Jan. 11, 1955 B. E. WATT 2,699,513

RADIATION DETECTOR

Filed March 18, 1950

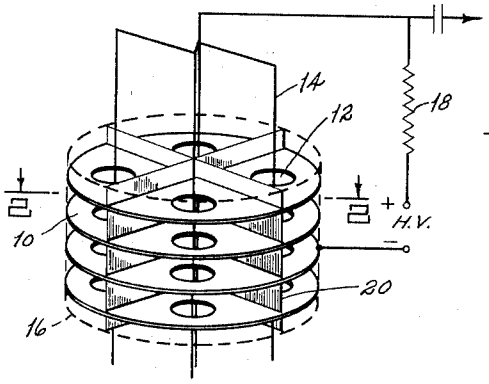


Fig. 1.

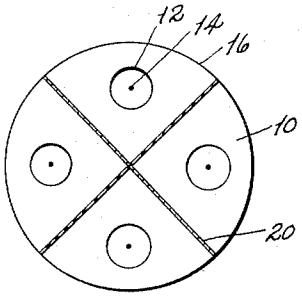


Fig. 2.

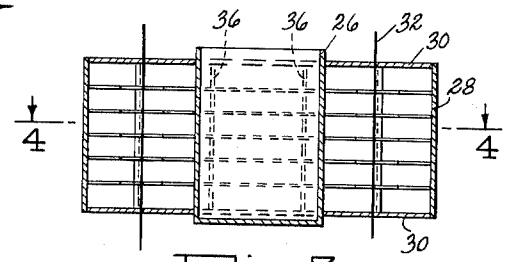


Fig. 3.

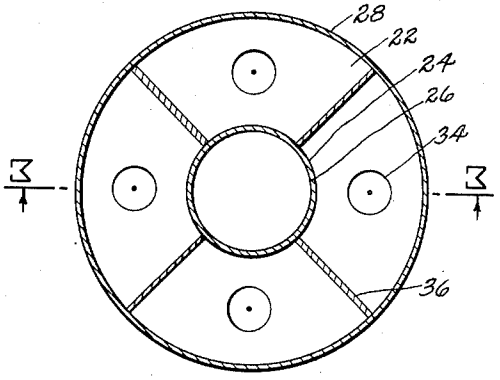


Fig. 4.

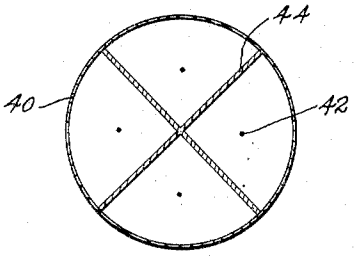


Fig. 5.

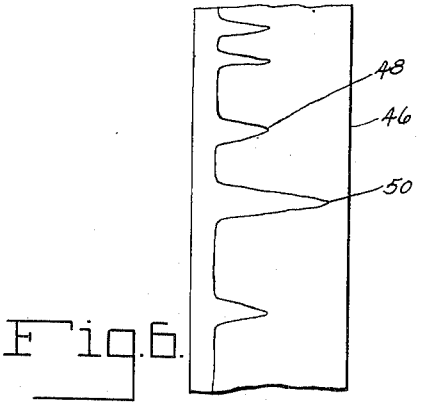


Fig. 6.

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RADIATION DETECTOR

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5 Claims. (Cl. 313—93)

This invention relates to radiation detectors and more particularly to improvements in gamma ray detectors of the pulse producing or counter type. The principal object of the invention is the provision of such a detector which will have a greater efficiency and a higher counting rate than the detectors presently used.

In the U. S. Letters Patent No. 2,397,071 granted March 19, 1946 to D. G. C. Hare a gamma ray counter is disclosed which is several times more efficient than the conventional Geiger-Mueller counter. In the Hare detector the cathode is formed of a plurality of metal discs or plates disposed in parallel separated relation, the plates being provided with one or more series of aligned holes, along the axis of which holes an anode wire extends. The cathode and anode are disposed within a sealed housing containing a suitable gas filling. The improvements which will be described are applicable particularly to a counter of this type.

Certain experiments in which an oscilloscope was used to permit the observation of the operation of various counters have shown that in a multi-anode type of counter some or all of the anodes were discharging due to the trigger effect of photons released in the vicinity of another anode wire. Because of this fact the efficiency of a counter is impaired and the counting rate is reduced. This is, of course, due to the fact that when all of the anode sections of one of these counters discharge simultaneously all of these same sections must "recover" before the device is ready for another discharge or pulse.

In accordance with this invention means are provided in the form of baffles or partitions placed between and at right angles to adjacent cathode plates so as to divide the counter into a plurality of substantially independent sections each section having one anode wire. In this manner each anode wire is prevented from "seeing" any other anode wire and the photon emission in one section therefore does not affect any of the other sections. Thus, assuming a gamma ray enters one section of the counter and through the ejection of an electron from the cathode metal causes ionization of the gas in that section and thus a pulse on the anode wire, the other sections of the counter will be in readiness to receive another gamma ray and to be discharged thereby before the first section has recovered. It is obvious, then, that due to the dividing up of the counter into several sections the overall counting rate will be greatly increased.

For a better understanding of the invention reference may be had to the accompanying drawing, in which

Fig. 1 is a somewhat diagrammatic, isometric view of a counter embodying the invention;

Fig. 2 is a plan view more or less on the line 2—2 of Fig. 1;

Fig. 3 is a vertical sectional view through a "cup-shaped" counter taken on the line 3—3 of Fig. 4;

Fig. 4 is a horizontal section on the line 4—4 of Fig. 3;

Fig. 5 is a horizontal section through a modified form of counter; and

Fig. 6 is a section of a record strip illustrating the operation of the counter shown in Fig. 5.

Referring to the drawing and particularly to Figs. 1 and 2, a plurality of thin metallic cathode plates or discs 10 are shown as arranged in parallel separated relation in a bank. The bank of cathode plates is provided with a plurality, four in this instance, of series of holes 12 the holes in each series being in alignment. Each series of holes 12 has disposed along its longitudinal axis an anode wire 14. The bank of cathode plates forming one

electrode and the anode wires 14 forming the other electrode are positioned within a suitable sealed housing shown diagrammatically by the dotted lines 16. The housing 16 is filled with a suitable gas such as a mixture of argon and ammonia. The housing 16 may be of any suitable material such as glass or metal and if metal is used the anode wires 14 will, of course, be electrically insulated from the top and bottom of the housing where they pass through it. As is well known to those familiar with this subject, a high voltage is applied across the cathode and anode through a resistor 18, and when the gas within the housing is ionized due to the ejection of an electron from the cathode, material the counter will discharge or, in other words, a pulse will occur and this will be detected by measuring the voltage drop across the resistor in well known fashion. The counter so far described is substantially the same as that disclosed in the aforementioned Hare Patent No. 2,397,071.

Between the adjacent cathode plates and between the endmost plates and the top and bottom of the housing 16, a plurality of baffles or partitions 20 are mounted as by securing them to the cathode plates by welding. The partitions 20 are disposed in alignment and one set of partitions is placed midway between two adjacent series of holes 12. In the counter illustrated, there are four anodes and the partitions 20, therefore, are in the form of a right angle cross. It is understood that the invention is not limited to a counter with four anodes since any suitable number may be used.

In Figs. 3 and 4 the invention is illustrated as applied to a gamma ray counter of slightly different form. In this counter the cathode members are in the form of annular discs or plates 22, the plates being provided with relatively large center holes 24 through which a cup member 26 is disposed. The cup member 26 is preferably in the form of a cylinder closed at its bottom. A cylindrical section 28 is disposed about the periphery of the bank of cathode plates 22 and top and bottom cover members 30 serve to enclose the cathode bank and that portion of the anode wires 32 passing through the aligned holes 34 in the bank. In this case the baffles or partitions 36 extend radially from the outer surface of the cup 26 to the inner surface of the outer housing portion 28, and as is the case with the form shown in Fig. 1, the partitions 36 are disposed in alignment and serve to divide the counter into sections each having its own anode wire. The counter shown in Figs. 3 and 4 is particularly suited to the measurement of the radioactivity of samples such, for example, as ore specimens which can be placed within the cup 26.

In the counters thus far described, it has been found that cathode plates of a high atomic number metal such as tantalum, about 0.006 inch in thickness are very satisfactory. The plates are spaced apart about 3/16 of an inch and the diameter of the holes 12 and 34 is about 5/8 of an inch. In addition to preventing photon emission from one section affecting another section, the partitions 20 also serve to support the cathode plates and prevent sagging or distortion thereof even when the plates are of a soft metal such as lead or are thinner than 0.006 inch. Again it has been found that the partitions afford an additional advantage, this residing in the fact that the partitions which are preferably of the same metal as the cathode plates provide additional cathode area from which electrons can be ejected into the gas within the counter sections when the partitions are struck by gamma rays. In comparing counters, one having cathode plate holes ½ inch in diameter and the other having holes 5/8 inch in diameter, it was found that with the counter having the 5/8 inch holes a better plateau resulted. While without the provision of the partitions the increase in the size of the holes would cause a slightly lower efficiency due to the removal of some of the cathode area, the addition of the partitions provided sufficient extra cathode material to more than overcome this slight decrease in efficiency. Again in comparing two similar counters, one with and one without the partitions, it was found that the counter having the partitions had an efficiency 18 per cent greater than the one not having the partitions.

With a counter as illustrated in Figs. 1 and 2, still

another effect is provided which may be desirable when certain measurements are made. It may at times be desired to measure separately gamma rays entering the counter from different directions such as when a counter is used, for example, in surface exploration of the earth. In this case the anode wires **14**, instead of being connected together to form a single anode, would be connected separately to individual amplifiers as is disclosed in the U. S. Letters Patent No. 2,489,133 granted November 22, 1949 to Gerhard Herzog, each amplifier being connected to a separate recorder, and the partitions **20** would be formed of a metal highly absorbent to gamma rays such as lead or, if formed of some other metal, would be of sufficient thickness to absorb gamma rays. Thus, assuming a gamma ray enters one section of the counter, that section would be discharged by the gamma ray but the gamma ray would not be able to pass through the partition **20** into another counter section. By measuring independently the outputs of the anode wires **14**, an indication can be had as to the intensity of gamma rays entering the different sections and in the case of surface exploration this will show from which direction the gamma rays of greatest intensity are coming.

Still another effect or advantage of the longitudinal baffles or partitions through a counter is obtainable. It is sometimes desirable to detect occasional gamma rays of high energy in the presence of intense low energy gamma radiation. In the past attempts have been made to do this by enclosing counters in shields of varying thicknesses so that the greater the energy of a gamma ray, the greater shield thickness the gamma ray would penetrate, but this has not been too satisfactory. Owing to the exponential absorption law for gamma rays in matter and the relatively low rate of change for the absorption coefficient with gamma ray energy it is often impracticable to use lead or other such filters around the counters. When the energy of both gamma rays is above 2 m. e. v. the absorption coefficient for the high energy gamma ray is nearly the same as for the low energy one.

In lead the absorption coefficient for the high energy gamma rays may even be greater than that for the lower energy gamma rays. When an electron passes through matter the energy is lost rather uniformly along the path. For electrons with very high velocity (beta rays) the thickness of material which they can penetrate depends almost linearly on their energy. This fact can be used to detect only high energy gamma radiation, i. e., to discriminate between high and low energy gamma rays. As an example, Fig. 5 shows a counter having a cylindrical cathode **40**, four anode wires **42** and longitudinal baffles or partitions **44** parallel to the wires and separating the counter into four sections each having its own anode **42**. As has been previously described, with this arrangement a discharge in one section cannot initiate a discharge in the other sections due to the photon emission. A beta ray passing through only one section can initiate a discharge in only that section and a beta ray which penetrates a baffle plate **42** between two sections can initiate a discharge in both sections. With a suitable thickness for the baffle **42** only the beta rays generated by the high energy gamma rays can penetrate the baffle and hence only high energy gamma rays can cause simultaneous, that is, coincident, discharges of the two sections. As is well known, there are many ways to detect and record the coincident discharges, one of the simplest being to connect the anode wires together and to record only the large size pulses caused by coincident discharges. By suitable amplification it is, of course, possible to record simultaneously the intensity of both the high and low energy gamma rays. Fig. 6 illustrates diagrammatically a section of a record strip **46**. The smaller pulses such as that indicated at **48** are those due to the discharge of a single counter section and represent, therefore, the weak gamma rays. The large pulse at **50** is caused by the substantially coincident discharge of two of the counter sections and thus represents a high energy gamma ray. Thus, with a counter of this type, it is possible to discriminate between low and high energy gamma rays.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof, and

therefore only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. A gamma ray detector of the electrical pulse producing type comprising a sealed housing adapted to contain a gas filling, a cathode in said housing formed of a plurality of thin annular metal plates disposed in separated relation in a parallel bank, said plates being provided with a plurality of series of aligned holes, an anode wire disposed axially through each series of holes, a cup member fitting snugly within the center holes in said plates and said housing fitting snugly around the perimeters of said plates, and a plurality of partition elements disposed between and substantially perpendicularly to each adjacent pair of plates and extending substantially radially from the outer surface of said cup member to the inner surface of said housing.

2. A gamma ray detector of the electrical pulse producing type comprising a sealed housing adapted to contain a gas filling, a cathode in said housing formed of a plurality of annular metal plates disposed in separated relation in a parallel bank, said plates being provided with a plurality of series of aligned holes, an anode wire disposed axially through each series of holes, a cup member fitting snugly within the center holes in said plates and said housing fittingly snugly around the perimeters of said plates, and a plurality of thin metal partition elements disposed between and substantially perpendicularly to each adjacent pair of plates and extending substantially radially between adjacent holes from the outer surface of said cup member to the inner surface of said housing, said partition elements serving to divide said detector into a plurality of longitudinal chambers each having one series of aligned holes and one anode wire.

3. A gamma ray detector of the electrical pulse producing type comprising a sealed housing adapted to contain a gas filling, a cathode in said housing formed of a plurality of round thin metal plates disposed in separated relation in a parallel bank, said plates being provided with a plurality of series of aligned holes disposed at equal distances from the centers of said plates, an anode wire disposed axially through each series of holes, a plurality of partition elements of the same metal as said cathode disposed between and substantially perpendicularly to each adjacent pair of plates, said partition elements intersecting at the centers of said plates, and said partitions extending to the inner surface of said housing, thus forming walls around corresponding holes in said adjacent plates and serving to divide said detector into a plurality of longitudinal sections, each having one series of aligned holes and one anode wire.

4. A gamma ray detector of the electrical pulse producing type comprising a cylindrical cathode member forming the side walls of a sealed housing adapted to contain a gas filling, a plurality of longitudinal shielding partitions of the same material as said cathode member intersecting along the longitudinal axis of said cylindrical member and extending radially to the inner surface of said cylindrical member so as to divide the space within said cathode member into a plurality of independent longitudinal closed sectors and an anode wire disposed axially longitudinally through each of said sectors.

5. A device of the electrical pulse producing type for detecting gamma radiation comprising a sealed housing adapted to contain a gas filling a series of substantially parallel and spaced plate members forming a cathode within said housing, a shield intersecting said plates and said housing to divide the plates into a plurality of substantially independent sectors, said plates being formed with a plurality of series of holes, at least one series of holes being in each sector, the holes in each series being arranged in alignment, and an anode for each sector comprising a wire disposed axially through each series of holes and electrically insulated from said plate.

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