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A RELAY-TRANSISTOR SEQUENTIAL GRID SCRAMBLER[1]

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In most experiments involving electric shock, it is necessary to change polarities of grids rapidly. A variety of designs for grid scrambling devices is available but the choice of a unit for a particular laboratory depends upon the range of experimental procedures that require the use of shock, the number of experimental chambers requiring scrambled shock, the cost of the shock scrambling unit, and the availability of usable equipment on hand that could be adapted.

The early devices for scrambling shock (Skinner and Campbell, 1947; Wycoff and Page, 1954) utilized motor-driven switches to change grid polarities. In Skinner and Campbell's design, patterns of grid shock are varied with more than one grid at each polarity as the motor activates each switch. In the Wycoff and Page device, one polarity of shock is provided to one grid at a time while all others are kept at the opposite polarity. Problems with both devices arise from the relatively short life of the switches (which must pass high voltages) and from the high cost of providing a separate motor-driven scrambler for each experimental chamber in large laboratories. A motor-driven scrambler utilizing mercury switches to alternate polarities (Owen and Kellermeier, in press) has been suggested for its long life expectancy and silent operation. But it is not recommended for procedures that require shock durations less than 1 sec.

Another type of scrambler which is somewhat less expensive ($50 per box) has been suggested by Hoffman and Fleshler (1962). This device incorporates a relay switching circuit that can be expected to possess a long life, especially since it is activated only during a scheduled shock, unlike the motor-driven devices that often operate continually. The relay scrambler alternates four patterns of grid shock in a similar manner to the original Skinner and Campbell motor-driven alternator. A problem with this type of grid scrambling in experiments involving long shock durations (such as escape), has been raised by Sloane (1964). He has claimed that subjects can sometimes discriminate differences in densities of shock that occur on different grids and has suggested rewiring grid positions to avoid density differences.

Several suggestions have been made for solid state type scrambling devices. One of these (Markowitz and Saslow, 1964) utilizes a ring counter constructed from neon bulbs. This device, which should have an exceedingly long life, is about the same in price per box as the Hoffman and Fleshler (1962) device. However, there is as much as a 10% difference in the shock voltages between different grids, thus raising the possibility of discrimination of these differences in escape experiments.

An electronic grid scrambler that steps constant power ac at 60 cps along the grids has been reported by England (1964). Features of the electronic circuit include silence of operation and reliability. However, a number of supplementary relays are also required to provide shock to more than one experimental testing chamber.

A scrambler that changes polarities only while the subject is not being shocked has also been suggested (Parks and Sterrit, 1964). This device is driven by a solenoid stepping switch which is controlled by a transistorized feedback amplifier that terminates the search upon delivery of current. The only difficulty with this device is the noise (both electrical

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and auditory) generated during the search, but this could be eliminated by using more expensive transistorized ring counters with relays.

The present scrambler is a hybrid transistor[2] and relay[3] device that incorporates the speed and longevity of relays. It is relatively inexpensive for laboratories operating a large number of rat boxes at once. Furthermore, it provides equal densities of shock on all grids, thus preventing problems that arise with long shock durations. A supplementary feature is the possible use of the components for standard digital programming when the shock scrambling is not needed.

The circuit shown in Fig. 1 consists of two parts: (a) the cycling segment which includes the transistors and the relay contacts shown below the relay coils, and (b) the high-voltage scrambling circuit above the relay coils. If one cycle of shock is sufficient, switch 1 would be placed in the position shown, connecting 24 v dc to the diode of the coil of relay 2. When ground is provided at the coil of relay 6 (operate), the following sequence of events occur: the clock MV-5 immediately sets FF-1, thus driving relay 7 through the relay-driver RD-5, and relay 1 locks on from the pulse of relay 7. After the clock sends out a second pulse, the flip-flop resets, releasing relay 7 and thus locking up relay 2. Each successive MV-5

[2]Digibits, obtainable from Tech. Serv. Inc., 5451 Holland Drive, Beltsville, Md.

[3]Allied #TF-154-6c, obtainable from Allied Control Co., Inc., 2 East End Avenue, New York City.

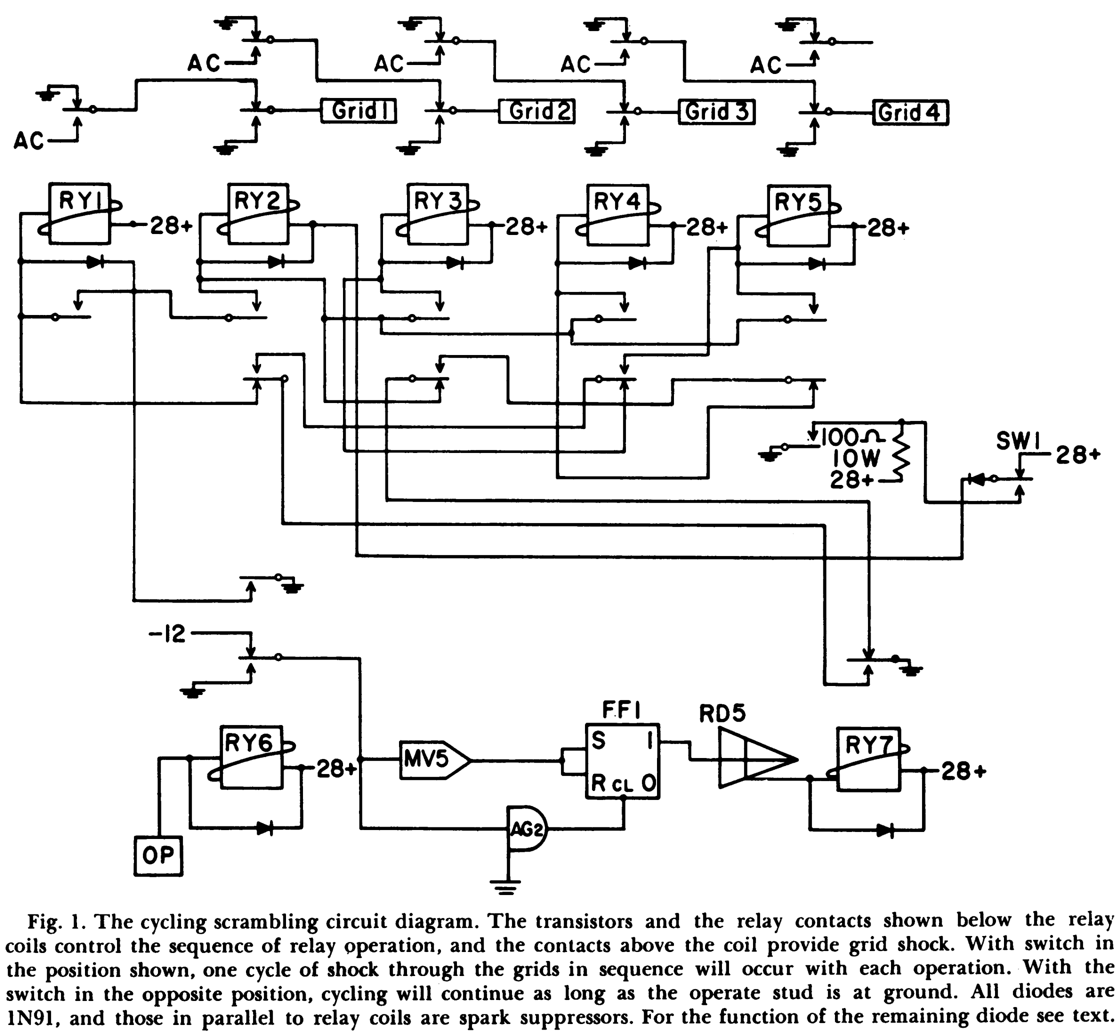

Fig. 1. The cycling scrambling circuit diagram. The transistors and the relay contacts shown below the relay coils control the sequence of relay operation, and the contacts above the coil provide grid shock. With switch in the position shown, one cycle of shock through the grids in sequence will occur with each operation. With the switch in the opposite position, cycling will continue as long as the operate stud is at ground. All diodes are 1N91, and those in parallel to relay coils are spark suppressors. For the function of the remaining diode see text.

clock pulse locks up the next relay in the chain, until the fifth relay is operated. When relay 1 is the only relay in the chain in the locked position, ac is provided at grid #1. When both relay 1 and relay 2 are on, the second grid is the only one charged, all the others remaining at ground. Relay 5 terminates the sequence, leaving all grids at ground as in the initial state.

If more than one cycle of grid shock is desired, switch 1 is in the down position, providing 24 v dc through a shunt resistor and diode to the coil of relay 2. A lead connects the junction of the resistor and diode to the normally open contact of relay 5. In this mode, operation of the first four relays in the chain is as described above, but the operation of the fifth relay grounds the shunt resistor, causing relay 2 to release itself and all other relays farther along in the chain, since the diode prevents ground from passing through RY 2's coil to the lock up contacts on RY 3, 4 and 5. At this point grid #1 will again receive the ac potential and will begin the sequence anew until ground is removed from the operate stud. Since the sequential lock-in relay circuit is the heart of this scrambler, it would be possible to use any timing source—such as a relay timing circuit—to provide pulses to the relay chain instead of the present transistor logic. The timer would have to provide pulses at the desired repetition rate and each pulse would have to be on 50% of the timing cycle.

The device has a life-span limited only by the life of the relays. Since in most cases the relays are operated only during the scheduled shock, the scrambler should provide over 500,000 shocks, depending upon the shock voltage, before replacement of the plug-in relays is necessary. The shock duration at each grid is controlled by the adjustable MV-5, but it must be at least 20 msec long to assure reliable relay operation.

A final advantage of the present system is the ease with which it can be expanded to handle more than one experimental box. With six-pole relays, each set of relays can deliver shock to two boxes for yoked control experiments. The same timing circuit can be used to operate more than one set of shock relays by adding a diode network at the operate stud. Eight rat boxes are presently being operated from one scrambling circuit, and over 300,000 shocks have been delivered without any failures.

The cost of the relay sequencing system for the four grids in the diagram would be $20; each relay costs $3.94 and sockets are $0.73. This would handle two rat boxes, since the relays have six poles. The present timing circuit incorporating two relays plus transistor units would cost approximately $50 giving a total of $70 for two rat boxes with four grids each.

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