May 4, 1965 E. W. POOR, JR 3,182,221

SECONDARY EMISSION MULTIPLIER STRUCTURE

Filed July 22, 1963 2 Sheets-Sheet 1

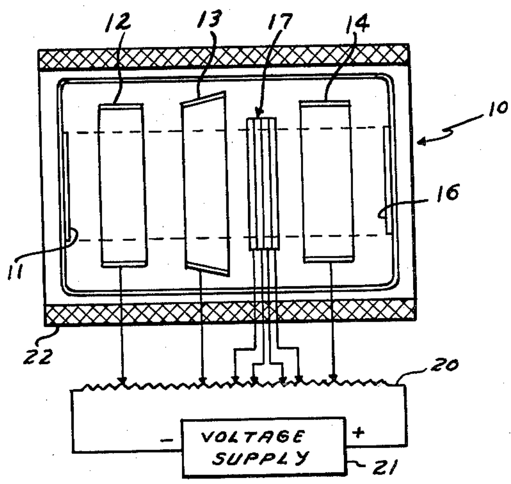

Fig-1

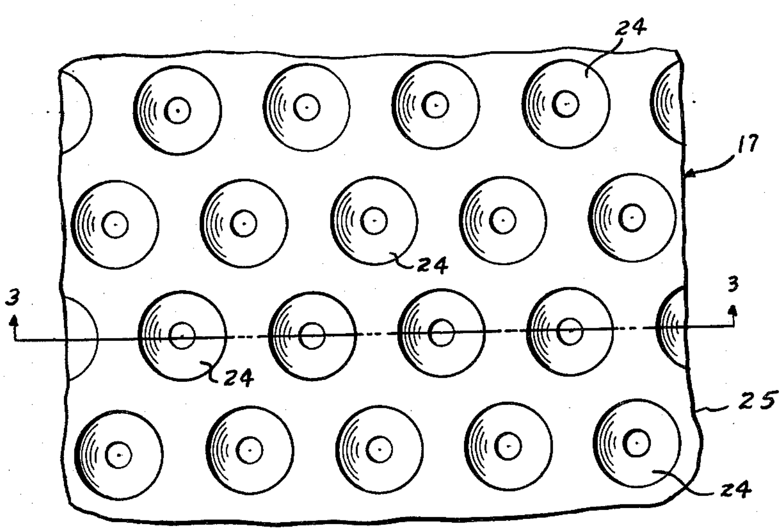

Fig-2

INVENTOR
E.W. POOR, JR.
BY Wade Koontz
ATTORNEY
and
Richard J Killoran
AGENT

May 4, 1965 E. W. POOR, JR **3,182,221**

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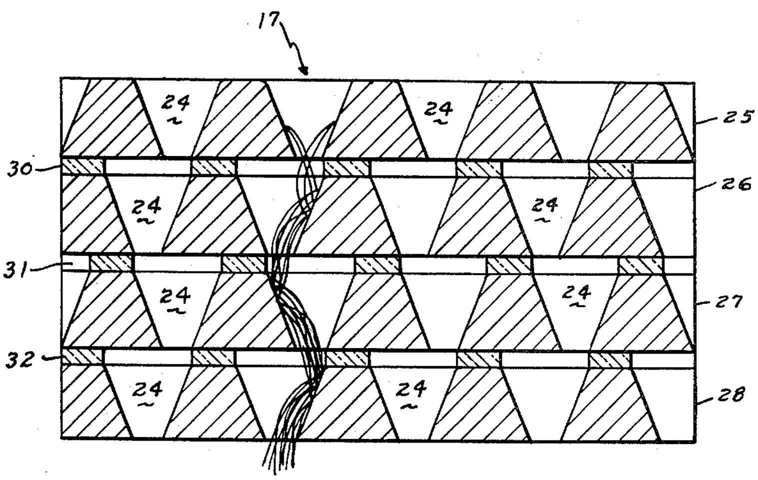

Fig-3

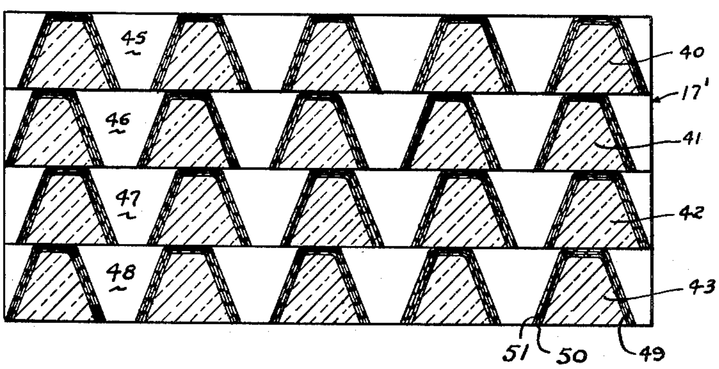

Fig-4

INVENTOR.
E. W. POOR, JR.
BY Wade Koontz
ATTORNEY
Richard J. Killoren
AGENT

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3,182,221
SECONDARY EMISSION MULTIPLIER STRUCTURE

Edmund W. Poor, Jr., Yardville, N.J., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Air Force
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3 Claims. (Cl. 313—103)

This invention relates to an improved secondary emission multiplier structure for use in electron tubes wherein there is an electron-optical image, such as image intensifier tubes.

One object of this invention is to provide a secondary emission multiplier structure which provides improved resolution over prior art structure.

This and other objects will be more fully understood from the following detailed description taken with the drawing, wherein:

FIG. 1 is a schematic drawing showing an image intensifier containing the secondary emission structure of the invention;

FIG. 2 is an enlarged front view of a portion of the secondary emission structure of the device of FIG. 1;

FIG. 3 is a sectional view of the device of FIG. 2 along the line 3—3; and

FIG. 4 is a sectional view of a modification of the secondary emission structure shown in FIG. 3.

There are two main types of secondary emission multiplier structure used for amplifying electron optical images. These are the mesh structure for electron multipliers and the Venetian blind structure for electron multipliers. In the mesh structure all of the electrons emitted from the surface of one wire in a mesh will not land on the same wire of the mesh in the succeeding stages. As a result it can be shown that the resolution of a structure containing N stages varies inversely with N so that the resolution decreases with an increase in the number of stages.

In the Venetian blind type of structure the resolution in a line perpendicular to the slats can never be greater than the number of slats, and the resolution in a line parallel to the slats will vary with N, the number of stages.

According to this invention the secondary emission structure consists of a plurality of plates or sheets of material each having a number of tapered substantially conical shaped holes arranged in identical patterns with the adjacent sheets displaced laterally with respect to each other so that the holes are alternately staggered first to one side and then to the other. With this arrangement the electrons from the wall of one hole in the one stage will strike the wall of only one hole in the succeeding stages.

The plates may be made of a material having secondary emission properties, or may be a material without secondary emission properties which have the walls of the holes coated with secondary emissive material. The sheets may be made conductive in which case they would have to be separated by sheets of insulating material with holes therein matching the larger diameter of the holes in the sheets of the secondary emission electrodes. The secondary emission electrodes could also be made of insulating material such as glass with tapered holes therein. The holes would then be coated with a secondary emissive material. One face of these electrodes can be coated with a conducting material such as aluminum for making contact with the secondary emission material. Since the other surface of these electrodes need not be coated with conductive material the sheet can be stacked without using separate layers of insulating material therebetween.

Referring now to FIG. 1 of the drawing reference numeral 10 refers to an image intensifier tube having a photocathode 11, accelerating electrodes 12, 13, and 14 and a phosphor screen 16. A secondary emission image intensifying structure 17 shown in greater detail in FIGS. 2, 3 and 4 is located between accelerating electrodes 13 and 14. The secondary emission structure 17 is shown with four stages. However, it is obvious that more or fewer stages could be used if desired. The electrodes from the photocathode 11 to the accelerating electrode 14 are held at increasingly more positive potentials by means of spaced taps on voltage divider 20 connected to voltage supply 21. A focusing coil 22 surrounds tube 10 and produces an axial magnetic field.

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The image intensifying structure 17 consists of a plurality of plates 25, 26, 27 and 28 of a material having secondary emission properties such as silver-magnesium. Each plate has tapered holes 24 etched therein as shown in FIGS. 2 and 3. The second plate 26 is displaced laterally with respect to plate 25, as shown in FIG. 3, so that the holes in plate 26 are off center with respect to the holes in plate 25. The next plate 27 is then displaced in the opposite direction with respect to plate 26 as shown in FIG. 3. The fourth plate 28 is then displaced in the same direction as plate 26. The plates 25, 26, 27 and 28 are insulated from each other by means of insulator plates 30, 31 and 32 such as glass. The insulating plates 30, 31 and 32 have holes etched therein of the same size as the larger diameter of the holes in plates 25, 26, 27 and 28. The plates 25, 26, 27 and 28 could also be made of a conductive material not having good secondary emission properties such as silver. In this case the holes could be processed to provide good secondary emission properties, as, for example, the holes could be oxidized and cesiated.

With either of these structures the voltage leads could be connected directly to the plates 25, 26, 27 and 28.

An alternate form of structure to that shown in FIG. 3 is shown in FIG. 4 which structure 17′ consists of plates 40, 41, 42 and 43 of insulating material, such as Corning Fotoform glass with tapered holes such as 45, 46, 47 and 48 etched therein. Such structures with up to 600 holes per square inch have been made. The holes can be coated with a secondary emissive material such as antimony which is cesiated. So that electrical contact can be made with the secondary emissive surfaces a layer 49 of aluminum or other conducting material can be evaporated onto the top surface of the insulating material before secondary emissive material is applied. The conductive material should extend down into the holes to make good contact with the secondary emission material. A layer 50 of antimony can be evaporated over the aluminum which is then cesiated, as indicated schematically at 51, to provide good secondary emission properties. Since the bottom surface of the plates 40, 41, 42 and 43 are not coated with conducting material, and since the exposed small bottom holes are located adjacent the large holes in the succeeding plates no insulating sheets are required between the plates in this modification. Since the plates can be made as thin as .01 inch, a ten-stage structure would be only .1″ thick when separating sheets of insulation are not required. These dimensions are to be illustrative only and it is obvious that thicker plates could be used if desired.

Though the secondary emission structure has been described as used in an image intensifier tube many other uses are obvious such as in an image orthicon and electron microscope.

There is thus provided an improved secondary emission multiplier structure for use in electron tubes wherein there is an electron optical image.

While certain specific embodiments have been described in detail it is obvious that numerous changes can be made without departing from the general principles and scope of the invention.

I claim:

1. A secondary emission multiplier structure comprising: a plurality of parallel plate members each contacting the surface of each adjacent plate member; each of said plate members having a plurality of holes therein; the holes in said plate members being aligned to provide a continuous passage through the multiplier structure; the holes in at least a portion of said plate members being tapered between one surface and the other, with the surface of said tapered holes having secondary emissive properties; all of the holes in said plate members being tapered in the same direction through said multiplier structure, each of said plate members with tapered holes therein being laterally displaced with respect to each adjacent plate with holes therein, whereby the centers of the tapered holes are displaced from the center of the other tapered holes in the continuous passage through the multiplier structure, said plate members including means for insulating the secondary emissive surface of each plate from the secondary emissive surface of adjacent plate members and means for applying a voltage to the secondary emissive surfaces of said plate members.

2. A secondary emission multiplier structure comprising: a plurality of parallel plate members of conductive material; an insulating plate member between each pair of conductive plate members and contacting the surface of each adjacent conductive plate member; each of said plate members having a plurality of holes therein; the holes in said plate members being aligned to provide a continuous passage through the multiplier structure; the holes in each of said conductive plate members being tapered between one surface and the other, with all of the holes in said conductive plate members being tapered in the same direction through said multiplier structure; a secondary emissive coating on the tapered surface of the holes in said conductive plate members; each of said conductive plate members being laterally displaced with

respect to each adjacent conductive plate member, whereby the centers of the tapered holes are displaced from the center of the other tapered holes of each adjacent conductive plate member in the continuous passage through the multiplier structure; and means for applying a voltage to the secondary emissive surfaces of said conductive plate members.

3. A secondary emission multiplier structure comprising: a plurality of parallel insulating plate members; each of said plate members having a plurality of tapered holes therein; the holes in said plate members being aligned to provide a continuous passage through the multiplier structure; a conductive coating on one surface of each of said plate members and extending into said tapered holes, to thereby provide one conductive surface and one insulating surface on each of said plate members; said conductive surface on each sheet being positioned adjacent and contacting the insulating surface of the next adjacent plate member; all of the holes in said plate members being tapered in the same direction through said multiplier structure toward the surface having the conductive coating; a secondary emissive coating on the tapered surface of each of said holes; each of said plate members being laterally displaced with respect to each adjacent plate member, whereby the centers of the tapered holes are displaced from the center of the other tapered holes of each adjacent plate member in the continuous passage through the multiplier structure; and means for applying a voltage to the secondary emissive surfaces of said plate members.

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DAVID J. GALVIN, *Primary Examiner.*

JAMES D. KALLAM, *Examiner.*