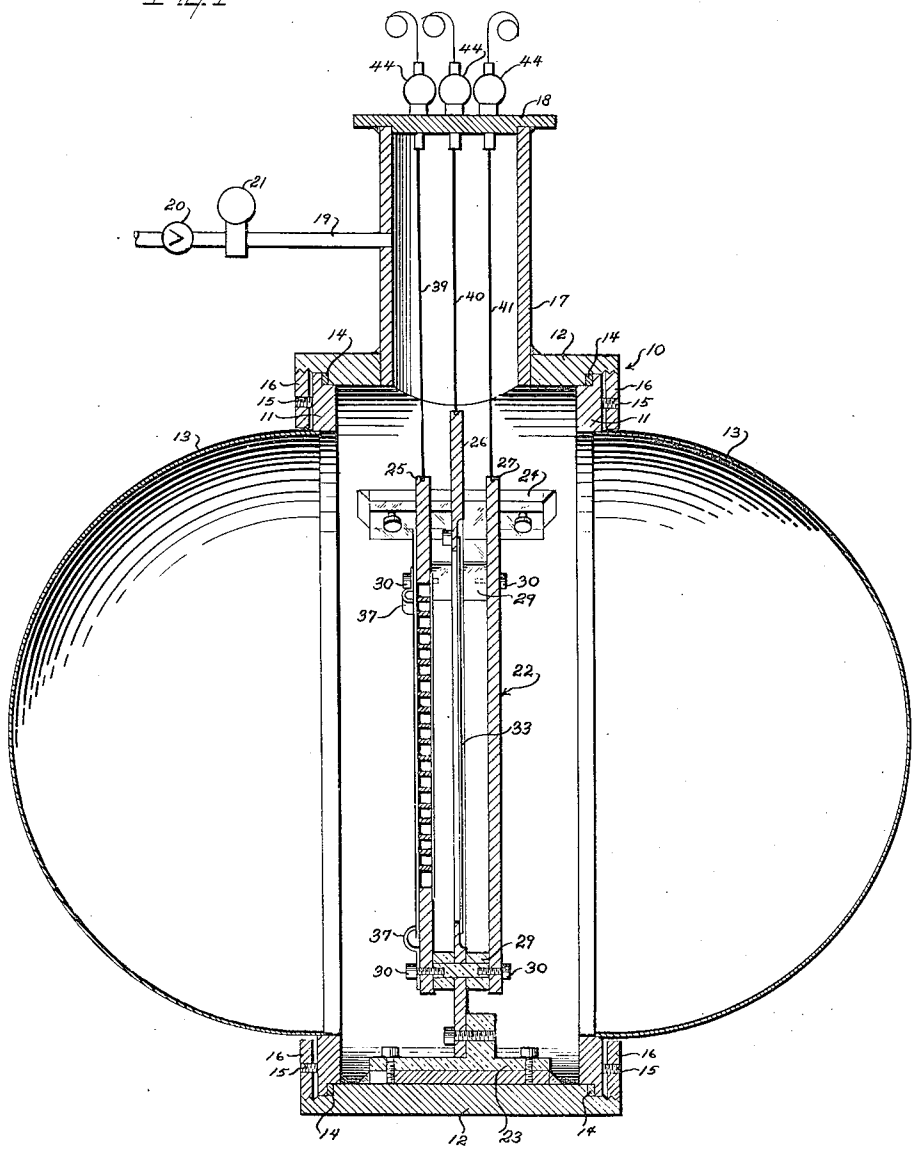
May 2, 1950 E. R. GRAVES 2,506,419

METHOD AND APPARATUS FOR DETECTING IONIZING PARTICLES

Filed May 28, 1945 2 Sheets-Sheet 1

Fig. 1



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2 Sheets-Sheet 2

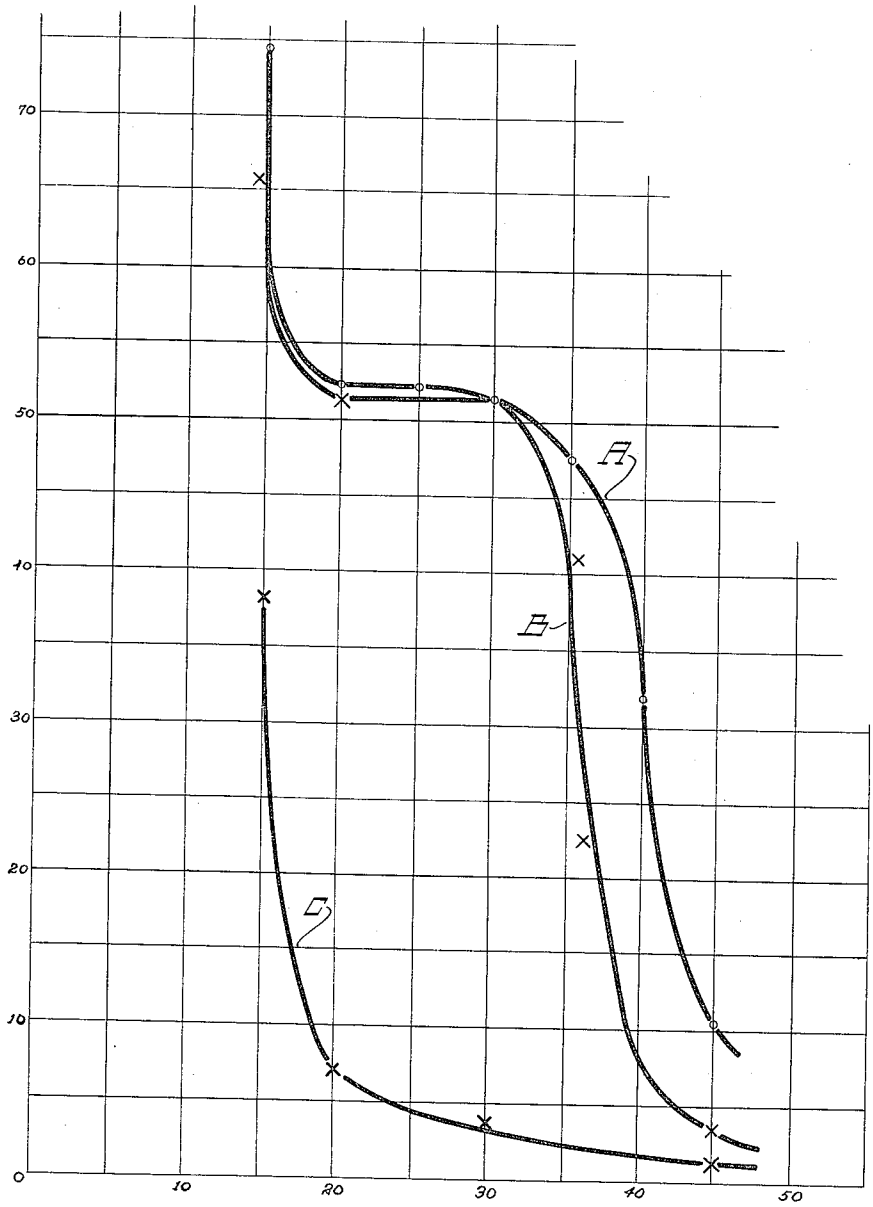


Fig. 2.

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR DETECTING IONIZING PARTICLES

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3 Claims. (Cl. 250—27.5)

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This invention relates generally to a method of detecting ionizing particles of a particular type when accompanied by ionizing particles of a different type, and to apparatus for carrying out said method.

More particularly the invention relates to a method which permits the detection of ionizing particles, such as fission fragments when accompanied by other ionizing particles, such as by large numbers of alpha particles.

While various known devices may be employed for counting fission fragments, such as the conventional ionization chamber and proportional counters, these devices have proved unsatisfactory for the above counting in the presence of large numbers of alpha particles, since while individual fission fragments possess energy of substantially larger magnitude than do individual alpha particles, thereby resulting in more ionization and hence a larger pulse from an ionization device, it is possible that large numbers of alpha particles may add together or pile up in a manner to equal in degree the ionization, hence the resulting pulse, caused by one or more fission fragments. To achieve accurate counting under the above conditions it is necessary to employ a method of counting which discriminates between pulses resulting from ionization caused by fission fragments and pulses resulting from an aggregation of alpha particles.

It is known that when an alpha particle is directed through ionizable material such as through a gas within an ionization chamber, ionization caused thereby is substantially constant over a considerable portion of the range of the alpha particles, but with a substantial increase in ionization near the end of the range followed by a rapid decrease in ionization as the energy of the particle is rapidly expended. It is further known that when a fission fragment is directed through an ionizable material, ionization caused thereby is greatest at the beginning of the range, declining rapidly thereafter. Conversely the method may be employed for detecting ionizing particles of the type which produce increasing ionization throughout a portion of their range.

In the present method of counting, the above principles are employed in a manner to permit cancellation of the effects of substantially uniform ionization such as may be caused by alpha particles over preselected portions of their paths and to permit recording of non-uniform ionization caused by ionizing particles, such as fission fragments.

A still further object of the invention resides in

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the provision of apparatus for carrying out the above method, said apparatus comprising an ionization chamber adapted to discriminate between ionization between fixed points resulting from nuclear particles of the type which cause substantially uniform ionization when directed through an ionizable medium and nuclear particles of the type which cause non-uniform ionization when directed through the ionizable medium.

In the drawings, in which like parts are identified by the same reference numeral:

Figure 1 illustrates in vertical section an apparatus incorporating the present invention.

Figure 2 is a graph comparatively illustrating the pulse counting rate resulting from alpha particle ionization between individual electrode pairs and the pulse counting rate resulting from balancing the pulses initiated by substantially uniform ionization appearing between one electrode pair, against pulses of opposite polarity initiated in like manner appearing between the opposite pair of electrodes.

Referring to Figure 1, a device which is particularly adapted for carrying out the above method is illustrated in vertical axial section. The device includes generally a drum shaped body portion 10 including a pair of annular members 11, which may be of brass, maintained in clamped engagement with a cylindrical housing 12, also of brass, to provide a main frame or support for the device. A pair of hemispheres 13, preferably of aluminum, have marginal portions in pressed fit engagement with the inner walls of members 11, the hemispheres being marginally soldered to members 11 to provide a positive fluid seal therebetween and the required structural strength to withstand varying conditions of pressure. Annular gaskets 14 are disposed between complementarily flanged portions of cylinder 12 and members 11 to insure fluid sealing relation therebetween, gaskets 14 being maintained under clamping pressure of members 11 in respect to cylinder 12 by means of a plurality of screws 15 in pressure engagement with members 11, screws 15 being equally spaced circumferentially of ring 16 in threaded engagement therewith, ring 16 being threaded to cylinder 12. Cylinder 12 has its upper wall portion suitably apertured to receive cylinder 17, the lower open end of which leads into central portion 10 of the device, the opposite end of cylinder 17 being closed by a suitable end plate 18, cylinder 17 being suitably sealed, such as by soldering, to both cylinder 12 and end plate 18. Fluid communication is established between the interior and the exterior of the device through

gas conduit 19, a suitable control valve 20 and gas pressure gage 21, being associated therewith.

A multiple electrode assembly, generally designated 22, is vertically disposed within central portion 10, assembly 22 being rigidly maintained therein by suitable insulating mountings 23 and 24, disposed adjacent the lower and upper ends, respectively, of the assembly 22, said mountings being maintained in clamped engagement with the inner wall of cylinder 12 in a suitable manner. Assembly 22 includes three rigid circular plates 25, 26, and 27, preferably of brass, plate 26 being provided with a centrally disposed circular aperture with reduced margin, as shown, plate 27 being unapertured except as required for mounting, and plate 25 being provided with a plurality of closely spaced bores to provide a collimator, the bored portion of plate 25 defining a concentrically disposed circular area in plate 25, the diameter of which is less than the diameter of circular aperture of plate 26, the relative dimensions being such that any fragment or particle emitted through the collimator will be confined to the area of foil 33 to insure accuracy of counting. Plates 25 and 27 are disposed on opposite sides of plate 26 and are maintained equidistant from plate 26 and in parallel spaced relation therewith by means of insulating spacers 29 and suitable clamping studs 30. Plate 26 finds its support on mountings 23 and 24, plates 25 and 27 being mounted to plate 26 by means of above mentioned spacers 29.

The central aperture of plate 26 is completely closed by a sheet of thin aluminum foil 33 the margin of which overlaps the margin of plate 26 adjacent the aperture thereof, the foil being suitably bonded to plate 26, as by soldering, to maintain foil 33 rigid. A sheet of thin foil 35, preferably of aluminum, is suitably bonded to the inner wall of plate 25, contiguous therewith and completely covering and marginally overlapping the collimator portion thereof. The outer wall of plate 25 is provided with a suitable sample sheet 36 which may be of metal foil or other suitable material upon which samples of material to be tested have been thinly deposited. Sheet 36 may be maintained in detachable clamped engagement with plate 25 by means of a plurality of circumferentially spaced clamps 37. Plates 25, 26, and 27 which are electrically insulated from their supporting structures as well as from each other in the manner above described, function as electrodes during operation of the device. Suitable electrical conductors 39, 40, and 41 lead from upper portions of plates 25, 26, and 27, respectively, through end plate 18 which is suitably apertured to receive a corresponding number of electrical insulators 44 in fluid sealing relation to plate 18.

Operation of the device is as follows. Assuming sheet 36, having samples of material to be tested, for example, protoactinium, deposited thereon, has been attached to plate 25 as shown, ring 16, member 11, and hemisphere 13 illustrated on the left hand side of the view shown in Figure 1 having been removed during installation of sample sheet 36 and subsequently replaced, the device is in readiness for the introduction of a suitable inert gas. Conduit 19 is connected with a suitable evacuation device and, with valve 20 open, atmospheric air is evacuated from the device, valve 20 being closed and conduit 19 being connected to a source of argon, or other suitable inert gas under pressure, which is then introduced into the device until pressure gage 21 reads, for example, fifteen pounds with valve 20 closed, which pressure has been found satisfactory when using argon. Suitable electronic recording apparatus, which forms no direct part of this invention and is therefore not illustrated, is connected to record pulses appearing between electrodes 25 and 26, considered as one pair of electrodes, and between electrodes 27 and 26 considered as a second pair of electrodes, said pulses arising as the result of ionization between the electrode pairs later described.

With sample material, disposed on sheet 36, of a type which produces fission upon being bombarded by neutrons, the device shown in Figure 1 is placed in proximity to a neutron source, not shown, such a source being placed on the left hand side of the device, as shown in Figure 1, to permit the neutrons to penetrate the left hand aluminum hemisphere 13 and continue therethrough with sufficient energy to cause fission upon bombardment of the material on sheet 36. Hemisphere 13 is preferably of a material of low atomic number, such as aluminum, to permit neutron penetration therethrough with permissible energy losses, i. e. the unexpended energy of a substantial number of the neutrons transmitted therethrough must be sufficient to cause fission of the material to be tested upon capture thereby. The purpose of providing hemispherical side walls or windows 13 rather than employing planiform walls is to permit the use of a relatively thin material without danger of wall collapse due to pressure differential between the exterior and interior of the device. The device is not limited in use to sample material fissionable only upon bombardment by neutrons, since spontaneously fissionable sample may also be used.

It is known that when a suitable material fissions as the result of neutron bombardment, or spontaneously two particles of lesser weight than the original "exploded" atom are emitted, that the emitted particles travel in opposite directions, i. e. in 180 degrees angularity. Assume, for example, that fission occurs in a sample portion disposed on sheet 36 substantially axially of one of the collimating bores and assume further that fission occurs in such a manner that the two resulting particles travel in linear paths substantially parallel to the axis of cylinder 12 and at right angles to the plane of electrodes 25, 26, and 27. The fragment traveling outwardly from plate 36 will obviously expend itself within the gas contained in the device without producing any pulse in electronic apparatus associated therewith due to its resulting ionization. The inwardly directed fragment will travel, at high energies, through the adjacent collimating bore of plate 25, through foil 35, through the space between electrodes 25 and 26, through aluminum foil 33, and through the space intermediate electrodes 26 and 27, arriving at electrode 27, the thickness of which serves to absorb the particle energy and terminate its path. During the above described path the fragment energy is sufficiently high to be virtually uneffected, as to its rate of travel, by either the negative polarity at which electrode 25 is maintained or by the positive polarity at which electrode 27 is maintained.

As stated above, ionization throughout the above described path may either progressingly decrease or increase, and since assembly 22 is completely submersed in a uniform ionizable medium, it follows that the ionization resulting from the fragment or particle traversing the dis-

tance between foil 35 and foil 33 will therefore be substantially greater or less than the ionization caused by the same fragment or particle traversing the distance from foil 33 to the inner wall of electrode 27. Considering only ionization resulting from the one fragment or particle above described, the resulting pulse between electrodes 25 and 26 due to ionization of the medium between foil 35 and foil 33 will be of either greater or lesser magnitude than the pulse between electrodes 26 and 27 due to ionization of the medium between foil 33 and electrode 27. Fragments or particles emitted at other angles within the restrictions imposed by the collimator bores act in the above described manner.

For simplification of description rather than limitation, assume that the device is to be used for detecting fission fragments, which cause decreasing ionization through the ionizable medium. Fission fragments are however normally accompanied by large numbers of alpha particles and while such particles are continuously emitted at random, it is obvious that many such particles accompanying the above described fission might traverse the collimator bore above described and define paths similar to the fission fragment path or in angular relation thereto, limited only by the physical dimensions of the collimator bore. Individually alpha particles produce only small amounts of ionization, but added together, or piled up, they may produce a pulse approaching in magnitude the pulse resulting from the fission fragment, were it not for the fact that the present invention provides effective means for balancing out the effect of ionization caused thereby in the following manner.

A large number of alpha particles may be emitted simultaneously with the above described fission, radiating in all permissible directions through the collimator bore above considered, and traversing the distance between the electrodes 25 and 27, passing through aluminum foil 33 without appreciable energy loss. Electrodes 25 and 26, are of such material, and electrodes 25, 26, and 27 are so spaced, with regard to the characteristics of the ionizable medium employed in the device, to insure passage of the alpha particles through foil 33 of electrode 26, arriving at electrode 27 while the alpha particles are still travelling within the substantially uniform portion of the alpha particle ionization curve. It is important that the alpha particles arrive at electrode 27 before the particles approach the terminating portion of their paths, which is characterized by rapidly increasing ionization followed by rapid decay. The function of the collimated portion of the electrode 25 is therefore to confine the angularity of such emission within limits of path lengths to insure substantially uniform ionization between electrodes 39 and 40, and between electrodes 40 and 41, as well as to limit the angularity of fission fragment paths intermediate the electrodes.

With the design of the device within the limits above described, ionization caused by varying numbers of alpha particles traversing the space intermediate electrodes 25 and 27 will produce like pulses between electrodes 40 and 41, it being well within the electronic art to balance out these pulses while recording the difference in magnitude between the pulses initiated between said pairs of electrodes as the result of ionization therebetween caused by fission fragments. It will be noted that ionization occurring within

the collimator bores of electrode 25 does not contribute to the total ionization occurring between electrodes 25 and 26 and the pulse caused thereby, due to foil 35 shielding those areas from the inter-electrode space.

Figure 2 shows in graph form three curves obtained by connecting the above described apparatus to associated electronic equipment in the following manner. Pulse recording apparatus was first connected between electrodes 25 and 26 to obtain curve A, which shows pulse counts per minute due to alpha particles only as a function of bias potential applied to the associated apparatus. Curve B was obtained by connecting electrodes 26 and 27 in the above described manner. Curve C was obtained by connecting electrodes 26, 27, and 28 to electronic equipment in the manner described herein to balance out the effects of alpha particle ionization. Curve C may therefore be considered a noise level or background count curve, it being evident that the method comprising the invention results in marked lowering of background due to alpha particles. This results in substantially improved discrimination between pulses due to fission fragments and those due to quantities of alpha particles, permitting the associated apparatus to be operated in a more sensitive condition, i. e., at lower bias potential, Figure 2.

Both the above described method and apparatus have equal utility in the detection of a particle or fragment which produces unequal ionization along its path when directed through a suitable medium when said particle or fragment is accompanied by one or more particles or fragments which also produce unequal ionization along the paths thereof in said medium, discrimination therebetween being obtained by known methods of discriminating between the resulting inter-electrode pulses.

What is claimed is:

1. A device of the character described having in sub-combination, an electrode assembly comprising three inherently rigid generally planiform elements in mutual parallel spaced relation to provide a pair of outer electrodes and an electrode disposed centrally thereof, said centrally disposed electrode being provided with an area of reduced thickness to permit passage of ionizing particles therethrough while providing an effective ion shield, one of said outer electrodes being provided with a collimated portion of sufficiently smaller area than the reduced thickness area of said centrally disposed electrode to confine particles emitted therethrough to said reduced thickness area, the inner surface of said collimator area being provided with a thin sheet of material adapted to pass ionizing particles while providing an ion shield, and means associating with said collimated electrode for the mounting of an ionizing particle emitter contiguous to the outer surface thereof.

2. A device for selecting and measuring ionizing fission fragments in the presence of other types of ionizing particles comprising a hermetic housing of non-shielding material, means for supporting a first, second and third electrically conducting planar electrode in parallel relation in the housing, said first electrode and third electrode being insulatingly supported at equal distances on opposed sides of the second electrode, said first electrode being foraminated with a plurality of apertures aligned normal to the lateral faces of the electrodes, a planar sheet of ion shielding material secured to the first electrode inner planar face; said second electrode having a thickness

adapted to pass ionizing particles and provide an ion barrier; and said third electrode being a rigid conducting member.

3. An apparatus for sorting the ionization characteristics of ionizing particles of the type which produce non-uniform ionization in traversing an ionizable medium from ionizing particles of the type which produce substantially uniform ionization in traversing said ionizable medium comprising a hermetic housing of ionizable particle penetrating material, a first, second and a third electrode, each of the electrodes being planar, means for insulatingly supporting the electrodes in parallel relationship with the first and third electrode equidistant on opposed sides of the second electrode, said first electrode being provided with a plurality of apertures aligned normal to the planar surfaces thereof, an ionizable particle penetrating electrical conducting

sheet affixed to the inner surface of the first electrode, said second electrode comprising a supporting frame of conducting material and an ionizable particle penetrating electrical conducting sheet affixed to the frame, and said third electrode being a sheet of electrical conducting material, and an electrical terminal for each of said electrodes insulatingly supported in said housing.

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