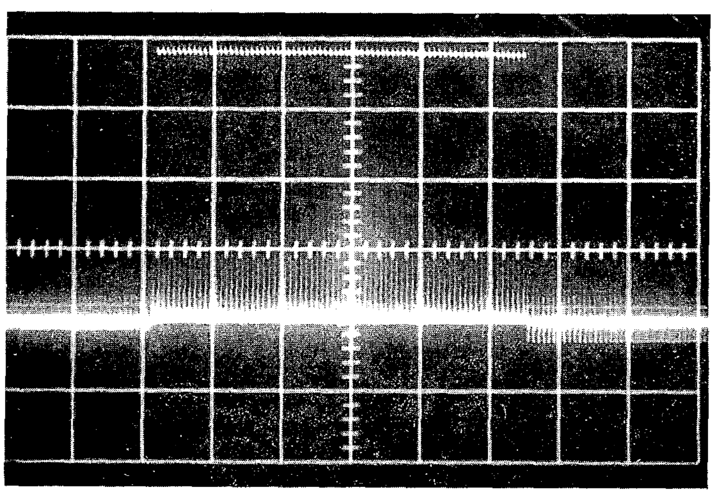
— 0

CALIB.

HORIZ.
2 MS/CM

FIGURE 19

FIRING PULSE TRAIN INPUT



— 0

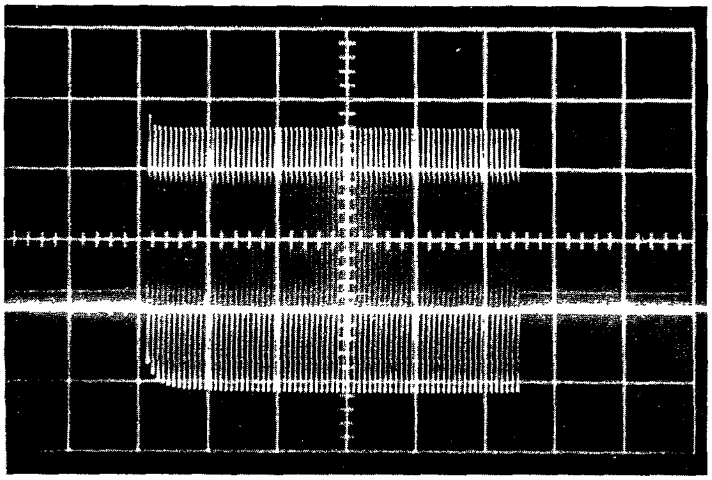
CALIB.

VERT.
5 VOLTS/CM

HORIZ.
1 MS/CM

FIGURE 20

FIRING PULSE TRAIN ACROSS SCR GATE



CALIB.

VERT.
2 VOLTS/CM

HORIZ.
1 MS/CM

FIGURE 21

DESCRIPTIVE PHOTOGRAPHS

SMALL MODULE

A —Conversion Module Assembly
B —Module Cover (Front)
C —Front Cover Screws (4)
D—Power Leads (3 AC, 2 DC)
E —Module Holding Lugs (2)
F —Heat Sink Buss Bar
G—Control Leads (Gate-white, Control Cathode-Red)
H—SCR Cathode (Pigtail) Connection
I —Control Harness & Plugs (2)

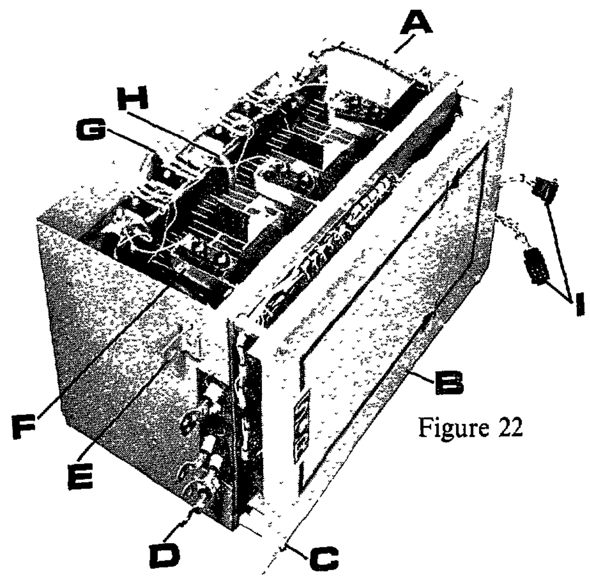


Figure 22

MEDIUM MODULE

A —Conversion Module Assembly
B —Module Cover (Front)
C —Front Cover Screws (4)
D—Power Leads (3 AC, 2 DC)
E —Module Holding Lugs (2)
F —Heat Sink Buss Bar
G—Control Leads (Gate-white, Control Cathode-Red)
H—SCR Cathode (Pigtail) Connection
I —Control Harness & Plugs (2)

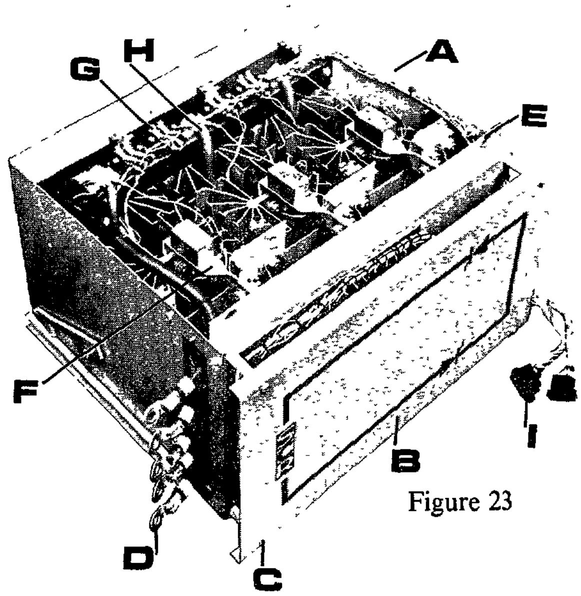


Figure 23

DESCRIPTIVE PHOTOGRAPHS

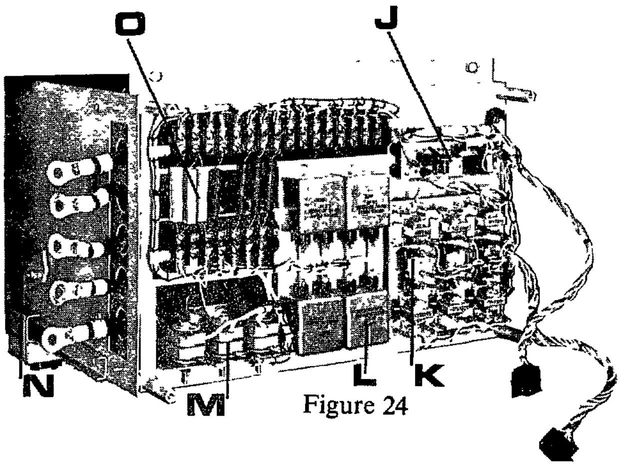


Figure 24

MEDIUM MODULE (con't)

J —Current Feedback Card
K—Pulse Transformer Card
L —Capacitor, Suppression
M—Thyrectors (Suppression)
N—Safety Catch (2)
O —Resistors, Suppression

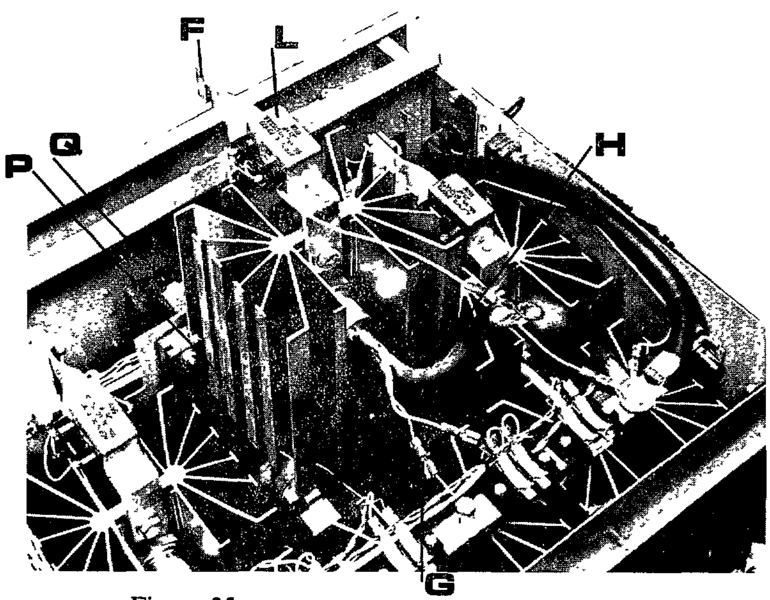


Figure 25

F —Heat Sink Buss Bar
G—Control Leads (Gate-white, Control Cathode-Red)
H—SCR Cathode (Pigtail) Connection
L —Capacitor, Suppression
P —Heat Sink
Q—Choke

DESCRIPTIVE PHOTOGRAPHS

LARGE MODULE

A —Conversion Module Assembly
B —Module Cover (Front)
C —Front Cover Screws
D—Power Leads (3 AC, 2 DC)
E —Module Holding Screws (4)
F —Retractable Lifting Plates (2)
G—Power Connections
H—Module Wheels
I —SCR Indicating Lights
J —Control Wire Plugs (3)
K—Fuses (6)
L —Power Connections
(3, to Remove Front Assembly)

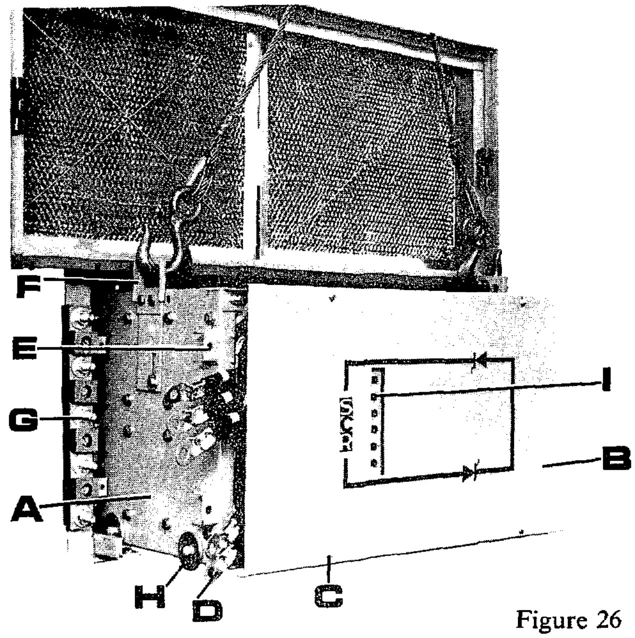


Figure 26

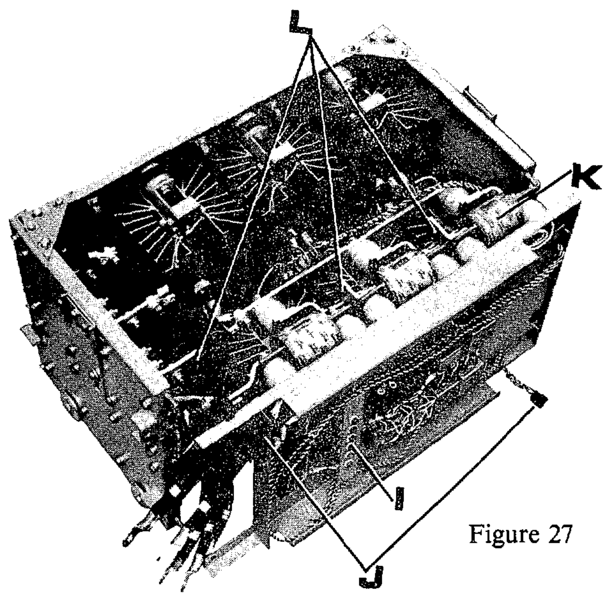


Figure 27

DESCRIPTIVE PHOTOGRAPHS

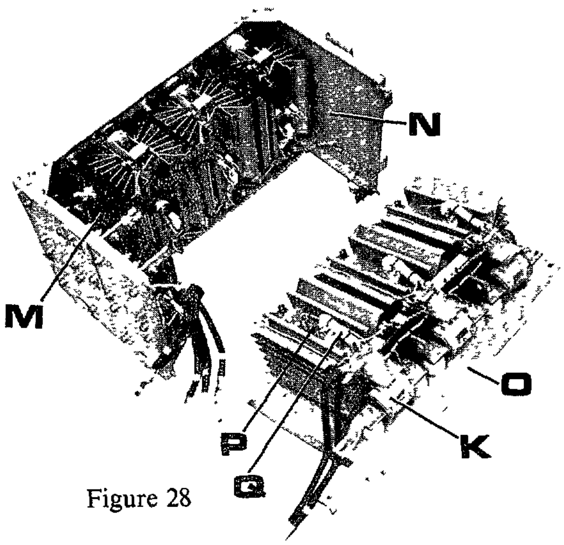


Figure 28

LARGE MODULE (con't)

K—Fuses (6)
M—Chokes (6)
N—Back Sub-Assembly
O—Front Sub-Assembly
P—Thermal Switch (2)
Q—Cathode Lead (Pigtail)
R—Control Lead Connections
(Gate-white, Control Cathode-Red)
S—Holding Screws (Heat Sink to Boss Bar)
T—Holding Screws (Heat Sink Mounting)
U—RC Network
V—Fuse Mounting Bolt

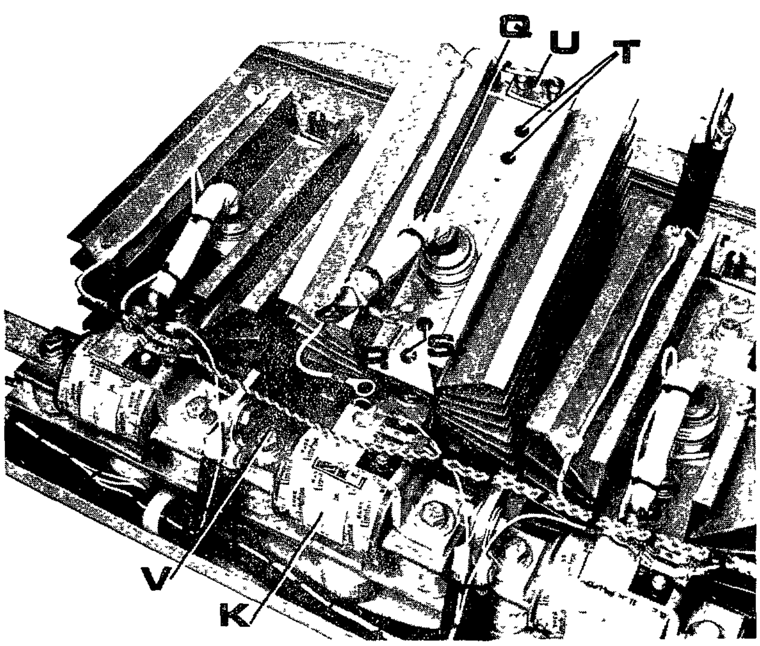


Figure 29

SPEED VARIATOR DEPARTMENT

GENERAL ELECTRIC

ERIE, PENNSYLVANIA

GEK-11015A (6/79) 500 (F)