A MERCURY SWITCH GRID SCRAMBLER FOR AVERSIVE CONDITIONING

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This grid scrambler was developed for such procedures as the shock titration schedule (Weiss and Laties, 1959) or any schedule where an electric shock stimulus is applied continuously or for intervals longer than short bursts. Mechanical switches in conventional motor-driven grid scramblers wear or break down under prolonged operation at high speeds. Also, the background noise created by mechanical switch scramblers can become aversive. An electronic scrambler similar to that described by Markowitz and Saslow (1964) has proven satisfactory for silent, continuous operation, except that in the shock titration schedule, it is difficult to control and monitor the changing shock levels.

The grid scrambler described here has been proven reliable and silent in over 1000 hr of operation on the shock titration schedule. As shown schematically in Fig. 1, it is a motor-driven cam shaft which rocks single pole, double throw mercury switches, *A* (Mercoide mercury switch No. 9-64R at \$2.70). The polarity of the current to any grid of the experimental cage is determined by the relative positions of the cam, *F*, and switch for that grid. Two switches are operated by each cam, one at the top and the other at the bottom of the cam. The switches are held by special clips,

B (Mercoide switch clip No. 7-57 at \$0.15) designed for this type of switch. A short piece of brass tube, *E*, is soldered to one end of each clip. This holds the clip to the pivot rod, *D*. A small piece of nylon, *C*, is cemented to the other end of the clip to act as a bearing surface against the cam. The two switches are held in position against the cam by a spring, *G*, connected between the clips. The springs are attached to solder lugs, *I*, soldered to the clips at the positions indicated in Fig. 1.

The cams are cut from 2-in. diameter nylon rod and are $\frac{3}{16}$ in. thick (Fig. 2). This material is sold as Nylon, Type 6/6 (Zytel 101) at approximately \$7.40 per foot, or is available in sheets. It is sold by most plastic materials distributors and by radio and electronic distributors, e.g., Allied Radio, 100 N. Western Ave., Chicago 80, Illinois. The use of nylon for the bearing surfaces contributes greatly to the silent operation.

The pivot rods and cam shaft, *H*, are made of $\frac{1}{4}$ -in. steel rod. The pivot rods are threaded only at the ends. The cam shaft is threaded its entire length except for the one end which is supported in the chassis by a self-aligning Oilite bearing. The $1\frac{1}{2}$ and $\frac{3}{4}$ in. dimension lines in Fig. 1 indicate the horizontal and vertical placement, center to center, of the cam

Fig. 1. A single cam with two mercury switches and component parts with a pictorial wiring diagram as described in the text.

Fig. 2. Dimensional diagram of a nylon cam.

shaft and pivot rods. The distances between cams are regulated by adjusting nuts on the shaft and the spacing between clips is maintained on the pivot rods with thin washers and collars, *J*, held in place with set screws. A short, rigid sleeve coupling connects the motor and cam shaft.

The motor (Dayton gear motor No. 5K206 at \$7.50) has a speed of 25 rpm developing 12 in.-pounds of torque. It is available in speeds of 1 to 50 rpm, but as the speed increases the torque decreases. In several experiments a 35 rpm motor was used. Occasionally the scrambler failed to start due to insufficient starting torque. As used in this grid scrambler, the 25 rpm motor produces enough force to operate eight cams and 16 switches.

The relative rotational positions of the cams when locked on the shaft are progressive, each cam being rotated approximately 20 degrees more than the preceding one. The cam configuration and motor speed control the frequency of polarity change. With the above motor and a four shouldered cam, the current polarity of each grid is switched 100 times per minute. This is adequate to allow an ammeter to monitor the current level with the animal acting as the resistance when used with a full wave dc constant current stimulator. The ammeter readings are the same as those recorded when different test resistances of known value are used in place of the animal. A check of the current flow with an oscilloscope connected across different pairs of cage grids revealed no transient wave forms while the scrambler was in operation. The patterns on the screen indicated polarity reversal of the current as well as definite breaks in the flow as the switches changed position or whenever the polarities on the two grids were momentarily the same.

All wires from the switches are fastened to terminal strips for convenience of wiring to the stimulator output terminals and to the Cannon KTP plug connector which is the receptacle for wires from the experimental cage grids.

The end walls and base of the chassis, Fig. 3, are of aluminum measuring $4\frac{1}{2}$ by 5 by $\frac{1}{4}$ in.

Fig. 3. Photograph of the mercury switch grid scrambler.

and $4\frac{1}{2}$ by 8 by $\frac{1}{8}$ in. respectively. The 8-in. length accommodates eight cams. The length is optional depending on the number of cams and switches to be operated. The terminal strips and plate with stimulator input, Cannon plug, fuse, and pilot light are supported by $\frac{3}{4}$ -in. aluminum angle strips bolted to the end walls.

Because of the slow rate of switching action, this scrambler should not be used for shock durations of less than 1 sec in length. Under intermittent use the scrambler should run continuously with the shock current from the stimulator turned on and off as needed. The maximum switching rate of the mercury switch used here has not been determined and the manufacturer fails to state this in the technical data sheet.

This grid scrambler was built at a cost of approximately \$80.00 for the parts.

REFERENCES

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- Markowitz, H. and Saslow, M. G. A reliable silent electronic shock scrambler. *J. exp. Anal. Behav.*, 1964, 7, 267-268.