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IONIZATION CHAMBERS, GEIGER-MULLER TUBES, AND THE LIKE

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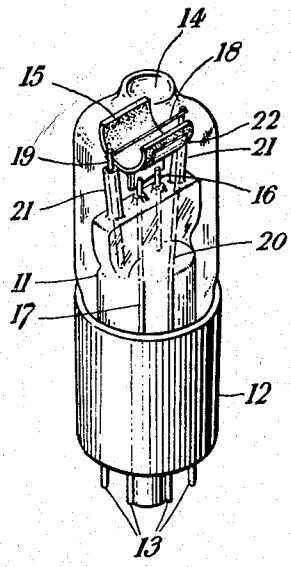


Fig. 1.

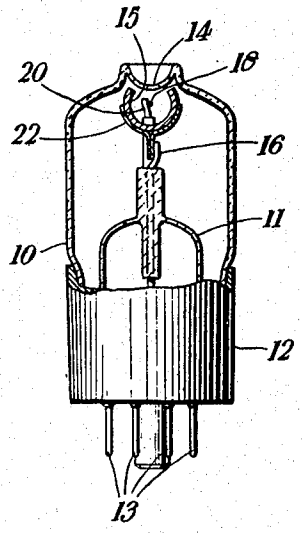


Fig. 2.

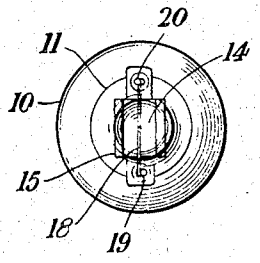


Fig. 3.

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IONIZATION CHAMBERS, GEIGER-MÜLLER TUBES, AND THE LIKE

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Application March 19, 1946, Serial No. 655,461
In Great Britain April 12, 1945

1 Claim. (Cl. 250—27.5)

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In the conventional form of Geiger-Müller or G-M tube the tubular cathode is long, its length being at least five times its diameter. This long form of G-M tube has been adopted with a view to providing as large an area of cathode as possible for the reception of cosmic radiation, or of radiation from radioactive materials, for the detection and measurement of which forms of radiation the G-M tube is usually employed. No really satisfactory method has so far been found of mounting the cathode in the glass vessel constituting the outer envelope of the tube in such a way that it will remain truly coaxial with the central wire anode. It is important that it should so remain as otherwise there is a tendency for a flashover to take place between the anode and the nearest point of the cathode.

One method of supporting the cathode is by forming inwardly projecting dimples or circumferential beadings on the glass envelope. These parts of the glass tend however to fracture, due to the different coefficients of expansion of the metal cathode and the glass, when the tube is subjected to high temperature baking during evacuation on the pump. Another method is to support the ends of the cathode by metal wires which are sealed into the glass. The wires are, however, liable to pull out or the glass seals to break during the baking process, with the result that the cathode becomes loose and is easily displaced by vibration. Spring supports for the cathode are unsatisfactory, because not only are the springs, being under compression, liable to fatigue but it is in any case difficult to ensure with that method that the cathode will be supported even initially in the proper position.

Our object is to provide an ionisation counter tube for use as a counter for detecting and estimating the intensity of radiation, e. g. X-rays or gamma rays, or of corpuscular energy in the form of charged particles such as alpha particles. Apart altogether from the difficulties of effectively supporting the electrodes, the conventional form of G-M tube above referred to is not very satisfactory for these purposes due to the correction which has to be made in use of the tube for the "local count" due to cosmic radiation and extraneous local radiation.

Our invention is based on the appreciation of the fact that, where the tube is to detect and measure a relatively concentrated beam of radiation or stream of particles, a long cathode is wholly unnecessary since only that portion of the cathode on which the radiation impinges is effective to generate electrons. We therefore pro-

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ceed on the basis that the cathode should be made as small as possible. This greatly facilitates use of the apparatus for the intended purposes, since it renders local counts, due to the shortening of the cathode, generally so insignificant in comparison with the effect undergoing measurement, that they can be ignored. Also the difficulties of supporting the electrodes disappear. The counter tube moreover is, since radio valve practice in the assembly of its components can be adopted, susceptible of manufacture on a commercial basis as distinct from being as hitherto a mere laboratory instrument.

In United States application Serial No. 655,460, filed March 19, 1946, now abandoned, we have described an ionisation counter tube in which these disadvantages are overcome, and the tube rendered susceptible of mass production by employing a short cathode (i. e. a cathode whose length does not substantially exceed its diameter) and supporting the cathode and anode on a press within the tube in the same fashion as the electrodes are supported in a radio valve. In the preferred construction described in United States application Serial No. 655,460, filed March 19, 1946, the envelope has a thin window through which the radiation or particles to be measured may pass into the tube, and the cylindrical cathode has an aperture opposite the window.

It will be appreciated that in the case of X-ray spectrum analysis the only effective portion of the cathode is that on which the beam of X-rays impinges, and the same is true in case of detection and estimation of β and α particles. While a cathode in the form of a complete cylinder with an aperture opposite the window in the envelope is quite satisfactory, the remainder of the cathode structure in this case (i. e. the part which does not receive the radiation) only serves the function of maintaining coaxiality of the cathode and anode. In the tube according to the invention the cathode consists only of a part-cylindrical portion disposed coaxially with the anode at the side thereof remote from the envelope and of size sufficient to receive the incident X-ray line or spot. Preferably, as in the case of United States application Serial No. 655,460, filed March 19, 1946, the envelope has a thin window for admission of radiation or particles to its interior.

The ionisation counter tube according to the invention therefore comprises, in its preferred form, an outer envelope, containing an inert gas, a thin window in the envelope for admitting radiation to the interior thereof, a press sealed into the envelope, a short part cylindrical cathode

supported by wires on the press with its concave surface facing the window, said cathode having a lead wire extending through the press to the exterior of the tube, and an anode also supported by wires on the press and also having a lead wire extending through the press to the exterior of the tube, the anode being disposed coaxially within the cathode between the same and the window.

This arrangement has the advantages of a very greatly reduced tendency to collect cosmic radiation, an enormous reduction in area of surface of the cathode which, however carefully prepared, may be contaminated with radioactive material, and of greater ease of mounting of the electrodes on the press. Unwanted photo-electric effects are diminished, it is easier to ensure physically and chemically uniform surfaces over the smaller area of the cathode, and, by elimination of the inoperative portion of the cylindrical cathode, it is possible to reduce the distance between the wall of the envelope (or the window when provided) and the cathode and therefore the distance of the cathode from the crystal, powder or other surface under examination. This is of great importance in X-ray spectrometry where lines or spots of weak intensity are to be measured.

The window in the tube may be so disposed in relation to the anode that the incident radiation does not impinge directly on the anode. The window is preferably of glass of approximately soap bubble thickness sealed in position in the envelope as described in United States application Serial No. 494,576 filed July 13, 1943, now abandoned.

While we have referred above to the special advantages of using a tube with a part-cylindrical cathode for purposes of X-ray spectrometry, the tube according to the invention is nevertheless useful for detecting and measuring X-rays under other conditions, and for detecting and measuring the effects of gamma rays, or of charged particles. In all cases the reduced size of the cathode and the possibility of reducing the distance between the impinged portion of the cathode and the window contribute to the successful operation of the tube.

The cathode is preferably substantially a half-cylinder.

The action of a counter tube is believed to be as follows: A slight ionisation produced by the entrance of a particle of photon initiates an avalanche process of cumulative ionisation and therefore large internal amplification, which is further increased, where the cathode is suitably prepared, by the ejection of particles from the cathode. In this process a large number of ultra violet photons are emitted from the excited gas atoms and tend to produce photo-electrons from the cathode. Some of these photo-electrons attach themselves to the gas molecules and form low mobility negative ions which, in turn, release their electrons under the influence of the high potential of the anode. New discharge centres are thus formed and the process is liable either to increase the inactive time of the counter (i. e. the time during which it is insensitive to ionizing particles) and so reduce its efficiency, or to produce multiple discharges instead of single discharges and so lead to spurious counts.

It is therefore preferred to employ a cathode having substantially no photo-electric emission in the neighbourhood of the visible portion of the spectrum. While a cathode made of a suitable metal, such as copper, will emit electrons in response to photons of X-ray wavelength, it is desirable, in accordance with normal practice in counter tubes, for the inner surface of the cathode to be of such a nature as to be responsive to low energy photons of X-ray wavelength, while at the same time having little tendency to emit electrons in response to photons of visible or ultra violet wavelengths. As is well known, this may be achieved by suitable selection of the material of the cathode and/or, in the case of a metal cathode, by the formation thereon of a surface film, e. g. of hydride or oxide, which stops the passage of any photo-electrons liberated from the metal or whose photo-electric threshold is at a much higher frequency than that of the ultra-violet photons produced in the ionisation process. This sensitisation is quite different from that employed in photo-electric cells which are required to respond to photons of wavelength of the order of 2500–9500 A. U., whereas counter tubes are required to respond to photons of X-ray wavelength, i. e. not exceeding say 10 A. U.

The gas filling consists basically of an inert gas, such as argon, which desirably contains a proportion—say 10%—of dry air, or other suitable polyatomic vapour, e. g. alcohol or acetone, which will cause recombination of ions and speedy extinction of the tube. The gas pressure will normally be relatively high, i. e. at least about three centimetres of mercury.

One specific form of counter tube constructed in accordance with the invention will now be described in detail, by way of example, with reference to the accompanying drawing, in which:

Fig. 1 is a perspective view of the tube,

Fig. 2 is a vertical section through the tube, and

Fig. 3 is a top plan view.

The tube comprises a glass envelope 10, into which is sealed a glass press 11, the envelope and tube being mounted in a standard radio valve base 12 of insulating material carrying the usual pins 13. The fact that the tube is mounted on a standard base is of considerable practical advantage as, when a defective tube is to be replaced, the new tube can be fitted with ease into the cooperating standard socket component in the detection apparatus of which the tube forms a part.

In the envelope 10 is a thin glass window 14, sealed by fusing the glass of the window to the boundaries of the aperture in the envelope. The window is preferably of approximately soap bubble thickness.

On the press are supported the two electrodes. The part-cylindrical cathode 15, which is made of copper having an internal surface film of oxide or hydride to reduce its tendency to emit electrons in response to photons of near visible wavelength while nevertheless enabling it to emit electrons in response to photons of X-ray wavelength, is supported, with its concave inner surface facing the window 14, by a pair of wires 16, 17. These wires, together with the wires 19, 20 supporting the anode, are of a metal or alloy of substantially the same coefficient of expansion as the glass of the press, e. g. tungsten in the case of hard glass. The wire 17 is led out through the press to one of the pins 13. A tungsten wire anode 18 is supported coaxially with the cathode by a pair of wires 19, 20, one of which 20 is led out through the press to another of the pins 13. The upper parts of the wires 19, 20 are enclosed in tubular upward extensions 21 of the press, and these wires are spot welded to the ends of the anode 18 and support the same coaxially within the cathode 15. The wires 16, 17, are spot welded at their upper

ends to a nickel or molybdenum contact strip 22 which embraces and is spot welded to the lower part of the cathode.

The internal diameter of the extensions 21 are greater than that of the wires 19, 20 so that an air space is left around the wires, thus increasing the leakage path between the wires and the cathode 15, and reducing to a minimum any tendency to a short between either wire and the cathode.

As will be observed the cathode 15 is substantially half cylindrical, which enables the anode 18 to be brought closer to the window 14 than would be possible were the cathode a complete cylinder with an aperture opposite the window. As shown, the distance between the anode 18 and the window 14 is less than the radius of the cathode 15.

The electrodes are assembled on the press prior to introduction thereof into the envelope. The press is then sealed into the envelope and the latter is evacuated, given the required filling of inert gas, sealed off and mounted in the base all in accordance with standard practice. It should, however, be mentioned that the electrodes are, prior to mounting of the press within the envelope, treated to free them so far as possible from contamination by radioactive material. The inert gas is preferably a mixture of argon and about 10% of dry air and its pressure, in a typical example, will be from 3 to 9 centimetres of mercury according to the tube characteristics desired.

What we claim as our invention and desire to secure by Letters Patent is:

An ionisation counter tube, for use in estimating and detecting alpha and beta particles and gamma radiation, comprising a single ionisation chamber having an outer envelope and containing a filling of inert gas, a press sealed into the envelope, and two electrodes only mounted on the press, said electrodes being a cathode in the form of a segment of a cylinder disposed with its concave surface facing a wall of the envelope and an anode coaxial with said cathode and said cathode being substantially insensitive to photons of wavelength adjacent the visible portion of the spectrum.

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