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J. HERMSEN ET AL
GEIGER-MULLER DETECTOR
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2,899,582

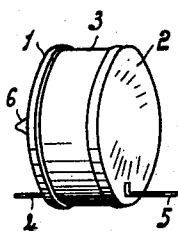


Fig. 1

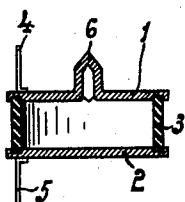


Fig. 2

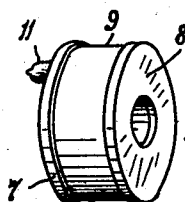


Fig. 3

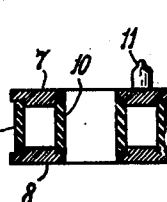


Fig. 4

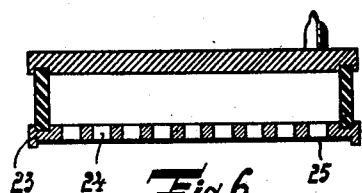


Fig. 6

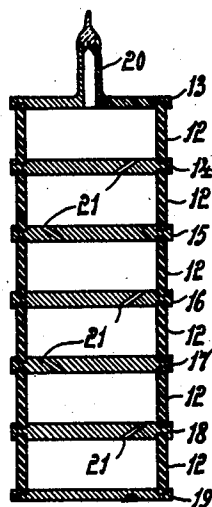


Fig. 5

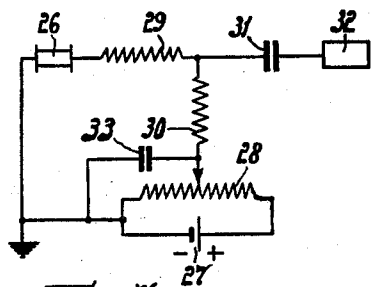


Fig. 7

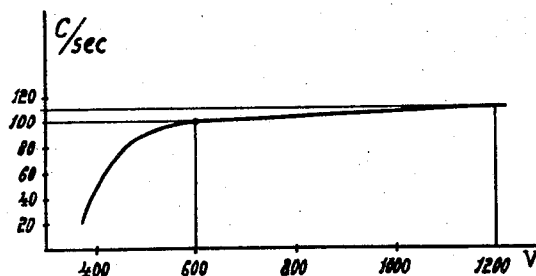


Fig. 8

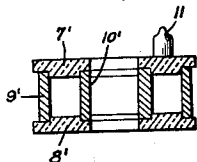


Fig. 4a

INVENTOR
JOHANNES HERMSEN
PIETER JOHANNES KRAAYVELD
BY *[Signature]*
AGENT

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GEIGER-MULLER DETECTOR

Johannes Hermesen and Pieter J. Kraayeveld, Amsterdam, Netherlands, assignors, by mesne assignments, to North American Philips Company, Inc., New York, N.Y., a corporation of Delaware

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This invention relates to electric discharge tubes of the kind known as Geiger-Müller counters for the detection of radiation of a corpuscular or electromagnetic nature, for example of alpha particles, beta particles and gamma radiation.

A discharge tube of the above-mentioned kind generally contains only two electrodes, a cathode and an anode, and is gas-filled.

Its operation is based on ion multiplication by the formation of Townsend-avalanches and the photo-electric effect in the gas and at the wall produced by a particle penetrating into the discharge space. For the sake of simplicity the term "particles" as used herein is to be understood to include radiation of electromagnetic nature.

In most known constructions of such counters the electrode system comprises a hollow cylindrical cathode and a filamentary anode arranged along axis of the cylinder. In order to improve the operation of the tube, more particularly to reduce its dead time, it has been proposed to use a so-called quenching gas in said tubes, more particularly gaseous hydrocarbons, for example alcohol. However, it was found subsequently that such counters could be considerably improved by the addition of a halogen to the gas-filling. Thus, counters are known which are filled with one or more rare gases with the addition of chlorine, bromine or iodine.

In order to change the properties of the counters, it has been proposed to change the form of the electrodes. However such changes detrimentally affect the plateau in the curve which shows the relationship between the operating voltage of the tube and the number of particles that is detected per unit of time. In many cases, one of the properties of the tube was improved but at the same time other properties were affected by this variation in a manner such that the tubes proved to be useless in practice.

In an electric discharge tube in accordance with the invention, use is made of plate-shaped parallel-arranged electrodes; however, the disadvantages to which the counter tubes described so far were subject are substantially obviated.

According to the invention, an electric discharge tube for the detection of radiation contains only plate-shaped parallel-arranged electrodes and is characterized in that the space in which the discharge is produced is closed by a wall, part of which is formed by two plate-shaped parallel-arranged electrodes while the remainder consists of insulating plates which are arranged substantially at right angles to the surface of the electrodes, and this space comprises a gas-filling consisting for at least 0.001% of a halogen.

The term "closed space" as used herein is to be understood to mean that from the space between two plate-shaped electrodes no photons and electrons can escape while conversely photons and electrons which are produced outside this space by the particle to be detected cannot produce a discharge within the space. The pro-

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vision of a few very slight suitable apertures for the passage of the filling gas consequently does not interfere with satisfactory operation.

The tests which have led to the invention have proved that the poor results which so far had been obtained with counters having plate-shaped electrodes were largely due to the fact that the discharge space, that is to say the space in which the ionizing processes occur, was not sharply delimited. Consequently, according to the invention, the space in which the discharge is produced is closed. In addition, it has proved necessary for the discharge space to contain a gas-filling which consists of at least 0.001% of a halogen quench. Furthermore, an important factor for the production of a satisfactory plateau consists in that the electric field in which the discharge occurs is homogeneous. Consequently, according to the invention, the space between the plate-shaped parallel electrodes is closed by insulating plates which are arranged substantially at right angles to the surface of the plate-shaped electrodes. Thus, they extend substantially parallel to the lines of force between the electrodes and substantially do not interfere with this field.

It was surprising to find that this combination of steps provided a counter having a plateau which usually is better than that of counters having a cylindrical cathode and a filamentary anode, the other properties remaining the same.

It should be noted that theoretically the operation of the counters in accordance with the invention cannot be completely explained. According to modern opinion with regard to discharge phenomena, several points are at variance with experience in producing satisfactory plateaus.

An important advantage of the discharge tubes in accordance with the invention is the large solid angle from which particles can be detected by the discharge tube, while the background is comparatively lower than in the Geiger-Müller counter tubes hitherto known.

It is not necessary for the plate-shaped electrodes to be flat. Although this construction provides certain structural advantages and is very suitable for some purposes in practice, the electrodes may alternatively have a curved surface.

Very satisfactory results have been obtained with tubes in accordance with the invention when the gas-filling consisted of a mixture of halogen and rare gas.

In order that the invention may readily be carried into effect, some embodiments thereof will now be described in detail with reference to the accompanying drawings, which also show a measuring circuit arrangement and a counting curve of one tube, and in which:

Fig. 1 shows a counter having flat circular electrodes;

Fig. 2 is a sectional view of the counter shown in Fig. 1;

Fig. 3 shows a counter having flat annular electrodes;

Fig. 4 is a sectional view of the counter shown in Fig. 3;

Fig. 4a is a cross-sectional view of a modification of the counter illustrated in Figs. 3 and 4;

Fig. 5 is a sectional view of a multiple counter;

Fig. 6 is a sectional view of a counter having a grid-shaped electrode;

Fig. 7 is a circuit diagram of a measuring arrangement and

Fig. 8 is a graph showing a counting curve measured with the aid of the circuit arrangement shown in Fig. 7 on a tube as shown in Figs. 1 and 2.

In Fig. 1, the counter comprises circular electrodes 1 and 2. Between said electrodes a cylindrical insulating plate 3 is arranged which is secured in a gas-tight manner in grooves formed in the circular electrodes 1 and 2, for example by cementing by means of enamel.

The electrodes 1 and 2 are provided with connecting strips 4 and 5. In addition, the electrode 1 is provided with an exhaust tube 6 which, subsequent to the filling of the counter, is closed so as to be gas-tight. As will be seen from Fig. 1 and more clearly from Fig. 2, the discharge space is entirely enclosed by the electrodes 1 and 2 and the cylindrical insulating plate 3. Since this configuration is substantially symmetrical, the electrodes 1 and 2 can be used either as the cathode or as the anode. If required, such a counter tube could be operated with the use of alternating voltage. The electrodes can be manufactured from the usual metals, for example ferrochromium, copper or chromium-nickel. The insulating cylinder 3 may consist, for example, of glass or ceramic material. The radiation to be detected can enter the discharge space either through the insulating cylinder 3 or through the electrodes 1 and 2, provided the thickness thereof is suitable to pass the radiation. In the latter case, radiation can be detected from a very large solid angle, while the insensitive region is maintained small, which is a great improvement upon the cylindrical counters hitherto known.

If required, one of the electrodes 1 and 2 or both electrodes may be replaced by a thin plate of mica, glass or ceramic material. In order to render this plate conductive, it can be coated internally and/or externally with a conductive layer, produced, for example, by deposition from vapour of aluminum, gold, silver, chromium or tin oxide.

Fig. 3 shows a counter comprising annular flat electrodes 7 and 8 (cf. also the sectional view of Fig. 4). Between these annular electrodes cylindrical insulating plates 9 and 10 are arranged. These electrodes 7 and 8 and the insulating plates 9 and 10 enclose an annular space in which the discharge occurs. The electrode 7 is provided with an exhaust tube 11 which is closed in a gas-tight manner after the tube has been filled with the gas mixture. The shape of this counter tube renders it particularly suitable for measuring the activity of a radio-active flowing liquid, for this liquid can be made to flow through a pipe which is arranged in the central aperture of the counter. By using a number of such counters surrounding one pipe through which the radio-active liquid flows, rates of flow can be measured in a simple manner and, if desired, differences in the radio-activity which are produced between the counter tubes can be recorded.

As an alternative, a counter can be manufactured of a structure identical to that of the tube shown in Figs. 3 and 4, in which, however, the electrodes and the insulating material are interchanged so that the plate-like electrodes have the shape of coaxial cylinders. This is illustrated in Fig. 4a, which shows coaxial electrodes 9' and 10' separated by annular, flat, insulating members 7' and 8'.

When the height of the counters shown in Figs. 1, 2, 3 and 4 is made comparatively slight, a number of counters can readily be stacked so that, so to say, a multiple counter is obtained. Alternatively, however, a multiple counter can be manufactured having a construction such that a number of discharge spaces are connected in series. Such a construction is shown in Fig. 5.

The tube shown in Fig. 5 comprises a number of insulating cylinders 12 with the interposition of a number of electrodes 13, 14, 15, 16, 17, 18 and 19 which are secured in grooves. Thus, a number of closed discharge spaces is produced between the electrodes. An exhaust tube for filling the counter tube is designated 20. In order to enable the gas-filling to penetrate into the discharge spaces, the electrodes have been provided with narrow ducts 21. These ducts are very narrow and bored in the electrodes so as to be oblique. In addition, the ducts provided in two successive electrodes do not register. Experience has shown that the ducts do not interfere with the operation of the tube, since

the discharge spaces are substantially closed. In the tube shown in Fig. 5 the electrodes 13, 14, 15, 16, 17, 18, and 19 alternately act as the cathodes or the anodes respectively of the interposed discharge spaces. Such a multiple construction provides the large advantage that all the properties of the tube are similar to the properties of a single discharge space, while the resolving power is higher, since six separate discharge spaces are connected in series.

Fig. 6 shows a discharge tube in accordance with the invention which is similar to the construction shown in Figs. 1 and 2. However, in this embodiment the plate-shaped electrode 23 is provided with a plurality of apertures 24. In order to obtain a gas-tight seal, a thin mica plate 25 is arranged on the grid-shaped electrode thus produced. Otherwise the construction is substantially similar to that of the discharge tube shown in Figs. 1 and 2. The apertures permit of varying the sensitivity of the counter. It will be evident, that it makes a large difference whether a particle enters the tube through the mica only or whether it must penetrate through a part of the electrode 23 also. Consequently, an equalizing effect can be obtained so that particles having widely different energies can be detected with the same degree of sensitivity.

The drawing shows counters in which the electrodes and the insulating parts also act as the tube wall. This, however, is not necessary. The constructions shown in the figures may, for example, be enclosed in an envelope. In this event, very slight ducts must again be provided in order to enable the gas-filling to penetrate into the spaces between the electrodes.

In order to provide a better understanding of the properties which may be obtained for a tube in accordance with the invention, a specific enumeration of the dimensions of a tube of the construction shown in Figs. 1 and 2 will be listed below, while measurements made by means of this tube will also be described.

In the counter tube measured, the electrodes 1 and 2 were made of ferrochromium which by means of an oxidizing process through the use of a glow discharge in an oxygen atmosphere were coated with a layer of chromium sesquioxide. The electrodes 1 and 2 were 2 mms. thick, their diameter being 32 mms. The distance between the electrodes 1 and 2 was 5 mms. The cylinder 3, which was made of glass and was secured in grooves formed in the electrodes 1 and 2 by means of glass enamel, was 1.5 mms. thick. The discharge space contained a gas mixture of 99.85% of neon, 0.10% of argon and 0.05% of bromine. The total gas pressure was 10 cms. of mercury.

The above-described counter was connected in a counting circuit shown diagrammatically in Fig. 7. In this circuit diagram, reference numeral 26 designates the counter, and 27 a power supply which was shunted by a potentiometer 28. The values of resistors 29 and 30 were 10^7 ohms and 10^6 ohms respectively. Reference numeral 31 designates a capacitor which supplies the pulses to be measured to a recording device 32. Capacitor 33 is a smoothing capacitor.

In measuring, a sample which emitted beta particles and gamma rays was arranged at a distance from the counter tube 26 such that the recording device 32 indicated 100 counts per second, when the supply voltage of the counter tube was adjusted to 600 volts by sliding the contact over the potentiometer 28.

Variation of the supply voltage supplying the counter tube produced the counting curve or discharge characteristic shown in Fig. 8. In this figure, the supply voltage of the counter tube in volts is plotted as the abscissa and the number of counts per second as the ordinate. As will be evident, this curve has a very satisfactory plateau. In operation, as is conventional, the voltage supplied to the counter tube is selected to have a value on the plateau.

What is claimed is:

1. A Geiger-Müller-type radiation detector comprising a plurality of wall members defining a substantially closed discharge space containing an ionizable gas filling including at least 0.001% of a halogen-type quench, two of said wall members having substantially parallel, spaced, substantially plate-like, conductive surfaces electrically insulated from one another and serving as cathode and anode electrodes, the remaining said wall members being electrically insulating and being arranged substantially at right angles to the plate-like conductive surfaces and defining therewith said substantially closed discharge space, and means for applying to the plate-like, conductive surfaces serving as cathode and anode electrodes a potential difference of a magnitude at which the detector operates along the Geiger-plateau region of its counting rate-voltage discharge characteristic.

2. A detector as set forth in claim 1 wherein the plate-like conductive surfaces are annular.

3. A detector as set forth in claim 2 wherein the remaining said wall members are coaxial cylinders.

4. A Geiger-Müller type radiation detector comprising a plurality of wall members defining a substantially closed discharge space containing an ionizable gas filling including at least 0.001% of a halogen-type quench, two of said wall members having substantially parallel, spaced, substantially plate-like, coaxial, cylindrical, conductive surface portions electrically insulated from one another and serving as cathode and anode electrodes, the remaining said wall members being electrically insulating and being arranged substantially at right angles to the plate-like conductive surface portions and defining therewith said substantially closed discharge space, and means for applying to the plate-like, conductive surfaces serving as cathode and anode electrodes a potential difference of a magnitude at which the detector operates along the Geiger-plateau region of its counting rate-voltage discharge characteristic.

5. A detector as set forth in claim 4 wherein the gas-filling includes a neon-argon rare gas mixture with bromine as the quench.

6. A Geiger-Müller-type radiation detector comprising a plurality of wall members defining a closed discharge space containing a low pressure ionizable gas filling including a rare gas and at least 0.001% of a halogen-type quench, two of said wall members having substantially parallel, spaced, plate-like, planar, conductive surfaces electrically insulated from one another and serving as cathode and anode electrodes for a gas discharge in said discharge space, the remaining said wall members being electrically insulating and being arranged substantially at right angles to the planar conductive surfaces and defining therewith said closed discharge space, means for applying to the planar, conductive surfaces serving as cathode and anode electrodes a potential difference of a magnitude

at which the detector operates along the Geiger-plateau region of its counting rate-voltage discharge characteristic, and means coupled to the planar conductive surfaces for deriving electrical signals related to radiation incident on the detector.

7. A detector as set forth in claim 6 wherein one of the said two wall members comprises an apertured metal plate, and an insulating plate overlies and seals the apertured plate.

8. A Geiger-Müller-type radiation detector comprising a plurality of wall members defining a closed discharge space containing a neon-argon low-pressure ionizable gas filling including at least 0.001% of bromine, two of said wall members comprising parallel, spaced, planar, circular, conductive, plate-like members electrically insulated from one another and serving as cathode and anode electrodes, the remaining said wall member being electrically insulating and comprising an annular ring arranged substantially at right angles and sealed to the periphery of the plate-like members and defining therewith said closed discharge space, and means for applying to the plate-like conductive members serving as cathode and anode electrodes a potential difference of a magnitude at which the detector operates along the Geiger-plateau region of its counting rate-voltage discharge characteristic.

9. A Geiger-Müller-type radiation detector comprising a plurality of wall members defining a substantially closed discharge space containing an ionizable gas filling including at least 0.001% of a halogen-type quench, two of said wall members comprising substantially parallel, spaced, curved, substantially plate-like, conductive members electrically insulated from one another and serving as cathode and anode electrodes, the remaining said wall members being electrically insulating and being arranged substantially at right angles to the plate-like conductive members and defining therewith said substantially closed discharge space, and means for applying to the plate-like, conductive members serving as cathode and anode electrodes a potential difference of a magnitude at which the detector operates along the Geiger-plateau region of its counting rate-voltage discharge characteristic, said potential difference applied to the cathode and anode electrodes producing in the discharge space a substantially homogeneous electric field.

10. A radiation detector as set forth in claim 9, wherein one electrode is hollow and lies within the other electrode.

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