

SOLID STATE MAGNET POLARITY REVERSING SWITCHES

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5 May 1975

1.0 INTRODUCTION

Over the past three or four years the Neutrino Laboratory has developed a series of solid state, double pole, double throw, polarity reversing switches for the magnets used throughout the beam line. Because of the wide variety of particles required for experiments, the magnet polarities had to be frequently changed.

Initially a small trim magnet was equipped with a solid state reversing switch because of the inherent frequency of polarity change required by such a trim magnet. Approximately forty-eight of these switches were built and operated throughout the Neutrino Laboratory. The switch reliability was excellent and as the need arose to change the polarity of larger magnets at a regular interval it became apparent that downtime and connection failures could be drastically reduced by incorporating high current reversing switches. Because of reliability requirements and economical availability of components the solid state SCR was chosen for the switching element.

A high voltage 200 amp switch was built and a high voltage 4500 amp switch was built. Presently there are 6/200 amp devices and 7/4500 amp types in use in the Neutrino Laboratory. Some of these switches have been in use for up to eighteen months. We have not had any failures on these switches and there has been no maintenance.

2.0 LOW CURRENT SWITCHES, TYPES 1 AND 2

The Type 1 switch was the first one built and was a convection cooled SCR arrangement. Figure 1 is the specification sheet for this switch and states the operating parameters and power handling capabilities. The switch was originally developed for the Sorensen DCR 40-250 series and was later incorporated into the Sorensen DCR 150-70 series of power supplies.

The bus connections on the switch assembly can be seen in Figure 2 and are made of copper plate. Connections for input-output are made with 2/ ϕ welding cable. The unit works well in a closed atmosphere and is conservatively rated. Over-temperature interlocking is accomplished by strategically spaced thermo switches.

The SCRs are controlled via a pulsed trigger from a control card located in the control bin of the power supply. The switch is only allowed to operate with zero magnet current. The control card has interlocking capability to prevent any gate triggering while the power supply is providing magnet current. The SCRs do not use DC trigger gate currents because the SCR is air cooled.

The next switch to be incorporated was the Type 2 and it was initially designed to operate at much higher peak inverse voltages with a forward current of 200 amps. The unit was designed to work with the Ling Electronics 55 kilowatt power supply unit. This switch is also air cooled, but uses forced air cooling instead of convection. The unit is housed in a utility box and is usually mounted to an interior wall of a building or enclosure. (See Fig. 3)

Connections are made to this switch via 4/ ϕ welding cable. The control and interlocking are similar to the Type 1 unit plus the added feature of looking for a shorted SCR each time the polarity is

switched. If a short is present the power supply is inhibited from supplying any output current and the operator is notified via a power supply status bit. The control board or module is mounted in the same enclosure as the power SCR circuitry. The unit is a plug-in board and provides all interlocking and gate trigger power needed to operate and control the switch status. Local display of individual fault mechanisms is provided for on the board. The SCRs in this unit are fired with a DC gate signal which remains on as long as the desired polarity is required. (See Fig. 4)

3.0 HIGH CURRENT REVERSING SWITCHES, TYPES 1a AND 1b

The largest switch developed by the Neutrino Section is a 4500 amp, 600 volt switch used with the Transrex 500-5 power supply unit. The switch uses aluminum internal bus and is water cooled. The aluminum bus is used as the cooling header for both supply and return water for the water cooled heat sinks involved with the SCRs. The control and interlocking is identical to the board used for the forced air Type 2 low current switch.

The high current switch is built in a modular fashion so that the number of SCRs can be modified to reduce switch cost. The 1a switch is a 4500 amp unit and the 1b is a 2250 amp unit. The 1b type switch can be easily converted to a 4500 amp switch with the addition of two SCR modules. Figure 5 states the specifications for this switch type and Figures 6a, b, c & d are pictorial layouts of the components.

4.0 FABRICATION

All of the switches were assembled on site by local talent. Some of the components were fabricated outside by vendors and assembled here. The 4500 amp switch with its unique aluminum bus has proved to be a

very worthwhile investment in that massive leads and cables no longer have to be moved by hand and the frequent occurrence of stripped copper threads no longer presents a problem.

5.0 CONCLUSION

At present all of the switches have proved to be very reliable and have required zero maintenance. Several more switches are in the process of fabrication. Available SCRs from the main ring allowed us to build these switches and thus we have been able to decrease our downtime and were also able to direct manpower to much more important requirements.

6.0 ACKNOWLEDGEMENTS

The author would like to thank Mr. Phil Livdahl of the Fermilab Accelerator Division, Dr. Tim Toohig and Dr. Richard Orr for their support of this ongoing program. I would also like to thank Mr. James Walker for the work on the LC-I prototype, Mr. Gary Ross and Mr. Chuck Worel for their very dedicated effort and hours of hard work in fabricating the 4500 amp switches, and Mr. Al Legan and Mr. Ross Doyle for their efforts on the mechanics of the bus work.



A. J.

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SUBJECT

Data Sheet DPDT Reversing Switch (Solid State)
Model L.C.-I

NAME

Gene Woods

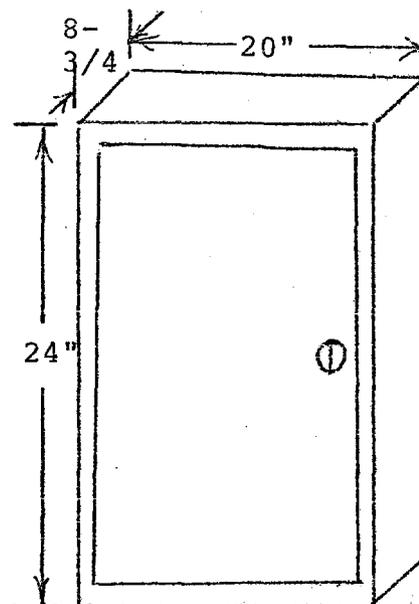
DATE

8/8/74

REVISION DATE

- 1) Input + 250ADC @Vm
- 2) Output + 250ADC @ Vm-2Vd
- 3) Vd=Voltage drop @ 250ADC=1.75VDC
- 4) Isolation to Ground=600VDC
- 5) Vm=maximum working voltage=200VDC
- 6) Control & Readout polarity of output can be reversed locally or remotely. Polarity change must be done at zero power input. Polarity indication is provided via local lamp display and remotable relay contact closure.
- 7) Cooling (air)
Maximum ambient=50°C

8) Physical description



- A) Weight=30 lbs.
- B) Door access from front
- C) All electrical power service from top.
- D) All electrical control service from left side.

REF.

Gary Ross/Chuck Worel

FIGURE 1

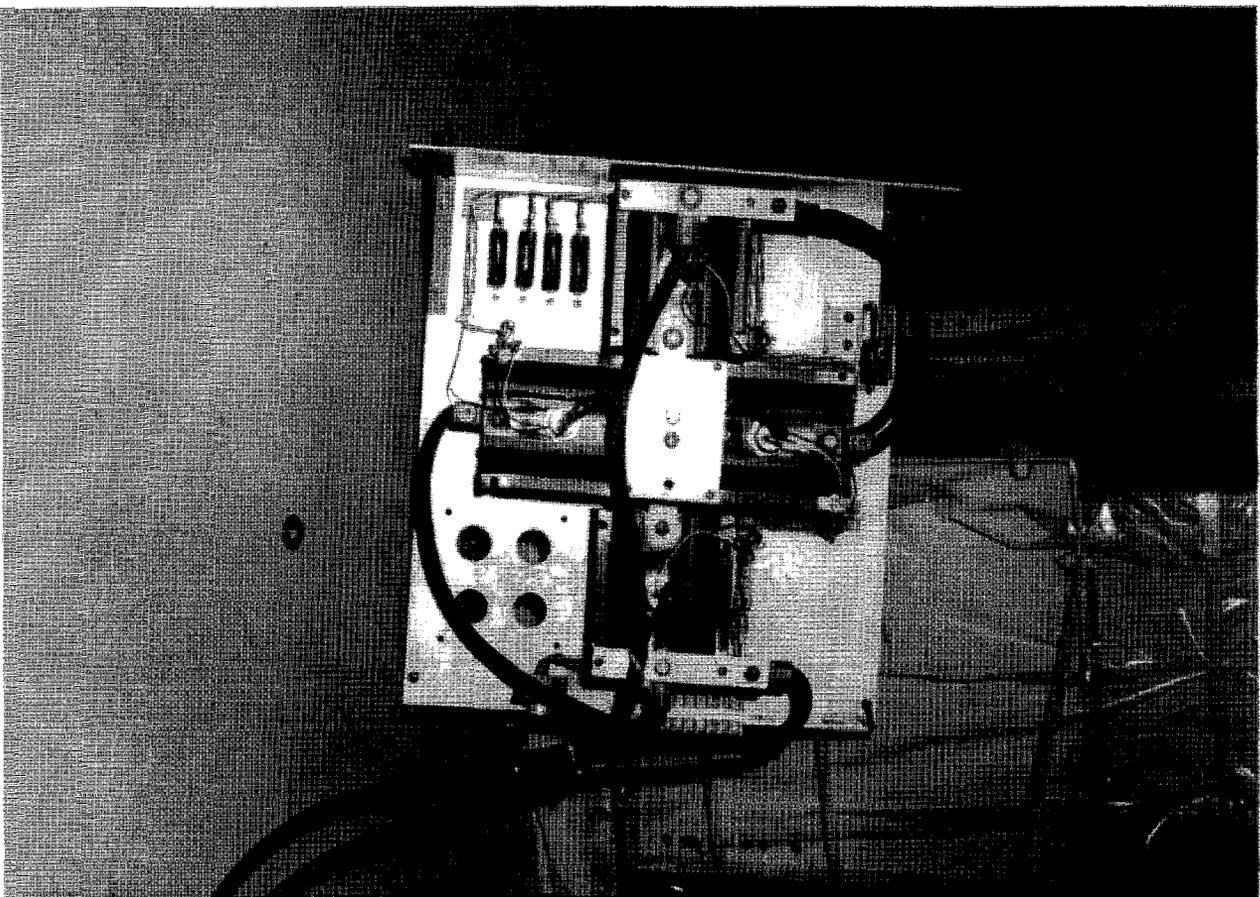


FIGURE 2

THE SOLID STATE REVERSING SWITCH (LC-1) INTENDED
FOR USE WITH SORENSEN MAGNET POWER SUPPLIES
(DCRA0-250A, DCRI50-70A)



ENGINEERING NOTE

Neutrino

A.2.

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SUBJECT

Data Sheet DPDT Reversing Switch (Solid State)
Model L.C.-II

NAME

Gene Woods

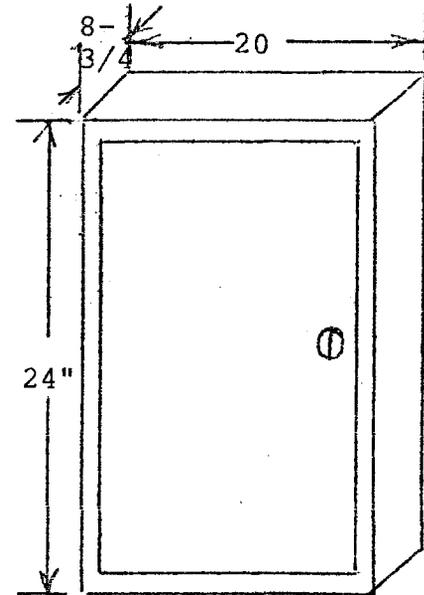
DATE

8/8/74

REVISION DATE

- 1) Input + 200ADC @Vm
- 2) Output + 200ADC @Vm-2Vd
- 3) Vd=Voltage drop @ 200DC = 1.75VDC
- 4) Isolation to Ground=600VDC
- 5) Vm=maximum working voltage= 600VDC
- 6) Control & readout polarity of output can be reversed locally or remotely. Polarity change must be done at zero power input. Polarity indication is provided via local lamp display and removable relay contact closure.
- 7) Cooling (air)
Maximum ambient=50°C

8) Physical description



- A) Weight=50 lbs.
- B) Door access from front
- C) All electrical power service from top.
- D) All electrical control service from left side.

REF.

Chuck Worel/Gary Ross

FIGURE 3

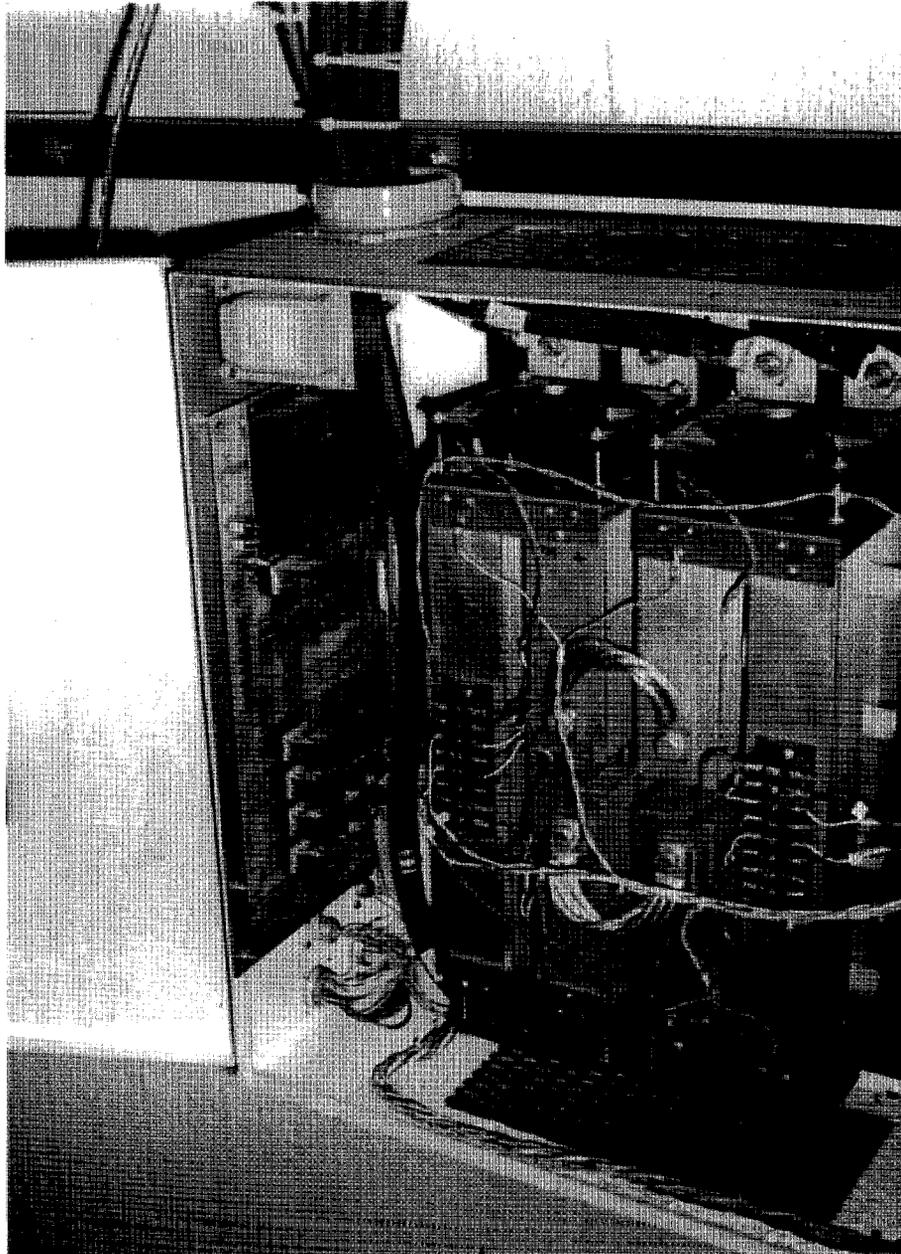


FIGURE 4

SHOWING FORCED AIR COOLED SCR SWITCH (LC-II) INTENDED
FOR USE ON THE LING ELECTRONICS POWER SUPPLY
(55kW UNIT)



SUBJECT

Data Sheet DPDT Reversing Switch (Solid State)
Model H.C.-I

NAME

Gene Woods

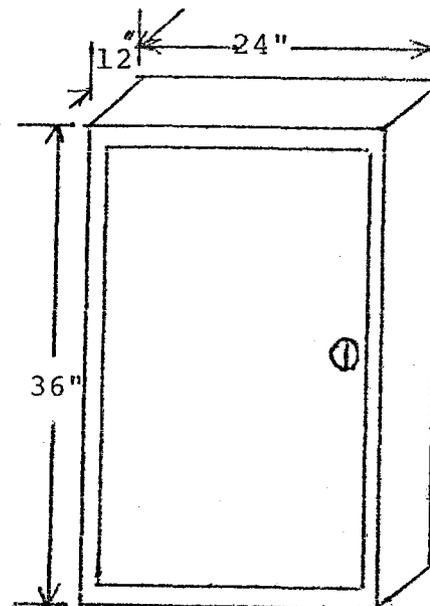
DATE

8/8/74

REVISION DATE

- 1) Input + 4500 ADC @Vm
- 2) Output \pm 4500 ADC @Vm-2Vd
- 3) Vd=Voltage drop @ 4500 ADC= 1.75VDC
- 4) Isolation to Ground=600VDC
- 5) Vm=Maximum working voltage = 600 VDC
- 6) Control & Readout polarity of output can be reversed locally or remotely. Polarity change must be done at zero power input. Polarity indication is provided via local lamp display and remotable relay contact closure.
- 7) Cooling (water, LCW)
Maximum ambient =50°C
Maximum inlet water temp.=45°C
Maximum pressure = 200 psi
Required flowrate = 6 GPM

8) Physical Description



- A) Weight=150 lbs.
- B) Door access from front
- C) All electrical power service from top.
- D) All electrical control service from left side.
- E) Cooling connections at bottom

REF.

Gary Ross/Chuck Worel

FIGURE 5

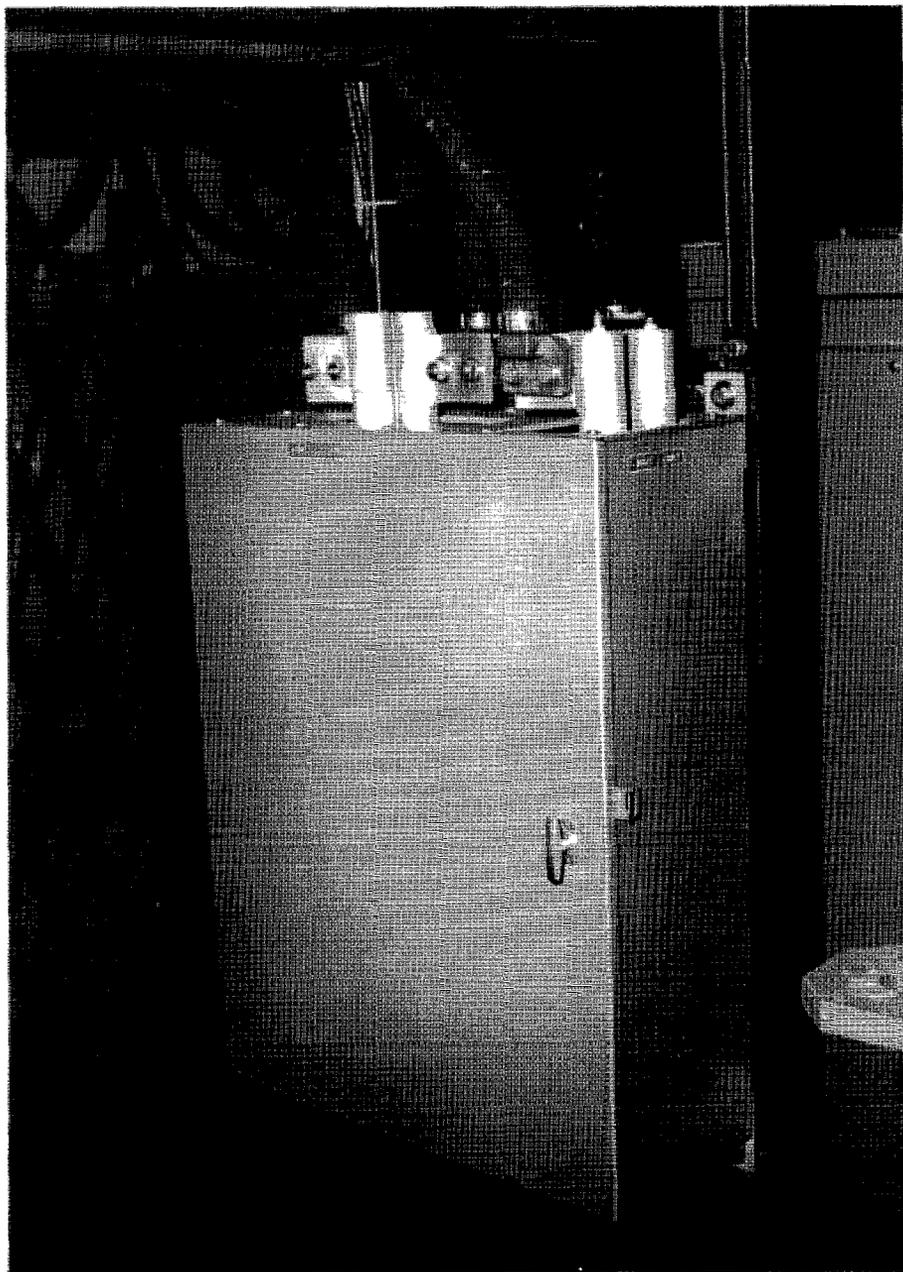


FIGURE 6a

TYPICAL INSTALLATION OF A 4500 AMP SWITCH (HC-Ia).
SWITCH WAS INTENDED FOR USE ON
TRANSREX 500-5 POWER SUPPLY

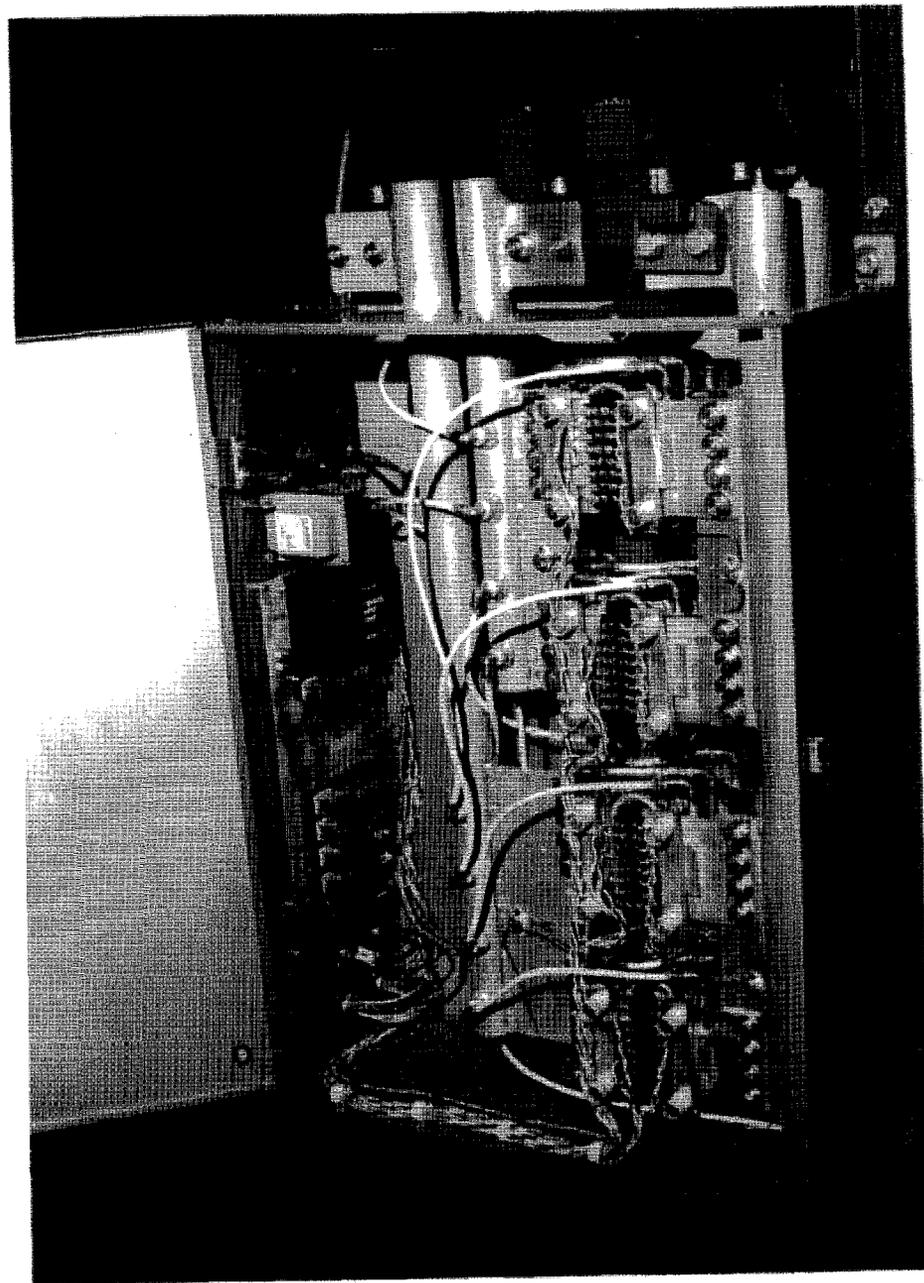


FIGURE 6b

INTERIOR VIEW OF HC-Ia SWITCH.
FIRING BOARD IS ON LEFT.

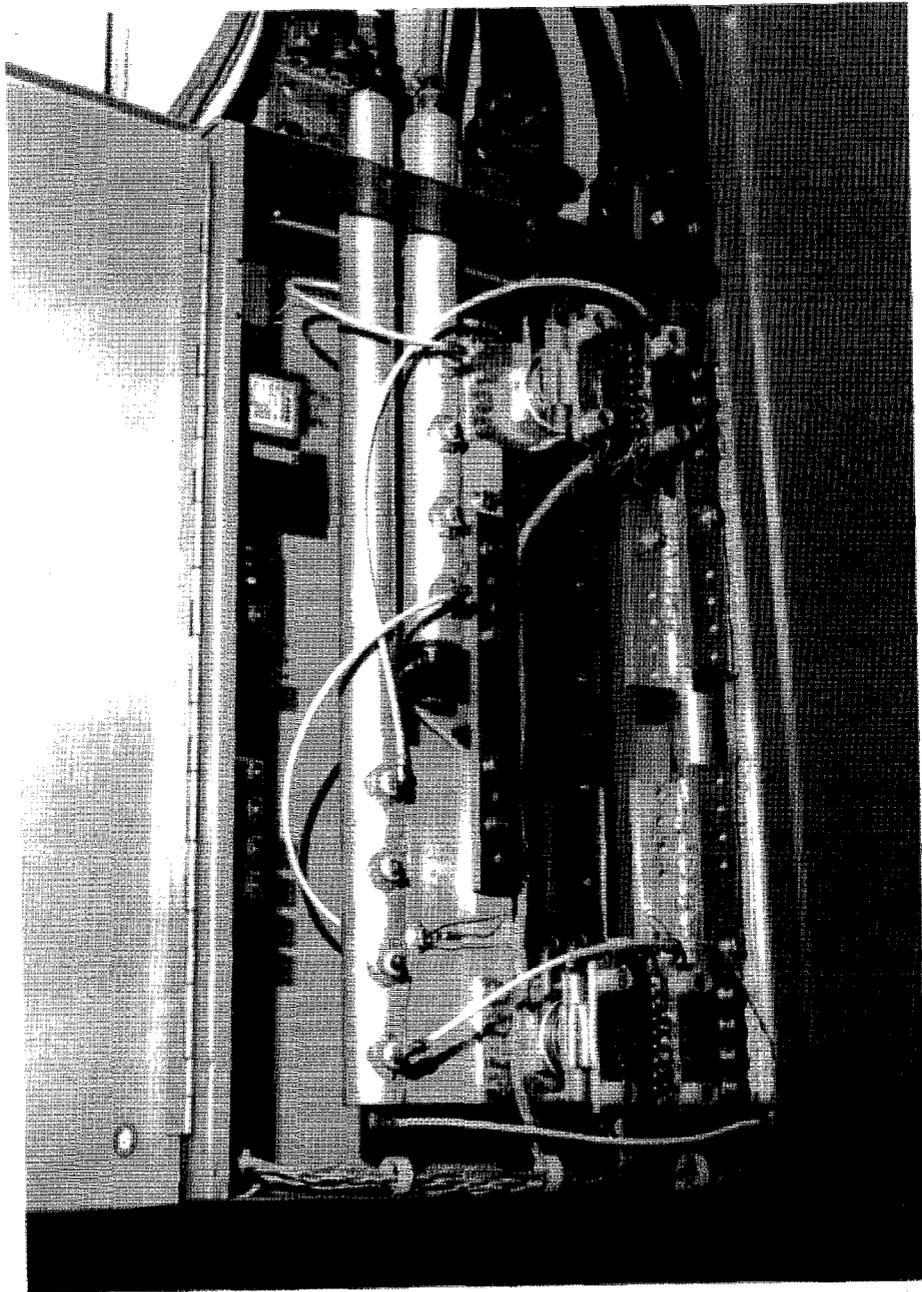


FIGURE 6c

INTERIOR VIEW OF HC-1b SWITCH. USUALLY USED ON TRANSREX 240-1.2 MAGNET POWER SUPPLIES. TWO SCR MODULES OF A HC-1a UNIT HAVE BEEN REMOVED FOR THE LOWER CURRENTS REQUIRED.

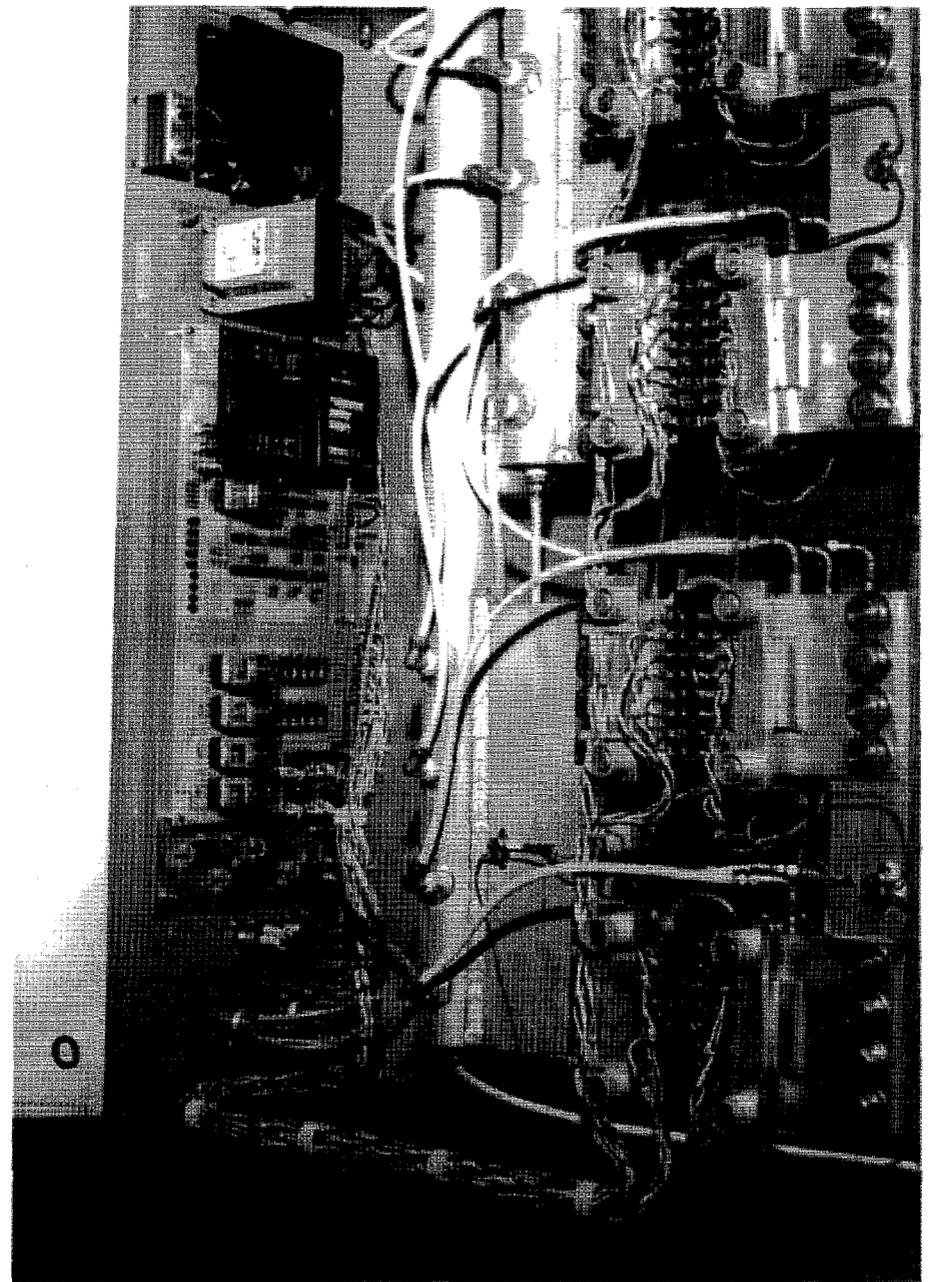


FIGURE 6d

DETAIL VIEW OF HC-1a SWITCH UNIT SHOWING CONTROL BOARD AND SCR MODULES.