JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1972, 17, 23-24 NUMBER 1 (JANUARY)

TECHNICAL NOTE

APPLICATIONS OF MATRIX SWITCHING[1]

Gollub (1960) described how electromechanical apparatus can be made more versatile with multiple-bank rotary switches, which allow the experimenter to change the connections in a given array of equipment simply by dialing the appropriate circuits. Another device that permits multiple connections is the matrix or cross-bar switch, originally designed for electrical operation in telephone switching, but now available in a manual version. A manual matrix or cross-bar switch consists of electrically independent columns along each of which a slider can be moved. The slider can rest in a neutral position, or can connect the column to any of several electrically independent rows.

Several types of manual matrix switches are available from Cherry Electrical Products Corporation, 3600 Sunset Avenue, Waukegan, Illinois 60085. One type (10 by 20 configuration, C10-01A matrix selector switch, approximately $35) is shown mounted on a standard micarta relay-rack panel in Figure 1. The switch consists of 10 columns, wired consecutively to the top 10 studs on the panel, and 20 rows, wired consecutively to the remaining 20 studs (two grounds studs are also shown at bottom left and right on the panel). The column studs are wired to quick connect terminals, on the back of the matrix switch; the row studs are wired to an edge connector receptacle along one side of the back of the switch. The current capacity of the contacts is rated at 2 amperes for continuous ac or dc operation, at 0.5 ampere for 48 v dc make-break operation, and at 0.15 ampere for 125 v ac make-break operation.

In Figure 1, the sliders for columns 1, 2, 3, and 10 and therefore the corresponding studs of the top 10 on the panel are connected, respectively, to rows 1, 2, 8, and 13 and therefore the corresponding studs of the remaining 20 on the panel; the sliders for columns 4 through 9 are in the neutral center position. A given row also can be connected simultaneously to more than one column by moving the sliders of two or more columns to that row.

The slider is carried by a spring that mates with indentations in the column, so that accurate location of and contact with a given row is unambiguous as the slider is moved along the column. The sliders move easily, provided that the columns are lubricated with a light application of graphite powder about once or twice a year. Twelve matrix switches mounted as in Figure 1 have been in regular use in an undergraduate laboratory course and in various research applications in this laboratory for more than six years; all remain in good working order at this writing.

The many cross-connections that are available permit a variety of arrangements. Each of the columns can be used as an input (*e.g.*, responses from each of several pigeon keys, reports of events in controlling circuitry) and each of the rows as an output (*e.g.*, various reinforcement-schedule circuits, stimulus events in the chamber). For example, if the order of stimuli in four-component chained schedules is to be changed from time to time, inputs corresponding to the four components can be connected to columns 1 through 4, and outputs corresponding to four stimulus lamps can be connected to rows 1 through 4; any order of the four stimuli can then be selected by appropriate placement of the sliders for the first four columns.

Only unusual circumstances call for the full 10-by-20 capacity of the matrix switch illustrated, but it is often possible to combine session-by-session modification of procedures, on one portion of the switch, with procedures that may be changed only occasionally, over large blocks of sessions, on another portion of the switch. In such cases, an index card can be trimmed to fit the cutout on the micarta relay-rack panel, and can serve as a template to fix the position of or restrict the movement of particular sliders; appropriate instructions for technical staff can also be written directly on this card.

When each of several subjects in a given apparatus is to be exposed to a different procedure, it is best to use a single column of the matrix switch to operate relays that control the relevant circuits; the likelihood of error is minimized by restricting the adjustment to a single slider. In his discussion of analogous applications of rotary switches, Gollub (1960) pointed out the desirability of requiring a change in the setting of the switch at the beginning of each subject's session, even if the conditions for some successive subjects are identical. The large number of available contacts on the matrix switch permits an additional precaution: a circuit can be arranged that prevents the experimenter, after one session has ended, from starting the next session until the appropriate slider has been moved. For example, assume that different procedures for four pigeons are controlled by positioning the column-1 slider at row 1, 3, 5, or 7, respectively. If the end of one session locks up a relay that prevents the start of the next session, and if this lockup can be broken only by a circuit that operates when the column-1 slider passes across row 2, 4, or 6, the experimenter must

[1]Supported by NSF Grants GE-2172 and GB-3164 to New York University.

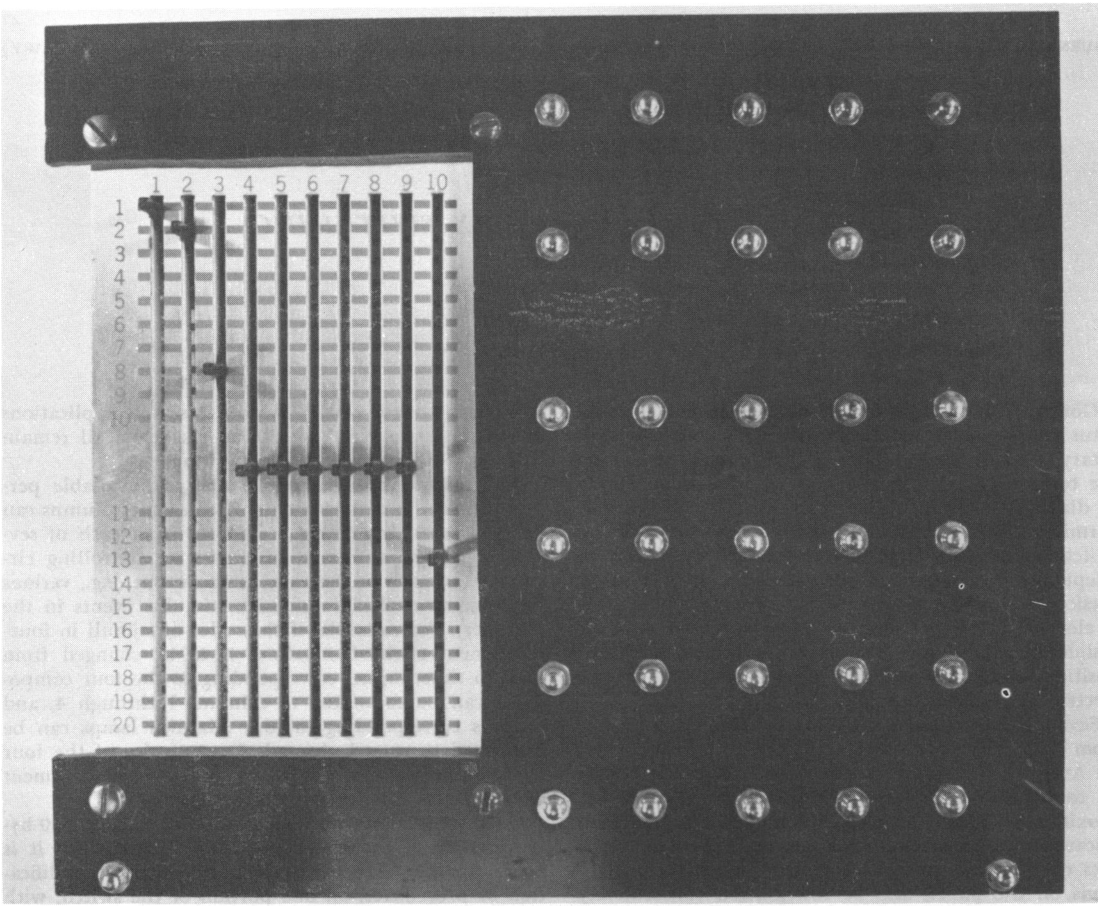

Fig. 1. Panel-mounted manual matrix or cross-bar switch. Details in text.

move the column-1 slider before any session is commenced.

A final application of the manual matrix switch that has proven of special value is in undergraduate laboratory courses. Students learn the operation of the matrix switch readily; laboratory instructions are easy to present in terms of slider positions; and apparatus can be arranged in advance for several successive laboratory sessions. For example, in one laboratory sequence on stimulus control, the single matrix switch illustrated in Figure 1 served each of the following functions: the experiment was turned on by moving the column-1 slider to row 1; one of four stimulus-control conditions, differing in the particular stimuli correlated with reinforcement and extinction, was selected by moving the column-2 slider to row 3, 4, 5, or 6; the reinforcement component was irregularly alternated with the extinction component by switching the column-3 slider between rows 9 and 10; the stimulus-control procedure was changed to a procedure for obtaining stimulus-control gradients by moving the column-10 slider to row 20; and the eight stimuli in the gradient were presented in counterbalanced orders by moving the column-9 slider in appropriate sequence among rows 11 through 18. Thus, this example demonstrates that a manual matrix switch can provide a large measure of flexibility without a substantial investment of time and accessory equipment.

A. Charles Catania and
George G. Zimbardo
New York University

REFERENCE

Gollub, L. R. Experimental flexibility. *Journal of the Experimental Analysis of Behavior,* 1960, **3,** 254.