ELECTRON OPTICS FOR A MINIFYING IMAGE TUBE

DESCRIPTION OF THE PRIOR ART

Heretofore, minifying image tubes, such as image intensifier tubes and X-ray converter tubes, have employed a succession of cylindrical focusing and accelerating electrodes disposed between the curved photocathode and a flat image converter screen. However, in these prior art tubes the final or anode electrode of the smallest diameter had its electron entrance aperture or mouth portion disposed downstream from the exit opening in the next preceding electrode such that an axial gap was created between the upstream end of the anode and the downstream end of the next preceding electrode. This electrode geometry results in distortion of the electron image as focused upon a flat image converter screen such that resolution is degraded near the outer perimeter of the image as compared to the resolution obtained near the center of the image. It is desired to obtain electron optics for such minifying image tubes which will yield a uniformly high resolution over the entire image of the converter screen.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of improved electron optics for a minifying image tube.

One feature of the present invention is the provision, in a minifying image tube, of an electron accelerating and focusing electrode structure including an anode electrode which projects at its upstream end into the exit portion of the next preceding electrode structure, whereby the equipotentials at the mouth of the anode are shaped to obtain near uniform resolution of the electron image focused on a flat converter screen over essentially all parts of the converter screen.

Another feature of the present invention is the same as the preceding feature wherein each of the focusing and accelerating electrodes is cylindrical with the mouth portions of each successively smaller electrode being disposed within the exit portion of the next preceding larger electrode to define a series of convergent electron focusing lenses.

Another feature of the present invention is the same as any one or more of the preceding features wherein the electrode structure upstream from the anode has an exit portion with dimensions constricted substantially relative to the dimensions of its upstream mouth portion.

Other features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view of a minifying image tube incorporating features of the present invention,

FIG. 2 is an enlarged detail view of a portion of the structure of FIG. 1 delineated by line 2—2 and depicting a prior art electrode structure, and

FIG. 3 is a schematic line diagram of a portion of the structure delineated by line 3—3 of FIG. 1 and depicting the shapes of the equipotentials for the electrode structure of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is shown a minifying image tube 1, in this case an X-ray converter tube, incorporating features of the present invention. The minifying image tube 1 includes an evacuable envelope structure 2, as of glass, having an outwardly domed spherical shaped face plate portion 3. A similarly domed conductive electrode structure 5, which is transparent to an X-ray photon image which passes through the face plate 3, is mounted within the domed face plate 3. A scintillator layer 6 is deposited on the inside concave surface of the conductive electrode 5 and a photocathode 7 is deposited over the inside surface of the scintillator layer 6.

X-ray photons passing through an object to be observed, pass through the face plate 3, conductive electrode 5 and are partially absorbed in the scintillator layer 6 to produce an optical photon image corresponding to the X-ray image to be observed. The photon image is partially absorbed in the photocathode 7 to convert the photon optical image into an electron image which is emitted into the evacuated envelope 2 from the photocathode 7.

A flat image converter screen 8, made of a conventional fluorescent material, is disposed at the end of a narrow neck portion of the envelope 2 at the opposite end of the tube 1. A very thin conductive layer 9, as of aluminum, is deposited over the converter screen 8 for applying a uniform electrical potential to the screen 8.

An electrode structure 11 is disposed between the photocathode 7 and the image converter screen 8 for accelerating and focusing the electron images emitted by the photocathode 7 onto the image converter screen 8 where an electron image is converted into an optical image for observation or use. In a typical tube 1, the diameter of the image focused upon the image converter screen 8 is approximately one/tenth of the diameter of the electron image produced from the photocathode 7. Thus, the electrode structure 11 serves to minify the image obtained from the photocathode 7 by a relatively large factor, such as by a factor of 10.

The electrode structure 11 includes a hollow cylindrical anode or fourth focus electrode 12 disposed adjacent the image converter screen 8 and operated at the same potential, as of about 25 kV positive with respect to the cathode, as that applied to the image converter screen 8 via the conductive electrode 9. The electrical potential for the anode 12 is supplied from a source of potential 13 via lead 14 and a feedthrough electrode 15.

A third focus electrode 16 is disposed immediately upstream from said anode electrode 12. The third electrode 16 includes a cylindrical mouth portion 17 which is constricted near its midpoint 18 and further constricted at its downstream exit portion 19. The upstream end or mouth portion 21 of the anode electrode 12 is disposed within the exit opening 19 in the third electrode 16. This geometry approximates that of a two cylinder electron lens and greatly facilitates obtaining uniform resolution of the electron image focused over