AN INEXPENSIVE GEIGER GATE FOR CONTROLLING PROBABILITIES OF EVENTS

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A previous communication (Millenson, 1963) described an apparatus for experimentally regulating probability of occurrence of various environmental events in relation to time or behavior. That apparatus made use of the near perfect random character of natural radioactive decay. A geiger counter tube was connected to an amplifier and pulse shaping circuit with a relay output whose contacts provided a probabilistic gate for other pulses (response inputs, reinforcement assignments, electric shocks, *etc.*) such that the probability of their passing the gate was proportional to the counting rate of the geiger tube. The counting rate was remotely controlled by varying the distance of a Cobalt⁶⁰ source from the geiger tube face. That method of controlling event probability has proved successful in several experimental settings. (For theory of operation, calibration curves, and applications see Millenson, 1963, 1964.) An important drawback, however, is the relative expense and complexity of the geiger counter amplifier circuit (Clark and Hull, 1965).

Recently, an inexpensive but reliable, self-contained geiger counter designed for amateur uranium prospectors has appeared on the market. This counter, in conjunction with a very simple two-stage transistor circuit, permits construction of a compact probabilistic gate at a cost of less than \$50. A considerable saving in cost can be made by dispensing with (a) remote control of the counting rate and (b) elaborate lead shielding of the geiger tube.

The basis of the present unit is a model 107C portable geiger counter (Precision Radioactive Instruments, Inc., Los Angeles 16, California) and available from Olson Radio, 206 S. Forge St., Akron, Ohio 44308, at a list

price of \$31.15. Model 107C contains a built-in circuit for amplifying and shaping the geiger pulses to 30 msec. Its output is used to drive a meter and high impedance headphones, but is not sufficient to drive a sensitive relay.

The two-stage transistor amplifier shown in Fig. 1 takes its input from the headphone output of 107C and amplifies the geiger pulses sufficiently to drive a relay. The first stage employs a 2N35 in an emitter follower configuration to match the high output impedance of the geiger counter output. The second stage employs a 2N404 as a relay driver. The components are uncritical; a different (and cheaper) output relay would probably serve equally well. Since our gate is used in conjunction with "noisy" electromagnetic control circuitry, the circuit of Fig. 1 is completely enclosed in a 4 by 4 by 2 in. metal box (Bud C1793) and shielded coax (RG 58U) is used between it and 107C. Two 9 v batteries power the circuit, but a small power pack with an output of 15-24 v could be substituted. Model 107C, a portable unit, is battery driven. But

Fig. 1. Two stage transistor relay driver. S_1 is a SPST toggle switch. Ry 1 is a 5000 ohm, 2.8 ma hermetically sealed 7 pin miniature plug-in sensitive relay (Potter and Brumfield, PW5LS). All resistors are in ohms unless otherwise indicated.

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the drain is minute and the batteries last nearly their shelf life.

A radioactive source about as potent as the luminous dial of a wrist watch is supplied with model 107C. The probability is varied manually by positioning the source (held fast by a ring stand clamp) at various distances from the geiger tube face. The pulses being gated through the contacts of Ry 1 must be of standard width if the device is to control probability accurately. Furthermore, depending on the degree of overlap of pulse being gated and geiger pulse, the actual output pulse widths will vary from 0.0 to 30 msec so that the sensitivity of the driven circuitry following the gate is a parameter of the probability. Once the pulse widths and the sensitivity of the driven circuit are fixed, straightforward empirical calibration is obtained by observing what percentage of 1000 or so potential event pulses pass Ry 1 sufficiently to actuate subsequent cir-

cuitry at various geiger count rates. In the present laboratory conditions, holding both the gate pulse width and pulses to be gated constant at about 30 msec and varying the count rate from background (about 25 counts/min) to full maximum (the source against the tube face), probabilities from $\frac{1}{50}$ to nearly unity can be achieved. To obtain indefinitely lower probabilities n such geiger units may be connected in series without impairing randomness.

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