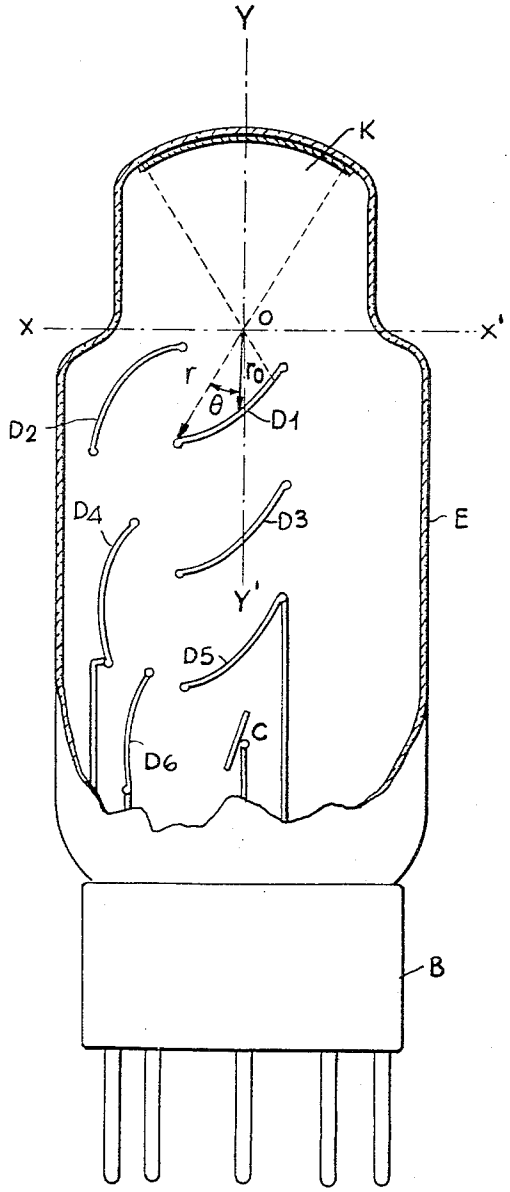
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PHOTOMULTIPLIER TUBES

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PHOTOMULTIPLIER TUBES

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4 Claims. (Cl. 313—94)

This invention relates to photomultiplier tubes.

It is well known that in using such tubes for scintillation counting a scintillating source, producing flashes of constant intensity, should produce output pulses which are also of constant magnitude. This requirement means, firstly, that the photoelectric emission from the cathode and, secondly, that the overall multiplication should be constant from pulse to pulse.

One of the factors which affects the multiplication obtained from any given target or dynode is the angle of incidence of an electron impinging on a target; if an electron strikes a target at a glancing angle the mutiplication ratio is higher than for an electron incident normally on the target, and in general the multiplication ratio increases as the direction of incidence becomes more oblique.

According to the present invention the cathode is so shaped that the electrons converge at a focussing point and the first dynode has a contour which is part of the surface of revolution of a curve of the form $r=r_0 \exp(a\theta)$ (i.e. a logarithmic spiral) about an axis of approach perpendicular to the axis of the electrons and passing through said focus point. It will be appreciated that the logarithmic spiral may be regarded as generated in a reference plane passing through the axis of the tube. In cases in which the cathode is at the end of the tube and the electrons progress along the tube the axis of approach of the electrons to the first tube will coincide with the axis of the tube. Preferably the origin of the logarithmic spiral substantially coincides with the focus point of the primary electrons passing from the cathode to the first dynode.

In order that the invention may be more clearly understood reference will now be made to the accompanying drawing which shows diagrammatically the arrangement of the cathode end of an electron multiplier.

The drawing shows an end window type photomultiplier having an envelope E. Within the envelope is a photo cathode K which may be a coating on the inner surface of the end of the envelope. There are also five dynodes, i.e. secondary electron emissive electrodes, D1–D6 and a final electron collector C. The dynodes, and electron collector are mounted on pillars extending upwards from a base B. In the drawing most of the pillars have been omitted for purposes of clarity. The electrons which are emitted over the area of the photocathode are accelerated and focussed to pass through a focus point O before being incident on a first secondary emitting dynode D1. The trajectories of electrons lying in a reference plane passing through the axis will appear approximately to pass through and diverge from the focus point O which is located in front of the first dynode, say at a distance r_0. If now in the same plane a curve is drawn according to the polar equation

$$r=r_0 \exp(a\theta)$$

with the focus point O as origin, then all the electron trajectories which diverge from O will intersect this curve (which is a logarithmic spiral), at a constant angle, independent of the range of θ the angle of divergence of a given ray from the central ray passing through O. Such a curve therefore gives according to the present invention the desired cross-sectional shape of the dynode where it intersects the given plane. Suppose now that a straight line XOX', lying in the given plane, is drawn through O at right angles to the axis of approach of the electrons, i.e. YY', and that the above mentioned curve is rotated about this line, then the surface generated by the logarithmic spiral curve will provide the required contour of the dynode and will have the property that over the surface all the rays passing through O and striking the dynode D1 will be incident on it at a constant angle.

It is not essential that O should lie on the photocathode side of the dynode as the geometrical construction described above is also applicable if O lies on the side of the dynode remote from the photocathode.

However, it may be desirable that O should lie at a suitable distance from the dynode for the given construction to be mechanically and constructionally feasible, and to ensure this it may also be desirable to allow the beam to pass through more than one aperture, such apertures being in plates maintained at appropriate potentials to allow O to be in a suitable position. It will also be appreciated that O may not necessarily coincide with the physically narrowest part of the electron beam, but is to be found by projecting backward in straight lines the rays which strike the dynode until the point of intersection is reached, which will be the position of O required.

It will be seen that the invention is particularly applicable to large area "end window" photomultiplier tubes in which the electrons emanating from the photocathode cross over at a wide angle, and would otherwise strike the first dynode over a wide range of angles.

With the present invention variations in multiplication at the first multiplying stage due to the wide spread of angles may be avoided. This is important at the first multiplying stage, since in the subsequent stages many more electrons are involved in the multiplication processes and the effects of unequal multiplications will be averaged.

What I claim is:

1. A photo multiplier electron tube comprising an evacuated envelope, a photoemissive cathode coating on the inside surface of said envelope, means for focussing the electrons emitted from the cathode at a point in an axis of the emitted beam, means for maintaining constant amplitude output pulses including a first secondary electron emissive dynode located to receive the electrons emitted from the cathode and having a contour which is substantially part of the surface of revolution of a logarithmic spiral about an axis perpendicular to the axis of said beam whereby all electrons passing through said focus point and striking said first dynode will be incident thereon at a constant angle for providing a constant instantaneous multiplication factor to said tube for each electron passing through said focus point and to said first dynode from any point on said cathode, at least one other dynode in cascade with said first dynode and an electron collector positioned to receive electrons from the last dynode.

2. A photo multiplier electron tube comprising an evacuated envelope, an emissive cathode, means for focussing electrons emitted from said cathode substantially at a point of the axis of the emitted beam, means for maintaining constant amplitude output pulses including a first dynode for receiving electrons from said cathode which dynode has a contour which is substantially part of the surface of revolution of a curve of the form $r=r_0 \exp(a\theta)$ about an axis perpendicular to the axis of ap-

proach of the electrons passing through the focus point whereby all electrons passing through said focus point and striking said first dynode will be incident thereon at a constant angle for providing a constant instantaneous multiplication factor to said tube for each electron passing through said focus point and to said first dynode from any point on said cathode, at least one other dynode in cascade with said first dynode and an electron collector for receiving electrons from the last dynode.

3. A photo multiplier electron tube comprising an evacuated envelope, a photo emissive cathode coating on the inside surface of the end of said envelope, means for focussing electrons emitted from said cathode substantially at a point on the axis of the emitted electron beam, means for maintaining constant amplitude output pulses including a first dynode for receiving electrons from said cathode which dynode has a contour which is substantially part of the surface of revolution of a curve of the form $r=r_0 \exp(\alpha\theta)$ about an axis perpendicular to the axis of approach of the electrons passing through the focus point whereby all electrons passing through said focus point and striking said first dynode will be incident thereon at a constant angle for providing a constant instantaneous multiplication factor to said tube for each electron passing through said focus point and to said first dynode from any point on said cathode, at least one other dynode in cascade with said first dynode and an electron collector for receiving electrons from the last dynode.

4. A photo multiplier electron tube comprising an evacuated envelope, an emissive cathode, means for focussing electrons emitted from said cathode substantially at a point on the axis of the emitted beam, means for maintaining constant amplitude output pulses including a first dynode for receiving electrons from said cathode which dynode has a contour which is substantially part of the surface of revolution of a curve of the form $r=r_0 \exp(\alpha\theta)$ about an axis perpendicular to the axis of approach of the electrons passing through the focus point, said curve having its origin at said focus point whereby all electrons passing through said focus point and striking said first dynode will be incident thereon at a constant angle for providing a constant instantaneous multiplication factor to said tube for each electron passing through said focus point and to said first dynode from any point on said cathode, at least one other dynode in cascade with said first dynode and an electron collector for receiving electrons from the last dynode.

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