Note on the Nature of the Gas Mixture in Self-Quenching Geiger-Mueller Tubes

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The effect of different quantities of the "quenching gas" on the discharge mechanism of Geiger-Mueller tubes has been investigated. The experimental results are correlated with the general picture of the discharge mechanism; a very brief and integrated preliminary account of the mechanism is given.

FROM studies on the breakdown of spark gaps, and from theoretical and experimental work on the discharge process of Geiger-Mueller tubes itself, we conclude that the intrinsic difference between self-quenching and non-self-quenching G-M (Geiger-Mueller) tubes lies in the particular nature of the action of ultraviolet photons in each case.

In the G-M tube which is not self-quenching, a great number of photons are emitted during the discharge process. These travel through the gas to the cathode wall and produce a considerable number of photoelectrons there. Part of these attach to molecules forming negative ions of relatively small mobilities. The negative ions release their electrons when reaching the strong fields in the vicinity of the wire, thus forming new discharge centers, unless the field conditions have been kept such that multiplication cannot occur until all negative ions are collected. This accounts for the fact that a high external resistance is required for the proper operation of such tubes, high enough to make the recovery time RC of the tube greater than the collecting time of the negative ions.

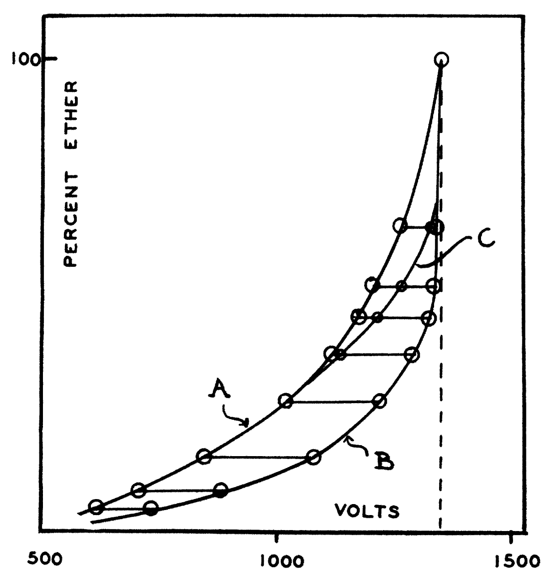

FIG. 1. The plateau region for the argon/ethyl-ether counter. The counter is ½″×3″. The central wire is 0.003″; the total pressure, 6 cm of Hg.

In so-called self-quenching G-M tubes, no evidence has been found for the presence of photons at appreciable distances from the wire. It was suggested[1] that the addition of the polyatomic gas which causes the essential modification of the tube to a self-quenching one may quench the production of these photons by providing modes of energy loss other and more probable than by excitation of ultraviolet energy levels. However, experimental evidence, particularly the phenomena of perpetuation of the discharge process along the wire as studied with a "segmented" G-M tube,[2] and a finding to be reported here, seem to suggest that ultraviolet light quanta are still produced, but are quickly absorbed by the "quenching gas," probably within a distance of a few mean-free paths in the gas.

Thus it is the purpose of the quenching gas to absorb all ultraviolet quanta produced, or ultimately to make the probability of production of negative ions by way of photons and photoelectrons as nearly as possible equal to zero. Since this probability will depend on the density of the quenching gas, an investigation was made of the quenching properties as a function of the partial pressure of the quenching gas. This was accomplished by studying the width of the

[1] M. E. Rose and S. A. Korff, Phys. Rev. **59**, 850–859 (1941).
[2] W. E. Ramsey, Phys. Rev. **61**, 96–97 (1942); H. G. Stever, Phys. Rev. **59**, 765 (1941), and Phys. Rev. **61**, 38–52 (1942).

"plateau," for mixtures of argon as the "multiplication gas" and ethyl-ether as the quenching gas. The plateau is defined as that region of applied electrode potentials which lies between two limits *A* and *B*, such that beginning at the potential *A* all pulses are of a convenient pulse size (three volts in this case), and that the tube starts to show multiple discharges when the potential is increased beyond *B*, and the tube is operated with a normally small external resistance of 1 megohm. The appearance of such multiple pulses can be interpreted in the light of the above picture of the mechanism as being evidence for the production of photoelectrons, their subsequent capture and release, and thereby the repetition of the discharge process.

Figure 1 shows the results of the plateau measurements for a tube containing argon/ethyl-ether at 6-cm total pressure; the partial ether pressure is expressed in percentage of total pressure. It can be seen that for this total pressure, an ether content of about 20 to 25 percent yielded the optimum plateau. At relatively high ether contents, the pulses were no longer of equal amplitudes but showed appreciable distribution in size up to potentials indicated by curve *C*, although the average pulse size was still approximately 3 volts at *A*. In the light of the picture outlined the following explanation suggests itself: At great densities of the quenching gas the absorption of photons becomes so intense that even the propagation of the mechanism along the wire cannot always take place along its entire length. The pulse size, being proportional to the total amount of charge produced, may then be nearly proportional to the length along which each discharge is able to propagate before it fails in producing at least one more photoelectron. The pulse size may thus be subject to appreciable fluctuations.

Similar measurements concerning optimum plateau conditions were made at different total pressures, and the following data obtained:

Total pressure	Approx. % ether for opt. plateau
6 cm	20 to 25%
15 cm	7 to 10%
40 cm	approx. 3%.

It appears that the absolute pressure or density of the quenching gas alone determines the quenching characteristics regardless of what the total gas pressure may be, the partial ether pressure for optimum conditions being about 1.5 cm of mercury. It seems noteworthy that this finding seems to favor the concept of photons being *absorbed* by the presence of a sufficient amount of the quenching gas, in preference to a picture of the mechanism involving the assumption of some action by which this gas prevents the creation of quanta during the ordinary discharge process.