Jan. 27, 1959 G. W. BAIN 2,871,368

IMAGE MULTIPLIER

Filed Sept. 21, 1956

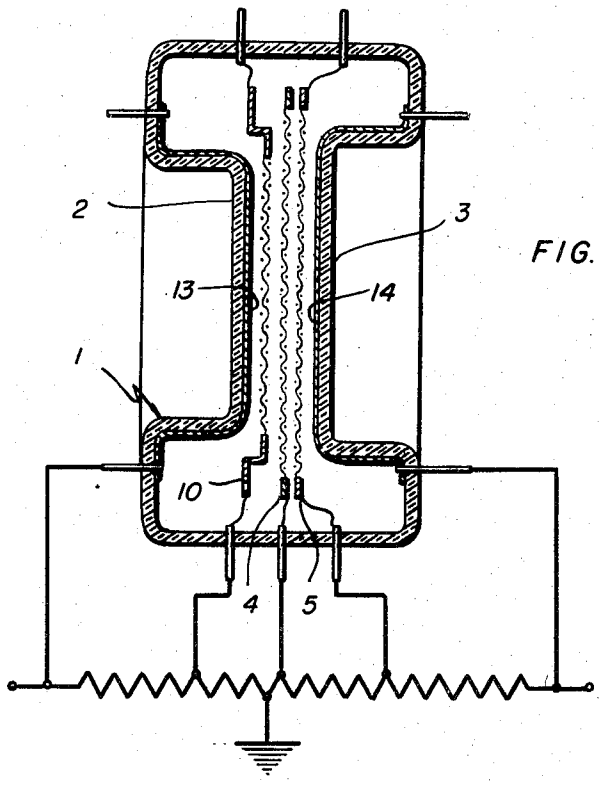


FIG. 1

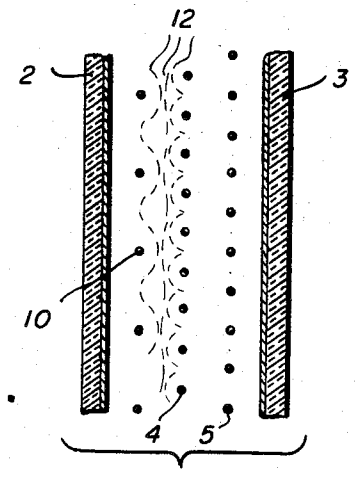


FIG. 2

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United States Patent Office 2,871,368
Patented Jan. 27, 1959

2,871,368

IMAGE MULTIPLIER

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Application September 21, 1956, Serial No. 611,198

6 Claims. (Cl. 250—213)

This invention relates to image multipliers of the electron type and is particularly directed to means for improving the resolution of the amplified image.

Image multipliers of the Weiss type comprise a planar photocathode disposed parallel to one, two or more fine-mesh dynodes, and a phosphor anode. The sides of the dynodes facing the cathode are coated with a semi-insulating material capable of high secondary emission. The potential between the cathode and first dynode is relatively high, so that an electron image originating at the cathode produces a like image on the first dynode. The secondary electrons are drawn through the interstices of the first dynode to the second dynode, where the multiplying action is repeated. Unfortunately, the secondary electrons emitted at the face of the first dynode have random velocities and directions and some of the electrons will move across the face of the dynode and enter holes removed from the point of origin of the electrons. This phenomenon, of course, confuses the information among the picture elements and reduces picture resolution.

The object of this invention is to provide, in an image multiplier, means for retarding secondary electrons normal to the face of the first dynode toward the cathode so that all secondary electrons will pass through openings adjacent their points of origin.

The objects of this invention are attained by spacing a coarse-mesh screen with high transmissivity immediately in front of the first dynode to produce a retarding field and to turn all secondary electrons toward and through the first dynode.

The above-mentioned and other features and objects of this invention and the manner of attaining them will become more apparent and the invention itself will be best understood by reference to the following description of an embodiment of the invention taken in conjunction with the accompanying drawings, wherein:

Fig. 1 is a half-sectional view of an image multiplier embodying this invention; and

Fig. 2 is an enlarged detail view with field strength lines of the region immediately surrounding the first dynode of the tube of Fig. 1.

In Fig. 1 is shown an electron multiplier with envelope 1 having two parallel windows 2 and 3. The windows are of good quality glass with high light transmissivity for the visible light region. A photocathode 13 is prepared on the inner face of window 2. While composition of the photocathode is unimportant to the understanding of this invention, it is suggested that the cathode be prepared by caesiating, in the usual manner, a film of antimony evaporated over a high transparency conductive electrode on the area to be sensitized. The inner surface of window 3, on the other hand, is prepared with a film of any phosphor material 14 which luminesces when bombarded with electrons. Such a phosphor anode, for example, may comprise zinc sulfide (ZnS).

Two dynode electrodes 4 and 5 of extended area are

disposed in spaced parallel relation between the windows. Three, four, or more, dynodes may be employed, if desired. Each dynode electrode preferably embodies a circular frame carrying a taut screen with minute, evenly spaced holes throughout the area of the screen. The screens may be woven or produced by the photo and acid-etching technique. Conveniently, the screens may comprise sheets of nickel or copper with holes etched therethrough about 300 per linear inch. Good results are obtained when the area of the openings thus formed comprise 30% to 50% of the area of the screen. The forward face of each screen, facing the cathode, is prepared for high secondary emission by evaporating a material of proper semi-conducting properties on the face of the screen. Such material may be magnesium oxide, MgO, evaporated over magnesium metal or silver metal to a sufficient depth to insulate the underlying metal conductor from bombarding electrons. Grids 4 and 5 are preferably made with 300 to 500 mesh with holes about .002 inch diameter.

According to an important feature of this invention, the screen electrode 10 is disposed between the cathode and the first dynode electrode. The screen 10 may, if desired, be constructed similar to the dynode electrodes with a supporting frame and a tautened planar screen in the frame. The openings in screen 10, however, are large compared to the openings in the dynode electrodes and the metal of the screen is relatively fine so that the transmissivity of the screen is high compared to the transmissivity of the dynode electrodes. For example, conductors and openings of the screen 10 may be so selected as to intercept as little as 5% or 10% of the collimated primary electrons from the cathode. That is, the transmissivity of the screen 10 may be as high as 90% to 95% when, for example, a mesh is woven of .001 inch wire with .020 inch spacings.

The electrodes of the image amplifier of this invention are energized with potentials that increase progressively from the cathode to the phosphor anode. Conveniently, the electrodes are tapped to the potentiometer, as shown. Where the spacing between the cathode and screen 10 is .050 inch and the spacing between the screen 10 and dynode 4 is .020 inch, and the spacing between dynodes 4 and 5 is .005 inch, and where the spacing between the last dynode (5) and the phosphor anode 3 is .010 inch, the cathode may be operated at —200 volts, grid 10 at —100 volts, dynode 4 at zero volts, dynode 5 at +200 volts, and phosphor anode 3 at +4000 volts. Such voltages, which are mentioned merely by way of example, repress electron emission toward the cathode. The gradients, it has been found, should be at least 400 volts per inch in front of the dynodes. That is, for a grid to dynode spacing of .020 inch, the voltage difference between grid 10 and dynode 4 should be at least 80 volts (.020" x 400 volts per inch). As shown in Fig. 2, equipotential lines 12 are formed along the front face of the first dynode with distinct dips into the openings of the dynode. Hence, secondary electrons having axial velocity toward the cathode are retarded and turned toward and into the openings. A negligible number of electrons have sufficient velocity to escape to the next adjacent opening. It follows that picture resolution is materially improved.

While the principles of the invention have been described in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of the invention.

What is claimed is:

1. An electron discharge device comprising a photocathode, a plurality of multiplier dynode grids and a

phosphor anode, said cathode, grids, and anode being planar and in parallel spaced relation for amplifying electron images originating at said cathode, characterized in that a planar grid of relatively high electron transmissivity compared to the transmissivity of said multiplier grids is disposed between said cathode and the first multiplier grid and circuit connections are provided for impressing on said last-named grid a potential higher than the potential of said cathode and lower than the potential of said multiplier grid thereby to decelerate secondary electrons from the first multiplier grid.

2. In an electron discharge device: a plurality of parallel spaced planar electrodes comprising in succession a photocathode, a relatively open mesh grid, a plurality of relatively closed mesh grids treated on the cathode-side to enhance secondary emission, a phosphor anode, and circuit connections for impressing on said open mesh grid a potential higher than the potential of said photocathode and lower than the potential of said closed mesh grid adjacent thereto whereby secondary electrons emitted from said adjacent closed mesh grid are repelled away from said photocathode.

3. In the combination defined in claim 2, said open mesh grid being of a metal selected for low secondary emission characteristics.

4. An electron discharge comprising a planar photocathode, a parallel spaced phosphor anode, a plurality

of planar grid electrodes disposed in parallel spaced relation between said cathode and anode, the electron transmissivity of the grid adjacent said cathode being relatively higher than the electron transmissivity of the remaining grids, said remaining grids having relatively higher secondary emission characteristics than said first grid, and circuit connections for impressing on said adjacent grid a potential higher than the potential of said photocathode and lower than the potential of the grid on the side of said adjacent grid remote from said photocathode whereby secondary electrodes emitted by said remote grid are repelled away from said photocathode.

5. In the combination defined in claim 4, means for applying successively higher potential between the anode, grid, and cathode electrodes, the voltage gradient at the front surface of said remote grid being of the order of 400 volts per inch.

6. In the combination defined in claim 4, means for applying voltages to the mentioned electrodes to produce at least 400 volts per inch decelerating field for the secondary electrons in the openings of said remote grid.

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