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AEC RESEARCH AND DEVELOPMENT REPORT

A SCRAM BYPASS SYSTEM USING ZENER DIODES AS LOGIC ELEMENTS

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A SCRAM BYPASS SYSTEM USING ZENER DIODES AS LOGIC ELEMENTS

by

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ABSTRACT

A control chassis containing a group of reactor scram relays is described. A bypass switch is provided for each of the relays, but a zener diode logic circuit requires a certain minimum number of relays not to be bypassed before the reactor can be started up. The reactor is scrammed when any one of the unbypassed relays calls for a scram, or when less than the minimum number of scram relays is in service.

A SCRAM BYPASS SYSTEM
USING ZENER DIODES AS LOGIC ELEMENTS

DISCUSSION

At the Savannah River Laboratory it is desired to operate a certain test reactor only if three or more nuclear trips[1] are operating in the scram system. It is further desired that the reactor operator maintain positive control of the choice and number of these trips. A special chassis has been installed in the reactor control room to permit this type of operation.

The chassis contains a master scram relay and seven individual scram relays, one for each of seven nuclear instrument trips (Figure 1). The front panel of the control unit is equipped with seven key-operated switches and seven sets of indicator lamps. The switches are two-position types marked "READY" and "BYPASS", and the 21 indicator lamps are marked and colored as follows: "SCRAM" is red, "READY" is green, and "BYPASSED" is amber. The panel is positioned so that the reactor operator can visually verify the condition of each circuit.

The switches cannot be operated without their keys, which the operator may keep in his possession for positive control. Logic circuits within the chassis cause the master relay to scram the reactor (or prevent its startup) if more than four switches are in "BYPASS" position simultaneously.

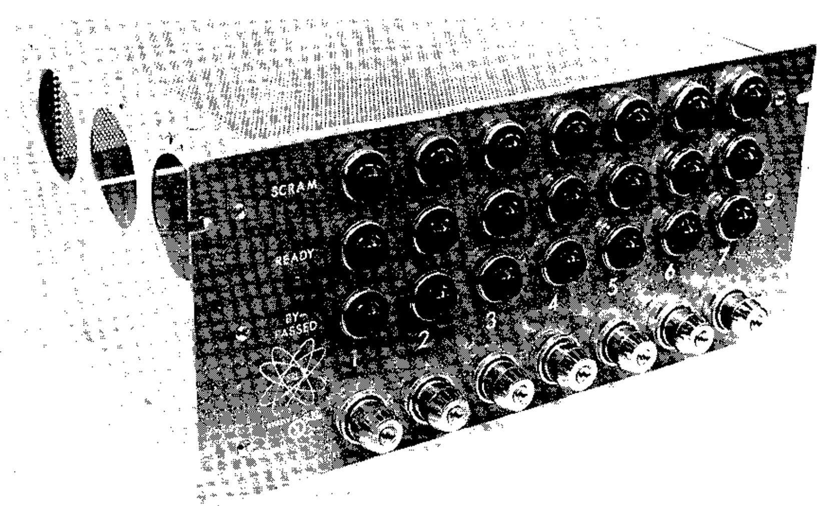

FIG. 1 CONTROL CHASSIS, SHOWING FRONT PANEL

CIRCUIT DESCRIPTION

Figure 2 shows the chassis external connections through barrier-type terminal strips on the rear apron. The individual scram relays are plug-in types, and Figure 3 shows their interconnections. Master relay power comes from a self-contained DC supply, consisting of isolation transformer, silicon diode bridge, and filter capacitor. AC leads to this supply and to the lamps are fused separately.

The master relay coil is operated through zener diodes Z1 through Z8. Z1 through Z7 are 30-volt types, and the bypass switches are arranged to bypass them in the "READY" position. Z8 is an 18-volt unit that is not bypassed so that its voltage drop is added to the drop across the remainder of the series circuit. Master relay RY8 operates at 24 volts and drops out at 10 volts. Thus, if four of the 30-volt diodes are not bypassed, the total diode voltage drop will be

$$4\ (30) + 18 = 138 \text{ volts.}$$

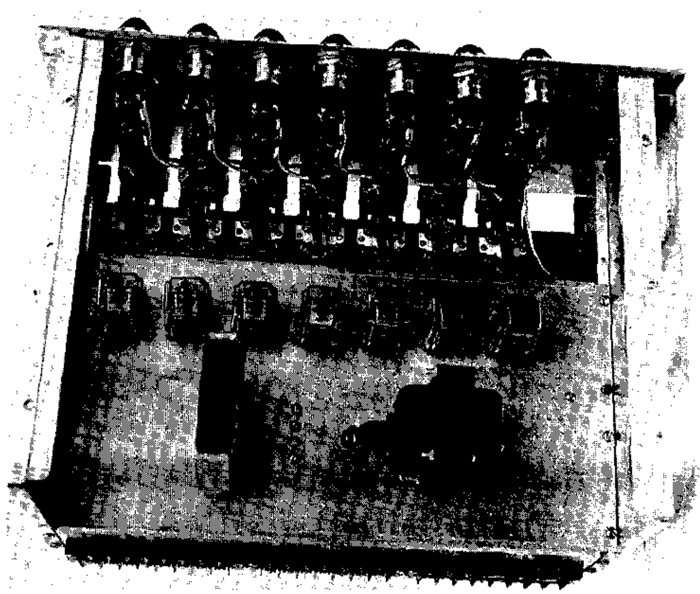

FIG. 2 TOP REAR VIEW, SHOWING EXTERNAL CONNECTIONS, PLUG-IN RELAYS, ETC.

The DC supply voltage is approximately

$$\sqrt{2}\,(115) = 162 \text{ volts,}$$

leaving the relay voltage at

$$162 - 138 = 24 \text{ volts,}$$

which is sufficient to energize it. Obviously, then, removing the bypass from more of the 30-volt diodes reduces the relay voltage to zero, causing the relay to drop out and initiate a scram.

The other extreme condition occurs when all of the 30-volt diodes are shorted, and the relay voltage becomes

$$162 - 18 = 134 \text{ volts.}$$

In actual practice the voltage will be lower, because the additional current drain will decrease the power supply voltage and increase the zener diode drop slightly at the same time. The relay coil is capable of withstanding this overcurrent for sustained periods because it is bolted to the aluminum chassis for heat sinking.

One normally-open contact on each of the individual scram relays (RY1 through RY7) is shorted when its switch is in the "BYPASS" position. These contacts are connected in series with a normally-open contact on the master relay and into the reactor scram system. A second set of normally-open contacts (on RY1 through RY7) is used without the master relay to operate an external annunciator that signifies a nuclear scram. A contact on RY8 is also connected to an external annunciator that indicates when less than three nuclear trips are in the "READY" state.

Indicator lamps are connected so that an amber light is on above any switch in the "BYPASS" position, while either a red or green light is on above any switch in the "READY" position. The green light, which indicates normal reactor conditions, is switched off and the red light switched on by a Form "C" contact (SPDT, break-before-make) on the individual trip relay (RY1 through RY7). Thus, whenever a nuclear scram occurs, the lights tell the operator where it originated.

The relay system is fail-safe because normal reactor operating conditions keep all unbypassed relays energized. Failure or removal of a relay, or failure of the DC power supply causes a scram. Prestartup tests of the nuclear trips guard against internally shorted zener diodes and stuck (or welded) contacts.

This scram bypass system has operated satisfactorily at the Savannah River Laboratory for almost two years. It is the main nuclear scram panel in the Process Development Pile control system, and has been completely trouble-free since it was installed in February 1962.

REFERENCES

1. W. J. Woodward. A Versatile Electronic Trip Device. USAEC Report DP-897, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, S. C. (1964).

Parts List (see Fig. 3)

Part	Description
C1	Capacitor, 10 μf - 600 VDC, G.E. 23F876
D1-4	Silicon Diode, 0.5A-400 PIV, 1N1084
F1	Fuse, 3A-125V, Type 3AG
F2	Fuse, 1-1/2A-125V, Type 3AG
L1-7	Lamp, 130V-6W, G.E. 656, in Dialco Socket Assembly 19901-531 (Red Lens)
L8-14	Lamp, 130V-6W, G.E. 656, in Dialco Socket Assembly 19901-532 (Green Lens)
L15-21	Lamp, 130V-6W, G.E. 656, in Dialco Socket Assembly 19901-533 (Amber Lens)
RY1-7	Relay, 3PDT, 115 VAC, Potter & Brumfield KRP14A, in Amphenol 78-S-11 Socket
RY8	Relay, DPDT, 5KΩ, Potter & Brumfield LM11
S1-7	Switch, 4PDT (1 Pole Unused), Key-Operated, Square "D" TS1K3 with TF & TB Contact Blocks
T1	Transformer, 50W Isolation, Stancor P6410
TB1,3	Barrier Strip, Cinch-Jones 8-142Y
TB2	Barrier Strip, Cinch-Jones 7-142Y
Z1-7	Zener Diode, 30V-1W, Motorola 1N3031A
Z8	Zener Diode, 18V-1W, Motorola 1N3026A

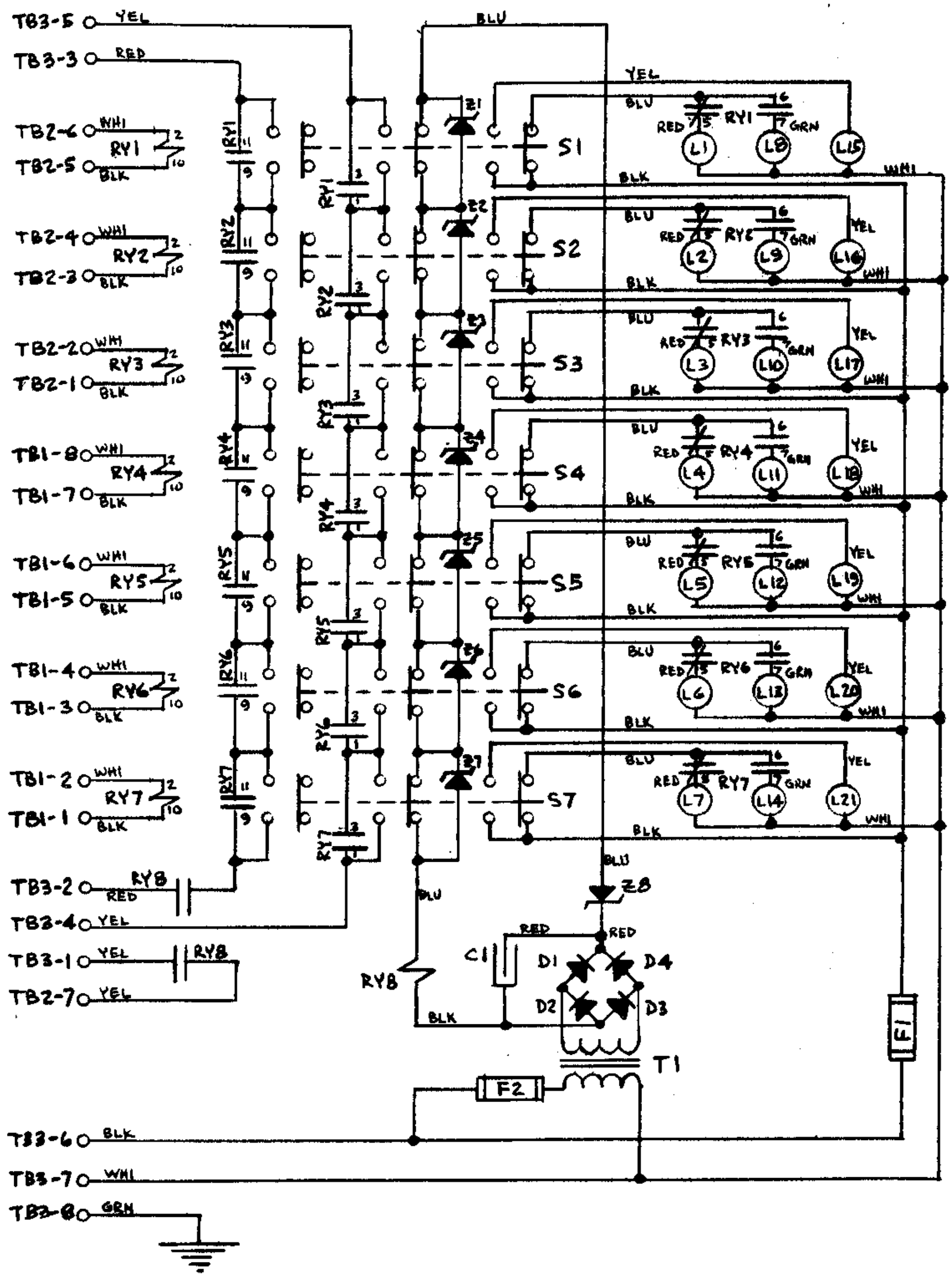

FIG. 3 SCHEMATIC DIAGRAM OF BYPASS SYSTEM