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United States Patent [19]

Hasker et al.

[11] B **3,919,583**

[45] **Nov. 11, 1975**

[54] **ELECTRON GUN WITH GRID AND ANODE HAVING ORTHOGONAL ELONGATED APERTURES**

[75] Inventors: **Jan Hasker; Jacobus Johannes Maria Joseph De Klerr,** both of Eindhoven, Netherlands

[73] Assignee: **U.S. Philips Corporation,** New York, N.Y.

[22] Filed: **July 20, 1973**

[21] Appl. No.: **381,074**

[44] Published under the Trial Voluntary Protest Program on January 28, 1975 as document no. B 381,074.

Related U.S. Application Data

[63] Continuation of Ser. No. 166,935, July 28, 1971, abandoned.

[52] **U.S. Cl.** **313/448;** 313/414

[51] **Int. Cl.²** **H01J 29/46;** H01J 29/56

[58] **Field of Search** ..... 313/83, 82 R, 82 NC, 86, 313/448, 449

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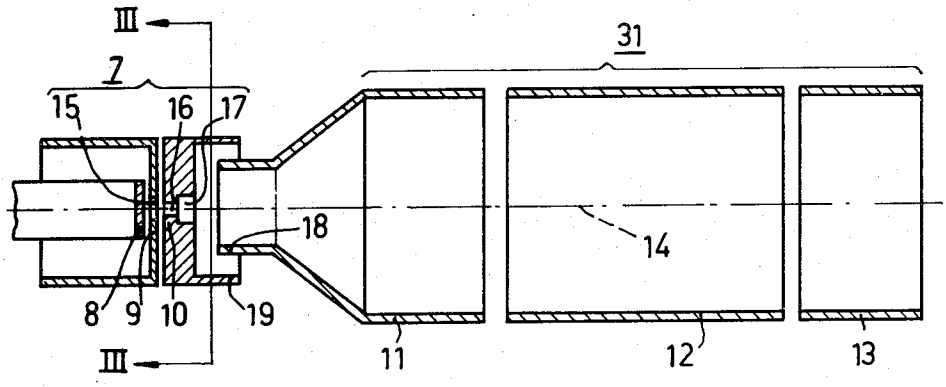
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[57] **ABSTRACT**

A cathode-ray tube, particularly an index-tube, having a narrow, elongated spot. The electron gun of the tube comprises an astigmatic lens, since its grid has a narrow, elongated opening. In order to avoid S-shaped deformation of the spot upon simultaneous deflection of the electron beam in the horizontal and vertical directions the anode of the electron gun is provided with an opening which widens up in the direction towards the target plate on the side remote from the cathode in planes parallel to a plane going through the axis of the electron gun and the direction of length of the spot produced by the electron beam at the centre of the target plate. The anode opening preferably has an elongated sectional area in planes at right angles to the axis of the electron gun the longitudinal direction of said area intersecting substantially at right angles the direction of length of the grid opening in order to reduce the dependence of the width of the spot upon the beam current.

1 Claim, 12 Drawing Figures



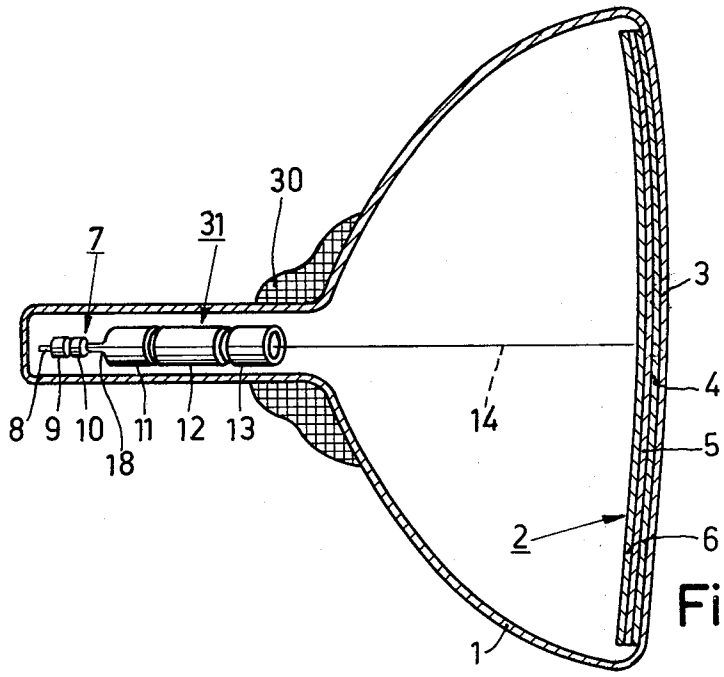


Fig.1

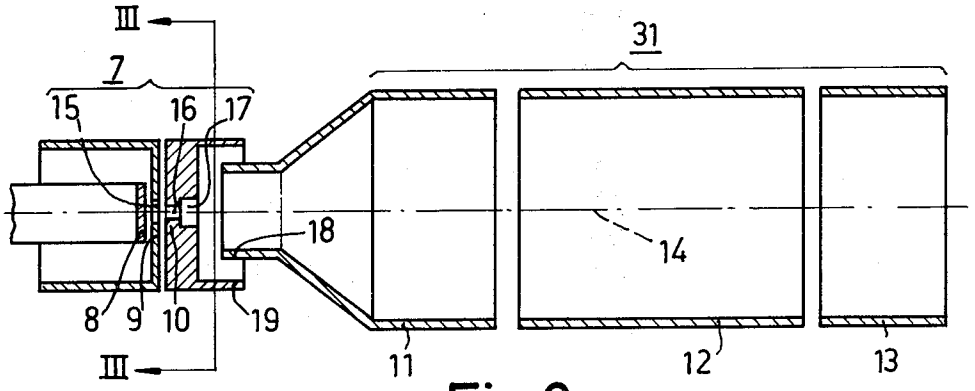


Fig.2

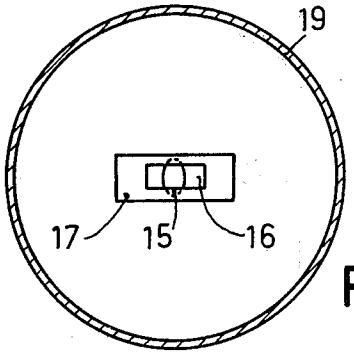


Fig.3

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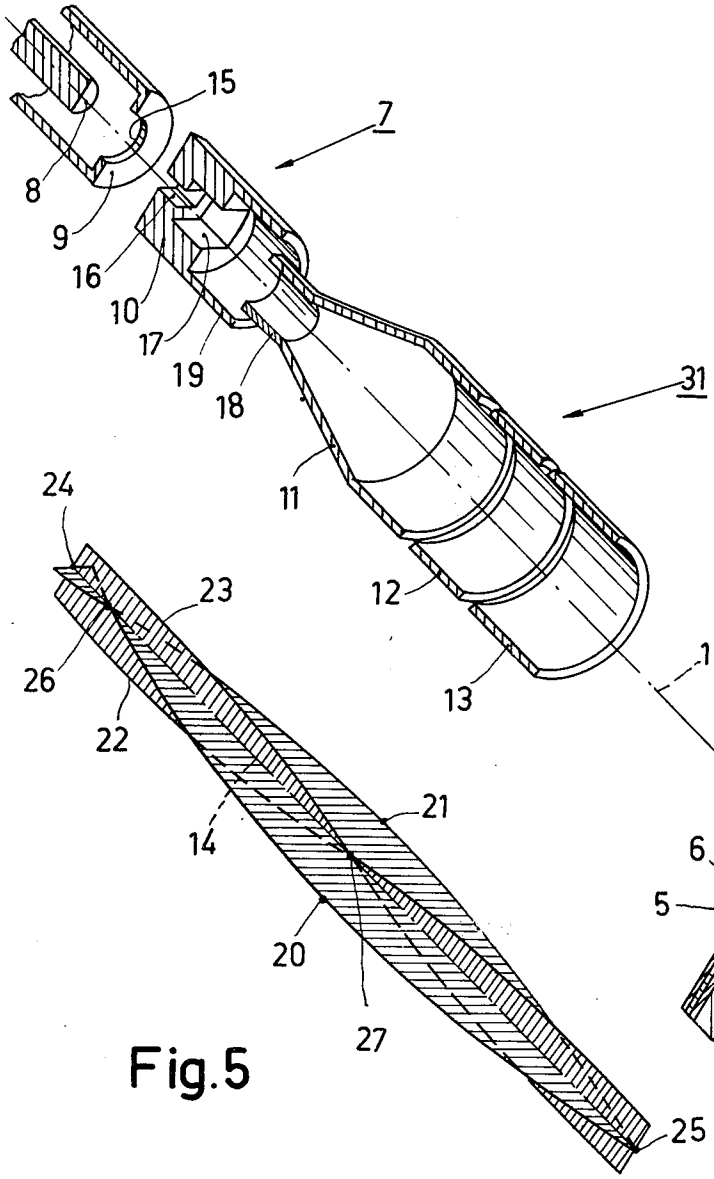


Fig.5

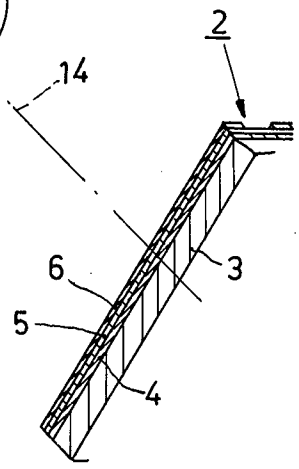


Fig.4

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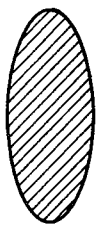


Fig.6



Fig.7

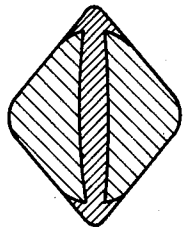


Fig.8

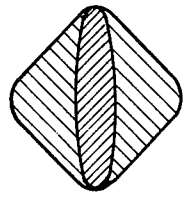


Fig.9

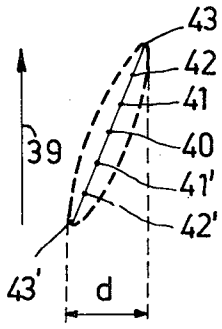


Fig.10

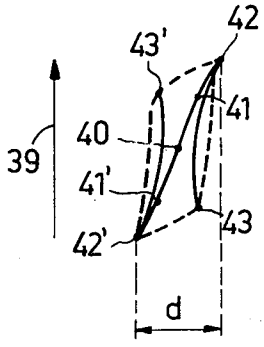


Fig.11

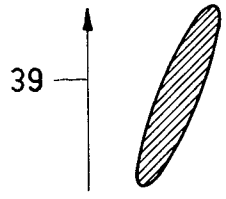


Fig.12

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ELECTRON GUN WITH GRID AND ANODE HAVING ORTHOGONAL ELONGATED APERTURES

This is a continuation of application Ser. No. 166,935, filed July 28, 1971, now abandoned.

The invention relates to a cathode-ray tube comprising an electron gun having, axially aligned, a cathode, a grid, an anode and an acceleration electrode for producing an electron beam, the cathode-ray tube further comprising a focusing lens and a target plate struck by the electron beam as a narrow, elongated beam spot. The grid has a narrow, elongated opening, whose direction of length is substantially parallel to the direction of length of the spot produced by the electron beam at the center of the target plate, so that the electron gun comprises an astigmatic lens for providing a structure of the electron beam such that electron paths in an imaginary plane extending in the direction of length of the spot are focused at a point at a given distance in front of the target plate on the electron-gun side and electron paths in an imaginary plane at right angles to the direction of length of the spot are focused substantially on the target plate.

Cathode-ray tubes of the kind set forth are known and are employed, inter alia, in devices in which the cathode-ray tube is formed by a so-called index-tube. This kind of device can display color television images, in which case the target plate of the cathode-ray tube comprises a large number of narrow, substantially parallel phosphor strips, which are scanned by the electron beam along lines at right angles to the strips by means of magnetic deflection means. Adjacent phosphor strips emit light of different colors at the impact of electrons and successive phosphor strips are separated from each other by black, non-active strips. On the side of the electron gun the phosphor strips and the black strips are covered by a very thin, electron-permeable metal layer, on which regularly spaced index-strips extending parallel to the phosphor strips, are arranged for the determination of the position of the electron beam.

In order to ensure an image of satisfactory quality, the phosphor strips and the index-strips have to be very narrow, usually, at the most, a few tenths of a millimeter. An optimum color reproduction is achieved when the dimension of the spot of the electron beam in a direction at right angles to the phosphor strips is substantially equal to the width of the phosphor strips.

In order to obtain a picture of adequate brightness, beam currents up to a few milliamperes are required. In order to avoid saturation of the phosphors by an excessive current density, the dimension of the spot in the direction of the phosphor strips has to exceed the dimension at right angles to the phosphor strips.

Dutch Pat. application No. 6717635 of the present applicant discloses an electron gun for use in a cathode-ray tube of the kind referred to in the first paragraph, in which by means of an astigmatic lens formed by the configuration of a cathode, a grid having a narrow, elongated opening, an anode and an acceleration electrode, there is obtained an electron beam whose structure is appropriate for use, inter alia, in an index-tube.

It has been found, however, that with this electron gun, at simultaneous horizontal and vertical deflections across the target plate of the electron beam whose structure is such that, with deflection means specially designed to keep the width of the deflected spot at a minimum and particularly at high beam currents, an S-shaped deformation of the elongated spot sets in, as a result of which the effective width of the spot increases.

The invention has for its object to provide a cathode-ray tube which does not exhibit this disadvantage.

According to the invention the cathode-ray tube comprises an electron gun having, axially aligned, a cathode, a grid, an anode and an acceleration electrode for producing an electron beam, and further comprises a focusing lens and a target plate struck by the electron beam in a narrow, elongated spot. The grid has a narrow, elongated opening whose direction of length is substantially parallel to the direction of length of the spot produced by the electron beam at the center of the target plate, so that the electron gun comprises an astigmatic lens for producing a structure of the electron beam such that on electron paths in an imaginary plane extending in the direction of length of the spot the electron beam is focused at a point at a given distance in front of the target plate on the electron-gun side and on electron path in an imaginary plane at right angles to the direction of length of the spot the beam is focused substantially on the target plate. The anode has an opening which widens, on the anode side remote from the cathode and in planes parallel to both a plane going through the axis of the electron gun and the direction of length of the spot of the electron beam at the center of the target plate, the opening widening in the direction towards the target plate. The invention is based on the recognition that the S-shaped deformation of the beam spot arising from simultaneous horizontal and vertical deflection of the beam across the target plate, is due to astigmatism of the deflection means, where in the non-deflected state, the distance between the point where electron paths in the plane going through both the axis of the gun and the direction of length of the spot are focused and the target plate is larger for electrons emitted at a large distance from the axis of the gun than for electrons emitted more closely to the axis, the former electrons striking the target plate, when the beam is not deflected, near the end of the longer axis of the spot, that is to say, on the same side of the axis of the gun as the latter electrons. Such aberrations in the non-deflected beam are also due to a sharp bend in the equipotential lines near the beam on the side of the anode opening remote from the cathode. By widening the anode opening on this side, in planes extending parallel to the plane going through the axis of the electron gun and the direction of length of the spot produced by the non-deflected beam, with such widening in the direction of the cathode towards the target plate, the sharp bend of the equipotential lines and hence the aberrations in the non-deflected beam and, therefore, also, the S-shaped deformation of the spot with simultaneous horizontal and vertical deflection are strongly reduced.

It has furthermore found that in a cathode-ray tube in accordance with the invention, the width of the spot at right angles to its longitudinal dimension, for a deflected beam as well as a non-deflected beam increases appreciably less with increased current strength of the electron beam than in a cathode-ray tube to which the invention is not applied.

An advantageous construction of a cathode-ray tube embodying the invention is such that the anode opening widens stepwise. This involves material advantages in the machining of the opening, while it has been

found that by this construction a high reduction of the aberrations is obtained.

It has even been found that aberrations are satisfactorily reduced when the opening widens in one step. A very advantageous construction is then such that on the side of the target plate the anode opening develops into a rectangle.

The cathode-ray tube embodying the invention is otherwise preferably constructed so that in planes at right angles to the axis of the electron gun the anode opening has an elongated sectional area, whose direction of length intersects substantially at right angles the direction of length of the grid opening. This aspect of the invention is based on the recognition that the variation of the width of the spot with the current strength of the electron beam is also due to the fact that at a higher current strength a larger portion of the cathode surface is emissive than at a lower current strength. Thus more electrons emanate from the cathode at a comparatively large distance from the axis of the electron gun. When considering electron paths in a plane at right angles to the direction of length of the spot starting from the cathode at a comparatively large distance from the axis of the electron gun in a direction parallel to said axis, it appears that after having intersected the axis near the grid such paths are further remote from the axis at the area of the anode than electron paths emanating from the cathode close to the axis. These electron paths are thus located near the edge of the anode opening, which gives rise to spherical aberration. This spherical aberration and hence the final width of the strip of impact on the target plate therefore depends upon the current strength. This dependence can be reduced by widening the anode opening in the plane concerned thus rendering it elongated, the longer axis in said plane.

The invention will be described with reference to the accompanying drawing, which shows by way of example a so-called 110° index-tube. In this tube the electron beam can be bilaterally deflected over 55° along a diagonal.

In the drawing

FIG. **1** shows a cathode-ray tube embodying the invention,

FIG. **2** depicts the geometry not to scale of an electron gun of a cathode-ray tube as shown in FIG. **1**,

FIG. **3** is a sectional view taken in the plane III of FIG. **2**,

FIG. **4** is a perspective sectional view not to scale of an electron gun, a focusing electrode, a final acceleration electrode and part of the target plate of a cathode-ray tube as shown in FIG. **1**,

FIG. **5** illustrates schematically the course of two paraxial electron paths in a plane going through the axis of the electron gun and the direction of length of the spot and of two paraxial electron paths in a plane going through the axis and being at right angles to the former plane,

FIGS. **6** to **12** illustrate various forms of the spot to show the effect of the invention.

The various parts are designated in the figures by the corresponding reference numerals.

FIG. **1** shows in the envelope **1** of a cathode-ray tube a front plate **3**, provided with a target plate **2** formed by a layer **4** having narrow phosphor strips luminescing in different colors and inactive black strips, a thin metal layer **5**, which is permeable to electrons and reflects light from the layer **4**, and a layer **6** of index-strips producing the indexing signal controlling the beam; the tube comprises furthermore an electron gun **7**, having a cathode **8**, a grid **9**, an anode **10** and an acceleration electrode **11**, a focusing electrode **12** and a final acceleration electrode **13**. The acceleration electrode **11**, the focusing electrode **12** and the final acceleration electrode **13** together form the focusing lens **31**. Fastening means for these parts are not shown, nor are their electrical connections. The electron gun **7** and the electrodes **12** and **13** are aligned with respect to the axis **14** of the tube. A set of deflection coils **30**, shown schematically, deflect the electron beam produced by the electron gun **7** across the target plate **2**. The distance of the cathode **8** from the target plate **2** is about 385 mms. The distance of the cathode **8** from the center of the focusing electrode **12** is about 60 mm. The length of the focusing electrode **12** is about 30 mm.

Referring now to FIG. **2**, reference numeral **8** designates the cathode of the electron gun **7**. The grid **9** has an elliptical opening **15**, the longer axis of which lies in the plane of the drawing and has a length of 0.69 mm. The shorter axis of the opening **15** has a length of 0.23 mm. The anode **10** has a rectangular opening **16**, which develops into a rectangular opening **17**. The long rectangular side of the opening **16** and the long rectangular side of the opening **17** are at right angles to the plane of the drawing. The rectangular sides of the opening **16** have lengths of 0.5 and 2.5 mm respectively and those of the opening **17** have lengths of 1.0 and 5.0 mm. A spout **18** of the acceleration electrode **11** is partially located inside a cylindrical portion **19** of the anode **10**. The distance between the cathode **8** and the grid **9** is 0.085 mm. The distance between the grid **9** and the anode **10** is 0.35 mm. The thickness of the grid **9** is 0.05 mm. The depth of the openings **16** and **17**, viewed in the direction of the axis **14**, is 0.2 and 0.5 mm respectively. The inner diameter of the cylindrical portion **19** is 10 mm. The inner diameter of the spout **18** is 4.5 mm and the distance between the ends of the spout **18** and of the opening **17**, measured in the direction of the axis **14**, is 3 mm.

FIG. **3** is a sectional view taken in the plane III—III in FIG. **2** in order to illustrate the edges of the openings **15**, **16** and **17** in their relative positions.

FIG. **4** shows in a perspective sectional view the electron gun **7**, the focusing electrode **12**, the final acceleration electrode **13** and part of the target plate **2**. The sectional plane goes through the axis **14** and extends parallel to the phosphor strips in the layer **4** of the target plate **2**. This sectional plane is shown in FIG. **4** in vertical position.

For illustrating the structure of the electron beam in the sectional plane of FIG. **4** and in the plane normal thereto FIG. **5** shows schematically and perspectively a few electron paths starting parallel to the axis **14** at a given distance from the center **24** of the cathode and terminating near the center **25** of the target plate. The plane drawn in vertical position contains two paraxial electron paths **22** and **23** and the perspective, horizontal plane contains two paraxial electron paths **20** and **21**. From FIG. **5** and from FIG. **4** it will be apparent that the structure of the electron beam, owing to the astigmatic lens referred to above, is such that an elongated spot having its longer axis in vertical position is obtained on the target plate **2**. The electron paths **20** and **21** are focused by the electron gun **7** at point **26** of

the axis **14** located near the grid **9**, between the grid **9** and the anode **10.** Owing to the action of the electron gun **7** together with the focusing lens **31,** formed by the electrons **11, 12** and **13,** the electron paths **20** and **21** diverging from point **26** are focused at point **25.** The electron paths **22** and **23** are focused at point **27** by the electron gun **7** co-operating with the focusing lens **31,** which point is located near the center of the focusing electrode **12.** The electron paths **22** and **23** diverging from point **27** terminate near point **25** on the longer axis of the strip of impact.

FIGS. **6, 7** and **8** illustrate schematically the shape of the spot for a non-deflected beam, at three different strengths of focusing lens and with beam currents exceeding about **1** mA and an acceleration voltage of 25 kV, for a cathode-ray tube to which the invention is not applied. The focusing lens strength can be varied by varying the potential of the focusing electrode **12.** FIG. **7** shows an electron beam spot produced with a focusing lens of higher strength than that of FIG. **6,** the beam spot of FIG. **8** being produced with a stronger focusing lens than that of FIG. **7.** In FIGS. **6** through **8** regions of high intensity are finely shaded and regions of low intensity are coarsely shaded. In fact the transitions between these regions are fairly gradual. A fairly low-strength focusing lens gives rise to a fairly thick core (FIG. **6**); with a higher strength focusing lens the core is narrower and on either side of the core a veil of low intensity can be perceived (FIG. **7**). With a still higher strength focusing lens, the core is still thinner and the veil on either side of the core is larger, but the core then assumes approximately the shape of a dumb-bell (FIG. **8**). With an increase in beam current the width of the core increases materially for the three lens strengths concerned. With reference to FIGS. **6, 7** and **8** it is stated that the length of the spot does substantially not vary with a variation of the strength of the focusing lens, because with a non-deflected beam the electron paths in a plane going through the axis of the electron gun in the direction of length of the spot are substantially focused at the optical center of the focusing lens (point **27** in FIG. **5**) and that the intensity of the veil on either side of the core of the spot of impact of FIGS. **7** and **8** decreases with an increasing distance from the core.

For a given strength of the focusing lens, at which the width of the core of the spot is substantially equal to that shown in FIG. **8,** FIG. **9** shows the shape of the spot in a cathode-ray tube embodying the invention. The cathode-ray tube is adjusted so that in a non-deflected beam electron paths in a plane extending in the direction of length of the spot and going through the axis of the electron gun are substantially focused at the optical centre of the focusing lens with the aid of an appropriate potential of the anode **10.** With the same value of the beam current the length of the spot is then smaller than without the use of the invention. A variation of the strength of the focusing lens results in a behavior of the spot which is qualitatively comparable with that illustrated in FIGS. **6, 7** and **8,** the difference being, however, that as a result of the application of the invention a dumb-bell shape is no longer produced, while, in addition, upon an increase in beam current the width of the core of the spot, even of a deflected beam, increases markedly less with different strengths of the focusing lens than without the use of the invention.

FIG. **10** shows schematically the spot, with maximum deflection both in the horizontal and the vertical directions, in the case of a paraxial structure of the non-deflected beam in the plane going through the axis of the electron gun in the direction of length of the spot of the non-deflected beam, the distance between the focusing point of electrons emitted parallel to the axis of the electron gun in this plane and the target plate being such that with maximum deflection in the horizontal and vertical directions the length of the spot is equal to the length of the spot of a non-deflected beam. The focusing in this plane in the cathode-ray tube of FIG. **1** substantially corresponds with that illustrated in FIGS. **6, 7** and **8.** The arrow **39** indicates the direction of length of the spot of a non-deflected beam. Tilting of the spot is caused by the deflection means, which are designed so that the width of the spot upon deflection is at a minimum. In FIG. **10** reference numeral **40** designates the point of impact of an electron emitted from the cathode in the direction of the axis of the electron gun; **41, 42, 43** designate the points of impact of electrons of a non-deflected beam emitted parallel to the axis of the electron gun at linearly increasing distances from the axis in the plane going through said axis in the direction of length of the strip of impact. Owing to the paraxial structure of the beam the points **41, 42** and **43** are located at linearly increasing distances from point **40.** The points **41', 42'** and **43'** are the points of impact of electrons emitted symmetrically to the electron paths associated with points **41, 42** and **43** with respect to the point of intersection of the axis of the electron gun and the cathode. The broken curve illustrates the contours of the core.

For a maximum deflection in the horizontal and vertical directions by the same deflection means FIG. **11** illustrates the points of impact of the electrons indicated in FIG. **10** in the case of a non-paraxial structure of the non-deflected beam in the plane going through the axis of the electron gun and the direction of the spot of the non-deflected beam. In this plane the distance between the focusing point of the electron paths and the target plate is larger for electrons emitted at a large distance from the axis of the electron gun than for electrons emitted nearer said axis, the former electrons impinging on the targer plate, when the beam is not deflected, near the end of the longer axis of the strip of impact, that is to say, on the same side of the axis of the gun as the latter electrons. By a suitable choice of the potential of the anode **10** the beam is focused in said plane again so that upon deflection the length of the spot remains substantially constant. The broken curve of FIG. **11** illustrates the S-shaped contours of the core of the spot upon maximum deflection in the horizontal and vertical directions. Owing to the non-paraxial structure of the beam, points **41, 42** and **43** are not located at linearly increasing distances from point **40;** but on the contrary are located, as shown in FIG. **11.**

By using the invention the situation illustrated in FIG. **10** is approached far better than without the use of the invention. This permits of using this system at higher beam currents by strongly reducing the effective width *d* (FIG. **10**) by suppressing said tilting of the spot with the aid of separate correction means. It will be obvious that, when the invention is not applied, the decrease in effective with by straightening the position is appreciably smaller.

FIG. 12 shows the shape of the core of the spot with maximum deflection in the horizontal and vertical directions in a cathode-ray tube embodying the invention. The spot being, in fact, substantially straight. As stated above, it is then useful to correct the inclined position of the straight spot by separate correction means.

The electrodes of this embodiment of the cathode-ray tube have, in operation, the following voltages relative to the cathode **8**:

Grid **9**: between about −160 and −60 V,
Anode: about 2 kV
acceleration electrode **11**: 25 kV
focusing electrode **12**: 7 kV
final acceleration electrode **13**: 25 kV.

The cathode used is an osmium-plated L-shaped cathode having an operational temperature of 1,050° C.

What is claimed is:

1. A cathode-ray tube comprising an electron gun having, axially aligned, a cathode having substantially rotational symmetry, a grid, an anode and an acceleration electrode for producing an electron beam, said cathode-ray tube further comprising an electron focusing lens and a target plate comprising stripes of electroluminescent material oriented in a first direction, said grid having a narrow, elongated opening that extends in said first direction and forms an astigmatic lens for producing an electron beam wherein electron paths lying in an imaginary plane extending in said first direction are focused at a point located at a given distance from said target plate on the side of said electron gun and electron paths lying in an imaginary plane at right angles to said first direction are focused substantially on the target plate, said anode comprising an elongated opening that has a major axis extending at substantially right angles to said first direction and that has a minimum width dimension exceeding the width of said grid opening, said anode opening intersecting the first anode face facing said grid so as to form a first aperture and intersecting the second anode face removed from said grid so as to form a second aperture, said second aperture being wider than said first aperture so that said anode opening widens in step-wise manner from said first face to said second face, said anode opening being substantially rectangular at said second anode face.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,919,583
DATED : November 11, 1975
INVENTOR(S) : JAN HASKER ETAL

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 "De Klerr"

to -- De Klerk--.

Signed and Sealed this

twenty-fifth Day of *May 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks