

[54] **IMAGE AMPLIFIER HAVING EXTERNAL ELECTROSTATIC SHIELD**  
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 [22] Filed: **May 23, 1968**  
 [21] Appl. No.: **731,442**

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**FOREIGN PATENTS OR APPLICATIONS**

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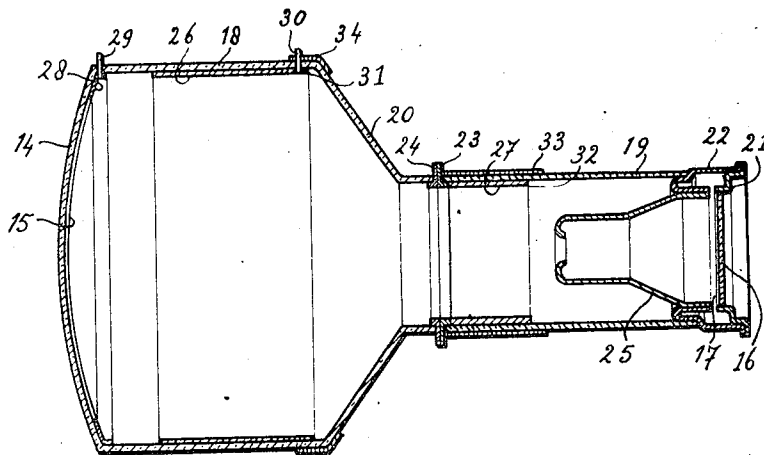
[30] **Foreign Application Priority Data**  
 June 6, 1967 Netherlands.....6,708,012  
 [52] **U.S. Cl.**.....313/102, 313/313  
 [51] **Int. Cl.**.....H01j 39/14, H01j 39/18, H01j 29/06  
 [58] **Field of Search** .....313/313, 94, 102; 315/8

[57] **ABSTRACT**

An electron optical image tube with a focus electrode having the form of a thin metallic film on the inner surface of the glass envelope is provided with an external conductive shield which carries electrode potential. The shield is in radial registry with the electrode edge, but extends a short distance beyond the edge to relieve the same from local high potential gradients.

[56] **References Cited**  
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**3 Claims, 2 Drawing Figures**



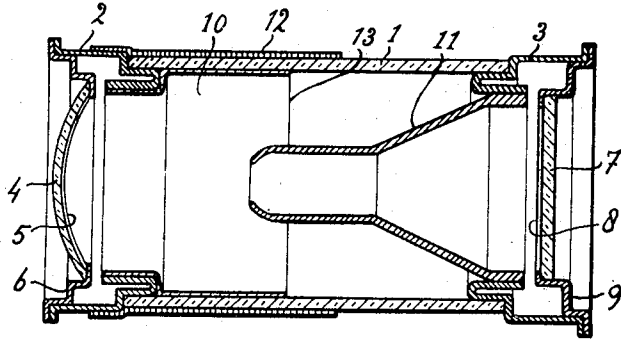


Fig. 1

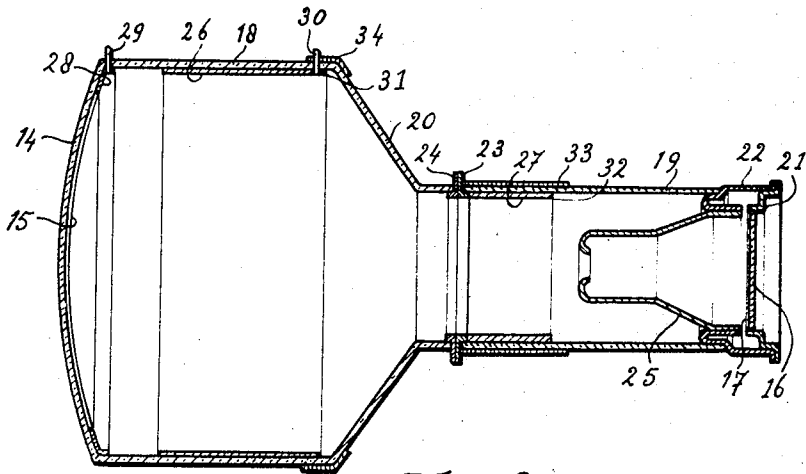


Fig. 2

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## IMAGE AMPLIFIER HAVING EXTERNAL ELECTROSTATIC SHIELD

This invention relates to an electron optical image tube having in an evacuated envelope at one end thereof a photocathode, at the other end thereof a fluorescent screen and an electron optical focusing electrode system between the photocathode and the fluorescent screen, which electrode system comprises at least one tubular electrode in the form of a metallic coating on the inner surface of the envelope.

The use of focusing electrodes that have been formed by depositing a thin metallic film on the inner surface of the tube wall, e.g. by evaporation in vacuo, is well known in the art and is advantageous a.o. in that such electrodes are very "vacuum clean" compared to separate metallic sleeves. With the latter type of electrodes difficulties are often encountered during manufacture or in operation due to impurities sticking to the electrodes, gas inclusions and the like, and this notwithstanding very careful cleaning and outgassing.

However, other objections may rise when using metallic film electrodes due to the high electric field strength building up at the extremely sharp edges of the electrodes which tend to reduce the voltage at which the image tube can be operated safely. It is well known to improve the capability of image tubes to resist high electrical stress by providing for additional surface creeping distance, that is the distance along the glass wall from the electrode edge to other conducting parts such as electrodes, leads etc. To that end the glass wall may be folded or bulged, or the electrode may be applied to a separate glass sleeve mounted in the envelope. Provisions of this kind tend to result in increased tube dimensions and more difficult manufacture. On the other hand it has been proposed to reduce local high potential gradients in the region of the electrode edge by overlapping that edge by a band of semiconductive material. Since this material is applied with a binder to the inner surface of the tube wall, it may cause other problems such as the development of unwanted gas within the tube (compare British Pat. specification No. 839,681).

This invention has for its principal object to provide a simple means for improving the electrical stability of electron optical image tubes having one or more electrodes in the form of metallic coatings.

In accordance with the invention there is provided on the outer circumferential surface of the envelope a conductive shield in radial registry with at least one edge of said metallic coating which shield has, in operation, the same electric potential as said metallic coating and extends axially a short distance beyond the said edge.

The external shield effectively deflects electric field lines from the sharp edge of the electrode thereby reducing the field strength in that region. Electric discharge phenomena starting from the edge and proceeding along the glass wall may thus be effectively prevented under actual operating conditions. It has been shown that such discharges may noticeably contribute to the undesirable background-brightness of the tube, i.e. the initial brightness of the anode screen in the absence of any illumination of the photocathode.

Preferably, the conductive screen extends a distance beyond the electrode edge lying between one-half and 10 times the thickness of the glass wall of the tube at

the place of the edge. With extensions smaller than that a sufficient reduction of field strength at the electrode edge may not be obtained, while longer extensions would not material add any more to the desired effect and would have the drawback that the distance outside the envelope between parts carrying different electric potentials would be unnecessarily reduced.

The conductive shield may be provided directly on the outer surface of the tube, e.g. by applying thereto a coating of a conventional conductive paint, a graphite suspension or the like. Alternatively, it can be placed as a separate cylindrical sleeve around the tube.

In a multi-electrode tube it will generally be found satisfactory if only the edge on the anode side of the electrode nearest to the anode is provided with an external conductive screen having the same potential as the electrode. As is well known in the region near the photocathode the potential gradient along the tube axis is generally not very high and, accordingly, potential differences between electrodes in this region will be small in comparison with that between the last focus electrode and the anode. Nevertheless, if it is feared that too high field strengths might develop at other electrode edges too, these may be protected by external conductive shields as well. If both edges of one electrode should be protected, one single shield may be applied which extends beyond the electrode on both sides.

A particularly favorable embodiment of the invention is found when applying it to a diode type of tube of which the photocathode and anode screen are carried by glass windows which are connected vacuumtight to a substantially cylindrical glass tube through intermediate metallic ring structures and whose electron optical focusing system consists of a cylindrical electrode carrying photocathode potential and having the form of a metallic coating on the inner surface of the glass tube, and a further electrode carrying the same potential as the anode screen and having the form of a tube widening in the direction of the anode screen. Such diode tubes are required nowadays in large quantities for use in night viewing binoculars, sniperscopes, etc. In view of these applications it is important that the tubes are cheap, simple and, above all, small, notwithstanding a relatively high operating voltage. With these tubes the full operating voltage is applied between the metallic film cylinder electrode and the anode electrode which mostly projects into the cylinder electrode. Accordingly, the edge on the anode side of the cylinder electrode will be subject to very high field strengths if no conductive shield is utilized in accordance with the present invention. This shield may extend to the metallic ring joint between the cylindrical tube wall and the photocathode window, so that it attains photocathode potential.

A special problem arising in connection with diode image tubes resides in the very narrow dimensional limits that have to be kept up in making the tube envelope. Otherwise, in the finalized tube the anode screen may not be in axial registry with the electron optical image plane and the resultant tube will lack definition and must be rejected. If, however, an external conductive shield is applied in accordance with the invention, this may be utilized as a surprisingly effective means to bring about a small axial shift of the electron

optical image plane so as to bring it into registry with the actual position of the anode screen. To that end, upon completion of the tube, the exact distance which the conductive shield should extend beyond the focus electrode edge may be determined experimentally for each tube so that maximum definition at the anode screen is obtained.

It may be remarked that it has been well known per se to coat certain parts of the outer surface of image tubes with a conductive layer carrying the potential of a focus electrode. Compare e.g. the British Pat. specification No. 802,960 describing a layer of that kind which is in registry with an open space between the anode and an intermediate electrode. That electrode, however, is not a thin metallic coating on the inner surface of the glass wall, but a metal sleeve. Thus, it will not present the problem solved by the invention. On the other hand, the prior art conductive shields were intended to prevent random local charges accumulating on the inner glass wall surface from laterally deflecting the electron beams on their way to the anode screen. Similar random charges have not been noticed in the type of tubes to which the present invention relates and whose main focus electrode is a metallic film formed on the glass wall itself.

Some embodiments of the invention will now be described in connection with the drawing in which:

FIG. 1 shows a diode image tube in axial cross-section; and

FIG. 2 shows a tube with two focus electrodes in the form of metallic films, likewise in axial cross-section.

Referring to FIG. 1 the tube shown therein has a cylindrical glass part 1 having its ends sealed to metal rings 2 and 3. A curved window 4 carries the photocathode 5 and is sealed to a metal ring 6. Similarly, a plane window 7 carrying the fluorescent screen 8 is sealed to a metal ring 9. The rings 2 and 6, as well as the rings 3 and 9, are sealed together by welding.

The electron optical focusing system consists of a cylindrical electrode 10 which is formed against the inner surface of the glass wall 1, preferably by evaporation in vacuo, and a tubular electrode 11 widening in the direction of the anode screen 8 and whose narrow end projects into the cylindrical electrode 10. This electrode 11 will be termed hereinafter the cone electrode, though it will be clear from FIG. 1 that it has not necessarily an exact conical shape. Electrode 10 overlaps the ring 2 so that in operation it carries photocathodes potential. Cone electrode 11 is mounted in the ring 3 and has therefore the same potential as the screen 8 (anode potential). The space within the cone electrode is virtually free from any electric field.

In accordance with the invention a conductive layer 12, e.g. of metallic paint, is applied on the circumferential outer surface of the cylindrical glass wall 1. This layer overlaps the ring 2 so that it automatically attains cathode potential, and extends in the direction of the anode to a point slightly beyond the edge 13 of the cylinder electrode 10. The length of the extension is suitably selected between  $\frac{1}{2}$  and 10 times the thickness of the glass wall. In the example shown it is about 3 times that thickness. Between the limits set by the effectiveness of the shield in relieving the edge 13 from

excessive field strengths, the ultimate axial distance between the edges of the shield and the electrode can best be experimentally determined so that maximum definition of the anode screen image is achieved.

In the tube of FIG. 2 the front window 14 carrying the photocathode 15 and the rear window 16 with anode screen 17 are sealed to a glass tube having two cylindrical portions 18 and 19 of different diameters and a conical shoulder portion 20. Vacuumtight seals between the window 16 and tube portion 19, as well as between the latter portion and the shoulder portion 20, having been accomplished by means of welded metal rings 21, 22 and 23, 24, respectively. The tube is a tetrode in that it has, in addition to the photocathode and the cone electrode 25 which is at anode potential, two other electrodes 26 and 27, each having the form of a metallic film deposited on the inner surface of the wider cylindrical tube portion 18 and the narrower portion 19, respectively. These four electrodes have different potentials in operation. Photocathode 15 receives its potential through the metallic annulus 28 and the lead 29. Electrode 26 through the lead 30, electrode 27 through the ring 23 and anode electrode 25 through ring 22. Typical values for these potentials may be:

Photocathode	0 Volts
Electrode 26	120 Volts
Electrode 27	8000 Volts
Anode	20000 Volts

From these values it appears that at the edge 32 of electrode 27 and, to a far lesser degree, at the edge 31 of electrode 26 high local potential gradients may be expected. Accordingly, in registry with these edges conductive layers 33 and 34, respectively, are provided on the outer circumferential surface of the tube. Layer 33 extends from ring 23 up to a point about two times the glass thickness nearer to the anode than the electrode 27. Due to the conductive contact with ring 23 this layer 33 has the same potential as electrode 27. The layer 34 extends from slightly in front of the edge 31, such that it contacts the lead 30, up to a point on the shoulder portion 20 of the tube such that it clearly projects from the edge 31 in the direction of the electrode 27.

What I claim is:

1. An electron optical image tube having an evacuated glass envelope having two cylindrical body portions, one of larger diameter than the other with a substantially frustoconical portion connecting said two cylindrical portions, a glass window at each end of said glass envelope extending in a plane substantially perpendicular to the axis of said envelope, a photocathode carried by the window at the end of the larger diameter portion of said envelope and a fluorescent anode screen carried by the window at the end of the smaller diameter portion of said envelope, metallic ring connecting means forming a vacuum tight seal between the glass window carrying said fluorescent anode screen and the associated end of the smaller diameter portion of said envelope, a first and second cylindrical electrode each in the form of a metallic coating on the inner surface respectively of the large and smaller diameter portions of said envelope, said cylindrical electrodes having configurations such that under nor-

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mal operating conditions at least one edge of said electrodes may be subject to field emission due to concentration of electric field lines, a conductive shield coaxial with said second cylindrical electrode positioned on the outer circumferential surfaces of the smaller diameter portion of said envelope, said shield in operation having the same electrical potential as said second electrode, with at least one end of said shield extending axially beyond the associated edge of said second cylindrical electrode, a distance that is between one-half and ten times the thickness of the glass wall of the envelope at the place of said edge, whereby said edge is substantially relieved of said concentration of electric field lines, a further electrode in the form of a tube having an inner end portion of one diameter, and an outer end portion substantially in the shape of a cone extending towards said fluorescent anode screen and widening in the direction of said fluorescent anode screen, said further electrode being adapted to have the same

potential as said fluorescent anode screen, said first cylindrical electrode and said photocathode being adapted to being connected to the same source of electric potential.

5 2. An electron optical image tube as claimed in claim 1 in which the edge of said shield extends axially beyond said second cylindrical electrode toward said anode screen by a distance approximately twice the glass thickness of the glass wall of the envelope at said edge.

10 3. An electron optical image tube as claimed in claim 1 in which an additional conductive shield is provided encompassing the larger diameter portion of said envelope and having an edge thereof extending beyond the adjacent edge of said first cylindrical electrode in the direction toward said frustoconical connecting portion.

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