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3,039,016

ELECTRODES

Filed June 30, 1958

2 Sheets-Sheet 1

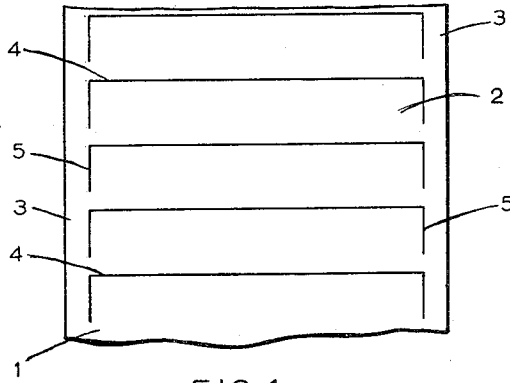


FIG. 1.

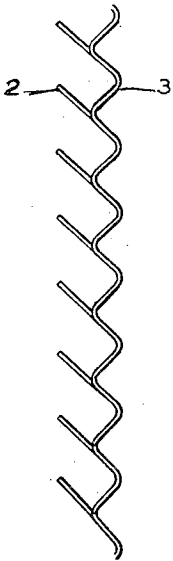


FIG. 2.

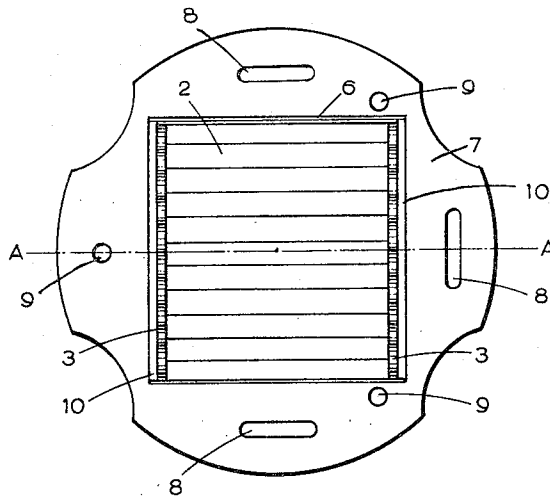


FIG. 3.

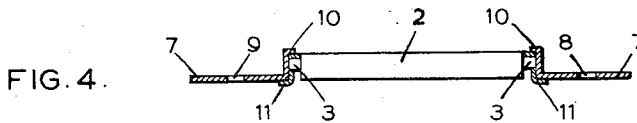


FIG. 4.

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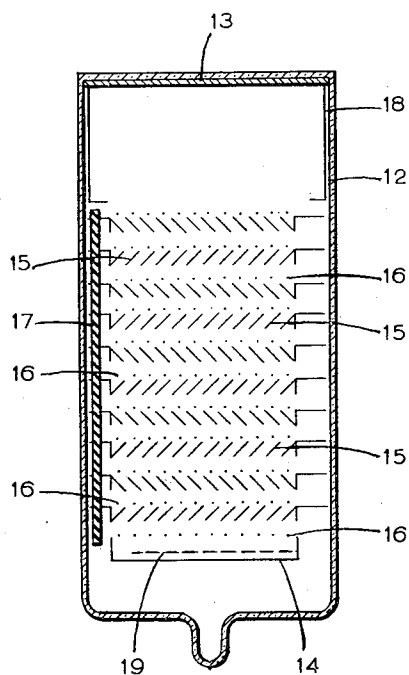


FIG. 5

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ELECTRODES

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7 Claims. (Cl. 313-348)

This invention relates to electrodes of the kind comprising a plurality of inclined slats which are usually parallel to one another.

Electrodes of the kind comprising a plurality of inclined slats are frequently employed as dynodes in photomultiplier tubes and are arranged in alignment with one another such that electrons from the photocathode of such a tube bombard the slats of the first electrode and give rise to secondary electrons which are accelerated by the field due to a grid attached to the facing side of the slats of the next electrode towards the latter electrode and give rise to further secondary electrons, the process being repeated with several electrodes. The electrodes which are more remote from the photocathode are liable to emit light in addition to producing secondary electrons and if such light is transmitted back to the photocathode instability of the tube frequently results. In order substantially to prevent such undesirable transmission of light the slats of each electrode are so arranged that adjacent edges of adjacent ones thereof terminate in substantially common planes substantially perpendicular to the electrode, so that substantially no gaps exist in the plane of the electrode between said slats and the emitted light is therefore substantially prevented from being transmitted to the photocathode. An electrode having a plurality of slats fulfilling such a condition is not usually made from a flat sheet of metal since when portions of the metal sheet forming said slats are bent so as to be inclined to the direction of electron flow, in order to make adjacent edges of adjacent slats terminate in common planes substantially perpendicular to the electrode the metal has to be extended, and sufficient extension is difficult to effect. As a result the slats of each electrode are usually separately constructed and are individually welded, with the required inclined disposition, to a metal frame. Such a method of manufacturing an electrode, however, is expensive due to the time and degree of precision required.

An object of the present invention is to provide an improved method of manufacturing an electrode having a plurality of inclined slats.

According to one feature of the invention there is provided a method of manufacturing an electrode having a plurality of inclined slats comprising piercing a metal sheet to provide incisions defining opposite edges and portions of transverse edges of a plurality of slats leaving side portions of said sheet connected to said slats, causing the side portion between the incisions defining said transverse edges thereof to be inclined to said sheet to cause said slats to be inclined and to reduce the effective length of said side portions so that the opposite edges of said inclined slats are brought closer together.

According to another feature of the invention there is provided an electrode comprising a plurality of slats integral with side portions at positions adjoining the ends of said slats in which said side portions joining said slats and said slats are inclined to said electrode and the effective length of said side portions is less than the physical length thereof.

According to another feature of the present invention there is provided a method of manufacturing an electrode having a plurality of inclined slats comprising forming

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said slats from a sheet leaving said slats connected to side portions of said sheet and deforming said side portions so that the longitudinal edge of one inclined slat is closer to the adjacent longitudinal edge of another inclined slat than would be the case if said side portions were not deformed.

Preferably said side portions are deformed by being corrugated, the corrugations being such as to cause said slats and the parts of said side portions connected to said slats to lie in planes inclined to said electrode.

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

FIGURE 1 is a plan view of a sheet of metal severed so as to form therefrom a plurality of slats in accordance with a preferred embodiment of the invention,

FIGURE 2 is a side elevation of said sheet after deformation,

FIGURE 3 is a plan view of an electrode formed by the method of the invention and mounted in a frame,

FIGURE 4 is a section of FIGURE 3 through the line AA, and

FIGURE 5 shows a sectional view of a photo-multiplier tube incorporating a plurality of electrodes as shown in FIGURES 3 and 4.

Referring to the drawings which illustrate a preferred embodiment of the invention an electrode is formed from a flat metal sheet 1 which is pierced along the lines shown in FIGURE 1 so as to form slats 2 leaving the ends of said slats 2 integral with side portions 3 of the sheet. For this purpose the sheet 1 is provided with a plurality of parallel incisions 4 each equal in length to the required length of a slat said incisions being separated from one another by a distance equal to the required width of a slat, and at each end of each parallel cut a further coterminous perpendicular incision 5 is provided having a length less than said width. Preferably the three incisions forming each slat are made simultaneously by the same tool, or all of the incisions required for the slats of one electrode may be simultaneously made.

It will be appreciated that the slats 2 are interconnected by the side portions 3 and in order to reduce the space between said slats 2 the side portions 3 are deformed, preferably by corrugating said side portions 3 as shown in FIGURE 2 in a forming tool. The extent of deformation, for example the depth of the corrugations, will determine the space between the slats and at the same time when the corrugations are disposed as shown in FIGURE 2 will cause said slats 2 to be inclined, and it can conveniently be arranged that when said slats 2 are inclined adjacent edges of adjacent ones thereof terminate in common planes perpendicular to the plane of the electrode, so that substantially no gaps exist between said slats in the plane of the electrode. Suitable metals for forming such an electrode are alloys of silver and magnesium, or of beryllium and copper, or stainless steel or nickel or its alloys.

FIGURES 3 and 4 show the electrode, formed as described above, mounted in a frame 6 having a flange 7 so as to be suitable for location within the envelope of a photo-multiplier tube for example. Slots 8 and apertures 9 are provided in said flange the slots 8 for the passage of lead-in wires to the electrodes and the apertures 9 for said location. The frame 6 is provided with a bent over portion 10 projecting inwardly from each of opposite sides thereof and the portions 10 can conveniently be employed for locating the slats 2 in position by engaging the corrugated side portions 3. The slats 2 can be held in position by means of strip members 11 shown in FIGURE 4 which engage the corrugated side portions 3 on

the opposite side thereof to said bent over portions 10, said members 11 being welded to the frame 6.

In FIGURE 5 there is shown a photomultiplier tube having an envelope 12 housing a photo cathode 13, a collector electrode 14 and a plurality of electrodes 15 such as are shown in FIGURES 3 and 4. In the present embodiment ten electrodes 15 are provided these serving as dynodes in operation of the tube. In order to accelerate electrons from one electrode 15 to the next, each electrode 15 is provided with a grid 16 attached to the side of the slats thereof nearer the photocathode 13. The ten electrodes 15 are mounted in frames 6 having flanges 7 as shown in FIGURES 3 and 4 and are arranged one above the other and in alignment with one another so that the apertures 9 and slots 8 in the ten flanges 7 are also in alignment. The electrodes are mounted in position by means of three insulating rods 17 passing through the aligned apertures 9, only one of said rods being shown in FIGURE 5. As shown the slots of adjacent electrodes 15 are arranged to be inclined in opposite senses in well known manner. The photo cathode 13 which comprises photo emissive material deposited on the end wall of the envelope 12 is coupled to a tubular screen 18 having an annular flange at its end remote from said photocathode 13, said screen 18 serving to render the field between photocathode 13 and the first electrode 15 more uniform than would be the case in the absence of said screen 13. Coupled to the collector electrode 14, which incorporates a stabilising mesh 19, is a further grid 16 serving to accelerate electrons from the last dynode to said collector electrode 14. Thus in operation of the tube suitable different potentials are applied to the electrodes and in response to light-incident on the photocathode 13 electrons are generated, are multiplied by electrodes 15 and collected by collector electrode 14.

Although the present invention has been described with particular reference to substantially planar electrodes employed as dynodes in photomultiplier tubes it may be applied to other electrodes of the kind comprising a number of inclined slats. For example it may be applied to a cylindrical shaped electrode, or an electrode of other curved form.

What we claim is:

1. A method of manufacturing an electrode having a plurality of inclined slats comprising piercing a metal sheet to provide incisions defining opposite edges and portions of transverse edges of a plurality of slats leaving side portions of said sheet connected to said slats, causing the side portion between the incisions defining said transverse edges thereof to be inclined to said sheet to cause said slats to be inclined and to reduce the effective length of said side portions so that the opposite edges of said inclined slats are brought closer together.

2. A method of manufacturing an electrode having a plurality of inclined slats comprising piercing a metal sheet to provide incisions defining opposite edges and portions of transverse edges of a plurality of slats, leaving side portions of said sheet connected to said slats and corrugating said side portions to cause the side portion between the incisions defining said transverse edges thereof to be inclined to said sheet to cause said slats to be inclined and to reduce the effective length of said

side portions so that the opposite edges of said inclined slats are brought closer together.

3. A method of manufacturing an electrode having a plurality of inclined slats comprising piercing a metal sheet to provide incisions defining opposite edges and portions of transverse edges of a plurality of slats leaving side portions of said sheet connected to said slats, causing the side portion between the incisions defining said transverse edges thereof to be inclined to said sheet to cause said slats to be inclined and to reduce the effective length of the side portions, so that adjacent ones of said opposite edges of adjacent inclined slats terminate in substantially common planes substantially perpendicular to the electrode.

4. A method of manufacturing an electrode having a plurality of inclined slats comprising piercing a metal sheet to provide a plurality of parallel incisions in said sheet each equal in length to the required distance between the transverse edges of a slat and separated from one another by a distance equal to the required distance between opposite edges of a slat and a further co-terminous perpendicular incision in said sheet having a length less than said distance between said opposite edges at each end of each of said parallel incisions to form a plurality of slats leaving side portions of said sheet connected to said slats, causing the side portion between the incisions defining said transverse edges thereof to be inclined to said sheet to cause said slats to be inclined and to reduce the effective length of said side portions so that the edges of said inclined slats are brought closer together.

5. An electrode comprising a plurality of slats integral with side portions at positions adjoining the ends of said slats in which slats said side portions joining said slats and said slats are inclined to said electrode and the effective length of said side portions is less than the physical length thereof.

6. An electrode comprising a plurality of slats integral with side portions at positions adjoining the ends of said slats in which said side portions are corrugated and the corrugations are disposed so that each of said side portions joining said slats and said slats are inclined to said electrode and the effective length of said side portions is less than the physical length thereof.

7. An electrode comprising a plurality of slats integral with side portions at positions adjoining the ends of said slats in which each of said side portions joining said slats and said slats are inclined to said electrode and the effective length of said side portions is less than the physical length thereof so that adjacent opposite edges of adjacent slats terminate in substantially common planes substantially perpendicular to said electrode.

References Cited in the file of this patent

UNITED STATES PATENTS

2,075,639	Castle	Mar. 30, 1937
2,236,041	Teal	Mar. 25, 1941
2,246,172	Hergenrother	June 17, 1941
2,340,500	Zunick	Feb. 1, 1944
2,460,381	Forgue	Feb. 1, 1949
2,836,755	Sommer	May 27, 1958
2,841,728	McGee	July 1, 1958