SOME ELECTRONIC CONTROL UNITS FOR OPERANT BEHAVIOR STUDIES: I. A RESPONSE AND REINFORCEMENT CONTINGENCY TRANSLATOR[1]

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We have developed in our laboratory a versatile translator for response events and reinforcement contingencies. We have used it extensively, and it has reached a stage of development in which its functioning is of high reliability. The unit is a central one around which various types of auxiliary apparatus may be employed to produce a wide variety of experimental conditions. In subsequent apparatus notes, we will describe several of the supplementary systems we are using in the study of temporal schedules of reinforcement.

Among the functions of the translator the following may be noted: (a) it accepts response data electronically (in the form of pulses); (b) it passes these data to recording devices; (c) on external signal, it provides a timed reinforcement for the next response or for any number of subsequent responses; (d) on another external signal, it removes reinforcement availability; (e) on an external panel, it permits manual testing of each of its functions.

The control unit has a number of advantages for behavior researches, including the ability to handle very high rates of responding (surpassing the response rate of any known organism, and approaching, if not surpassing, the limit of any currently available recording or print-out device). It can be driven by any experimental programing system at virtually unlimited speed (up to 100 kilocycles). It is compact, and provides long trouble-free operation.

The circuit diagrams of the apparatus are given in Figs. 1 and 2, each accompanied by an index of components. The operation of both circuits may be traced as follows:

(1) The response pulse is generated by closure of the pigeon key (K), or, if switch Sl is thrown, key pecks may be manually simulated by push button Bl on the control panel. K, of couse, may be any manipulandum operating as a switch.

(2) Each closure of K operates relay RY1, feeding a response pulse into the one-shot (El), which in turn puts out a square wave of consistent amplitude and duration. The latter operates the Sodeco response counter through the circuit involving half of tube Tl and relay RY3. The occurrence of a response is also indicated on the panel face by a flash of neon light N3. The duration of the standard pulse from El is controlled by the magnitude of capacitor C2, for which a value must be chosen that provides an output pulse of sufficient duration for the operation of the particular recording mechanism being used. (We have found 0.05 microfarad a satisfactory value of C2 for both Sodeco counters and Gerbrands cumulative recorders.) Most recording devices have a sizable refractory period which must be taken into account in the setting of C2. Response events within the refractory period of the recorder can be reinforced by the present system, if so desired. Mechanical counters do not have the resolving power for responses which this electronic system provides, but electronic counters of very short refractory period are available with counting resolution which can be made equal to the resolution of the present reinforcement system, if necessary.

The apparatus as described was developed in conjunction with research supported by the National Science Foundation under Grants G-3408 and G-5517. Earlier support for design of a first model was given by the Eugene Higgins Fund of Columbia University.

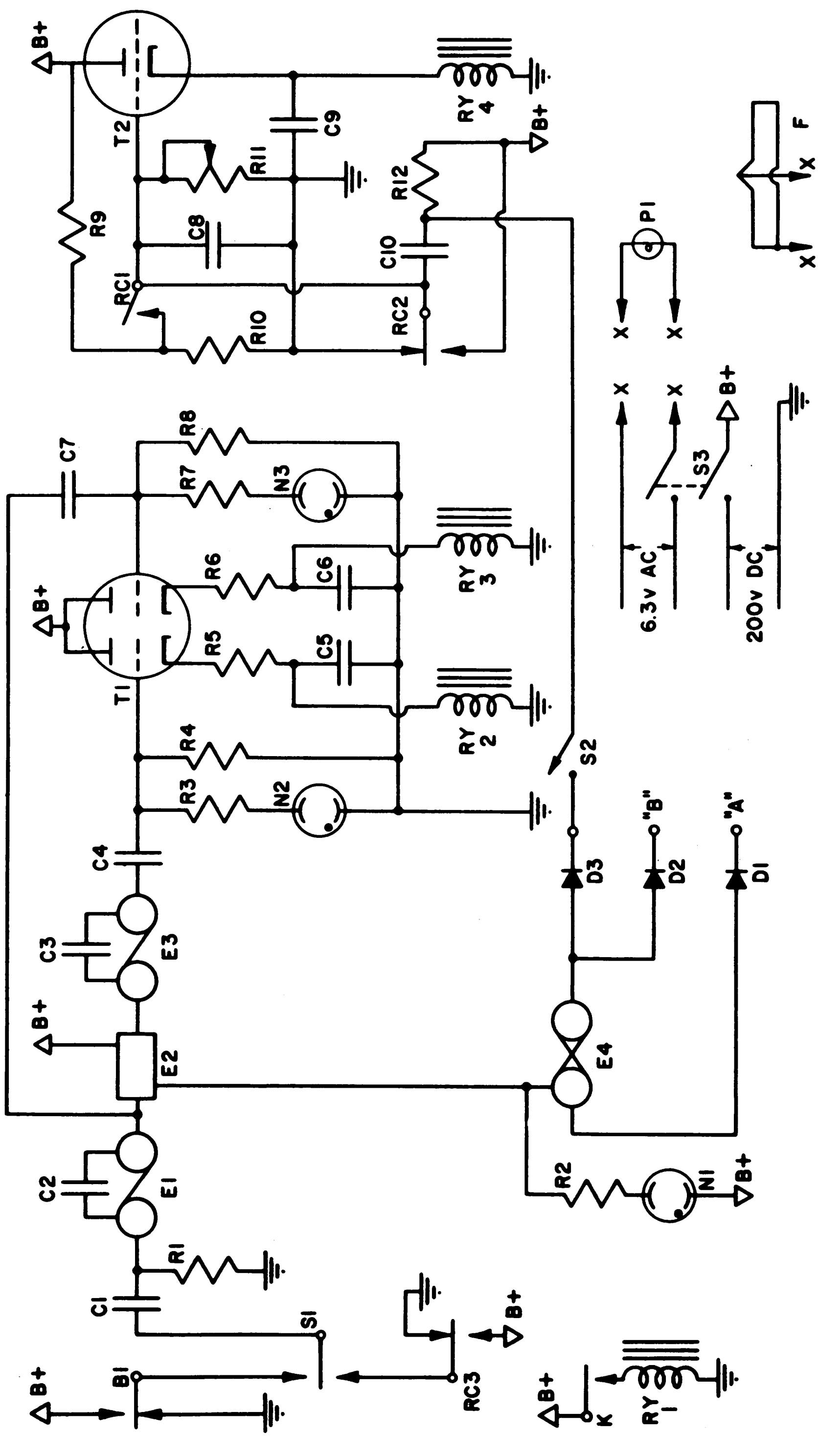

Figure 1. Circuit diagram of the translator.

(3) The output of El also is coupled to E2, a pulse gate, which will pass or block the negative-going side of the output pulse of El that operates the reinforcement circuits. The state of the gate is determined by E4, a flip-flop (bi-stable multivibrator) controlled from an external programing system. The state of E2 is visually indicated on the control panel by N1, which glows when the gate is open. Pulses from the external programing system are shaped by two Schmitt trigger circuits to insure correct amplitude and rise time for reliable operation of E4. Figure 2 is the circuit diagram of one such trigger. Operation of a Schmitt trigger requires only grounding of its input, which can be accomplished either manually by button B2 or by relay circuit; alternatively, external programing systems may be used which activate the trigger by electronically generated pulses. There are, of course, two buttons with the function of B2, one at the input to each Schmitt trigger, which produce, respectively, the "pass" and "block" states of E2.

(4) The reinforcement circuit consists of one-shot E3 which operates tube T1 (the half not used for response counting) in a manner identical with the response-counting circuit. This output of T1 operates RY2, the contacts of which are RC1 and RC2, charging the timing circuit associated with tube T2. The duration of reinforcement is controlled by the discharge time of this circuit and may be set by R11 which controls the holding time of RY4. RY4 operates the feeder and reinforcement counter. The occurrence of a reinforcement is visually indicated on the control panel by a flash of N2.

Index For Figure 1

R1—1 megohm, 1/2 watt	C1—.05 mf., 300 v.
R2—1 megohm, 1/2 watt	C2—.05 mf., 300 v.
R3—1 megohm, 1/2 watt	C3—.05 mf., 300 v.
R4—1 megohm, 1/2 watt	C4— .5 mf., 200 v.
R5—10 K ohm, 1 watt	C5—.25 mf., 200 v.
R6—10 K ohm, 1 watt	C6—.25 mf., 200 v.
R7—1 megohm, 1/2 watt	C7— .5 mf., 200 v.
R8—1 megohm, 1/2 watt	C8— .5 mf., 200 v.
R9—10 K ohm, 1 watt	C9—.25 mf., 200 v.
R10—6.4 K ohm, 2 watt	C10—100 mmf.
R11—5 megohm, 2 watt(variable)	
R12—100 K ohm, 1/2 watt	
B1—Manual response pushbutton	
K—Pigeon key	
RY1—28 volt mercury-wetted-contact relay**	RC1—Contacts on RY2
RY2—10 K ohm plate relay	RC2—Contacts on RY2
RY3—10 K ohm plate relay	RC3—Contacts on RY1
RY4—10 K ohm plate relay	
E1—EECO one-shot Z-8348*	N1—NE51 neon bulb
E2—EECO pulse-gate Z-8327*	N2—NE51 neon bulb
E3—EECO one-shot Z-8348*	N3—NE51 neon bulb
E4—EECO flip-flop Z-8342*	
S1—Manual response switch, SPDT toggle	D1—diode 1N34A
S2—Reset after reinforcement switch, SPDT toggle	D2—diode 1N34A
S3—Power switch	D3—diode 1N34A
"A"—"pass" input from Schmitt trigger	T1—12AT7 tube
"B"—"block" input from Schmitt trigger	T2—12AT7 tube

*All EECO plug-in circuits are manufactured and sold by the Engineered Electronics Co., 506 East First Street, Santa Ana, California.

**Similar to HG1042 made by C. P. Clare Co.

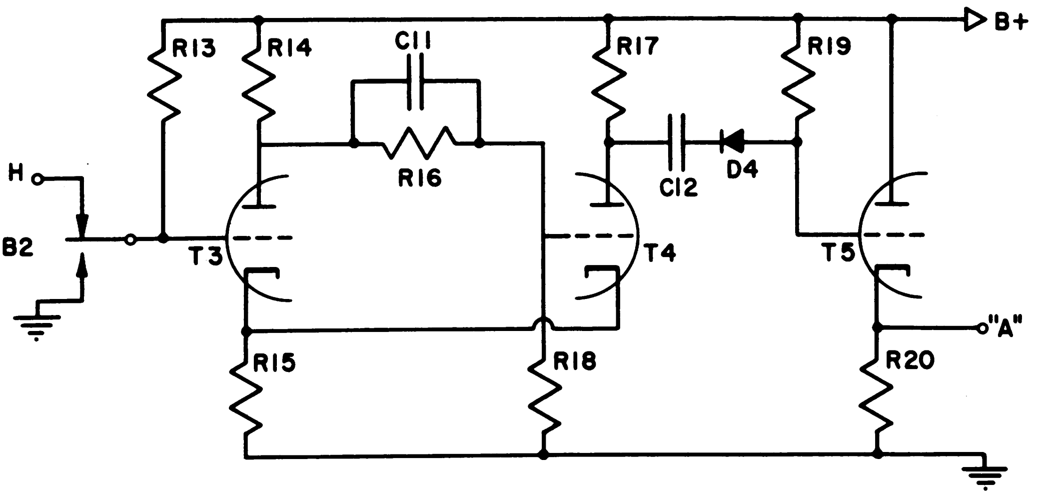

Figure 2. Circuit diagram of the Schmitt trigger. Two of these auxiliary circuits are used in conjunction with the translator.

Index For Figure 2

R13—210 K ohm, 1/2 watt
R14— 10 K ohm, 1/2 watt
R15— 15 K ohm, 1 watt
R16—220 K ohm, 1/2 watt
R17— 33 K ohm, 1/2 watt
R18—100 K ohm, 1/2 watt
R19—100 K ohm, 1/2 watt
R20— 33 K ohm, 1 watt
"A"—"pass" input to translator
H—"pass" input from programmer
B+—200 v DC+

C11—50 mmf.
C12—100 mmf.

T3—one-half 12AX7 tube
T4—one-half 12AX7 tube
T5—one-half 12AT7 tube

D4—diode 1N34A
B2—Manual pushbutton

Duplicate above circuit for "block" pulse using other half of T5.

(5) To accomplish regular reinforcement, switch S2 is opened. If S2 is closed, the occurrence of reinforcement sends a pulse from the circuit associated with RC2, resetting the flip-flop E4, blocking the gate E2, and preventing further reinforcements until the flip-flop is again pulsed by the programing system.

(6) We have worked out convenient control panel and chassis arrangements of these circuits which simplify wiring and contribute to the ease of operation. Details are available on request.

Received October 8, 1959