TECHNICAL NOTE

AN EFFICIENT, INEXPENSIVE RELAY GRID SCRAMBLER
FOR MULTIPLE BOXES¹

Grid scramblers should be efficient in two senses: (1) each pair of grid bars should be of opposite polarity equally often, and (2) the frequency of opposite polarity in each pair should be maximized; *i.e.*, approach a limit of 50% of the time. Snapper (1966) described a device that is efficient in the first sense, and criticized other scrambling devices in terms of their expense, unequal density of shock, or unsuitableness for applications requiring long and short shock durations.

The device described by Snapper is inefficient in the second sense because at any moment only one grid bar is "hot" with respect to all others. Thus, a given pair of bars in a set of 18 will be of opposite polarity only 11.11% of the time. In addition to being efficient in

the senses indicated above, a scrambler should be inexpensive, even though it serves several chambers with many grid bars in each. The accompanying diagram illustrates a grid scrambler that meets these criteria.

The basic scrambling unit is illustrated in the right-hand portion of Fig. 1. The paired relays RL_{1A} - RL_{1B} , RL_{2A} - RL_{2B} . . . RL_{nA} - RL_{nB} switch the shock polarity on grid bars 1, 2, . . . , n , respectively, in each of four

¹Supported in part by grants MH-03337 and HE-06336 from the National Institutes of Health. Reprints may be obtained from the author, Department of Medical Psychology, University of Oregon Medical School, Portland, Oregon 97201.

Fig. 1. Schematic circuit diagram for grid scrambler and accompanying control circuitry for scrambling four independent shock sources across four grids of n bars each. See text for description of function. Relays are Allied KN105-3C-24D and diodes are Sarkes Tarzian F-2.

experimental chambers. Each of these paired relays operates in flip-flop alternation when momentary closure of a NO contact on RL_0 provides a pulse through isolating diodes to relays RL_{iB} ($i = 1, 2, \dots, n$). Given that RL_0 is operated, the B capacitors then charge. They subsequently discharge through NC contacts on the B relays to operate the A members of each pair when the B relays release. During operation of the A relays, the A capacitors are charged for subsequent discharge through NC contacts on the A relays to operate the B members of each pair. Thus, once started by RL_0 , the relay pairs RL_{iA} and RL_{iB} flip-flop at some rate determined by the time constants of their RC networks. Spark suppression of the flip-flop relays is accomplished with NE-2 neon bulbs to increase the life expectancy of the unit.

In the prototype described here, shock is delivered from four independent shock sources (0-500 v ac with 750 kilohm series resistance), illustrated in the diagram as shock sources 1 through 4, by closure of switches $SW_1, 2, 3$, or 4. Operating one or more of these relays supplies high voltage to the appropriate pole(s) of the flip-flops, simultaneously operates RL_0 , which supplies ground for charging the capacitors on the flip-flop relays, and operates RL_0 by capacitor discharge.

Efficiency of the scrambler is achieved by matching the relay coils and RC networks in each flip-flop so that the on-times of both members of a pair are equal. Thus, each grid bar is plus and minus equally often and each bar is "hot" with respect to every other bar about 50% of the time. Because they must be tailored for each pair of relays to create equal on and off times, the specific values of R and C used for each flip-flop

are not given. Scrambling is achieved by having each pair of flip-flops operate at a different rate, so that with continued operation the flip-flops go in and out of phase with each other. For maximum efficiency with brief durations of shock a single alternation pattern is delivered to the grid at shock onset. This is accomplished by inverse wiring of + and - (shock voltages) to the NO and NC contacts of alternate flip-flops. Maximum phase shifting (or scrambling) is achieved by maximizing the differences in flip-flop rate among the various elements of the scrambler. In the prototype described here, flip-flop rates varied between 60 per min (using approximately 10 ohms and 250 mfd in the RC networks) and 360 per min (requiring only 10 ohms and 35 mfd).

Economy results from using each flip-flop for four shock circuits. Even greater economy is possible because two additional shock circuits can be scrambled for every pole added to each of the flip-flop relays. Even with only four circuits, the cost for each 18-bar grid is \$42.00. The unit, as designed, has been in operation for over a year without breakdown. During that time it delivered more than 10,000 shocks of 0.5-sec duration to each of the four experimental units in an experiment on CER suppression.

REFERENCE

Snapper, A. G. A relay-transistor sequential grid scrambler. *J. exp. Anal. Behav.*, 1966, 9, 173-175.

F. ROBERT BRUSH
University of Oregon
Medical School