Modified High Speed Geiger Counter Circuit

Although the speed of the circuit designed by Neher[1] is quite satisfactory, it suffers from the disadvantages of requiring insulation for the cylinder and shielding if two or more Geiger counters are used to count coincidences. Also, the capacity of the cylinder for large counters introduces a longer reaction time. With the circuit to be described the cylinder of the counter is grounded.

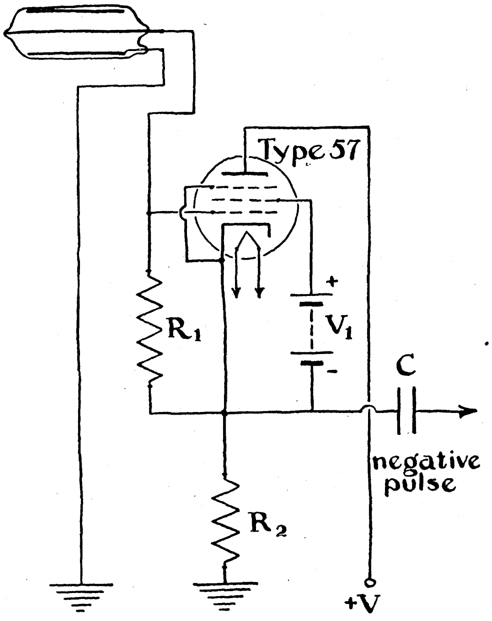

FIG. 1. High speed Geiger counter circuit. $R_1=5\times10^6$ ohms; $R_2=10^6$ ohms; $V_1=45$ volts; $V=$counter threshold$+100$ v; $C=50$ to $100\mu\mu f$.

The circuit is shown in Fig. 1. Since there is no bias on the control grid the radio tube is normally in a conducting state. Since the drop in potential across the tube is small, practically the full potential, V, is across the Geiger counter. When an ionizing particle passes through the counter a negative charge flows to the wire and thence to the control grid. The 57 tube then becomes nonconducting and the resistance R_2 pulls the cathode, grid, etc. toward ground potential. Cathode-ray oscillograph figures indicate that in all cases the potential of the cathode drops only to threshold potential or at most only a few volts below. The potential then recovers itself either partially or completely depending upon the time before the beginning of the next pulse. If the threshold of the counter becomes greater than 1500 volts, it is advisable to place a resistance of say 5×10^5 ohms between the high voltage supply and the cathode to by-pass some of the current. This keeps the drop in voltage in the 57 tube from becoming too large, because of the grid current.

The advantages offered by this circuit over the previous one are: (1) The cylinder of the Geiger tube is grounded. (2) High potentials are not applied across the radio tube. (3) No grid bias is necessary. (4) Either a positive or negative pulse may be taken off. (A positive pulse may be obtained from the plate by inserting a resistance of, say, 2×10^5 ohms in the plate lead.) The disadvantages are: (1) An insulated heater supply must be provided. (2) There is a constant drain of about one milliampere on the high voltage supply. If it is desired a self-bias may be used for the screen potential.

Further details will be published in this journal at a later date.

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[1] H. V. Neher and W. W. Harper, Phys. Rev. **49**, 940 (1936).

Multivibrator Geiger Counter Circuit

Recently Getting[1] has described a Geiger counter circuit which may be called a choked multivibrator. Brammer, Miss Hodge and the writer have employed this circuit for more than a year, obtaining the fundamental idea from a paper by Gingrich, Evans and Edgerton.[2] There are several features of its operation which deserve further discussion.

(1) When one is not attempting to secure very high speeds of operation, the constants of the circuit can be varied widely. We have used '32 tubes as well as '57 tubes. We have had no success with the '53 double triode, no doubt because of its large grid current. With either '57 or '32 tubes, plate voltages as low as 135 (with correspondingly low screen grid voltages) are satisfactory.

(2) The circuit shown by Getting is asymmetrical. Referring to his figure, the time constant of the second grid circuit is much lower than that of the first. The constants of our circuits are similar. The advantage is this: when the second tube initiates the return of the circuit to its normal condition after a count, and the output pulse is taken from the plate circuit of the *first* tube, the output capacity can be varied considerably without affecting the total recovery time. This facilitates the use of different recording circuits and mechanisms.

(3) There are two slight modifications which greatly increase the convenience of operation. (a) In practice, when the circuit recovers, the voltage at the plate of the first tube may "overshoot," going below the normal value and finally returning to normal. Unless controlled, this can result in doubling the number of pulses which actuate the recording circuits. The trouble can be cured by merely cutting down the regeneration; a potentiometer replaces the plate resistance of the second tube and the coupling condenser is connected between the first grid and the variable tap of the potentiometer. (b) Similarly, when the output pulse is secured from the plate of the first tube, it can be varied in magnitude by substituting a potentiometer for the plate resistance of that tube.

(4) Getting states that the Neher-Harper circuit requires the first vacuum tube to stand the entire counter voltage, and remarks that all the tubes are used within their ratings in the multivibrator circuit. However, the writer tried a modification of the Neher-Harper circuit in which the tube operated at rated potential; the source of high voltage for the counter was inserted between one counter terminal and the plate of the first tube; this source was an *unshielded* bank of B batteries, about 1000 volts in all, but no trouble was experienced in getting the arrangement to count. It was used both with the counter wire on the grid of the first tube and with the cylinder of the counter on the grid. (Of course the circuit constants were appropriately changed in going from one of these arrangements to the other. The counter wire was always positive to the cylinder in these tests.) A real advantage of the multivibrator over the Neher-Harper arrangement is that it works with the first grid normally at ground potential. When the grid potential is adjusted in the Neher-Harper circuit the voltage applied to the counter is altered, and this change must be compensated in many types of work.

(5) Dr. Getting remarks that the statistics of the multivibrator circuit are different from those of previous ones. Brammer and the writer[3] have treated the corrections for recovery time in any circuit which controls the counter voltage during the discharge and the subsequent period in which the ions are swept out of the counter. It is believed that in general the analysis given applies to both the multivibrator circuit and the Neher-Harper circuit.

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[1] Getting, Phys. Rev. **53**, 103 (1938).
[2] Gingrich, Evans and Edgerton, Rev. Sci. Inst. **7**, 450 (1936).
[3] Ruark and Brammer, Phys. Rev. **52**, 322 (1937).

Note on the Existence of Heavy Beta-Rays

During the winter of 1936–37 the author, together with J. J. Turin, E. R. Gaerttner and D. S. Bayley, carried out some rather extensive experiments in an effort to determine whether or not beta-rays of nuclear origin behaved differently from those of extranuclear origin. The results of a comparison of nuclear beta-rays with recoil electrons produced by gamma-rays seemed at the time to indicate that a difference in penetrating power existed.[1] The idea that the total energy (mass plus kinetic) might be the same for all the beta-rays from a given kind of emitter, and equivalent to the energy lost by the nucleus was at that time discussed as an alternative to the neutrino hypothesis. In the course of discussion of this idea at the Washington Conference on Theoretical Physics[1] many grave objections to such a mechanism were brought forward, the principal of which were the results of calorimetric experiments on Ra E, measurements on the primary ionization of beta-rays, and the stopping power of matter for beta-rays of various momenta from a given source. However, in spite of these arguments, experiments specifically designed to test such a hypothesis were carried out by the group of which the author was a member, and also by C. T. Zahn and A. H. Spees. The latter have already published a preliminary note[2] on their results. Inasmuch as the same question has again been raised[3] (this time in regard to Ra E it seems appropriate to describe briefly an experiment performed in this laboratory which bears directly upon the question raised, even though a different beta-ray emitter (Li^8) was used.

Li^8 emits a continuous spectrum of beta-rays having an upper limit of 12 Mev.[4] Using the cloud chamber method already described[5] we measured the absorption in $\frac{1}{2}$ cm of carbon of a group of beta-rays coming from about the center of the spectrum. We next carried out the same absorption measurements on a group of beta-rays which originated near the upper limit of the spectrum, but which had been slowed down to the same momentum as those measured in the first case, by passage through about $1\frac{1}{2}$ cm of carbon surrounding the source. The results indicated that the beta-rays from these two widely separated parts of the spectrum were absorbed very nearly alike when brought to the same momentum. On the hypothesis considered by us, and later by Jauncey,[3] the beta-rays originating near the middle of the spectrum (say 10 mC momentum) should have lost roughly six times as much energy as those taken from the upper end of the spectrum. In fact a consideration of the kinetic energy shows that they should not have passed through the $\frac{1}{2}$ cm carbon absorber in the cloud chamber at all. Results for the fractions stopped by the carbon are given below, based upon a total of about 1000 tracks.

Momenta of incident particles, in units mC	6 to 8	8 to 10	10 to 12	12 to 14
Unfiltered	64%	45%	34%	15%
Filtered	63%	41%	27%	17%

In addition to this, the loss of momentum suffered by those particles which passed through the carbon absorber was found to be the same for the filtered and unfiltered groups, and agreed with the theoretical predictions for ordinary electrons. It therefore appears that if in the case of Ra E the rest mass is continuously variable and is a function of the initial momentum,[3] the phenomenon does not extend to all beta-ray emitters, and cannot be thought of as clearing up the question of the conservation of energy in beta-ray emission.

In the course of the experiments described a few individual beta-rays (amounting to only a small fraction of a percent of the total number) appeared to behave in an anomalous way, but a satisfactory interpretation of these cases has not been found.

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[1] Breit, Rev. Sci. Inst. **8**, 141 (1937).
[2] Zahn and Spees, Phys. Rev. **52**, 524 (1937).
[3] Jauncey, Phys. Rev. **52**, 1256 (1937); Phys. Rev. **53**, 106 (1938); Phys. Rev. **53**, 197 (1938).
[4] Bayley and Crane, Phys. Rev. **52**, 604 (1937).
[5] Turin and Crane, Phys. Rev. **52**, 63 (1937); Phys. Rev. **52**, 610 (1937).