Sept. 2, 1941. J. D. McGEE 2,254,617

ELECTRON DISCHARGE DEVICE

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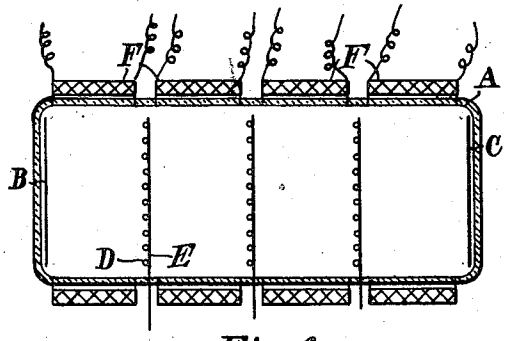


Fig. 1.

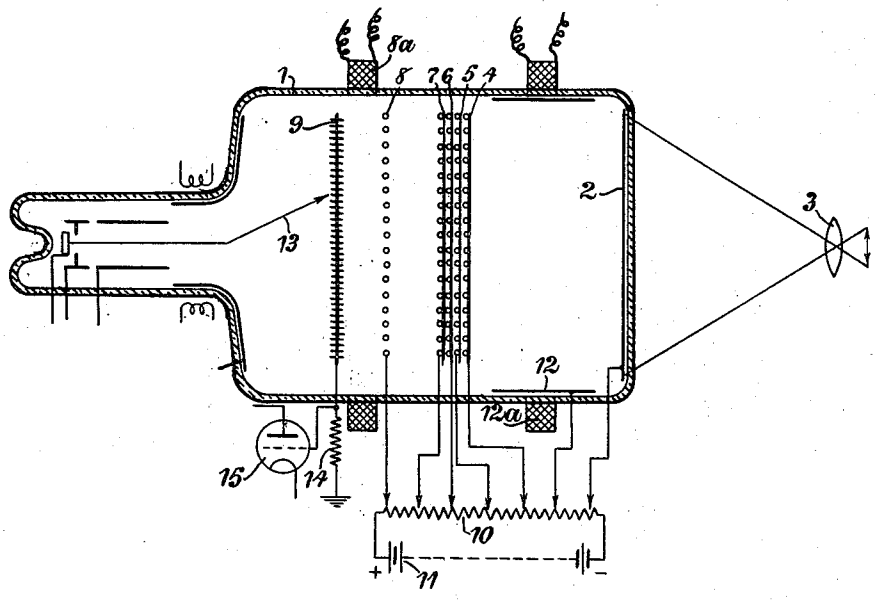


Fig. 2.

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ELECTRON DISCHARGE DEVICE

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1 Claim. (Cl. 250—175)

This invention relates to electron multipliers employing electron permeable electrodes and to an improved electron permeable electrode and to a method of making such an electrode.

A kind of electron multiplier to which an electrode in accordance with the invention is applicable is described in the specification of British Patent No. 457,493. In Figure 1 of this specification the target electrodes are in the form of meshes or grids, primary electrons impinging on the metal of the mesh and releasing secondary electrons which are drawn through the interstices in the mesh. A very thin continuous metal film may also be used as the target.

It has been found to be exceedingly difficult to manufacture electron permeable electrodes comprising thin metallic films which are sufficiently robust to be handled during their mounting in the envelope of the discharge device. It is therefore one of the objects of the present invention to provide an improved electron multiplier employing an electron permeable electrode and to provide an improved electrode for use in such multipliers and a method of making such improved electrodes.

According to one feature of the invention an electron multiplier is provided comprising a source of primary electrons and one or more secondary electron emitting electrodes permeable to electrons, each secondary electron emitting electrode comprising a thin metallic film through which electrons can be passed, the film being supported upon a fine mesh structure, the interstices of the mesh being sufficiently small to enable the thin film to withstand the normal air currents encountered in a room.

According to another feature of the invention a method of making electron permeable electrodes is provided comprising applying to a mesh structure a soluble layer so as to cover the interstices of the mesh, applying to the soluble layer a thin metallic film and dissolving the soluble layer so as to leave the metallic film supported on the mesh structure.

A further object of the invention is therefore to provide an electron multiplier in which several stages of electron amplification can be employed in a relatively small compass and without the aid of special focussing lenses.

According to another feature of the invention an electron multiplier is provided comprising a number of secondary electron emitting electrodes and consisting of a thin metallic film mounted upon a grid-like supporting structure such films being so thin as to be pervious to the flow of electrons and arranged so close together as to avoid the necessity of providing special lenses between successive electrodes for focussing purposes. The grid-like supporting structures are arranged to be in alignment and are held at increasing positive potentials for the purpose of accelerating secondary electrons emitted from the first multiplying electrode, the tertiary electrons emitted from the secondary multiplying electrode, and so on.

In order that the said invention may be clearly understood and readily carried into effect it will now be more fully described with reference to the accompanying drawing in which:

Figure 1 illustrates diagrammatically an electron multiplier employing electron permeable electrodes in accordance with the invention, and

Figure 2 illustrates an electron discharge device embodying the invention and suitable for use as a television transmitting tube.

As shown in Figure 1 the electron multiplier comprises an evacuated envelope A having at one end a photo-sensitive cathode B and at the other end a screen C which is rendered luminous under the impact of electrons. Between the cathode B and screen C are three electron permeable electrodes in accordance with the invention comprising meshes or grids D which support the thin metallic films E. These metallic films are arranged to be secondary emissive so that photoelectrons liberated from the cathode B on projecting an optical image thereon impinge on the first secondary emitting electrode releasing secondary electrons which are then caused to impinge on another secondary electron emitting electrode. This is repeated any desired number of times and the produced electrons are finally projected onto the screen C. The velocity of the various electron streams and the potentials at which the electrodes are maintained in operation serve to cause amplification of the original photoelectrons liberated from the cathode B, the device shown in Figure 1 functioning in a known manner as a picture multiplier. Suitable focussing means may be necessary between the various electrodes, such focussing means being indicated by magnetic focussing coils F. Accelerating electrodes may also be provided between the various electrodes in known manner. The invention is of course not limited to the type of multiplier shown in the drawing since, if desired, it may be applied to other types, such as to the type of multiplier in which the screen C is replaced by a mosaic screen arranged to be scanned by a suitable

scanning beam to generate picture signals suitable for use in television transmission.

The interstices in the mesh supporting the metallic film should be sufficiently small so as to enable the films to withstand normal room currents and for this purpose the diameter of the interstices of the mesh should be about 0.1 millimeter.

In manufacturing the electron permeable electrodes a mesh is preferably employed having a small shadow ratio, for example 10%, the mesh having about 200 meshes per linear inch. The mesh may be immersed in a solution of cellulose acetate or collodion in acetone for the purpose of applying to the surface of the mesh the soluble layer upon which the thin metal film is initially formed.

A thin metal is then applied to the mesh in any suitable manner as by evaporating the metal or otherwise fractionally applying it, as by sputtering, so that the metallic film is supported over the interstices of the mesh by the solute. The mesh is then immersed in a suitable solvent for the cellulose or collodion film whereby the cellulose or collodion film is dissolved away from the metal mesh leaving the thin metal film on the mesh. The solvent should act fairly slowly on the soluble film otherwise local variations in surface tension of the film may disrupt the film of metal. As soon as the cellulose or collodion is dissolved the metal film will contact with the metal wires of the mesh and will effectively adhere thereto. The mesh carrying the metallic film may then be removed from the solvent, the mesh being removed at an angle to the surface of the solvent in order to avoid rupturing of the film. When the solvent is evaporated the film will be found firmly to adhere to the mesh. Composite metal films may be made in the same manner.

It is possible during the manufacture of the electrodes so to adjust the thickness of the metal film that when the film is subjected to electron bombardment the film is sufficiently thick to prevent the passage of incident electrons from one side to the other and yet sufficiently thin to permit the film to emit secondary electrons from the opposite side due to the impact of the incident electrons.

Figure 2 of the drawing illustrates an electron picture amplifier in which the necessity of providing special focussing means such as the coils F in Figure 1 are avoided. Figure 2 also shows the invention as applied to a discharge device suitable for use in a television transmitting system.

As shown in Figure 2, an evacuated envelope 1 is provided having at one end a photo-sensitive cathode 2 upon which an optical image is projected through an optical system 3 whereby an electron image of the optical object is released from the photo-cathode 2. The photo-electrons emitted by the cathode 2 are accelerated and focussed upon a first amplifying or target electrode 4. Additional amplifying stages 5, 6 and 7 may be employed, the emitted electrons being accelerated by a further electrode 8 onto a double-sided mosaic screen 9. The electrodes 4, 5, 6 and 7 comprise thin metallic films supported upon grid-like structures, these thin films being preferably formed in the manner above described. The electrodes 4, 5, 6 and 7 are mounted close together and parallel with one another and in operation are held at positive potentials which increase progressively towards the screen 9 said potentials being derived from a potentiometer 10 connected across a battery 11. For example the difference in potential between adjacent electrodes may be as high as several hundred volts. The grid-like structures supporting the thin films are mounted so that the grid wires are substantially aligned and the distance between successive electrodes is maintained as small as possible, for example 0.5 mm. or less. Owing to the small distance separating adjacent electrodes the electrostatic field between adjacent electrodes may be as high as 5,000 volts per centimetre. Photo-electrons from the cathode 2 are accelerated and focussed onto the first electrode 4 being accelerated and focussed by an electrode 12 and focussing coil 12a as shown. So long as the electrodes are sufficiently close together the original electron image may be amplified by the successive electrodes without substantial loss of definition and without detrimental spurious effects due to the fast primary electron stream.

As stated above, the grid structures upon which the metallic films are supported should be maintained in alignment as far as possible, firstly in order to reduce the effective area of impenetrable structure presented to the electron stream and secondly in order to employ the electrostatic focussing effect due to the potentials applied to the grid-like structure which latter structure projects some distance from the metal films. This latter effect also serves to reduce or eliminate lateral diffusion of the electron stream.

In the example shown the amplified electron image is projected onto the double sided mosaic screen 9 the image being accelerated by the electrode 8 and focussed by a coil 8a the electrode 8 being composed of an uninsulated grid-like structure and being maintained at a high positive potential with respect to the electrode 7. The electrode 8 should be disposed as close as possible to the electrode 7 with the wires of the electrode 8 aligned with the wires of the electrode 7. The mosaic screen 9 is arranged to be scanned on the side opposite to that on which the electron image is projected by a cathode ray beam 13 which is produced and deflected over the surface of the screen 9 in known manner. The scanning of the screen 9 produces signals across a signal resistance 14 which signals may then be amplified in the usual way by a thermionic valve amplifier the first valve of which is indicated at 15.

If desired the focussing coil 8a may be omitted and the mosaic screen 9 or a fluorescent screen as hereinafter referred to is then disposed close to the electrode 8, the small distance between the latter electrode and the mosaic screen or the fluorescent screen being insufficient to permit of a substantial spread of electrons.

Instead of projecting the amplified electron image onto a mosaic screen it may, if desired, be projected onto a screen adapted to be rendered luminous under the impact of electrons such as the screen C of Figure 1. In this latter case the invention may be applied to a tube for reconstituting television signals or it may be used in a picture transformer, an electron telescope, or an electron microscope, or otherwise, where found desirable.

I claim:

An electron discharge device comprising a planar source of electrons constituting a current image, an electron responsive electrode positioned parallel to the source of electrons, a plurality of secondary electron emitting electrodes positioned in parallel relationship between the source of electrons and the electron responsive electrode,

each of said secondary electron emitting electrodes comprising a thin electron permeable metallic film mounted on a grid-like supporting structure, means positioning said secondary electron emitting electrodes in relatively closely spaced relationship, means to focus the electrons from the source upon the first of the secondary electron emitting electrodes, the secondary electrons from the last secondary electron emitting electrode being adapted to be focussed upon the electron responsive electrode, and leads whereby the secondary electron emitting electrodes may be maintained at increasingly positive potentials with respect to the source of primary electrons, the spacing between the secondary electron emitting electrodes being less than one millimeter.

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