THE MEASUREMENT OF LOW ALPHA-ACTIVITIES USING GAS FILLED DETECTORS

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بسم الله الرحمن الرحيم

A B S T R A C T

The possibility of using a wire-plane streamer counter with air filling at atmospheric pressure for precise measurement of low alpha activities by presence of other types of radiation has been investigated.

For this purpose some important properties of such counter were examined. Independence of the counter efficiency and plateau length on the external resistance has been found. Also investigations were made on the counting characteristics in relation to their dependence on the temperature, humidity and electrode spacing. The streamer and spark mode of operation have been examined and the related mechanism is also studied.

The sensitivity of the wire plane streamer counter was investigated when a collimated beam of alpha particles was moved perpendicular to the anode wire and parallel

to the cathode plane, and also when shifted parallel to the plane of the cathode in the direction from anode wire towards the cathode.

The extrapolated number distance range in air is given for alpha particles in air.

The fitting of Popkov's formula, to the corona current experiment results shows that a reasonable agreement can be obtained only when the empirical constant P is given a certain value which varies with the height parameter.

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INTRODUCTION

The presence of nuclear radiation can be defined by a device capable of counting individual charged particles which may be made by a combination of two electrodes in a gas. The device will detect the passage of charged particles through the volume between the electrodes and manifest this passage in the form of an electrical impulse. Such a device is considered to form a detector. A detection system can be considered to consist of two parts, a detector and a measuring apparatus. The interaction of the radiation with the system takes place in the detector. The measuring apparatus takes the output of the detector and performs the functions required to accomplish the measurements.

The nuclear counters in most frequent use today are the ionization chamber(1), the proportional counter(2), the Geiger Müller counter(3) and the Scintillation counter(4).

In all of these instrements, a part of the energy of the charged particle is used up in the ultimate production of a pulse of electric charge. A large portion of the energy dissipated in matter must however appear as heat, and it is therefore possible to detect a sufficiently high energy flux by some form of thermal sensitive device, such as a thermocouple.

Nuclear-radiation detection systems can be classified as to whether their operation, is of the pulse type or not. In the pulse operation the output of the detector is a series of signals separated or resolved in time. Each signal represents the interaction of a nuclear particle with the detector.

The Geiger-Muller tube and the spark counter are example of pulse type detectors. In the nonpulse type of operation of a detection system, the quantity measured directly is the average effect due to many interactions of the radiation with the detector.

In 1934, Greinacher[5] proposed the "spark counter" and subsequent papers of his pioneer work described in general terms the properties of various types of electrodes and various geometrical arrangements. Later more detailed investigations were reported by other workers[6-9].

In all these counters a discharge is initiated in air atmospheric pressure from a point at a distance of about 1 mm.

Recently Laboric and Blanc[10] succeeded to improve the characteristics of this type of detectors.

In 1945 Chang and Rosenblum[11] presented a wire-plane spark counter which did not suffer such limitation. This counter is mostly operated in air at atmospheric pressure and is sensitive to heavily ionizing particles such as alpha-particles and fission fragments. The counter consists of a thin metallic anode stretched parallel to a plane metallic cathode at a distance of about 1.5 mm.

If a strong electric field is applied between the electrodes of the system a faint carona glow becomes visible around the anode, and a quiescent, carona current flows. The passage of heavily ionizing particle through the sensitive - volume of the counter produces a visible audible spark which can be quenched by a resistance capacitance net work.

Payne[12] showed that this system becomes sensitive to proton and beta-radiation when operated in air at twice atmospheric pressure.

Pidd and Madanskey[13,14] in 1949 constructed a parallel plate spark counter to provide a uniform sensitive avalanch volume for the detection of ionizing radiation. The mean advantages of this counter over other detector lies in its speed of response. It provided a pulse of several hundred volts with a rise time of 5×10^{-9} sec.

Connor[15] 1951 and others[16,17] replaced the flat metal cathode by a rod of a few millimeters diameter the wire rod counter does not appear to present any advantages above the wire plate counter. The counting characteristics have also been extensively studied along with the effect of temperature, pressure and humidity[18,19,20,21,22]. Also the detection efficiency of the counter has been measured as a function of the angle of incidence of alpha particles wire-cathode size and their separation[20,21,22].

Connor[15] in 1951 noticed that when operating the corona counter with anode-to cathode separation greater than 3 mm., the glow discharge has its onset potential 250 V below the spark thersholed voltage for alpha particles.

On amplifying the quenchcircuit output pulses about one hundered fold, nonsparking events could be made to activate a scaler.

However Hanvendale[23] showed that the conventional corona counter in air at atmospheric pressure can be operated in two modes depending on wire diameter and electrode spacing. At low gaps spark action occurs while at larger spacings breakdown terminals at the streamer stage of spark development. He showed that the advantages of streamer mode of operation are low counter dead time (0.2 u sec), absence electrode corrosion by sparking and that the discharge is autoquenched.

Harrison[24] gave the conditions which are suitable for good working plateau in a corona streamer counter.

However, the measurement of low-alpha-activities requires, like other low-activity measurement, complicated counting apparatus and heavy shielding arrangement.

There are two reasons for these additional complications[25] :

1. Every detector of alpha particles is sensitive also to other types of particles causing the ionization;
2. The background of the counter, caused by cosmic radiation and by the natural activity of surrounding

materials puts a lower limit on the activities that can be measured by the counter. Although it is possible to lower radically the background it is impossible to get off it completely.

Streamercounters with inhomogeneous field and with air-filling at atmospheric pressure are sensitive only to particles with large ionization power like fragments of decayed nuclei and alpha particles. Their sensitivity to other types of radiation can be often neglected. This property of streamer counters of the mentioned type enables to use them for precise measurements of extremely low alpha activities also in the case when other types of radiation with lower ionization power is present.

Using a streamer counter it is necessary to apply neither a specialized electronic system as anticoincidence system, nor a shielding arrangement for suppresing the background. In many cases, especially by precise construction of the counter, the background tends to zero.