

March 13, 1956

G. HERZOG

2,738,431

MULTIPLE-PLATE RADIATION DETECTORS

Filed Feb. 14, 1952

Fig. 1.

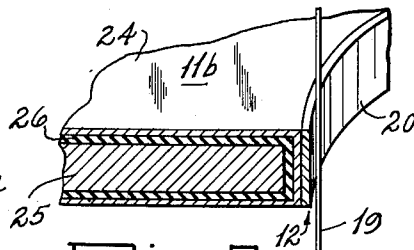
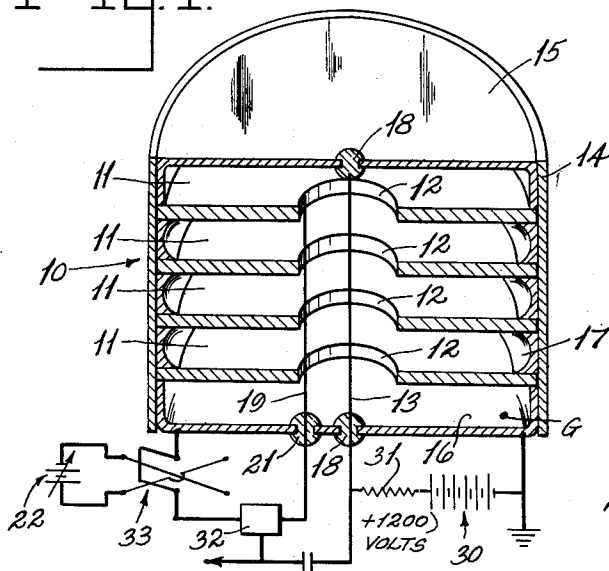


Fig. 2.

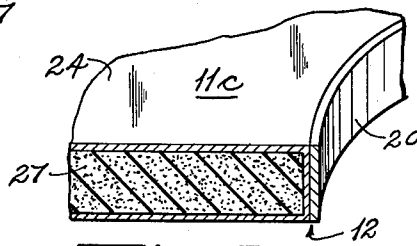


Fig. 3.

Fig. 5.

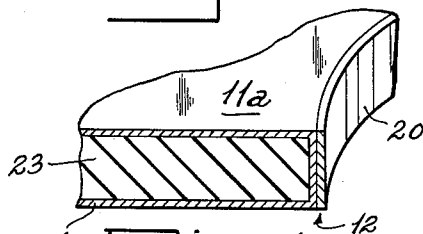
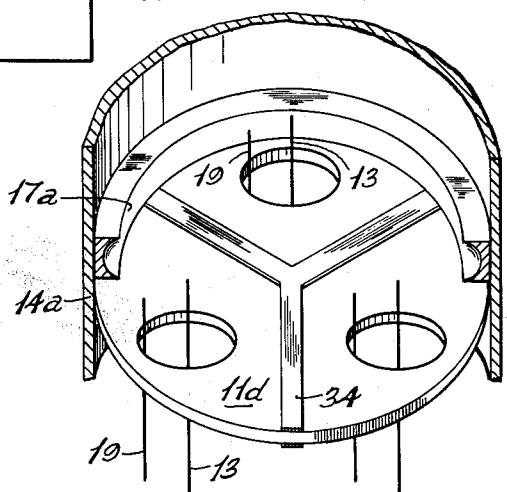


Fig. 4.

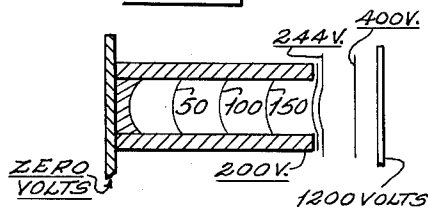


Fig. 7.

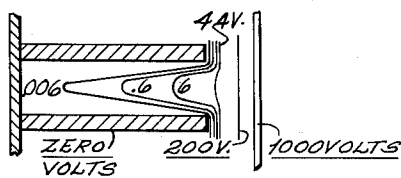


Fig. 6.

INVENTOR.
GERHARD HERZOG
BY
J. H. Graham
ATTORNEY

1

2,738,431

MULTIPLE-PLATE RADIATION DETECTORS

Gerhard Herzog, Houston, Tex., assignor to The Texas Company, New York, N. Y., a corporation of Delaware

Application February 14, 1952, Serial No. 271,544

8 Claims. (Cl. 250—83.6)

2

This invention relates to improvements in Geiger-Mueller radiation detectors and in particular to the types thereof variously known as multiple plate detectors, Hare detectors, and Texaco detectors. As is known these detectors have much higher efficiencies for the detection of penetrative radiation such as gamma rays than the original or proto-type Geiger-Mueller tubes. A brief review of why this is so will be helpful in understanding the objects of the present invention and how they are attained.

In proto-type Geiger-Mueller tubes the cathodes are cylindrical and are usually positioned, during operation, with their curved outer surfaces facing broadside to the source of radiation. As a result of this geometry the great majority of the impinging penetrative photons never get to be detected. This shortcoming, which is inherent in this type of tube, may come about in either or both of two ways: (1) because many photons simply fail to become involved in interactions within the cathode, and therefore fail to produce the charged particles needed for ionizing the gas filling of the tube if current pulses are to be produced, and/or (2) because many of the charged-particle by-products of the interactions which do take place fail to escape from the cathode into the gas filled interior of the tube. It comes about primarily in the first way because the cathode walls are so thin that the majority of the impinging photons of penetrative radiation go right through the entire tube without having interactions. Nor does the presence of a large volume of gas within the tube improve matters to any substantial degree since interactions occur in substantial numbers only in dense materials. Thus, incidentally, it should be borne in mind that the gas, which is so essential for the counting mechanism, i. e., for the gas amplification afforded by Townsend avalanches, is of substantially no significance in contributing to the total number of interactions. It comes about primarily in the second way because the cathode walls are so thick that a great many of such interactions as do take place will occur within them at greater distance from their interior surfaces than the penetrative ranges of the charged-particles which are released as by-products of these interactions. In other words the charged-particles have very limited capability for penetration as compared to the photons of the initial radiation. From the foregoing it will be seen that there is no possible wall thickness for these tubes at which high detection efficiencies will be achieved. All that can be hoped for is to avoid such extremely poor efficiencies that use of the tubes is impractical.

Multiple plate detectors have provided a great increase in detection efficiency by the use of stacked arrays of wafer-like cathode elements whose exposure to radiation is successive, if it is directed at their surfaces, and is deep, if it is directed at their edges. Thus a gamma ray which impinges on an end of the stack will have repeated opportunities to interact in thin elements from which the charged particle by-products can easily escape whereas one which enters an edge of a cathode element or penetrates one of its sides at a very small grazing angle, will have single excellent opportunity due to its continuous long path through

dense material, while its charged-particle by-products also have an excellent chance of escaping. This is because very often they will move off from the interaction point in entirely different directions than extrapolations of the paths of the radiation which produced them, i. e., they will often move off in directions having large components at right angles to the exposed surfaces of the cathode element. Therefore multiple plate detectors offered a type of structure which results in an increase in the percentage of interactions and at the same time permits a higher percentage of the ionizing charged particles produced by the interactions to escape into the gas.

To provide total edgewise areas of exposure of corresponding magnitude to the broadside areas afforded by the outer surfaces of the cylindrical cathodes of the proto-type Geiger-Mueller tubes, each of these tubes employed a plurality of the wafer-like cathode elements arranged in slightly spaced-apart relationship to constitute a dense stacked array. As an overall result the multiple plate type detectors include, by volume, much higher percentages of solid materials than was ever possible in the proto-type Geiger-Mueller tubes.

In addition to the occurrence of an interaction within the cathode, and of the escape of one or more ionizing charged particles from the point of interaction into the gas filling of the tube, one more occurrence is necessary to complete the detection of an intercepted photon of radiation. It is that the charged particle(s) bring about a Townsend avalanche. To do this, it (or they) must ionize one or more atoms of the gas, i. e., produce secondary electrons, in a region within the tube where a sufficient accelerating gradient exists to start an avalanche of ionization. In proto-type Geiger-Mueller tubes this last requirement is met almost automatically, in most cases, because all parts of the interior surfaces of their cathodes are directly exposed to their centrally located anodes. Therefore any negative charged particle which escapes into the interior of the tube and/or any secondary electron which it produces by ionization has a very great likelihood of being accelerated toward the anode. To meet this requirement in multiple plate detectors, arrangements have been devised which are intended to afford unimpeded discharge paths to an anode from all regions, adjacent the surfaces of the cathode elements, into which charged particles are likely to escape. For example in many of these arrangements each of one or more fine wire anodes extends in perpendicular, rather than parallel, relationship to the surfaces of the cathode elements, such as through a row of aligned holes formed respectively therein, the elements being positioned in alignment and adjacent to each other, though slightly spaced apart, to make this possible. Thus both surfaces of each element can "see" exposed portions of an anode along straight lines which are unobstructed by any part of any other cathode element. A simple example of such an arrangement is one in which each of the cathode elements is a circular disc having a small central aperture; the discs are arranged with their perimeters and apertures in alignment and their surfaces in a parallel spaced relationship; and a single fine wire anode extends through the center of the aligned row of apertures.

Thus multiple plate detectors met two urgent needs: (1) provision in the detector head of greater amounts of dense material disposed in the most probable paths of the penetrative radiation to be detected; and (2) provision of a geometry affording a high-escape incidence of the charged-particle by-products of interactions and open paths which do not physically obstruct collection of the particles by the anode(s) despite the large amounts of material comprised in the cathode and the complex arrangement thereof. However these complex arrangements have the disadvantage that they have interfered with the electrical operation of the tube in such a way that it is often difficult to achieve

a high percentage of actual collection of the charged-particle by-products and/or their secondaries by the anode(s) of the tube despite the open paths.

The difficulty arises from the fact that no interelement spacing is ever totally satisfactory. If very small spacings are used, e. g., with a view to increasing the number of cathode elements containable within a given detector and thereby increase the incidence of interactions, then the electron-collecting field of the anode(s) is not able to penetrate deeply enough into the inter-element spacings to draw out most of the escaped charged particles and/or the secondary electrons which they produce in the gas. Because of this many of these particles will not be able to start Townsend avalanches and the interactions which produced these particles will go uncounted. If, on the other hand, large spacings are used, e. g., to increase the efficiency of the device for collecting escaped charge particles and/or the secondaries which they produce, then the incidence of interactions will be reduced.

Moreover, while it might seem that the collection of charged particles in a detector which has excessively close spacings between its cathode elements might easily be increased by increasing the anode-to-cathode potential, this is not available as a satisfactory practical expedient. One reason for this is that certain anode potentials should not be exceeded if one is to obtain certain kinds of operation, e. g., operation on the plateau or proportional counting. Another reason is the possibility of cold emission from the edges of the cathode elements which face toward the anode(s) if an excessive anode-to-cathode potential is used.

Similarly, while the collection of charged particles might be increased by increasing the number of anode wires which pass through the stack of cathode elements (see Figs. 3, 4, 5, 7 or 8 of U. S. Patent 2,397,071), it should be borne in mind that each time that a hole is made in a cathode element it reduces the total amount of dense material comprised therein and thereby reduces the probable incidence of interactions.

Accordingly it is an object of the present invention to provide improvements in Geiger-Mueller radiation detectors of the kind described above whereby one may use unusually small spacings between adjacent cathode elements and yet attain unexpectedly high efficiency in collecting the charged-particle by-products of interactions and/or the secondary electrons produced thereby.

In general these objects are attained by including in the detector means which are effective independently of the anode(s) to provide in region(s) into which charged particles are likely to escape and in which their secondaries are likely to be produced, stronger collecting fields than those which normally would be provided therein as a result of the potential applied between the cathode and the fine-wire anode(s). As is known there is a very great concentration of the available field about a Geiger-Mueller anode. Because of this the field gradients which exist near to portions of the cathode structure are relatively very low. According to embodiments of the present invention, which are shown herein by way of example, increased electron collecting fields are established in the regions in question by forcing direct currents through or along the surfaces of the cathode elements radially outward from the edges of their apertures to produce gradients which extend along and between the electrodes as far as desired, whereby escaped charged particles and/or their secondaries are forcibly drawn from these regions and projected into the field(s) of the anode(s) wherein they receive their final acceleration for producing Townsend avalanches.

In the drawing:

Fig. 1 represents a longitudinal section through a multiple-plate Geiger-Mueller detector embodying improvement features of the present invention;

Figs. 2-4 represent very much enlarged cross sectional views of fragmentary portions of types of cathode ele-

ments which are suitable for use in the detectors shown herein;

Fig. 5 is a fragmentary partially-sectioned view of another embodiment of the present invention; and

Figs. 6 and 7 represent plots showing qualitatively the difference in the configurations of the fields which exist between the cathode elements of prior art multiple-plate detectors and those of the present invention.

The detector 10 shown in Fig. 1 comprises a plurality of cathode elements 11 positioned in parallel spaced relationship and having a centrally positioned row of aligned apertures 12 through which extends a fine wire anode 13. This arrangement of the structure of the detector 10 is in accordance with the prior art of so-called "multiple-plate detectors."

The thicknesses and proportions of the various elements which appear in the drawing and the spacings between them have been chosen for simplicity and clarity and are not intended necessarily to be representative of actual dimensions. Likewise no attempt has been made in Fig. 1 to show cross sectional details of the cathode elements 11 since this is not feasible in the small space available.

With regard to proportions which are suitable for the presently disclosed detector 10 the following is noted. According to the prior art the spacings between cathode plates of any given diameter can't be reduced beyond a certain point without adversely effecting the collection of charged particles as explained above. For example, the conclusion has been empirically reached that cathode elements having two inch diameters should not be spaced any less than $\frac{3}{16}$ of an inch apart. However by using means as proposed herein to set up strong electron accelerating fields in the interelement spacings, independently of the anode(s) fields the spacings of the cathode plates can be made considerably smaller than was ever previously possible.

The active electrode parts of the detector 10, e. g., its cathode elements 11 and its anode 13 are mounted within an hermetically sealed envelope comprising a rather thin-walled cylinder 14 and end closures 15 and 16 joined together, for example by R. F. Welding, soldering in a hydrogen atmosphere, brazing or the like, in the assembled relationship shown in Fig. 1. The diameter of the cathode elements 11 is such they fit snugly within the cylinder 14. They may be supported therein in a variety of suitable ways such as by being press fitted thereto and/or spot welded. A ring-shaped or annular spacer 17 may also be press fitted into the cylinder 14 between each pair of cathode elements 11 to ruggedize the structure; to maintain proper spacing between the elements; and to perform an electron-optical function which is to be further described below. The anode 13 is supported under tension between a pair of insulating, e. g., glass or ceramic beads 18 which are sealed into centrally located openings within the end closures 15 and 16.

According to the present invention electric fields for the pre-acceleration toward the anode(s) of negative charged particles which escape into or are produced within the inter-cathode-element spacings are provided for by forcing currents through, or along the surfaces of, the cathode elements from the edges of their apertures 12 radially outward to their circular perimeters. To this end their perimeters are conductively connected to the metallic inner surface of the cylinder 14 which therefore may serve as a terminal to which the negative pole of a current source may be connected, while the inner edges of their apertures 12 should preferably be sufficiently conductive so that any points thereof can serve as terminals to which the positive pole can be connected to cause substantially equal currents to be forced radially outward toward the perimeter of the element over equivalent segments thereof. Any suitable means may be employed for causing the inner edges to be appropriately conductive. For example conductive coat-

ings, like the coatings 20 shown in Figs. 2-4 may be used, these being applied by applying a liquid or paste, e. g., aquadag solution or silver paste, or by sputtering on a material such as gold while the flat sides of the elements are appropriately covered with masks or templates. A lead 19 is utilized to provide a common and external terminal for connection of the inner edges of all of the apertures 12 to the positive pole of a current source. It comprises one portion which is connected in parallel to the inner edges of all of the apertures and another which extends through the end closure 16 via an insulating bead 21 to provide an external terminal pin. In the simplest type of embodiment the cathode elements 11 may be made of an homogeneous material having such a value of resistivity for a given solid volume that for the particular dimensions of the cathode elements a voltage drop adequate to provide the desired accelerating fields will be maintained along all radii between the inner edges of their apertures 12 and their outer perimeters for the expenditure of currents of practical magnitudes, i. e., of relatively small currents.

Because of a beaming electron optical effect which will occur between the cathode elements 11 during the operation of the detector 10, the high potential portions of its cathode elements will draw little or no current from the adjacent ionized gaseous filling, G, even when the detector might be counting at a very high rate. For this reason a current source 22 which is connected between the inner and outer edges of the cathode elements 11 does not have to be capable of providing much power. Accordingly the resistivity of the cathode elements as measured between the inner edges of their apertures 12 and their outer perimeters may be made extremely high whereby it will itself serve to limit the amount of current drawn from the source of current 22 and will at the same time cause most of the voltage drop in the current loop to occur usefully along the surface of the cathode elements.

Figs. 2-4 represent structures for the cathode elements 11 which make it possible for them to have the desired high resistance between their inner and outer edges and also to have other desirable characteristics as explained below. The simplest of these is that of Fig. 4. In this embodiment a cathode element 11a comprises an insulating core 23 carrying directly on all of its top, bottom and edge surfaces an extremely thin film or coating 24 of conductive or partially conductive material. The coating 24, for example, may be a very thin, such as monomolecular, layer of tungsten or other metal which has been evaporated onto the core, and in this way may readily be formed with desired high values of resistance. As is shown in Fig. 4 the inner edge of the aperture 12 of the element 11a carries a coating 20 for causing the edge to be more highly conductive than the other surfaces of the element whereby the entire inner edge will be at the same potential even if the current source is connected to it at a single point as for example by the lead 19.

An objection to making the cathode elements of a homogeneous resistive or insulating material, such as, on the one hand, the sort of material used for commercial carbon resistors for the elements 11, or, on the other, of a glass or ceramic material, for the insulating cores 23, is that the principal ingredients of most suitable kinds of such substances are usually low atomic number elements. However, as is known, such elements are not as capable of absorbing penetrative radiation as high atomic number elements and for this reason their use is not to be preferred for the cathodes of Geiger-Mueller detectors.

The embodiments shown in Figs. 2 and 3 have been devised to provide cathode elements which, in addition to having high electrical resistance, also comprise large percentages of high atomic number elements. To this end the element 11b shown in Fig. 2 comprises as a core 25, some preferred type of cathode element formed

of a high atomic number element, such as tantalum, but further includes an intermediate insulating coating 26 to prevent the core from short circuiting the coating 24. The insulating coating 26 may be of any suitable kind such as a coating of aluminum oxide applied over the core 26 as an oxide or, if preferred, applied by evaporating or sputtering a layer of metallic aluminium onto it and then oxidizing all of the exposed surface(s) of the layer.

The coatings 24 and 20 of the element 11b may be applied over the assembly comprising the core 25 and the insulating coating 26 in much the same way that as they are applied over the homogeneous core 23 of the element 11a and their functions in this embodiment are similar to those of that of Fig. 4.

The embodiment of Fig. 3 utilizes a special core 27 which comprises high atomic number particles sintered together in an insulating binder so that there will be no unbroken conductive paths from one point to another either through the core or along its surfaces, even if the particles are individually conductive, as they will be if they are filings of a metal such as tantalum. Suitable techniques for making the special cores 27 are available in such arts as that related to the manufacture of high-permeability di-electric ferrite cores for high frequency inductors, transformers, and the like. Because of the special construction used for the core 27 the coating 24 may be applied directly over it as shown in Fig. 3, i. e., without the use of an intermediate insulating coating. In this embodiment, as in the others, the inside edge of the aperture 12 carries a coating 20 to serve a useful purpose which has already been explained.

Fig. 6 represents how a part of the anode-to-cathode field in a prior art multiple plate detector fringes into the space between its cathode elements. Since most of the field is concentrated about the fine wire Geiger-Mueller anode, equi-potential surfaces which are approximately midway between the anode and inside edges of the apertures 12 may have values which are but small fractions of the anode potential, for example values in the neighborhood of 200 volts for an applied anode potential of 1,000 volts. Due to this nonlinear falling off of the field gradients at positions successively farther removed from the anode toward the cathode array none of the equi-potential surfaces which are near enough to the array to protrude or fringe into its interelement spaces will have very great magnitudes. Thus Fig. 6 shows that while one equi-potential surface, which is represented as having a potential of only 44 volts, does bulge toward the interelement space shown therein, it actually does not extend into it. One surface which is shown to fringe about one fifth of the way into the interelement space provides no more than a 6 volt gradient over the other four fifths of the way, and this, of course, is not a very high voltage for controlling such particles as photo-electrons, Compton electrons, and the sort of secondary electrons which they will produce in ionizing the gaseous filling G. Moreover this six volt gradient is also extremely nonlinear so that most of it is effective in a practical sense but for a very small fraction of the above-mentioned "other four-fifths of the way." As a result many negative charged particles which will escape from the cathode elements into a portion of each interelement space near the periphery of the detector may never escape out of the cathode array to regions where they can be accelerated toward the anode. Of course, such particles may have initial velocities of their own in such directions that they will escape from the cathode array without any "pre-acceleration," but this will be largely a matter of chance.

Fig. 7 shows how this situation is improved by arrangements such as those proposed herein. For one thing the pronounced nonlinearity of the field between the Geiger-Mueller anode and cathode has no significant influence on the magnitudes and the gradients of the fields which are established within the cathode array, and are

determined in the main by the potential difference which is maintained between the inner and outer edges of the cathode elements and the linearity of the inter-edge resistances of the cathode elements. Of course, this resistance will tend to be nonlinear because in each cathode element the volume of material for a given radially-measured increment is progressively greater at points which are located successively nearer to its perimeter. This nonlinearity however is far less pronounced than that of the field distribution represented in Fig. 5 and moreover it can be easily compensated for by forming the elements to be thinner and/or more highly resistive in regions successively nearer to their perimeters.

Fig. 7 shows how one may maintain a voltage difference of about 200 volts between the inner and outer edges of a cathode element so that strong pre-accelerating fields are provided in all regions within the cathode array into which the charged-particle by-products of interactions are likely to escape. Of course it is desirable for these negative particles, and/or the secondary electrons which they produce, to be beamed away from the surfaces of the plates so that they will not be recaptured thereon. To a certain extent some beaming action will be inherent due to the fact that the pre-accelerating fields within the cathode array will include a component which is contributed by the field of the anode and this component will have a configuration having an electron optical effect which is suitable for the purpose at hand. To further form the equi-potential surfaces with configurations suitable for such electron optical effects, the ring-shaped spacers 17 shown herein are formed with convex annular grooves facing inwardly in the manner shown in Fig. 1. Thus, since both the zero equi-potential surface and the components which are contributed by the field of the anode will be convex toward the anode the resultant surfaces will be similarly convex.

In a detector which is modified according to the present invention it may be necessary to use a slightly different anode potential than would be employed if the detector were not modified as shown herein to obtain certain desired kinds of operation, for example operation on the "plateau." For this reason the potential source 30 shown in Fig. 1 is represented as providing an anode potential of about 1,200 volts instead of, as is commonly the case, one about 1,000 volts.

If the amount of pre-acceleration employed within the array raises the negative particles to energy levels higher than the ionization potential of the gaseous filling of the detector, some electron multiplication will occur even before these particles pass out of the cathode array and into the direct influence of the anode field. As is known the ionizing potential which is essential for providing electron multiplication to produce a Townsend avalanche in prior art Geiger-Mueller detectors must be effectively eliminated immediately after the generation of an output pulse so that a detector can "recover" and therefore be ready for new counts. Otherwise the potential will also eventually accelerate the heavy positive ions back onto the cathode thereby producing secondary electrons and sustaining a continuous discharge. It is to avoid this that large quenching resistor 31 is usually employed in series with a cathode-to-anode energizing source. During a pulse it drops the applied potential to such a low value that the weak fields that remain within the detector cannot sufficiently accelerate the positive ions and free electrons to prolong the avalanches which produced these particles. Therefore all further ionization ceases and these residual particles are free either to diffuse thermally to the side walls, and similar interior surfaces of the tube where they can be absorbed in recombinations, or to get there by a combination of thermal "ambi-polar" diffusion and the aiding effect of being swept (in opposite directions and at lower than ionizing velocities) by and through these weak fields. Accordingly it may also be necessary at the end of a pulse to terminate the electron

multiplication which is produced by pre-acceleration within the cathode array so that it will not interfere with successful quenching of the tube. To this end an electronic switch 32 may be employed to disconnect the current source 22 from the cathode array during the terminal portion of each generated out-put pulse and the switch 32 may have its input connected to the anode 13 of the tube 10 so that the pulses generated in the detector can be used to actuate it. If preferred the switch may be utilized to reduce the current provided by the source 22, rather than to cut it off entirely, so as to leave reduced sweeping fields within the cathode array which may assist in recovery even though they are too weak to produce or sustain ionization.

In order to provide very flexible control of "pre-acceleration," the output voltage of current source should be adjustable in magnitude, as represented by the arrow associated with the source 22 in Fig. 1, and reversible in polarity, as by actuation of the double pole double throw switch 33 which also appears in this figure.

By reversing the polarity of the source 22 fields will be produced within the cathode array which will oppose the field of the anode rather than to aid it, i. e., which will actually urge and/or accelerate negative particles away from, rather than toward, the anode(s). The possibility of thus operating the detector 10 can be very useful for certain kinds of detection in which, as is well known, it may be advantageous to reduce the efficiency of the detector.

Fig. 5 shows a portion of a multiple-anode type of multiple plate detector. As is known this type of multiple plate detector employs cathode elements, such as the elements 11d of Fig. 5, each of which has a plurality of apertures (12) rather than a single, e. g., central, one, the detector being arranged so that there are as many fine wire anodes passing through the cathode array as the number of apertures in each element. This type of construction is preferably used for detectors which need to be relatively small in length and large in diameter rather than the converse. Thus a thin-walled cylinder 14a comprised in the envelope of this type of multiple plate detector will be like the cylinder 14 of the Fig. 1 embodiment except that it will be of larger diameter, and similar correspondence will exist between the annular spacers 17a of this detector and the spacers 17 of that of Fig. 1.

In this embodiment Y-shaped conductive electrode coatings 34 are applied to the surfaces of each of the cathode elements 11d so that, for reasons which will be readily understood by those familiar with the art, the pre-accelerating fields will be substantially as intense in interelement regions near the center of the cathode array as in interelement regions near its perimeters.

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 detector of penetrative radiation comprising a cathode array including a plurality of wafer-like elements stacked together with their surfaces in spaced-apart and coextensive relationship; an anode insulantly supported within the array to receive therewithin charged particles escaping from a plurality of said elements, terminal means connectable to an external high voltage source for establishing an electric field between said array and said anode; and means responsive upon connection of the array to another source of electrical energy to provide within the array and substantially throughout the spaces between said wafer-like elements electric fields supplementing said first-mentioned field in controlling the movement of negative charged particles along said spaces and toward said anode.

2. A radiation detector comprising a cathode array including a plurality of electrically connected wafer-like cathode elements stacked together with their surfaces in

spaced-apart and co-extensive relationship; an anode insulatingly supported within the array to receive therewithin charged particles escaping from a plurality of said elements, said elements comprising resistive material whereby they are adapted to offer along surfaces thereof which face each other significant conduction and substantial resistance to the flow of electrical current in directions aligned with the anode; and terminals for connecting said elements to a potential source for forcing electrical currents along said surfaces thereof in said directions.

3. A radiation detector comprising a cathode array including a plurality of apertured wafer-like electrically connected cathode elements stacked together with their surfaces in spaced-apart, and co-extensive relationship and their apertures in alignment, an anode supported centrally within a row of said apertures of the array to receive therewithin charged particles escaping from a plurality of said elements, said elements being comprised of resistive material whereby they are adapted to offer along surfaces thereof which face each other significant conduction and substantial resistance to the flow of electrical current in substantially radial directions with respect to the edges of the apertures; and terminals for connecting said elements to a potential source for forcing electrical currents along said surfaces in said directions.

4. A radiation detector comprising a cathode array including a plurality of electrically connected wafer-like cathode elements stacked together with their surfaces in spaced-apart and co-extensive relationship; an anode insulatingly supported within the array to receive therewithin charged particles escaping from a plurality of said elements, each of said elements comprising an insulating core and areas of the cores corresponding to said surface being coated with thin films of resistive material whereby said elements are adapted to offer along surfaces thereof which face each other significant conduction and substantial resistance to the flow of electrical current in directions aligned with the anode; and terminals for connecting said elements to a potential source for forcing electrical currents along said surface thereof in said directions.

5. A detector as in claim 4 in which said insulating core comprises high atomic number particles which may be individually conductive but are electrically isolated by being bound together in an insulating matrix.

6. A radiation detector comprising a cathode array including a plurality of electrically connected wafer-like cathode elements stacked together with their surfaces in spaced-apart and co-extensive relationship; an anode insulatingly supported within the array to receive therebe-

tween charged particles escaping from a plurality of said elements, each of said elements comprising a core which includes a high atomic number element, areas of the cores which correspond to said surfaces being coated with insulating material, the insulating coatings being coated with thin films of resistive material, whereby said elements are adapted to offer along surfaces thereof which face each other significant conduction and substantial resistance to the flow of electrical current in directions aligned with the anode; and terminals for connecting said elements to a potential source for forcing electrical currents along said surfaces thereof in said directions.

7. In a radiation detecting device comprising a plurality of plates disposed in separated relation and connected together electrically to form a cathode member, each plate being provided with at least one hole and the holes in the plates being disposed in alignment, an anode member comprising a wire extending through said aligned holes and insulated from said cathode plates, the improvement wherein said cathode plates are comprised of resistive material and adapted and arranged to have an electric potential applied thereto between separate locations located at different distances from the anode member, whereby an electric field may be developed in the space between the adjacent cathode plates in radial directions with respect to the anode member.

8. A radiation detector of the Geiger counter type comprising a plurality of plates arranged in a substantially parallel bank and connected together electrically to form a cathode, the plates being separated slightly to form spaces therebetween, each of said plates being provided with at least one hole therein, the respective holes being disposed in a line extending transversely through said bank, an anode wire extending through said holes, said plates being comprised of resistive material, and means for applying an electric potential between two locations on said cathode member at different distances from said anode wire, thereby to produce a potential gradient along said member in radial directions with respect to said anode wire.

References Cited in the file of this patent

UNITED STATES PATENTS

2,440,511	Hare	Apr. 27, 1948
2,480,808	Fearon	Aug. 30, 1949
2,499,489	Goldstein et al.	Mar. 7, 1950
2,519,007	Wilson	Aug. 15, 1950
2,606,295	Scherbatskoy	Aug. 5, 1952