Sept. 23, 1947. E. DER MATEOSIAN ET AL 2,427,663

GEIGER-MUELLER TUBE

Filed Nov. 8, 1945

FIG. 1

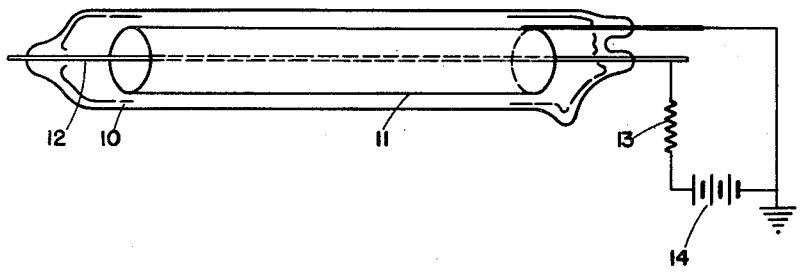
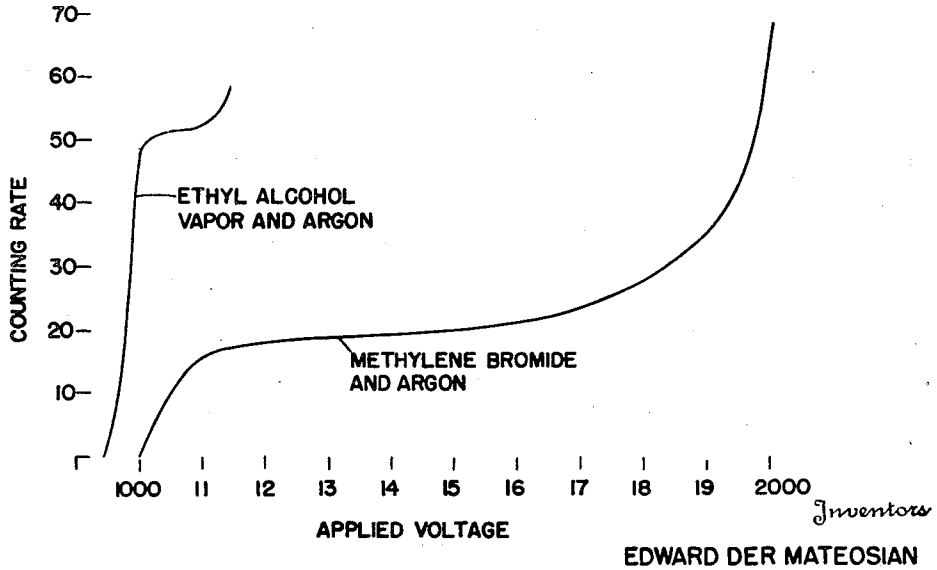


FIG. 2



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GEIGER-MUELLER TUBE

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3 Claims. (Cl. 250—83.6)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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Our invention relates to radiation detecting devices of the discharge type and particularly it relates to an improved form of Geiger-Mueller counter for the detection and measurement of various types of penetrating radiations, such as α, β, and γ rays and X-rays.

The general classification of Geiger-Mueller counters into slow and fast counters is a well chosen one, for, as long as the cylinder and concentric wire configuration of electrodes is maintained, the action of a well-made counter tube in its capacity for resolving pulses is most sensitive to the gases which it contains. The presence of an organic vapor in the gaseous filling of the tube modifies the discharge process in such a fashion that the tube recovers more readily from its conducting state than it does when it is filled with a pure inert gas. The Geiger-Mueller counter comprising a cylindrical cathode, a coaxial wire anode, and a glass envelope enclosing the electrodes and a rare gas filling including alcohol vapor as a quenching agent to speed the counting action of the tube is quite well known.

Theoretically there appears to be no justification for the prevalent use of alcohol vapor as the quenching agent in Geiger-Mueller counters, for one of the decomposition products of alcohol, water, is decidedly detrimental to the action of the tube. Unless very carefully prepared, the tubes containing alcohol vapor also tend to spark in the plateau regions of their characteristic curves.

It is an object of our invention to provide a Geiger-Mueller counter containing a gaseous atmosphere which obviates the operating disadvantages of the conventional alcohol vapor quenched Geiger-Mueller counter.

It is another object of our invention to provide a Geiger-Mueller counter which is characterized by its long life, capacity to count at high rates as indicated by its resolving power, and the long plateau of its operating curve.

It is another object of our invention to provide a gaseous filling for a Geiger-Mueller counter which is not critically sensitive to the preparation of the envelope and electrode surfaces and can be used in a tube with assurance of the production of a reliable operable counter tube.

Other objects and advantages of our invention will in part be obvious and in part appear hereinafter.

The nature, scope and advantages of our invention will be more readily and fully understood by reference to the following specification and drawings in which:

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Figure 1 represents a longitudinal cross-sectional sketch of a typical form of Geiger-Mueller counter;

Figure 2 is a pilot of performance curves to compare the counting action of a counter made according to our invention with the performance of an alcohol vapor quenched Geiger-Mueller counter.

Specifically, in accordance with our invention, we have found that the counting action of a Geiger-Mueller counter which ordinarily would be filled with a mixture of argon, or other rare gas, under a pressure of 1 to 50 centimeters of mercury, and alcohol vapor, under a partial pressure of 0.05 to 2 centimeters of mercury, can be much improved by filling the tube with the usual gas and alcohol vapor and, in addition, a trace of methylene bromide, or by filling the tube with the rare gas and methylene bromide in combination, or methylene bromide alone. That is to say, we have discovered that a trace of methylene bromide vapor in the gaseous filling of a Geiger-Mueller counter promotes and improves the quenching action of alcohol vapor, the methylene bromide can be used as the quenching agent, or the methylene bromide can be used as the sole gaseous constitutent of the atmosphere of the tube.

Referring to the drawing comprising Figure 1, there is illustrated in longitudinal cross-section a Geiger-Mueller counter having the essential structural elements, which include an envelope 10, which envelope is permeable to the radiation to be measured, a cylindrical cathode 11, and a coaxial anode 12. Electrical connections are made to the cathode and anode, respectively, and resistor 13 and battery 14 are merely conventional representations to indicate that in use the anode of the tube is held at a potential above that of the cathode.

One of the most significant measures of the efficacy of the counting action of a tube is the length of its "plateau" when its performance curve is plotted in terms of counting rate above background in response to a source of radiation of a given strength against anode-to-cathode voltage. The measure of the quality of a counter is the length of the "plateau" which shows in such a plot. The significance of the plateau is that the counter will respond to radiation of a given intensity by pulsing at a known rate when any voltage within the range included in the plateau is applied across the anode and cathode. When a counter is to be used to measure the intensity of unknown radiation it should have a long flat

plateau so that the measurement will be made in terms of a known pulsing rate when a voltage within the range of the plateau is applied to the tube.

A gaseous filling for a Geiger-Mueller tube which gives a long plateau in the performance curve is highly desirable because it makes almost immaterial certain factors in the tube construction which are ordinarily rather critical. For example, when a rare gas-alcohol vapor mixture is used as a filling for a Geiger-Mueller tube, the alcohol is such a critical quenching agent that the tube must be constructed with meticulous care in order that the final structure will have an operative plateau of about 100 to 200 volts. On the other hand when a quenching agent such as methylene bromide is used, in accordance with our invention, it is not necessary to take extreme precautions in the construction of the tube to obtain a final structure having a plateau of 300 or 400 volts. We have found that when elaborate precautions are taken in preparing the cathode cylinder and anode wire, when the metals are carefully cleaned and outgassed, and other such precautions taken, and also when the tube is filled with spectroscopically pure gas and methylene bromide a 2,000 volt plateau can be obtained. We have also found that when the tube is assembled with none of these precautions methylene bromide in the tube as a quenching agent will give a plateau of 200 or 300 volts whereas a similar tube constructed under the same conditions and using alcohol vapor as a quenching agent will give little or no plateau and will spark very quickly.

In Figure 2 we have plotted a performance curve for a Geiger-Mueller counter having an atmosphere consisting of argon at a partial pressure of 10 centimeters of mercury and ethyl alcohol vapor at a partial pressure of 0.5 centimeter of mercury. This tube corresponds to the standard internally quenched tube commonly used for radiation measurements and has a plateau in its performance curve approximately 100 volts in breadth. On the same coordinate axes we have plotted a similar performance curve for a similar Geiger-Mueller tube filled with an atmosphere comprising argon at a partial pressure of 10 centimeters of mercury and methylene bromide at a partial pressure of 0.5 centimeter of mercury. It is apparent that the plateau in the curve for the tube containing methylene bromide vapor extends over about 700 or 800 volts.

The method of constructing the Geiger-Mueller tube and filling it with an atmosphere for reliable rapid quenching in accordance with our invention will be more clearly understood by reference to the following description:

Example

A single counter tube having a glass envelope, a cylindrical cathode, and a tungsten wire anode arranged as shown in Figure 1 was sealed to a vacuum pumping system, carefully evacuated, and filled with a mixture of argon and methylene bromide. A performance curve for the counter was determined by measuring, with a scale-of-64, the response of the tube to a fixed source of gamma radiation as the voltage applied to the tube was gradually increased. As can be noted from the curve shown in Figure 2 which is a plot for a tube having a filling of 10 centimeters of argon and 0.5 centimeter of methylene bromide, a mixture of argon and methylene bromide exhibited very desirable counter properties in that a plateau 700 to 800 volts long was obtained. Another shell when filled carefully with spectroscopically pure argon at 10 centimeters of mercury and methylene bromide at 0.5 centimeter of mercury exhibited a plateau which was over 2,000 volts long and had a threshold at 1,000 volts.

The methylene bromide vapor quenched tubes are very much more insensitive to visible and ultraviolet light than the alcohol tubes. The background count was 8 counts per minute for the argon-methylene bromide mixture and 50 per minute for the alcohol argon counter. Similar results are obtained when the other gases are used with the methylene bromide, namely, neon, krypton, xenon, hydrogen, helium, etc. The usable lifetime of tubes constructed according to our invention is generally at least 5 to 10 times as long as that for alcohol vapor quenched tubes used for similar purposes.

In the construction of the tubes the materials used are not critical. We have obtained substantially similar results with copper, brass, nickel, aluminum, chrome iron, gold etc. cathodes.

From the above example and description it will be apparent that methylene bromide when used in combination with other gases or a filling in a Geiger-Mueller counter easily improves the operation of the tube several fold. With reasonable care, the tube plateau can be improved and the tube life increased by a factor of at least 2 or 3.

The pressure of the rare gas such as argon and the quantity of methylene bromide to be used in a Geiger-Mueller tube is determined by the intended use of the tube and the physical limitations of the characteristics. The greater the proportion of methylene bromide present in the gaseous filling of the tube, the greater can be the expected lifetime of the tube but the higher will be its threshold voltage. Less than 0.05 centimeter of mercury partial pressure of methylene bromide vapor in the tube filling will give rather poor and irreproduceable counting action of the resultant tube. The upper limit of the partial pressure of methylene bromide vapor to be used in the tube is determined generally by the vapor pressure of methylene bromide at ambient temperatures. The normal amount to be used is a partial pressure of about 0.1 centimeter to about 4 centimeters of mercury of methylene bromide vapor. Since methylene bromide (CH_2Br_2) is a liquid having a boiling point of 97° C., its vapor can be easily introduced into a tube in the amount needed.

As a general rule the threshold voltage of the tube will increase with the quantity of rare gas present. The average for the ordinary tube will be from 3 to 50 centimeters of rare gas such as argon. For a gamma ray counter with a low threshold voltage a gaseous filling comprising about 3 centimeters of argon and 0.1 centimeter of methylene bromide vapor should be satisfactory. This type of tube is one which depends upon impingement of the radiation on the cathode to cause a discharge within the tube. Another extreme in operation is that type of tube involving the absorption of relatively soft radiation by the gaseous filling of the tube, that is, to rely upon a photoelectric effect within the gas. This form of Geiger-Mueller counter is described more fully in United States Patent 2,386,785, issued October 16, 1945, to Herbert Friedman. The tube is also described in a paper discussing the application of Geiger counters to X-ray diffraction measurements published in

"Electronics," April 1945. Where the radiation to be measured is to be absorbed by the gaseous filling of the tube, the Geiger counter would be filled with argon at a pressure of about 50 centimeters of mercury and about 0.3 centimeter of methylene bromide. In such a counter it is desirable to provide a gas path of sufficient length to absorb all of the radiation or a known fraction thereof. For similar applications we have also found that a counter filled with an atmosphere consisting only of methylene bromide vapor gives reliable and rapid counting action.

Thus, it is apparent that in one aspect of our invention the methylene bromide vapor can be used as a quenching agent in a Geiger-Mueller counter to assist the normal quenching action of alcohol vapor in much the same fashion that certain promoters are used with catalysts in chemical reactions. A second aspect of the invention involves the discovery that methylene bromide not only assists the quenching action of the alcohol vapor but, when used alone, it at least equals and usually far exceeds alcohol vapor as a quenching agent in efficacy. A third aspect of the invention deals with the discovery that methylene bromide vapor can be the sole gaseous filling of the tube.

The essential advantages derived from the use of methylene bromide in a Geiger counter are prolongation of the useful life of the tube, extension of the tube plateau in performance, and improved response to radiation of a given intensity.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Having described our invention, what we claim as new and desire to secure by Letters Patent of the United States is:

1. A Geiger-Mueller tube characterized by its long life and rapid counting response to penetrating radiation comprising, in combination, a radiation permeable envelope enclosing an anode and cathode, and an atmosphere containing methylene bromide vapor.

2. A Geiger-Mueller tube characterized by its long life and rapid response to penetrating radiation comprising, in combination, a radiation permeable envelope enclosing an anode and cathode, and an atmosphere containing methylene bromide vapor in amount sufficient to make the partial pressure of said compound about 0.05 to about 5 centimeters of mercury.

3. A Geiger-Mueller tube characterized by its long life and rapid response to penetrating radiation comprising, in combination, a radiation permeable envelope enclosing an anode and cathode and an atmosphere consisting of methylene bromide vapor.

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