

[54] **ELECTRON TUBE FOR
ELECTRON-OPTICAL IMAGE
CONVERSION**

[75] Inventor: **Christian J. G. H. Wulms**,
Emmasingel, Eindhoven,
Netherlands
[73] Assignee: **U.S. Philips Corporation**, New
York, N.Y.
[22] Filed: **Apr. 6, 1972**
[21] Appl. No.: **241,771**

Related U.S. Application Data

[63] Continuation of Ser. No. 17,827, March 9, 1970,
abandoned.

[30] **Foreign Application Priority Data**

Mar. 13, 1969 Netherlands..... 6903860

[52] U.S. Cl..... **313/65 R, 313/102, 313/317**
[51] Int. Cl..... **H01j 31/52**
[58] Field of Search **313/65 R, 94, 99, 95, 101,**
313/102, 98, 64; 250/213 VT

[56]

References Cited

UNITED STATES PATENTS

3,474,275	10/1969	Stoudenheimer et al.	313/65 R
3,562,516	2/1971	Guyot	313/65 R
2,727,182	12/1955	Francken	315/10
2,828,433	3/1958	Frenkel	313/64 X
3,280,356	10/1966	Stoudenheimer et al.	313/65 R
3,558,893	1/1971	Ball	250/213 VT
3,688,146	8/1972	Bouwers	313/102

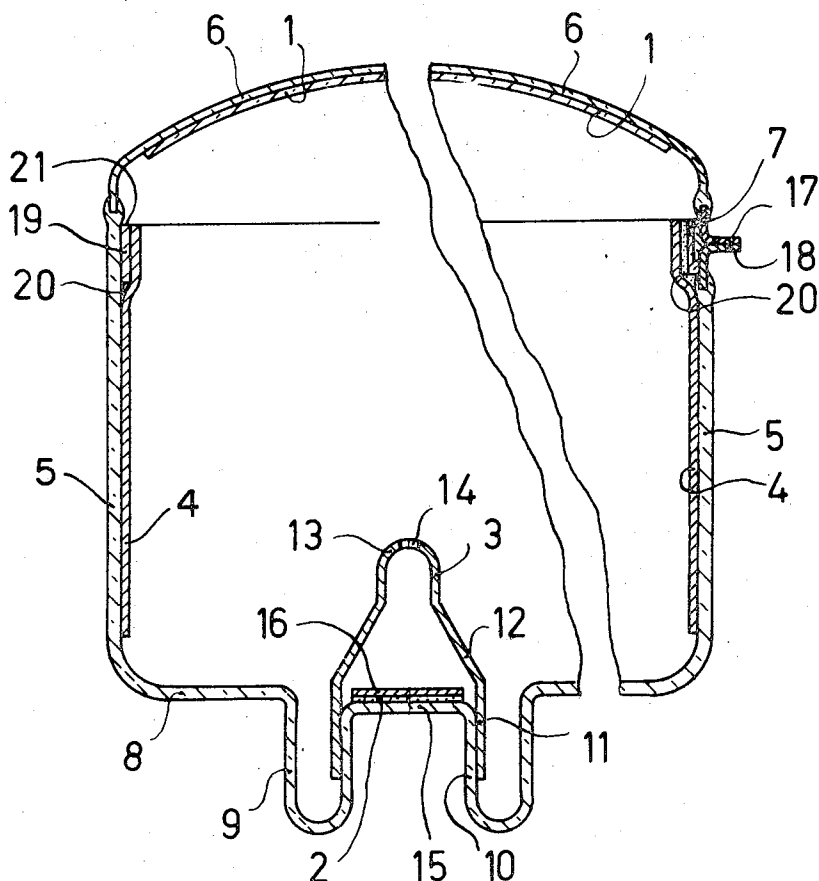
Primary Examiner—H. K. Saalbach
Attorney, Agent, or Firm—Frank R. Trifari

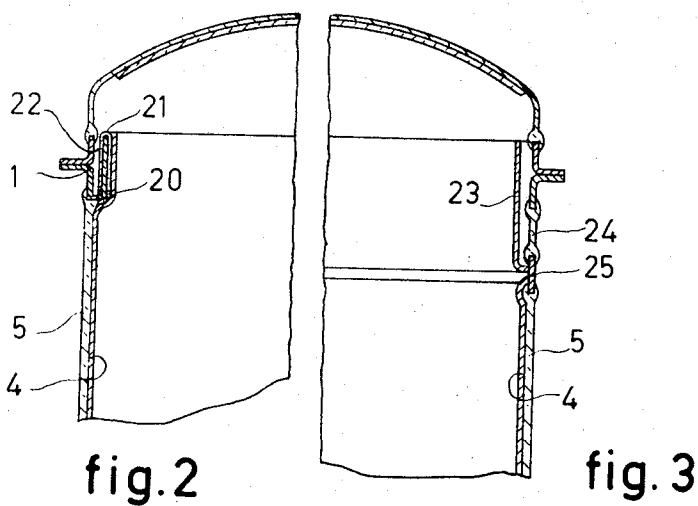
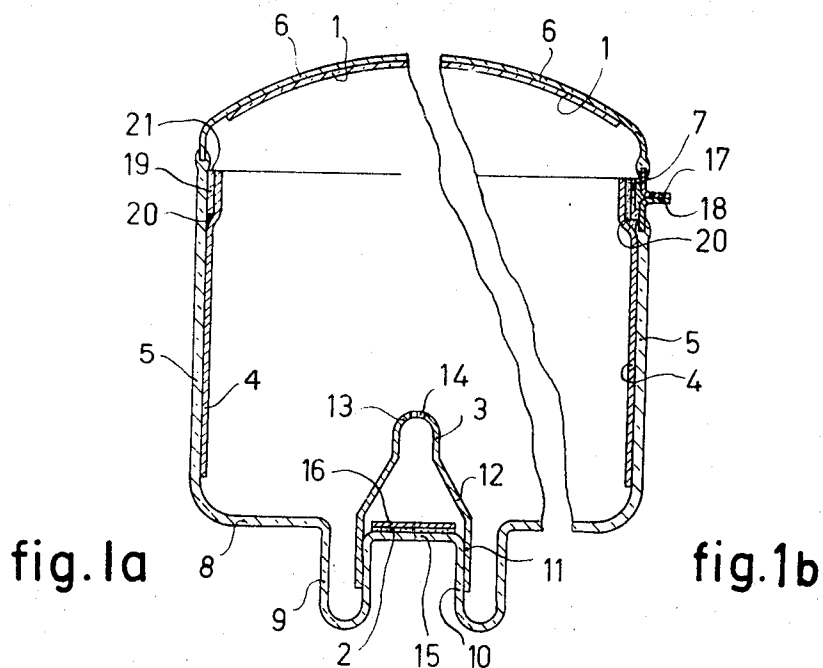
[57]

ABSTRACT

Electron-optical image converting tube comprising a photoelectric cathode and a focusing electrode applied to the tube wall, the end of the focusing electrode facing the photocathode being separated from the wall by insulating material which increases the insulation resistance between the photocathode and the focusing electrode.

7 Claims, 4 Drawing Figures





INVENTOR.

CHRISTIAAN J. G. H. WULMS

BY

Frank R. [Signature]
AGENT

ELECTRON TUBE FOR ELECTRON-OPTICAL IMAGE CONVERSION

This is a continuation of application Ser. No. 17,827, filed Mar. 9, 1970, now abandoned.

The invention relates to an electron tube for electron-optical image conversion comprising a cylindrical glass sheath closed at both ends, the inner surface of which is coated with a conductive layer and provided at one end with a substantially spherical glass window adapted to support a photo-electric cathode and at the other end a phosphor screen for capturing electrons emitted by the photo-cathode and focused by an electron-optical system arranged between the photo-cathode and the screen.

Electronic image tubes of this kind are known for image transformation, for example, for converting an X-ray image into a visible image and for increasing the brightness of visible images of low light intensity.

The conductive coating on the cylindrical sheath covers the wall substantially completely and terminates at a given distance from the photo-cathode. By applying an appropriate electric voltage to the coating a greater part of the photo-cathode is employed effectively than in the case in which this coating is at the potential of the photo-cathode.

Technological difficulties involved in the manufacture of electron image tubes completely made of glass have led to a connection between the window and the cylindrical sheath by means of a metal ring. This ring comprises two equal portions of circular section, having at one edge a projecting flange, while the other edge of one portion is connected with the window by being sealed to the cylinder wall and that of the other portion is connected in the same manner. The two flanges may be sealed together by welding.

The metal wall coating is usually of copper or aluminum and with tubes of the last-mentioned type it covers the sealing edge between the cylindrical sheath and the metal ring, to which it is connected electrically.

When the most appropriate electric voltage, usually a few hundred volts, is applied to the coating, the size of the photo-cathode surface imaged without defects is about 65 percent of the tube section. In general a comparatively large image converter is required relative to the size of the image to be transferred.

The invention has for its objects to provide an improvement in electron-optical image tubes in order to enlarge further the useful photo-cathode surface. This improvement is obtained in that in accordance with the invention with the metal coating on the wall of the cylinder sheath of the tube the end extending towards the cathode is at a distance from the cylindrical sheath and is prolonged along a surface separated from the sealing area between the cylindrical sheath and the glass window by insulating material. For this purpose an annular glass body may be provided inside the sheath and be secured to the wall by means of a kind of glass of lower melting point, for example, glass enamel.

The invention is based on the recognition of the fact that the comparatively narrow portion of the spherical window along the circumference of the photo-cathode not associated with the latter is slightly contaminated during the formation of the photo-cathode by a small deposit of photo-cathode material, so that its insulation resistance is reduced. When the wall coating terminates in the vicinity of the seal or at the metal connecting ring, the applied voltage will produce, due to the re-

duced resistance surface-conduction currents which result in electrons emerging from the neighbourhood of the edge of the photo-cathode which travel towards the phosphor screen under the action of the modified, usually no longer uniform potential distribution along other paths than those required for accurate focussing. The glass ring increases satisfactorily the insulation capacity between the wall coating and the photo-cathode, although the portion of insulation material between them is not materially prolonged.

It has been found that by applying the invention the active cathode surface is increased to 80 or 85 percent of the tube section.

If it is desired that the metal connecting ring be at cathode potential, it is advisable to increase further the insulation resistance between the wall coating and the metal ring. For this purpose the ring may be provided on the sealing side on the sheath with an inwardly projecting rim bent over parallel to the ring surface, so that between this rim and the ring a gutter-shaped space is formed. By covering the bent-over rim on the inner and outer sides with glass enamel which extends over the sealing edge, the insulation distance is materially prolonged.

A different embodiment in which a coating with glass-like insulating material is avoided is the application of a second metal ring in the cylinder wall, said ring being separated by a wall portion from the connecting ring, the former ring having connected with it a metal screen extending towards the photo-cathode beyond said intermediate wall portion insulating the two rings from each other, so that the connecting ring may be at photo-cathode potential.

The invention will be described more fully with reference to the drawing, in which

FIG. 1a is a sectional fragmentary view of one embodiment of the electron image tube of the invention;

FIG. 1b is a sectional fragmentary view of a modification of the tube of FIG. 1a; and

FIGS. 2 and 3 show each another embodiment of this invention.

In the electron image tube of FIG. 1a is shown a tubular jacket 5 made completely of glass, whereas FIG. 1b shows the embodiment in which the cylindrical jacket or sheath and the window 6 are interconnected by a metal ring 7. In its evacuated space the tube accommodates the photo-cathode 1, the phosphor screen 2, the anode 3 of the electron-optical system and the focusing electrode 4 formed by the wall coating. The envelope of this space is formed by a cylindrical glass sheath 5 and a glass window 6. As is shown in FIG. 1a the window 6 is directly connected with the cylindrical sheath 5. At the other end the cylindrical sheath 5 is closed by an end wall 8 having an embossed part 9 connected at the edge with a contracted part 10.

The photo-cathode 1 is arranged on the concave surface of the spherical window 6, in this case a photo-cathode for direct exposure as is common in a light intensifier. The display of X-ray images in visible light requires a phosphor layer which is provided with the supporting surface and the photo-cathode.

The anode 3 is arranged with a cylindrical rim 11 on the re-entrant part 10 and furthermore provided with a conical part 12 which terminates in a substantially spherical top 13 having an axial opening 14.

The part of the inner space enclosed by the anode 3 accommodates the phosphor display screen 2 arranged

on the flat upper surface 15 of the re-entrant wall portion 10. A thin metal coating 16, which is readily pervious to the electrons and which may consist of aluminum, considerably increases the radiation of the light produced in the phosphor layer in the viewing direction.

Since the metal ring 7 as illustrated in FIG. 1b is made of two parts with flanges 17 and 18, the connection between the window 6 and the cylindrical sheath 5 can be easily established. These two parts may each have sealed to them a metal ring portion, after which the flanges are interconnected in an airtight manner, for example, by welding.

The inner side of the sheath 6 is provided with an annular body 19 of glass or another refractory insulating material. The body 19 may be fastened by means of a vitreous material 20, for example, glass enamel, to the cylindrical sheath 5 or to the half of the metal ring sealed to the cylindrical sheath 5 in order to join the two tube portions 5 and 6 so that the connecting material covers in addition the sealing rim between the ring and the wall.

The metal inner coating 4 of the wall may be obtained in an appropriate manner by vapour deposition of metal particles, the whole surface being covered with the exception of the annular surface 21 of the body 19 in the sheath facing the photo-cathode 1. With this structure it is possible to keep this surface chemically clean, since the formation of the photo-cathode may be carried out before the two tube portions are sealed to each other.

The detail of a tube with a metal connecting ring of FIG. 2 shows that one half of the ring has a channel-shaped section, one limb 21 being coated with a vitreous insulating material 20, which covers in addition the sealing edge of the ring with the tube wall. On the inner side the metal coating 4 extends up to the end of said limb 21. The non-conductive coating 20 of this limb in the gutter-shaped space 22 forms an excellent insulation between the metal coating 4 and the ring 7, which may be connected to earth, so that non-uniform voltage distribution in the neighbourhood of the photo-cathode is completely avoided.

By providing a separate metal sleeve 23 inside the tube envelope in the manner shown in FIG. 3 a portion 24 of the cylindrical sheath 5 is used as an insulation. The metal wall coating 4 terminates at the metal intermediate portion 25 provided by the connection of the sleeve 23 and being annular in shape, the two edges of which are sealed to the cylinder wall. By its connection with the metal intermediate portion 25 the sleeve 23 is electrically connected to the conductive coating 4 and owing to the presence of the insulating portion 24 of the cylinder wall 5 it is no longer necessary to cover the wall of the sleeve with insulating material.

A further advantage of the constructions shown resides in that the metal coating operating as a focussing electrode in the electron-optical system can be extended towards the photo-cathode so as to terminate at a distance most suitable for the focussing effect independently of the disposition of the metal ring connecting the window with the cylindrical sheath of the tube.

What is claimed is:

1. An electron tube for electron optical image conversion, comprising a closed envelope of insulating material including a jacket portion having an axis of sym-

metry, and two opposite end portions, each provided with a transparent window arranged about said axis, a photo-cathode layer disposed adjacent the inner surface of one window,

a phosphor screen layer arranged adjacent the opposite window,

an anode structure mounted within said envelope around said phosphor screen and defining a passage for electrons emitted by said photo-cathode, an electrically conductive focusing coating provided on the inner surface of said jacket portion and surrounding at least a portion of said anode structure, a marginal portion of said focusing coating near said photo-cathode layer being spaced from said jacket portion to form an annular channel therewith, and

an insulating layer provided on the jacket portion within said annular channel to eliminate accidental contamination of said jacket portion by photo-cathode material.

2. An electron tube as claimed in claim 1, in which said jacket portion is of glass, said coating of insulating material including an annular glass body which is fastened to the tube wall by means of a glass material of lower melting point than that of the jacket portion, the focusing coating exceeding the inner surface of the glass body.

3. An electrode tube according to claim 1, wherein the end portion within said one window and said photo-cathode layer is made as a separate closure member and sealed to the rim of said jacket portion.

4. An electrode tube according to claim 3 further comprising a metal ring sealingly connected between said closure member and the rim of said jacket portion, at least a part of the inner surface of said metal ring forming together with the bent marginal portion of said focusing coating, said annular channel and being provided with said insulating layer.

5. An electron tube as claimed in claim 4, in which the metal ring is provided with a flange projecting inwardly and then bent over parallel to the inner surface of the ring thus forming a gutter-shaped space therewith, said flange being coated on the inner and outer sides thereof with a vitreous insulating material, the metal focusing coating exceeding the flange and being separated therefrom by the insulating layer.

6. An electron tube as claimed in claim 4 in which the said one window has a spherical surface.

7. An electron tube for electron optical image conversion comprising a closed envelope of insulating material including a jacket portion having an axis of symmetry, and two opposite end portions each provided with a transparent window arranged about said axis, a photo-cathode layer disposed adjacent the inner surface of one window,

an anode structure mounted within said envelope around said phosphor screen and defining a passage for electrons emitted by said photo-cathode, an electrically conductive focusing coating provided on the inner surface of said jacket portion,

a first metal ring sealing connecting said jacket portion to said one end portion having the window with the photo-cathode layer, a second metal ring sealingly interrupting said jacket portion at a distance from said first metal ring,

a metal sleeve disposed within and spaced from said jacket portion, said focusing coating and one end of said sleeve being connected to said second ring, said sleeve protecting the section of the jacket portion between the two rings from accidental contamination by the photo-cathode material.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,787,745

Dated January 22, 1974

Inventor(s) CHRISTIAAN J.G. WULMS

It is certified that error appears in the above-identified patent
and that said Letters Patent are hereby corrected as shown below:

On the title page change Inventor's name from "Christian"
to --Christiaan--.

Signed and sealed this 18th day of June 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents