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ELECTRON MULTIPLYING DEVICES AND CIRCUIT ARRANGEMENTS THEREFOR
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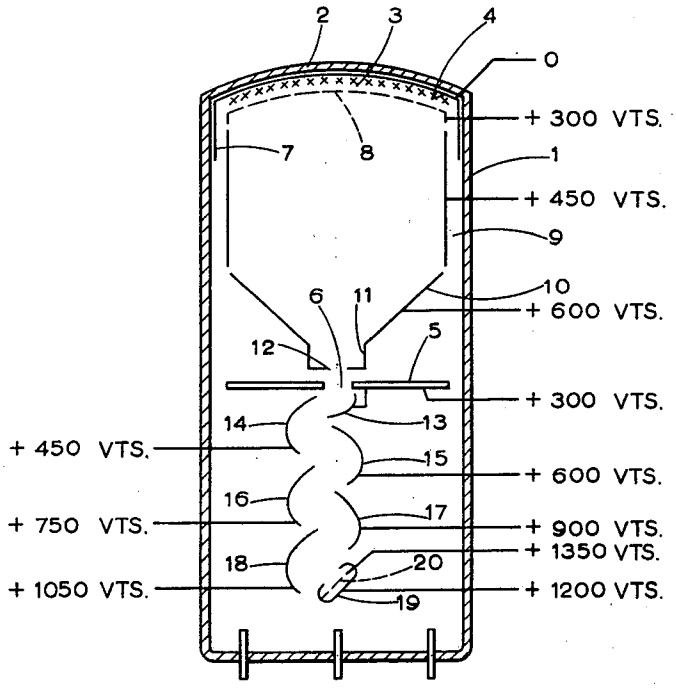


FIG. 1

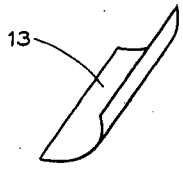


FIG. 2

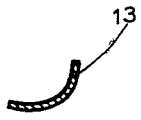


FIG. 3

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ELECTRON MULTIPLYING DEVICES AND CIRCUIT ARRANGEMENTS THEREFOR

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This invention relates to electron multiplying devices and circuit arrangements therefor.

In a photo-electric multiplier a radiation sensitive cathode is provided and electrons emitted from said cathode are caused to pass to a first multiplying electrode or dynode which emits secondary electrons which are caused to pass to a collector or to further dynodes prior to reaching the collector. In high speed multipliers such as are used for scintillation counting it is necessary for the electrons emitted from the cathode to be focussed into the first dynode structure with as little transit time spread as possible.

It is an object of the present invention to provide an improved circuit arrangement for an electron multiplying device with a view to achieving this desideratum.

According to one feature of the invention there is provided an electric circuit arrangement including an electron multiplying device comprising a radiation sensitive electron-emissive cathode on the inner surface of a domed support, electron focussing means including a foraminated electrode substantially co-extensive with said cathode and arranged to face said cathode at a substantially uniform distance therefrom, a dynode for receiving electrons emitted by said cathode, and means for applying potentials to the cathode and to said focussing means and said dynode such that the foraminated electrode has a potential which is positive with respect to the potential of said cathode to set up a substantially uniform radial electrostatic field between said cathode and said electrode, said dynode being located near the region of convergence of said radial field and the transit times to the dynode of electrons proceeding radially from said cathode are substantially equal.

Another object of the invention is to provide an improved electron multiplying device in which the transit times of electrons from the cathode to the first dynode are substantially equal.

According to another feature of the invention there is provided an electron multiplying device comprising a radiation sensitive electron-emissive cathode on the inner surface of a domed support, electron focussing means including a foraminated electrode substantially co-extensive with said cathode and arranged to face said cathode at a substantially uniform distance therefrom so that the electrons can be caused to leave said cathode in substantially radial directions by the application of a suitable positive potential to the electrode relative to said cathode, and a dynode located near the region of convergence of the radii from said cathode, said device being such that with the aforesaid potential applied to said electrode the transit times to the dynode of electrons proceeding radially from said cathode are substantially equal.

In order that the present invention may be clearly understood and readily carried into effect, the same will now be more fully described with reference to the accompanying drawings, in which:

FIGURE 1 illustrates diagrammatically one embodiment of the invention as applied to a radiation sensitive electron multiplier,

FIGURE 2 is a perspective view of the first dynode of the multiplier shown in FIGURE 1, and

FIGURE 3 is a cross-section of the dynode shown in FIGURE 2.

As shown in the drawings the reference numeral 1 indicates an evacuated glass envelope the end wall 2 of which is domed and in the particular example shown it is formed as a part of a sphere. The interior surface of the window 2 is provided with a radiation sensitive electron emissive cathode indicated at 3. The sensitive cathode may be formed of any suitable radiation sensitive materials such as antimony sensitised with caesium or antimony sensitised with a plurality of different alkali metals such as sodium, potassium and caesium, this cathode being deposited on a transparent conducting coating 4, for example, a Nesa layer. In some cases the coating 4 may be omitted. The envelope 1 is generally of cylindrical form and spaced from the cathode and facing the concave surface thereof is a circular electrode 5 having a central aperture 6 which is disposed with its centre substantially on the centre axis of the cathode 3. Between the cathode 3 and the apertured electrode 5 is a tubular electrode 7 which may be formed as an aluminium coating on the interior wall of the envelope, and said electrode 7 may be in electrical contact with the transparent conducting layer 4 or otherwise maintained at the potential of the cathode 3. Adjacent the electron cathode 3 is a foraminated electrode 8 having an imperforate cylindrical rim, the electrode 8 having substantially the same curvature as the cathode 3 so that it is substantially co-extensive therewith, said electrode 8 being followed by a cylindrical electrode 9 and by a conical electrode 10 provided with a tubular extension 11 at the apex the transverse end wall of the extension 11 having an aperture 12 therein. The foraminated electrode 8 may be of the honeycomb hexagonal type such as are employed in some types of klystron valves with the bars thereof defining the apertures radially disposed with respect to the cathode. The radial thickness of the grid may be 0.1" and may have an optical transparency of 90 percent or more. Thus the electrode 8 may have about 1096 apertures per square inch. The various electrodes so far described constitute when suitable potentials are applied thereto an electrostatic focussing system which causes electrons from the cathode 3 to pass through the apertures 12 and 6 and to be brought to a focus just beyond the electrode 5. The electrode 8 serves when suitable potentials are applied thereto and to the various other electrodes to set up a strong substantially radial field between the cathode 3 and electrode 8, and causes electrons emitted from the cathode to proceed substantially radially towards the dynode 13 and come to a sharp focus a little way beyond the centre of curvature of the cathode. The electrode 8 thus ensures that the path lengths of the electrons emitted from the cathode 3 are substantially equal and thereby affords a reduction of transit time spread of the electrons. In the embodiment shown the electrons are brought to a focus on the axis of the device and near to a first dynode 13 which is situated on the side of the electrode 5 remote from the cathode 3. The dynode 13 is followed by further dynodes 14, 15, 16, 17 and 18, there being a final dynode 19 having in front thereof a grid 20 which constitutes the collecting electrode of the multiplier. With the construction described a reduced image of the electrons released from the cathode 3 is formed on the dynode 13, the focus being in front of the latter electrode. The first dynode 13 is shown in detail in FIGURES 2 and 3, and as will be observed the dynode is formed from a strip of metal bent to an arcuate shape. The subsequent dynodes are shaped as shown and are likewise formed from a strip of metal bent as indicated. These dynodes will of course be formed so as to be capable of secondary electron emission and are known in the art.

In one particular embodiment of the invention the internal diameter of the envelope 1 may be 2½" and the radius of curvature of the cathode 3 may be 3¼". The radius of curvature of the foraminated electrode 8 may be 3" and both of the electrodes may have the same centre of curvature. The axial length of the foraminated electrode 8 together with its imperforate rim may be ⅜" and the rim may be spaced apart from the electrode 9 by a distance of ⅛". The latter electrode may be 2" in diameter and 1¾" long. The electrode 9 may be spaced from the conical electrode 10 by ⅛" and the conical portion of this electrode 10 may be ¾" long and its tubular extension 11, ½" in diameter and ¼" long, and the aperture 12 may be ¼" in diameter and spaced from the electrode by ¼". In operation of the construction described the electrode 7 and the conducting coating on which the cathode 3 is formed may be maintained at zero volts, the foraminated electrode 8 at a positive potential of 300 volts, the electrode 9 at a positive potential of 450 volts, the electrode 10 at a positive potential of 600 volts and the electrode 5 at a positive potential of 300 volts. The first dynode 13 may be electrically connected to this electrode 5 so that it is maintained at the same potential as the latter or connected to a separate source of supply so that its potential differs from that of the electrode 5 by a few volts, whilst the dynode 14 may be maintained at a positive potential of 450 volts and the subsequent dynodes and collector 20 at increasing potentials as is known in the art.

Although the dynodes are illustrated as being of particular known type it will be appreciated that other shapes of dynodes may be used. The invention is of course not limited to the use of the particular potentials referred to and it should be mentioned that any other suitable potentials may be used, although it should be pointed out that the foraminated electrode 8 should not be operated at a potential more negative than the electrode which receives the emission from the cathode, i.e., the electrode 13, owing to the liability of emission from the foraminated electrode 8. Furthermore other electrode arrangements may be employed instead of the electrodes 9 and 10 and in certain arrangements these latter electrodes may be omitted.

What we claim is:

1. An electric circuit arrangement including an electron multiplying device comprising a radiation sensitive electron-emissive cathode on the inner surface of a domed support, electron focussing means including a foraminated electrode substantially co-extensive with said cathode and arranged to face said cathode at a substantially uniform distance therefrom, a dynode for receiving electrons emitted by said cathode, and means for applying potentials to the cathode, to said focussing means and said dynode such that the foraminated electrode has a potential which is positive with respect to the potential of said cathode to set up a substantially uniform radial electrostatic field between said cathode and said electrode, said dynode being located near the region of convergence of said radial field and the transit times to the dynode of electrons proceeding radially from said cathode being substantially equal.

2. An electron multiplying device comprising a radiation sensitive electron-emissive cathode on the inner surface of a domed support, electron focussing means including a foraminated electrode substantially co-extensive with said cathode and arranged to face said cathode at a substantially uniform distance therefrom so that the electrons can be caused to leave said cathode in substantially radial directions by the application of a suitable positive potential to the electrode relative to said cathode, and a dynode located near the region of convergence of the radii from said cathode, said device being such that with the aforesaid potential applied to said electrode the transit times to the dynode of electrons proceeding radially from said cathode are substantially equal.

3. An electric circuit arrangement according to claim 1, wherein the cathode and the foraminated member are each formed as a part of a sphere.

4. An electric circuit arrangement according to claim 1, wherein a surface of the dynode electrode is disposed in proximity to the centre axis of said dome shaped cathode.

5. An electric circuit arrangement according to claim 1, wherein said foraminated electrode has an imperforate cylindrical rim extending in a direction away from said cathode.

6. An electric circuit arrangement according to claim 7, wherein said foraminated member has a radial thickness of at least 0.1 of an inch.

7. An electron multiplying device comprising a radiation sensitive electron emissive cathode on the inner surface of a support formed as part of a sphere, electron focussing means including a foraminated electrode substantially co-extensive with said cathode and arranged to face said cathode at a substantially uniform distance therefrom so that electrons can be caused to leave said cathode in substantially radial directions by the application of a suitable positive potential relative to said cathode, and a dynode having a secondary electron emissive surface disposed in proximity of the centre of curvature of said cathode, said device being such that with the aforesaid potential applied to said electrode the transit times to said dynode surface of electrons proceeding radially from said cathode are substantially equal.

8. A device according to claim 7, wherein said foraminated electrode has an imperforate cylindrical rim extending in the direction away from said cathode.

9. An electric circuit arrangement including an electron multiplying device comprising a radiation sensitive electron emissive cathode on the inner surface of a domed support, a foraminated electrode substantially co-extensive with said cathode and arranged to face said cathode at a substantially uniform distance therefrom, a dynode for receiving electrons emitted from said cathode, accelerating electrode means and decelerating electrode means arranged in succession around the path from said foraminated electrode to said dynode, and means for applying potentials to said cathode, said foraminated electrode, said accelerating electrode means, said decelerating electrode means and said dynode such that the foraminated electrode has a potential which is positive with respect to said cathode, said accelerating electrode means has a potential which is positive with respect to said foraminated electrode, and said decelerating means and said dynode have potentials which are positive with respect to said cathode but are negative with respect to said accelerating electrode means, said potentials being predetermined to set up a substantially uniform radial electrostatic field between said cathode and said foraminated electrode to cause the transit times to the dynode of electrons proceeding radially from said cathode to be substantially equal.

10. A circuit arrangement according to claim 9, wherein said cathode and said foraminated electrode are each formed as part of a sphere, and said decelerating electrode means comprises an apertured plate having its aperture near the centre axis of said cathode.

11. An arrangement according to claim 10, wherein said accelerating electrode means comprises a cylindrical anode and a conical anode, said conical anode converging towards the aperture of said decelerating electrode means.

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