A TRANSISTORIZED CIRCUIT FOR RECORDING CONTACT RESPONSES¹

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In psychological research it is frequently desirable to use a touch or contact response to operate counters, kymographs, and other recording equipment. A touch response may be defined as a response that is selectively reinforced when the organism contacts some prescribed and (usually) limited region of its environmental space.

A touch response has certain advantages peculiar to itself and not shared by other responses. In operant work, for example, a lever-touching response would be more desirable than a lever-pressing response in research with very young infant organisms (including the human infant), who lack the sort of motor coordination needed to depress a lever. Lever touching would also be preferable to lever pressing in comparative research, where differences in motor dexterity between the species tested may complicate the interpretation of results. Also, in drug research, it would seem that the touch response would be less subject to the effects of ataxia than the more complex (motor-wise) lever-pressing response.

Lever touching may also serve as an aid in shaping lever pressing. Once the animal had acquired a lever-touching response, it is a simple matter to make the lever-touch circuit inoperative and then require a lever depression as the appropriate (reinforced) response. This would be true particularly in experimental designs where the animal is required to exert some unusual force in order to activate the lever mechanism.

At another level, the type of subject (for example, the larger apes or psychotics) may be a strong inducement to use a touch response. Because the contact surface may be made to consist of a small metal plate that may be embedded in the wall of the experimental room or test cage, it is relatively indestructable and can stand untold abuse without requiring replacement or repair.

Finally, an electronic contact switch is frequently desirable in studies of fluid consummatory behavior (Hill & Stellar, 1951), or in research on taste sensitivities or preferences of various solutions. Such a switch permits the recording of every lap that the animal emits, as well as the frequency and distribution of laps. The circuit described below may be used in any of the above operations (among others) without requiring any changes or modifications.

Figure 1 shows the circuit of a highly sensitive and reliable transistorized contact electronic switch. It may be used to control recording equipment employed in any psychological problem in which the subject can be trained to touch, or does in fact touch (during the normal course of its behavior), selected regions of the behavioral space.

The electronic switch consists of a two-stage amplifier and a monostable multivibrator, both using transistors.² Transistors are used instead of vacuum tubes because of their small physical size, which permits the entire device, exclusive of the power supply, to be housed in a 2.25- by 3- by 5-inch aluminum Minibox (see Figure 2), and also because of

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²The junior author is responsible for the design of the present circuit.

Figure 1. Circuit and parts list of a transistorized contact switch.

Figure 2. Housing and parts arrangement.

their low power consumption and excellent reliability. A prototype switch has successfully completed three million switching operations without failure.

The animal, upon touching the point of contact (any conductor), applies a sinusoidal signal, in the range of 7500 to 8000 cycles per second, to the base of T1. The amplified output of T1 is in turn applied to the base of T2, which is biased such that clipping occurs at a low input amplitude. The output of T2 is then a square wave which is passed through a differentiating network to produce sharp positive and negative spikes. The negative spikes are removed by the 1N54A diode, leaving an output consisting of a series of positive trigger pulses, one for each positive square-wave loop; the number of pulses is determined by the duration of the contact response itself.

The trigger pulses are then applied to the multivibrator through the 0.1-microfarad coupling capacitor. The time constant of the multivibrator is adjusted such that conduction is transferred from T4 to T3 for a period of approximately 450 microseconds, so that each fourth trigger pulse will retrigger the circuit. As a result, the relay in the collector circuit of T3 is energized for approximately 90% of the switching cycle, with no current flowing through it for the remaining 10%. Because of the mechanical inertia of the relay armature and the electrical inertia of the relay coil, the relay cannot follow the very short off period, and remains closed as long as trigger pulses are supplied. Consequently, the relay closes on the first trigger pulse and opens after the last, each relay operation corresponding to one complete "on-off" contact. Contacts in excess of 25 per second are reliably followed by the relay.

The 7500- to 8000-cycle signal is supplied by an audio oscillator having a low-impedance output. It may be applied directly to a metal grid floor upon which the animal stands, or, at higher gain, to metal plates between which the animal stands. Estimating the resistance of a rat at 100,000 ohms, a signal applied directly to the floor need have a magnitude of only 0.2 volt in order to trigger the multivibrator.³ A higher voltage is needed, of course, when the signal is applied to metal plates. The approximate voltage, in this case, is found by trial and error and depends primarily on the amount of separation between the plates.

Use of a multivibrator time constant of approximately 450 microseconds insures freedom from response to stray transients that may find their way into the circuit, since a transient is not periodic and therefore cannot trigger the multivibrator for a number of cycles sufficient to activate the relay. Also, the low power requirements of the contact switch make its operation extremely economical and completely eliminates problems due to heat generation.

The relay is typically used to switch another (external) relay having multiple contacts with high current ratings in order to operate counters, stepping switches, etc.

REFERENCE

Hill, J. Harry, and Stellar, Eliot. An electronic drinkometer. *Science*, 1951, **114**, 43.

³Transistors of the same type may vary, however, in their gain characteristics. Accordingly, a slightly higher voltage may be required.