GAS AMPLIFICATION IN PROPORTIONAL COUNTERS

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1. INTRODUCTION

Several workers have studied the gas amplification factor and its variation with field strength for proportional counters. Rossi and Staub (1948) have given data for various gas fillings at different pressures. Rose and Korff (1941) have theoretically derived the following expression for the gas amplification factor in terms of measurable quantities like the wire diameter, the pressure of the gas inside the counter and the specific ionisation coefficient,

\[ A = \exp \left( a \cdot N \cdot C \cdot V \cdot r \right) \left\{ \left( \frac{V}{V_e} \right)^{\frac{1}{x}} - 1 \right\} \]

(1)

Measurements of gas amplification factors have been made by Rose and Korff (1941) and Rossi and Staub (1948) for testing the validity and scope of the above equation and also to determine which of the assumptions that have been made in the derivation of the theory are not completely justifiable. This paper describes measurements of gas amplification factor as a function of voltage under different conditions of pressure, gas filling and concentrations of the quenching agent.

2. EXPERIMENTAL DETAILS

The counter employed for the measurements was made of a copper cathode 10 cm. long and 3.5 cm. in diameter, with a 3 mil. central wire. Mono-energetic alpha rays from a PO\textsuperscript{210} source were used for the experiments.

The measurement of gas amplification factor was carried out according to the method used by Rossi and Staub (1948). Essentially, their method consisted in the use of an oscilloscope for the measurement of the pulse heights at various counter voltages. The counter was then operated in the ionisation chamber region and the electronic amplification necessary to produce an output pulse of the same height as before was taken as a measure of the gas amplification factor at the particular voltage. A linear
amplifier based on a circuit given by Elmore and Sands (1949) was constructed and used for the present measurements. The amplifier linearity for input pulses ranging from 100 \( \mu \text{V} \) (which was the minimum detectable signal above the noise level) to about 1 V (corresponding to a ratio of 1:10,000 in input pulse heights) was checked by standard methods.

The counter was filled with the gas to be studied and placed in a well-shielded box to avoid pick-up. The pulses from the counter were displayed on the oscilloscope screen after amplification. When the counter was operating in the ionisation chamber region, which is indicated by the pulse height remaining appreciably constant with changes in applied voltage, the pulse height on the oscilloscope screen was measured. The voltage was then increased in steps and the pulse height was adjusted to be the same as when the counter was operating in the ionisation chamber region, by means of the attenuator. The amplification factor corresponding to a given voltage was obtained by noting the attenuation that was introduced.

Ordinarily, such measurements would be limited by the setting in of space-charge effects. It has been shown (Venkatasubramanian, 1957) that space-charge effects become considerable at values of \( A \) as low as \( 10^3 \) for alpha particles whose entire track is assumed to be confined within the counting volume. Rossi and Staub have also confined their values to less than \( 10^3 \).

In the following experiments, this upper limit has been pushed up by making the alpha particle spend only part of its track inside the counting volume. The total ionisation is consequently less and hence space-charge limitations set in at higher values of \( A \). However, even this method cannot be carried too far, since if too small a portion of the track is spent inside the counter the error in the accurate computation of the pulse size increases. The author has therefore given values of \( A \) up to about 2,000 only.

3. RESULTS

Experiments were carried out on 10\% and 25\% argon-ethane and argon-CO\(_2\) mixtures. The results obtained are graphically represented in Figs. 1–3. The critical voltages given in Table I indicate the onset of the Geiger region. It is seen that the gas amplification values range up to 1,000 for the argon-ethane mixture and the argon-CO\(_2\) mixture. The gas amplification curves show some interesting features and these are discussed in Table I.

4. DISCUSSION

(a) Effect of Pressure.—Figure 1 gives the variation of \( A \) with the applied voltage for two different gas pressures for argon-ethane counters. The