June 20, 1944. H. G. STEVER 2,351,845

DIRECTIONAL GEIGER COUNTER

Filed July 21, 1941

Fig. 1

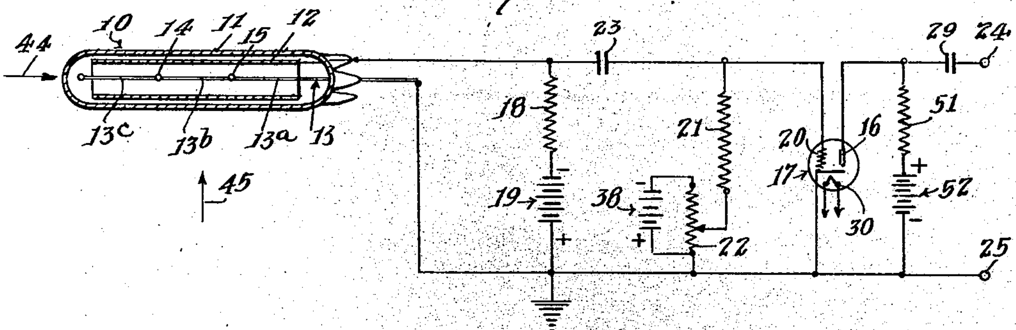


Fig. 2

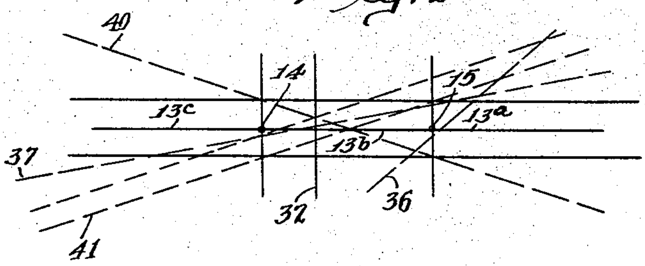
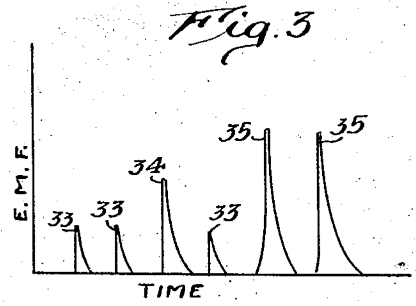


Fig. 3



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DIRECTIONAL GEIGER COUNTER

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6 Claims. (Cl. 250—83.6)

This invention relates to instruments for detecting or counting ionizing particles or ionizing radiation such as electrons, gamma rays, cosmic rays, etc., and more particularly to that type of instrument known as the "Geiger-Mueller counter."

An object of the invention is to provide a simple, inexpensive and reliable apparatus for determining the existence of ionizing particles and their direction of travel.

Another object is to provide a simple and effective method of operating a Geiger-Mueller counter to indicate the path of movement of ionizing particles, as well as their presence.

Another object is to facilitate counting of particles traveling in a particular direction, in the presence of a background of particles traveling in another direction.

The Geiger-Mueller counter is well-known in the art and in its usual form consists of a pair of electrodes consisting of a hollow cylindrical cathode and a wire anode positioned along the axis of the cathode, the two electrodes being mounted in a vessel containing suitable gases at a suitable pressure. When such a device has a sufficient potential applied between its cathode and anode, it will produce a discharge in response to movement of an ionizing particle through the space between the cathode and anode. The discharge caused by an ionizing particle can be quickly quenched so that each successive ionizing particle produces a separate, short discharge. It is a simple matter, and is well-known in the art, to employ any one of various counting circuits or devices responsive to the discharges for counting the number of the ionizing particles that have passed through the space between the cathode and anode of the tube during the period of the count.

The ordinary Geiger-Mueller tube, as described, is insensitive to the direction of the ionizing particles, since the magnitude and duration of the discharge is independent of the direction of the path of the ionizing particles.

In accordance with the present invention, I provide a simple, structural change in the conventional Geiger-Mueller tube, whereby the magnitude of the discharge initiated by an ionizing particle does vary according to the direction of travel of the particle.

My invention is based in part on the discovery that the discharge in a Geiger-Mueller tube ordinarily spreads over the entire length of the electrodes, but that the discharge can be localized to a section of the tube by interrupting the continuity of the exposed surface of the anode. This may be effectively done by fusing small, glass beads on the anode. If the anode is separated into three sections by two glass beads, the effect on the discharge is much the same as though three separate cathode-anode assemblies were employed, each completely segregated from the others by a gas-tight wall. If an ionizing particle passes through the space juxtaposed to only one section of the anode (as when the path of the particle is perpendicular to the axis of the tube), then the discharge initiated by the particle is confined to one section of the anode, and is of substantially fixed magnitude. On the other hand, if the ionizing particle passes through two sections of the tube, it initiates a discharge in both sections and the magnitude of the discharge is substantially twice that obtained when the particle passes through only one section. If the particle passes through all three sections of the tube, as when it is parallel, or nearly parallel, to the axis of the tube, then the discharge is initiated over the whole length of the anode, and the magnitude of the discharge is substantially three times what it is when the particle passes through only one section. In the circuit employed, potentials are developed that are approximately proportional in magnitude to the magnitude of the discharge of the tube.

It is quite obvious that by measuring the magnitudes of the discharges created, some information is obtainable as to the direction of the ionizing particles. Furthermore, it is readily possible to so adjust the energizing and recording circuit associated with the tube as to record only those ionizing particles which pass through two sections, or three sections, and thereby count the particles traveling in certain directions without interference by particles traveling in other directions.

For the purpose of more fully explaining the invention, a particular embodiment thereof will now be described in detail, with reference to the drawing, in which:

Fig. 1 is a schematic diagram of a Geiger-Mueller tube in accordance with the present invention, and a suitable energizing circuit therefor;

Fig. 2 is a schematic diagram showing typical paths of ionizing particles through my tube; and

Fig. 3 is a graph illustrating the magnitudes of discharges produced by ionizing particles traveling in different directions.

Referring to Fig. 1, I show a Geiger-Mueller tube 10 of my design, this tube incorporating as its essential elements, a gas-filled container 11 containing a hollow cylindrical cathode 12 and a wire anode 13 positioned coaxially with respect to the cathode 12. This tube is a conventional, Geiger-Mueller, fast-counter, tube, except for the fact that the anode 13 has fused thereon at two longitudinally spaced points, two glass beads 14 and 15, respectively, the beads being so positioned as to divide the anode into three substantially equal sections 13*a*, 13*b* and 13*c*, respectively. Although the size is not critical, the cylindrical cathode may conveniently be 1 inch in diameter and 8 inches long.

The anode 13 is connected to the positive, grounded terminal of a source of potential 19, and the cathode 12 is connected to the negative terminal of this source through a resistor 18. The cathode 12 is also connected, through a coupling condenser 23, to the grid 20 of a conventional three-electrode vacuum tube 17, the cathode of which is connected to ground. The grid 20 is also connected, through a resistor 21 and a potentiometer 22, to ground. The potentiometer 22 is connected across a source of potential 38, and provides a convenient means for biasing the grid 20.

The cathode of tube 17 may be of the heater type having a heater 30. The anode 16 of the tube is connected through a coupling condenser 29 to an output terminal 24 and through a resistor 51 to a source of anode potential 52, the other terminal of which is connected to the cathode. A second output terminal 25 is connected to the cathode of tube 17.

The potential applied between the cathode and anode of the Geiger tube from the source 19 is approximately the threshold potential so as to initiate a discharge in the tube in response to the passage of an ionizing particle through the space between the cathode and anode. As is well understood in this art, the potential is not high enough to initiate a discharge in the absence of an ionizing particle. The potential drop in the resistor 18 resulting from the discharge in the Geiger tube, swings the control grid 20 of the tube 17 positive, to thereby increase the plate current of the tube and apply an impulse through the coupling condenser 29 to the output terminals 24 and 25. Any suitable counting device may be connected to terminals 24 and 25.

If a discharge occurs throughout the entire tube, a momentary impulse of fixed potential is applied to the grid 20. The magnitude of this potential may be arbitrarily represented by the curves 35 of Fig. 3. However, if less than all of the tube is involved in the discharge, the potential of the impulse applied to the grid 20 is proportionally less. Thus if only one of the three sections of the anode 13 is involved, the potential of the impulse will be substantially one-third, as indicated by the curves 33 in Fig. 3. If two sections of the anode 13 are involved, the potential of the impulse will be approximately two-thirds of that developed when the entire tube is involved, as indicated by the curve 34 in Fig. 3.

The Geiger tube employed is preferably of the organic-vapor type, well known in the art. The internal action during a discharge builds up a space charge around the wire so that the discharge is immediately quenched and the tube is ready to respond to another ionizing particle. For reference, see the Ph. D. Thesis of H. G. Stever, California Institute of Technology, Pasadena, California. A suitable gas content, as disclosed in said thesis, consists of nine parts argon and one part xylol, at a pressure range between one to sixteen centimeters of mercury.

Referring now to Fig. 2, it will be observed that, in general, ionizing particles traveling in transverse paths, such as the path 32, pass through only one section of the Geiger tube, and initiate a discharge in only one section of the tube. If the potentials applied to the control grid 20 of tube 17 are plotted against time, as illustrated in Fig. 3, then the impulses developed by ionizing particles passing through only one section of the Geiger tube may be represented by the curves 33.

Referring again to Fig. 2, an ionizing particle traveling along a path 36 at an oblique angle to the axis of the Geiger tube, may pass through two sections thereof, juxtaposed to the anode sections 13*a* and 13*b*, respectively, and may initiate a discharge in each section, so that the charge applied to the grid 20 of the tube 17 has double potential, as represented by the curve 34 in Fig. 3. An ionizing particle traveling in a path 37 (Fig. 2) more nearly parallel to the axis of the Geiger tube, may pass through all three sections and produce a discharge from sections 13*a*, 13*b* and 13*c* of the anode to thereby apply to the grid 20 a charge of triple strength, as indicated by the curves 35 in Fig. 3.

The circuit of Fig. 1 can be adjusted to respond to the double charges 34 and the triple charges 35 without responding to the single charges 33. Or it can be adjusted to respond to the triple charges 35 without responding to either the single charges 33 or the double charges 34. This adjustment is effected by applying a proper bias to the control grid 20 of tube 17 by means of the potentiometer 22.

If it is desired that impulses be applied to the output terminals 24 and 25 only in response to ionizing particles that pass through all three sections of the Geiger tube, then the potentiometer 22 is adjusted to apply a negative bias to the control grid 20 slightly in excess of the peak potential of a double charge 34 (Fig. 3), plus the normal negative bias necessary to bias the tube 17 to the cut-off point. With this adjustment, the single charges 33 and the double charges 34 will not appreciably affect the plate current of tube 17, but triple charges applied to the control grid 20 will swing it sufficiently positive to cause a current flow and apply an impulse to the output terminals 24 and 25.

In Fig. 2 the lines 40 and 41 represent the approximate angular limits of the paths of particles that will produce triple discharges. Thus a ray traveling along either the path 40 or the path 41 would penetrate the space surrounding the central anode section 13*b* but not the end spaces surrounding the end sections 13*a* and 13*c*. However, a particle traveling parallel to either the path 40 or the path 41, but slightly spaced therefrom, would pass either through the front and mid sections, or the mid and rear sections of the tube, and would institute a double discharge.

A very useful feature of the invention is that it permits counting a directional ionizing radiation with substantially no hindrance from a non-directional background. Thus ionizing particles in the direction of the arrow 44 in Fig. 1 can be counted substantially without interference from particles traveling in the general direction of the arrow 45, by adjusting the potentiometer 22 so that the tube 17 responds only to charges of triple strength (the curves 35 in Fig. 3). In actual experiments with a source of particles in the direction of the arrow 45 giving 20,000 singles in a five-minute interval, it was possible to count ionizing particles traveling in the direction of the arrow 44 in the amount of 1140 particles for a five-minute interval, substantially without interference. Thus the count of the particles traveling in the direction 44 varied only from 1152 to 1140 when the source of particles traveling in the direction 45 was removed.

It is desirable, in order to prevent the discharge spreading from one section to another of the tube, to keep the photoelectric sensitivity of the cathode low. Methods of doing this are described in chapter VII of Procedures in Experimental Physics, by John Strong, to which reference is made for general information on Geiger counters.

The particular number of anode sections employed is not critical. Three sections have been found convenient in experimental work, but there is no reason to believe that better results might not be obtained with a different number and the invention is in no sense limited to the use of any particular number of sections.

Various departures from the exact construction described will be obvious to those skilled in the art, and the invention is, therefore, to be limited only as set forth in the appended claims.

I claim:

1. A Geiger-Mueller counter tube comprising a pair of elongated, parallel, uniformly spaced apart electrodes in a gas atmosphere, in which one of said electrodes is a cathode and the other is an anode, and the anode is separated into a plurality of sections by a band of electrically insulating material extending there-around.

2. A Geiger-Mueller counter tube comprising a pair of elongated, parallel, uniformly spaced apart electrodes in a gas atmosphere, in which one of said electrodes is a cathode and the other is an anode, and the anode is separated into a plurality of sections by a band of electrically insulating material extending there-around and in close contact with the surface thereof.

3. Apparatus as described in claim 1, in which said anode is in the form of a rod and said band of insulating material is constituted by a bead of insulating material fused on the rod.

4. Apparatus as described in claim 1, in which said anode is in the form of a rod and said band of insulating material is constituted by a bead of insulating material fused on the rod, the diameter of the said bead being of the order of several times the diameter of the rod.

5. In combination, a tube for detecting ionizing particles, said tube having a pair of elongated, parallel, uniformly spaced-apart electrodes in a gas atmosphere, one of said electrodes being a cathode and the other being an anode, and the anode having a band of electrically insulating material extending around it and separating the surface of said anode into a plurality of sections, circuit means connected to said electrodes for applying a potential therebetween of sufficient magnitude to initiate a discharge between said electrodes in any section thereof when the gas in that section is ionized by passage of an ionizing particle through that section, and indicating means selectively responsive to different potentials between said electrodes for distinguishing the discharges resulting from ionization in a plurality of said sections from discharges resulting from ionization in a lesser number of said sections.

6. The method of selectively counting ionizing particles of predetermined directional characteristics with a Geiger counter having an elongated anode and an elongated cathode juxtaposed thereto, which method consists in impressing approximately the threshold potential between said cathode and anode, insulatingly isolating longitudinally disposed portions of the surface of the anode from each other, whereby the magnitude of the discharge produced by an ionizing particle penetrating two or more portions of said tube is greater than the discharge produced by an ionizing particle traversing a lesser number of portions, and measuring the magnitude of the discharges produced by ionizing particles to thereby obtain an indication of the direction of travel of the particles.

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