United States Patent

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[54] **ELONGATED APERTURE ELECTRON GUN STRUCTURE FOR FLAT CATHODE-RAY TUBE**
9 Claims, 6 Drawing Figs.

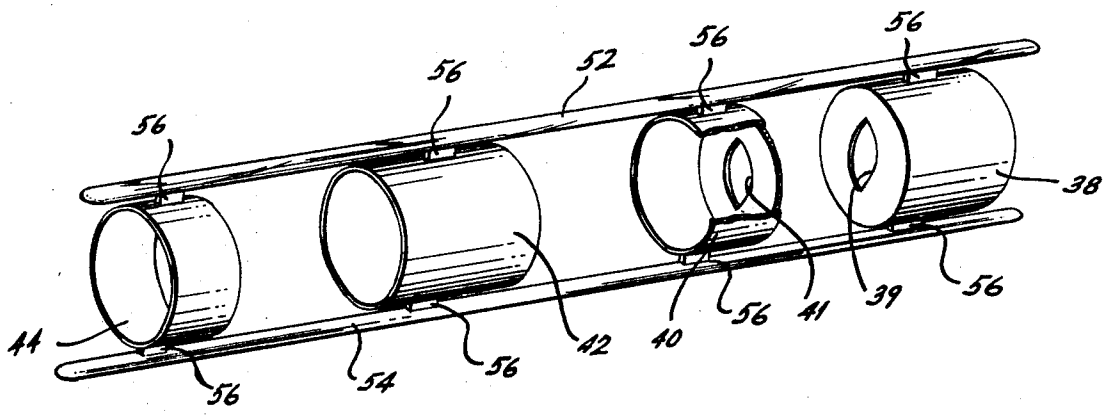
[52] **U.S. Cl.** **313/86,** 313/299
[51] **Int. Cl.** **H01j 1/46,** H01j 29/46
[50] **Field of Search** ..... 313/86, 85 (S); 313/83, 82, 299

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ABSTRACT: An electron gun for a flat cathode-ray tube wherein the control electrode and the screen electrode of the gun each have an elliptical aperture therein, and a flat cathode-ray tube employing such a gun. The major axes of the two elliptical apertures lie in a common plane which is oriented with respect to the faceplate of the tube so that an electron beam emitted by the cathode of the gun produces a substantially circular spot on said faceplate.



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2 Sheets-Sheet 1

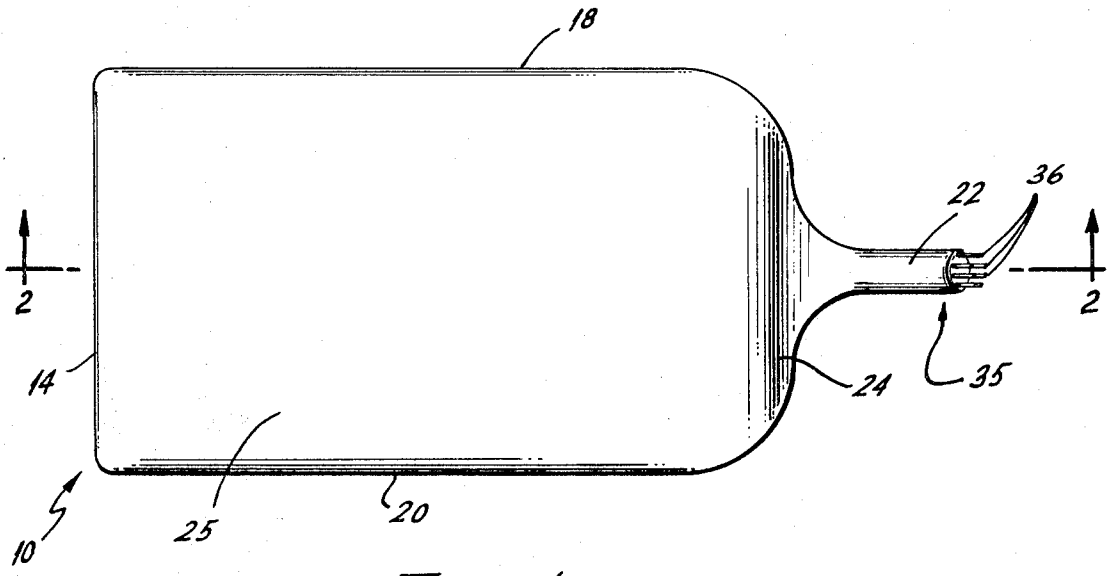


FIG. 1.

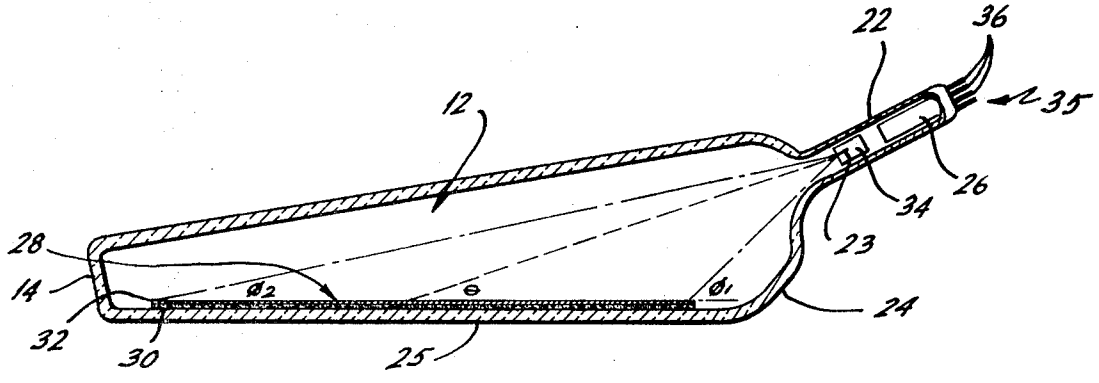


FIG. 2.

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FIG. 3.

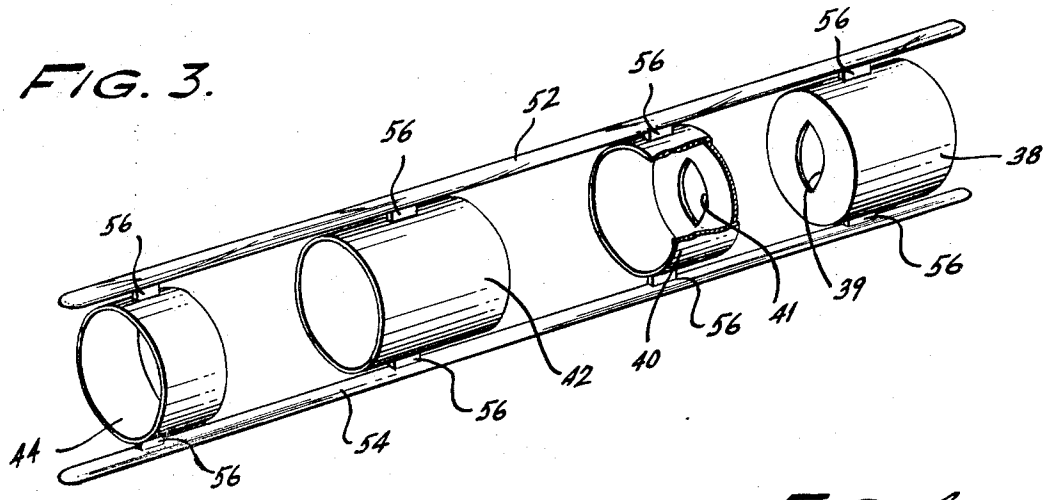
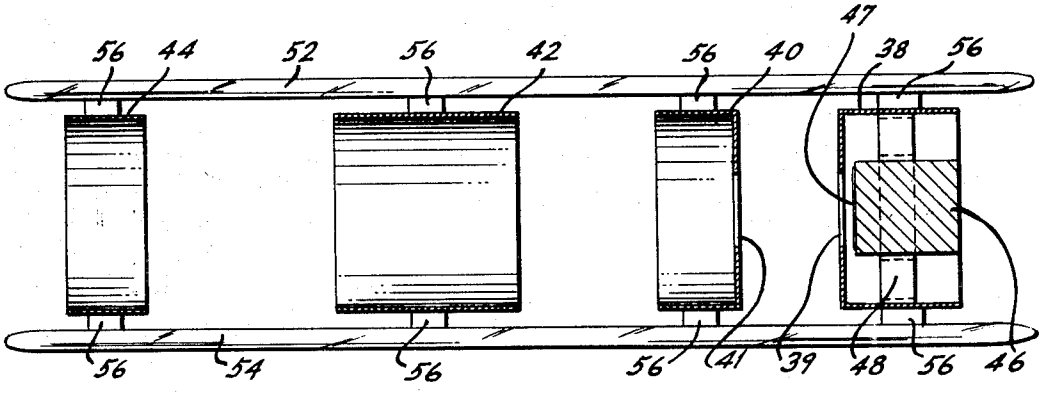


FIG. 4.



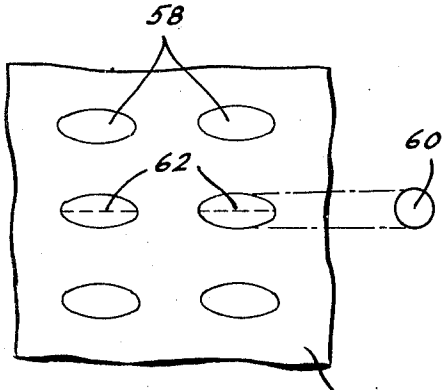


FIG. 5.

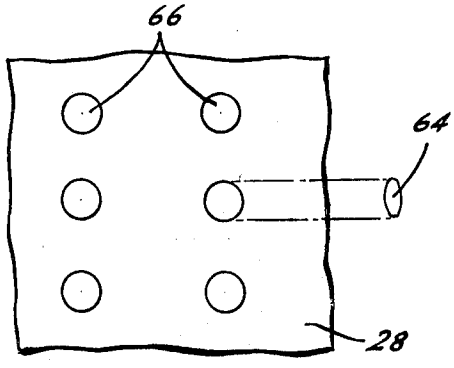


FIG. 6.

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ELONGATED APERTURE ELECTRON GUN STRUCTURE FOR FLAT CATHODE-RAY TUBE

Cathode-ray tubes in which the viewing faceplate is substantially flat and the beam deflection system of tube is positioned so that a line from the center of deflection of the tube to the center of the faceplate of the tube makes an acute angle with the faceplate (hereinafter referred to as "flat cathode-ray tubes" or "flat tubes") are advantageous because they have flat viewing screens and occupy less space in a direction perpendicular to the faceplate than do cathode-ray tubes in which the line from the center of deflection to the center of the faceplate is perpendicular to the faceplate. The latter tubes are referred to hereinafter as "conventional tubes." However, flat tubes have beam-focusing problems not found in conventional cathode-ray tubes. Because of the aforedescribed angular relationship in a flat tube, an electron beam of circular cross section produces, wherever it impinges on the faceplate, an elliptical spot elongated in substantially a single direction. By contrast, in a conventional cathode-ray tube, an electron beam of circular cross section produces a circular spot of light when perpendicular to the faceplate of the tube and, when not perpendicular, produces a spot elongated in a direction which changes as the point of impingement of the beam is changed. In both kinds of tubes it is desirable that a sharply focused circular spot of light be produced wherever the beam impinges the viewing screen. To this end, focus correction systems for altering the cross-sectional shape of the beam have been proposed for conventional tubes. However, since the way in which spots elongate in flat tubes is considerably different from the way in which spots elongate in conventional tubes, the focus correction systems applicable to conventional tubes are useless in flat tubes.

An object of the present invention is to provide a cathode-ray tube short in a direction perpendicular to the viewing screen.

Another object is to provide a flat cathode-ray tube with an improved electron gun for providing defocusing correction.

A further object is to provide an electron gun the beam of which produces a substantially circular spot wherever it impinges the faceplate of a flat cathode-ray tube.

In general, these and other objects of the present invention are achieved in a flat tube by use therein of an electron gun the control electrode and the screen electrode of which have respective elongated apertures therein.

Preferably, the apertures in the control electrode and the screen electrode are elliptical with coplanar major axes. Such electrodes supply an electron beam of elliptic cross section to the main focusing lens of the electron gun. The major axes of the elliptical apertures are oriented so that the plane defined by said major axes intersects the screen of the tube along a line which extends in a direction transverse to the direction of elongation of the spots which would be produced on the screen if a beam of circular cross section were incident thereon. Preferably the aforementioned plane intersects the screen of the tube along a line which is perpendicular to the aforementioned direction of elongation. Due to the orientation of the elliptical apertures and the acute angle that exists in a flat cathode-ray tube between the line extending from the center of deflection of the tube to the center of the faceplate of the tube, the region of the faceplate impinged by the elliptically shaped beam is substantially circular, and therefore a high resolution image can be formed by the beam on the faceplate of the tube.

Other objects and features of the invention will become apparent in the course of the following detailed description of the accompanying drawings, of which:

FIG. 1 shows a perspective view of a flat cathode-ray tube incorporating an electron gun structure according to the invention;

FIG. 2 is a sectional view of the tube shown in FIG. 1 taken along the line 2–2 and viewed in the direction indicated by the arrows;

FIG. 3 is a perspective view, partly in section, of the electron gun of the present invention;

FIG. 4 is a side elevation in section of the electron gun of FIG. 3; and

FIGS. 5 and 6 illustrate respectively the shape of spots produced on a section of faceplate of a flat cathode-ray tube comprising an electron gun which produces a beam of circular cross section and the shape of spots produced on a section of the faceplate of a flat cathode-ray tube comprising the electrode gun structure of FIGS. 3 and 4.

FIGS. 1 and 2 show a flat cathode-ray tube in accordance with the present invention. The tube includes an envelope **10** comprising a viewing section **12** having a side panel **14**, top and bottom panels **18** and **20**, respectively, a neck section **22**, and a flat faceplate **25**. A funnel section **24** connects the neck section **22** to viewing section **12** at an angle such that a line from the center of deflection **23** of the tube to the center of faceplate **25** forms an acute angle θ with faceplate **25**. An electron gun **26** in neck section **22** is adapted to project an electron beam onto a target **28** which in the embodiment of the invention shown is a luminescent screen on faceplate **25**. Screen **28** may comprise a layer **30** of phosphor material with a film **32** of aluminum thereon. Alternatively, screen **28** may be any other type of electron-beam-responsive screen such as the type of screen used in a storage tube. Beam deflection apparatus **34** is disposed between the electron gun **26** and the viewing section **12** for deflecting the electron beam across the screen **28**. Beam deflection apparatus **34** may comprise a first pair of electrostatic plates and a second pair of electrostatic plates oriented perpendicular to the first pair of plates. Alternatively, apparatus **34** may comprise a first pair of coils whose axes extend in one direction and a second pair of coils whose axes are perpendicular to the axes of the first pair of coils. Where electrostatic plates are used deflection of the electron beam is achieved by applying appropriate potentials to the plates. Where coils are used deflection of the electron beam is achieved by passing appropriate currents through the coils. While the deflection apparatus **34** is depicted as located within envelope **10**, it is to be understood that deflection apparatus **34** may be located outside envelope **10**.

Neck **22** is closed at its free end with a stem structure **35** which includes a plurality of lead-in conductors **36** for applying suitable voltages to the electrodes of the electron gun.

FIGS. 3 and 4 show the principal elements of electron gun **26** of FIG. 1. Gun **26** comprises a tubular control electrode cup **38**, a tubular screen electrode cup **40**, and a focusing-accelerating lens comprising tubular electrodes **42** and **44**. A tubular thermionic cathode **46** (FIG. 4) is mounted in a centrally apertured insulating disc **48** which in turn is fixed within the control electrode cup **38**. Cathode **46** is closed at one end, and is coated on the other end with an electron-emissive material to provide a circular electron-emissive surface **47**. To heat cathode **46** a heater of conventional form (not shown) may be provided therefor. The electrodes of the electron gun are mounted in coaxial spaced relationship along a pair of insulating rods **52** and **54** by mounting studs **56** which are fixed to the electrodes and embedded in the insulating rods **52** and **54**. Typically electrodes **38**, **40**, **42** and **44** are made of "305" stainless steel, and rods **52** and **54** are made of glass.

In operation both electrode **42** and electrode **44** are supplied with potentials highly positive with respect to the potential of cathode **46**. The potential supplied to electrode **44** is higher than that supplied to electrode **42**. Electrode **42** and **44** accelerate the electron beam passing through screen electrode **40** and produce a focusing field which causes the electron beam passing through screen electrode **40** to converge to a small spot on luminescent screen **28**.

In accordance with the preferred embodiment of the present invention, electrodes **38** and **40** have therein respective elliptical apertures **39** and **41**. Apertures **39** and **41** are aligned with each other, that is, the apertures are coaxial and their major axes are coplanar, so that the shape of the electron beam passing through aperture **39** is not changed appreciably by passage through aperture **41**. To this end, aperture **41** preferably is made slightly larger than aperture **39**. Preferably

the ratio of the length of the major axis to the length of the minor axis, hereinafter referred to as "axial ratio," of each apertures **39** and **41** is between about 1.3 and about 2.5. The optimum axial ratio depends on the value of the impact angle $_2$ (FIG.2). As the value of Φ_2 is decreased, the axial ratio of apertures **39** and **41** is increased.

The major axes of apertures **39** and **41** are oriented so that the plane defined thereby intersects screen **28** along a line transverse to the direction in which the spot of light produced on screen **28** by the electron beam from gun **26** would be elongated if gun **26** produced an electron beam of circular cross section instead of a beam of elliptical cross section, or if a beam of circular cross section were projected along the line extending from the center of deflection of the tube to the center of the faceplate of the screen. Preferably, said plane intersects screen **28** along a line which is perpendicular to the aforementioned direction of elongation.

FIG. **5** illustrates the shape of spots **58** that are produced on screen **28** when the electron beam **60** incident thereon is of circular cross section. Spots **58** are elongated in the direction of dashed line **62**. Such elongated spots are undesirable because they cover unnecessarily large areas of the screen and hence degrade the image resolution obtainable with the tube.

FIG. **6** illustrates the results realized by utilizing the electron gun of the present invention positioned as described hereinbefore. In accordance with the invention, elliptical beam **64** produced by the electron gun of FIGS. **3** and **4** is oriented so that substantially circular spots **66** are produced on screen **28**.

In the embodiment of the invention shown in FIGS. **1** and **2**, that is, with the neck section **22** of tube **10** attached opposite a vertical panel **14** of viewing section **12**, the common plane containing the major axes of apertures **39** and **41** is a vertical plane. However, neck section **22** of tube **10** alternatively may be attached opposite a horizontal panel of viewing section **12**, e.g. where panel **18** not located. In such a case the major axis of each aperture is horizontal and the major axes of both apertures are coplanar.

In the embodiment of the invention wherein the structure of the electron gun is that shown in FIGS. **3** and **4**, the various electrodes typically may have the following dimensions and spacings:

Outside diameter of all electrodes, in.	.395
Inside diameters of all electrodes, in.	.375
Axes of elliptical apertures:	
Electrode 38	
Major axis, in.	.036
Minor axis, in.	.018
Electrode 40	
Major axis, in.	.044
Minor axis, in.	.022
Spacing between cathode 46 and electrode 38, in.	.006
Spacing between electrodes 38 and 40, in.	.007
Spacing between electrodes 40 and 42, in.	.040
Spacing between electrodes 42 and 44, in.	.100
Length of electrode 38, in.	.300
Length of electrode 40, in.	.110
Length of electrode 42, in.	.220
Length of electrode 44, in.	.120
Distance from center of deflection 23 to the center of screen 25, in.	8.4
Distance from cathode emitting surface 47 to the center of screen 25, in.	10.3

Suitable D.C. voltages for operating such a gun are as follows:

Electrode 38	65 v. below cathode potential.
Electrode 40	400 v. above cathode potential.
Electrode 42	400 to 800 volts above cathode potential.
Electrode 44	15 kv. above cathode potential.

Typical impact angles for such a gun are as follows:

$\Theta=20°$

$\Phi_1=45°$

$\Phi_2=13°$

The foregoing dimensions, angles and voltages are merely exemplary and the invention is not limited thereto.

While the invention has been described with reference to a particular embodiment thereof, various modifications can be made without departing from the invention. For example, the production of an electron beam of elliptical cross section by the electron gun may be facilitated by providing one or more of the electrodes thereof with an elliptical internal cross section and/or by using a cathode that emits an electron beam of elliptical cross section. The major axis of each such electrode and such electron beam should lie in the plane defined by the major axes of apertures **39** and **41**.

Moreover, where circularity of the spots formed on the faceplate of the tube is not essential, elongated apertures other than elliptical apertures may be provided in electrodes **38** and **40**. For example, the apertures in electrodes **38** and **40** can be rectangular with the long sides of one rectangular aperture parallel to the long sides of the other rectangular aperture.

Furthermore a three electrode einzel lens can be submitted for the focusing-accelerating lens comprising electrodes **42** and **44**. An einzel lens comprises a pair of electrodes each maintained at a potential highly positive with respect to the cathode and a third electrode intermediate the pair of electrodes and at a potential intermediate the cathode potential and the potential of the pair of electrodes. Accordingly, I desire the scope of my invention to be limited only by the appended claims.

I claim:

1. In a cathode-ray tube comprising an electron-beam-responsive screen, means for projecting a beam of electrons thereagainst, and electron beam accelerating-focusing apparatus, said means comprising an electron-emissive cathode, a control electrode and a screen electrode, said tube having a center of deflection for said beam, said beam-responsive screen being oriented at an angle acute with respect to a line connecting said deflection center and the center of said screen, the improvement comprising an elliptical aperture in said control electrode and an elliptical aperture in said screen electrode, the major axes of both said apertures lying in a common plane.

2. The tube of claim **1** wherein said apertures are coaxial.

3. The tube of claim **2** wherein said apertures are oriented so that said common plane intersects said screen in a direction transverse to the direction in which a spot would be elongated if produced on said screen by a beam of circular cross section projected along said line.

4. The tube of claim **3** wherein said direction of intersection is perpendicular to said direction of elongation.

5. The tube of claim **4** wherein said aperture in each of said control electrode and said screen electrode has an axial ratio of between 1.3 and 2.5.

6. An electron gun comprising an electron-emissive cathode, a control electrode and a screen electrode, the improvement comprising an elliptical aperture in said control electrode and an elliptical aperture in said screen electrode, said elliptical apertures being coaxial and having coplanar major axes.

7. The electron gun of claim **6** wherein each of said apertures has an axial ratio of between 1.3 and 2.5.

8. In a cathode ray tube comprising an electron-beam-responsive screen, means for projecting a beam of electrons thereagainst, and electron beam accelerating-focusing apparatus, said means comprising an electron-emissive cathode, a control electrode and a screen electrode, said tube having a center of deflection for said beam, said beam-responsive screen being oriented at an angle acute with respect to a line connecting said deflection center and the center of said screen, the improvement comprising an elongated aperture in said control electrode and an elongated aperture in said screen electrode, the major axes of both said apertures lying in a common plane.

9. An electron gun comprising an electron-emissive cathode, a control electrode and a screen electrode, the improvement comprising an elongated aperture in said control electrode and an elongated aperture in said screen electrode, said elongated apertures being coaxial and having coplanar major axes.