A MODIFICATION OF THE HOFFMAN-FLESHLER GRID SHOCK SCRAMBLER¹

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The recycling relay scrambler described by Hoffman and Fleshler (1962), while basically an ingenious application of the four-relay ring, contains two limitations.

The first is due to the scrambling rate of a self-cycling ring, which with some relays may be too high for 60 Hz shock voltage. As a

result, shock voltage pulses of less than one half cycle duration can be delivered to a subject as shown in Fig. 1A. This materially affects the behavioral qualities of the shock and makes the delivered magnitude impossible to specify. The problem is inherent in any system that presents a shock in pulses shorter than the duration of one cycle.

The second problem stems from the existence of a "race" condition (Keister, Ritchie, and Washburn, 1951, p. 155) in the Hoffman-Fleshler circuit. Self-cycling in their circuit can occur only if the drop-out time of any given relay is less than the time required for successive

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A

B

Fig. 1. Voltage wave forms appearing across a 10 K ohm resistor connected to different grid bar outputs. A. Two typical waveforms from the Hoffman and Fleshler system, 200 msec sweep. B (top). Initiation of a burst produced by the cam-operated system described in this article, 200 msec sweep. B (bottom). Transitions over a period of 1 sec for an on-off fraction of .5 with the cam-operated system.

Fig. 2. State sequence and schematic diagram showing the Hoffman and Fleshler grid bar connections in the upper half with the cam-driven microswitch modification below.

pick-ups of two other relays in the ring.² Several relays tried in a replica of their circuit did not consistently meet this requirement, thus causing all relays to lock up in the operated state. In addition, environmental conditions, contact misadjustment and worn or dirty moving parts could increase the drop-out delay after all the relays have been in service for some time. The system apparently recycles with the relays recommended by Hoffman and Fleshler. However, as a general relay system, its recycling reliability is marginal.

In dealing with the first problem the use of a capacitor shunting the relay coil must be ruled out, since this would increase the relay drop-out time and insure locking up. Other methods of slowing the recycling rate, such as series capacitor and resistor schemes, or tran-

sistor delays, have their own special problems and were considered too complicated.

The simplest solution to both problems, for present purposes, was the cam operated microswitch arrangement shown in the lower half of Fig. 2. The grid bar wiring shown in the upper half is from Hoffman and Fleshler and is included for the reader's convenience. A 60 rpm motor driving the cam provided a minimum of 14 cycles of delivered shock voltage. The on-off fraction for different pairs of grid bars in this system ranges between .25 and 1.0 as indicated in the polarity sequence diagram in Fig. 2. Figure 1B shows the 0.5 on-off fraction of this system, and illustrates the undistorted 60 Hz voltage output across the grid bars.

A total of 150 hr of shock has been delivered with this system with no malfunctions.

REFERENCES

- Hoffman, H. S. and Fleshler, M. A relay sequencing device for scrambling grid shock. *J. exp. Anal. Behav.*, 1962, 5, (3), 329-330.
- Keister, W., Ritchie, A. E., and Washburn, S. H. *The design of switching circuits*. New York: Van Nostrand, 1951.

²When any relay, L, in the Hoffman and Fleshler ring is being actuated, the Form C contacts on that relay transfer ground from L-2 to L+1, thus permitting L-2 to release and L+1 to pick up. However, the release of L-2 is not a prerequisite for the actuation of L+1, and the actuation of L+1 immediately restores the ground to L-2. Therefore, if for any reason L-2 has a slow release characteristic, the entire ring will lock up with all relays actuated.