EUROPEAN PATENT SPECIFICATION

Date of publication and mention of the grant of the patent: 18.06.1997 Bulletin 1997/25

Application number: 95105053.3

Date of filing: 04.04.1995

Color cathode ray tube
Farb Kathodenstrahlröhre
Tube à rayons cathodiques couleur

Designated Contracting States:
DE FR GB


Date of publication of application: 18.10.1995 Bulletin 1995/42

Proprietor: KABUSHIKI KAISHA TOSHIBA
Kawasaki-shi, Kanagawa-ken 210 (JP)

Inventors:
  Minato-ku, Tokyo 105 (JP)
  Minato-ku, Tokyo 105 (JP)

  Minato-ku, Tokyo 105 (JP)
  Minato-ku, Tokyo 105 (JP)

Representative: Henkel, Feiler, Hänzel & Partner
Möhlstrasse 37
81675 München (DE)

References cited:
US-A- 4 636 683

- PATENT ABSTRACTS OF JAPAN vol. 5 no. 137
  (E-72) [809], 29 August 1981 & JP-A-56 073845
  (HITACHI SEISAKUSHO K.K.) 18 June 1981

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

The present invention relates to a color cathode ray tube and, more particularly, to a color cathode ray tube in which local doming of its shadow mask is suppressed.

Generally, in a color cathode ray tube, a shadow mask is arranged to oppose a phosphor screen comprising phosphor layers of three different colors formed on the inner surface of a panel. The phosphor screen is scanned with three electron beams emitted from an electron gun assembly through the shadow mask, thereby displaying a color image. In order to increase the color purity of the color image formed on the phosphor screen, the three electron beams emitted from the electron gun assembly must be selected by the shadow mask so that they correctly land on the corresponding phosphor layers of the three colors. For this purpose, the phosphor screen and the shadow mask must maintain a predetermined relationship with each other, i.e., the $g$ value representing the gap between the shadow mask and the phosphor screen must always fall within a predetermined range.

Generally, however, in a shadow mask type color cathode ray tube, of the electron beams emitted from the electron gun assembly, only 1/3 or less electron beams reach the phosphor screen, and other electron beams not reaching the phosphor screen collide against the shadow mask. Therefore, the shadow mask is heated by collision of the electron beams and expands to bulge toward the phosphor screen, causing so-called doming.

Doming is classified into doming in which, after an operation of a comparatively long period of time, the shadow mask body and the frame thermally expand at the same time to bulge from the central axis of the color cathode ray tube in the horizontal direction, and local doming in which the mask body locally thermally expands to bulge toward the screen within a comparatively short period of time. When the positional change of the shadow mask caused by doming exceeds the allowable range of the $g$ value, the electron beams land on the phosphor layers of the three colors with an error, thus degrading the color purity. Landing errors of the electron beams caused by doming largely differ depending on the position and luminance of the image pattern on the screen and the duration of the image pattern.

FIG. 1 shows local doming which occurs when a high-luminance image is locally displayed on the screen. Assume that a shadow mask 1 is supported by a phosphor screen 6 formed on the inner surface of a panel 2 through engagement of stud pins 3 provided to the panel 2 and elastic support members 5 mounted on a mask frame 4, to be located at a position indicated by a solid line with a predetermined gap from the phosphor screen 6. Even if an electron beam 7 having a low current density for displaying a low-luminance image collides against the shadow mask 1, the shadow mask 1 does not substantially cause a positional change, and the electron beam 7 passing through one aperture 8 located at a position A correctly lands on a corresponding phosphor layer 9. However, when an electron beam 7 having a high current density for locally displaying a high-luminance image collides against the shadow mask 1, the shadow mask 1 is locally heated and expands as indicated by an alternate long and short dash line. As a result, the aperture 8 is shifted from the position A to a position B, and the electron beam 7 does not correctly land on the corresponding phosphor layer 9 any longer, thus causing color misregistration.

As described above, when a high-luminance image is locally displayed on the screen, local mislanding occurs due to local thermal expansion of the shadow mask caused by collision of an electron beam having a high current density for displaying the high-luminance image, and this local mislanding tends to occur more likely at a portion closer to the two ends of the horizontal axis of the screen than in the central portion of the screen, especially in intermediate portions between the central portion of the screen and the two ends of the horizontal axis. This local mislanding caused by local thermal expansion of the shadow mask tends to occur more likely in a shadow mask having a larger radius of curvature.

Accordingly, to decrease mislanding caused by local thermal expansion of the shadow mask in order to prevent color misregistration, the radius of curvature of the shadow mask is preferably decreased. For this purpose, in conventional color cathode ray tubes in which the phosphor layers of three colors constituting a phosphor screen are formed as stripes elongated in the vertical direction, and a shadow mask is arranged to oppose this phosphor screen to have a plurality of slit type aperture arrays, each obtained by arranging a plurality of slit type apertures in an array in the vertical direction, aligned in the horizontal direction, a color cathode ray tube as follows is known. In this color cathode ray tube, the horizontal interval of the stripes of phosphor layers of three colors is sequentially increased from the center of the phosphor screen in the horizontal direction, and accordingly the horizontal interval of the slit type aperture arrays of the shadow mask is also sequentially increased from the center of the shadow mask in the horizontal direction, so that the radius of curvature of the section of the shadow mask in the horizontal direction is decreased, thereby suppressing mislanding caused by local thermal expansion of the shadow mask.

Recently, however, a color cathode ray tube having a flat panel is becoming the mainstream. In the color cathode ray tube having a flat panel, the curved surface of the shadow mask is also entirely flat. Therefore, if the radius of curvature of the section of the shadow mask is decreased only in the horizontal direction, as in the shadow mask described above, it is difficult to suppress doming caused by thermal expansion, especially local doming occurring within a comparatively short period of time, and to thereby eliminate mislanding.

It is an object of the present invention to provide a color cathode ray tube in which doming caused by thermal expansion of the shadow mask, particularly local doming occurring between the center and the two ends of the major
axis of the shadow mask, is effectively suppressed.

According to the present invention, there is provided a color cathode ray tube having a phosphor screen formed on the inner surface, defined by a concave curved surface, of the effective region of a substantially rectangular panel, and a substantially rectangular shadow mask opposing the phosphor screen and having an effective region defined by a curved surface. In this shadow mask, a plurality of slit type aperture arrays, each obtained by arranging a plurality of slit type apertures in an array in the direction of the minor axis of its effective region, are aligned in the direction of the major axis as known from US-A-4 636 683 or from PAJ, Vol.5, No. 137 (E-72) [809] & JP-A-56 073 845. In this color cathode ray tube, the difference \( d(k) = PL(k) - PC(k) \) between the array interval \( PL(k) \) of the slit type aperture arrays at a peripheral portion on the long side of the shadow mask and the array interval \( PC(k) \) of the slit type aperture arrays on the major axis is made to have a maximum within a distance range of 0.4h to 0.9h from the minor axis to the major axis, where \( h \) is 1/2 the length of the effective region of the shadow mask in the direction of the major axis, and the array interval of the slit type aperture arrays at the two ends of the minor axis is larger than that at the corners.

Regarding the array interval of the slit type aperture arrays, the array interval of the slit type aperture arrays at the two ends of the minor axis is set to be almost equal to that at the central portion.

With the above arrangement, even in, e.g., a color cathode ray tube having a flat panel providing an apparently natural image, the gap between the inner surface of the panel and the shadow mask can be relatively made larger at intermediate portions along the long side than at intermediate portions along the major axis, so that the radius of curvature of the section of the shadow mask at intermediate portions between the center and the two ends of the major axis of the shadow mask can be decreased in the direction of the minor axis. As a result, local doming that tends to occur at intermediate portions between the center and the two ends of the major axis of the shadow mask can be suppressed, thereby decreasing mislensing.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

**FIG. 1** is a view for explaining mislensing caused by doming of a shadow mask:

**FIG. 2** is a view showing the arrangement of a color cathode ray tube according to an embodiment of the present invention;

**FIG. 3** is a view showing a region on a phosphor screen shown in **FIG. 2** where a color image is formed;

**FIG. 4** is a graph showing the interval of the slit type aperture arrays on the horizontal axis and that on the end of the vertical axis in the horizontal direction of the shadow mask; and

**FIG. 5** is a graph showing a change in array interval of the slit type aperture arrays in the direction of the major axis of the shadow mask of the color cathode ray tube according to the embodiment of the present invention.

A color cathode ray tube according to a preferred embodiment of the present invention will be described with reference to the accompanying drawings.

**FIG. 2** shows a color cathode ray tube according to an embodiment of the present invention. This color cathode ray tube has an envelope comprising a substantially rectangular panel 12 and a funnel 13. The panel 12 has a skirt portion 11 extending from the peripheral portion of an effective region 10 defined by a curved surface. The funnel 13 is bonded to the skirt portion 11. The inner surface of the effective region 10 of the panel 12 forms an aspherical concave curved surface. A phosphor screen 14, obtained by aligning stripes of three-color phosphor layers, each emitting in blue, green, or red and elongated in the vertical direction, i.e., in the direction of the major axis, in the horizontal direction corresponding to the X-axis, i.e., in the direction of the major axis, is provided on the inner surface of the effective region 10. A shadow mask 15 is arranged to oppose the phosphor screen 14. The shadow mask 15 is substantially rectangular and consists of a mask body 16 and a mask frame 17. The mask body 16 has an effective region defined by a curved surface in which a large number of slit type apertures are formed, as will be described later. The mask frame 17 is mounted on the peripheral portion of the mask body 16. The mask body 16 is supported inside the panel 12 with stud pins 18 provided to the skirt portion 11 of the panel 12 and elastic support members 19 mounted on the mask frame 17 to engage with the stud pins 18, so that its effective region opposes the phosphor screen 14 through a predetermined gap. An electron gun assembly 23 for emitting an array of three electron beams 22B, 22G, and 22R traveling on the same horizontal plane is disposed in a neck 21 of the funnel 13.

The three electron beams 22B, 22G, and 22R emitted from the electron gun assembly 23 are deflected by the magnetic field generated by a deflecting unit 25 mounted on the outer side of the funnel 13, and scan the phosphor screen 14 horizontally and vertically through the apertures of the shadow mask 15, thereby displaying a color image on a rectangular region 26 shown in **FIG. 3**.

Regarding the slit type apertures of the shadow mask 15, a plurality of slit type apertures are arranged in an array to extend in the vertical direction through a bridge, and a plurality of slit type aperture arrays, each formed in the above manner to extend in the vertical direction, are aligned in the horizontal direction, so as to correspond to the stripes of three-color phosphor layers of the phosphor screen 14. Regarding the alignment of the slit type aperture arrays in the
horizontal direction, as shown in FIG. 4, assume that the interval of the slit type aperture arrays at the center \((X = 0, Y = 0)\) of the shadow mask 15 is \(P_0\), that the interval of the slit type aperture arrays at an end of the horizontal axis, i.e., at an end of the \(X\) axis is \(P_H\), that the interval of the slit type aperture arrays at an end of the vertical axis, i.e., at an end of the \(Y\) axis is \(P_V\), that the interval of the slit type aperture arrays at an end of a diagonal axis (at a corner) is \(P_D\), that 1/2 the number of slit type aperture arrays in the horizontal direction is \(n\), that the interval between the \((k-1)\)th and \((k)\)th slit type aperture arrays on the horizontal axis that changes from \(P_0\) to \(P_H\) is \(P_C(k)\), and that the interval between the \((K-1)\)th and \((K)\)th slit type aperture arrays at an end of the vertical axis in the horizontal direction that changes from \(P_V\) to \(P_D\) (a peripheral portion on the long side) is \(P_L(k)\). More specifically, assume that the interval of the slit type aperture arrays on the horizontal axis changes from the center of the shadow mask 15 in the direction of the horizontal axis as:

\[P_0 \ldots P_C(k) \ldots P_H\]

and that the interval of the slit type aperture arrays at an end of the vertical axis in the horizontal direction, i.e., at a portion on the long side, changes from the end of the vertical axis toward the end of the diagonal axis as:

\[P_V \ldots P_L(k) \ldots P_D\]

In order to decrease the radius of curvature of the section of the mask body in the horizontal direction, the interval \(P_C(k)\) of the slit type aperture arrays on the horizontal axis is set by equation 1 as follows with a constant \(A\):

\[P_C(k) = P_0 + A \sum_{i=1}^{k} PC(i-1)^2 \ldots (1)\]

An example of the change in interval \(P_C(k)\) of the slit type aperture arrays on the horizontal axis which is set by equation 1 is indicated by a curve 28 in FIG. 5. In contrast to this interval \(P_C(k)\) of the slit type aperture arrays on the horizontal axis, the interval \(P_L(k)\) of the slit type aperture arrays at the end of the vertical axis in the horizontal direction, as indicated by a curve 29 in FIG. 5, is set by equation 2 as follows with a constant \(Bm\):

\[P_L(k) = P_0 + \sum_{m=1}^{3} Bm \sum_{i=1}^{k} PL(i-1)^2m \ldots (2)\]

Then, when the constant \(Bm\) is appropriately selected, at an intermediate portion in the horizontal direction, the interval \(P_L(k)\) of the slit type aperture arrays at the end of the vertical axis in the horizontal direction is larger than the interval \(P_C(k)\) of the slit type aperture arrays on the horizontal axis to satisfy:

\[P_L(k) > P_C(k)\]

and the difference \(d(k)\) between them satisfying:

\[d(k) = P_L(k) - P_C(k)\]

can be maximized between the center and the end of the horizontal axis of the shadow mask, i.e., at an intermediate portion on the horizontal axis. In this case, the intervals \(P_H\) and \(P_D\) of the slit type aperture arrays at the end of the horizontal axis on the short side and at the end of the diagonal axis, i.e., at the corner, respectively, satisfy:

\[P_L < P_C\]

that is,
and, on the vertical axis, they satisfy:

\[ PL = PC \]

that is,

\[ PV = PD \]

As a practical example of this shadow mask, a shadow mask for a 28-inch color cathode ray tube will be described. In this shadow mask, there is the following choice:

- the interval of the slit type aperture arrays at the central portion of the shadow mask: \( PD = 0.70 \)
- the interval of the slit type aperture arrays at the end of the horizontal axis: \( PH = 0.84 \)
- the interval of the slit type aperture arrays at the end of the vertical axis: \( PV = 0.70 \)
- the interval of the slit type aperture arrays at the end of the diagonal axis: \( PD = 0.83 \)

The distribution of the intervals of these slit type aperture arrays is selected such that:

\[
\begin{align*}
A &= 1.903 \times 10^{-6} \\
B_1 &= 3.200 \times 10^{-6} \\
B_2 &= -1.040 \times 10^{-11} \\
B_3 &= -1.160 \times 10^{-16}
\end{align*}
\]

Then, the radius of curvature of the section of the shadow mask in the vertical direction can be set to 1,570 mm at a position 200 mm from the center of the shadow mask toward the end of the horizontal axis, which is smaller than that of 1,730 mm of a conventional shadow mask.

Therefore, when the shadow mask is formed as described above, local doming conventionally occurring at intermediate portions on the horizontal axis, i.e., local doming occurring within a distance range of 0.4h to 0.9h from the vertical axis, where \( h \) is 1/2 the length of the effective region of the shadow mask in the horizontal axis, can be suppressed, thereby decreasing local mislanding. As a result, a degradation in color purity can be greatly improved. When this shadow mask is applied to a color cathode ray tube having a flat panel, especially a color cathode ray tube that can display an image naturally, a large effect can be obtained.

When the radius of curvature of the shadow mask is decreased, as described above, the mechanical strength is improved, and a deformation of the shadow mask caused by an impact or vibration can be prevented, so that a degradation in color reproducibility caused by deformation can be prevented. Furthermore, the curved surface of the shadow mask can be formed at high precision, thereby decreasing occurrence of a defective product in the shadow mask manufacturing process.

The color cathode ray tube described above has a substantially rectangular shadow mask with an effective region defined by a curved surface opposing a phosphor screen which is formed on the inner surface, defined by a concave curved surface, of the effective region of a substantially rectangular panel. In this shadow mask, a plurality of slit type aperture arrays, each obtained by arranging a plurality of slit type apertures in an array in the direction of the minor axis of its effective region, are aligned in the direction of the major axis. In the color cathode ray tube described above, when the difference \( d(k) = PL(k) - PC(k) \) between the array interval \( PL(k) \) of the slit type aperture arrays at a peripheral portion on the long side of the shadow mask and the array interval \( PC(k) \) of the slit type aperture arrays on the major axis is maximized within a distance range of 0.4h to 0.9h from the minor axis in the direction of the major axis, where \( h \) is 1/2 the length of the effective region of the shadow mask in the direction of the major axis, the array interval of the slit type aperture arrays at the two ends of the major axis is larger than the array interval of the slit type aperture arrays at the corners, and the array interval of the slit type aperture arrays at the two ends of the minor axis is formed to be almost equal to that at the central portion, then the radius of curvature of the section of the shadow mask in the direction of the minor axis can be decreased between the center and the two ends of the major axis of the shadow mask while maintaining a small radius of curvature of the section of the shadow mask in the direction of the major axis. Therefore, local doming conventionally occurring at intermediate portions on the major axis can be suppressed to decrease local mislanding, so that a degradation in color purity can be greatly improved. When this shadow mask is applied to a color
cathode ray tube having a flat panel, especially a color cathode ray tube that can display an image naturally. A large effect can be obtained. The mechanical strength of the shadow mask is improved, and a deformation of the shadow mask caused by an impact or vibration can be prevented, so that a degradation in color reproducibility caused by deformation can be prevented. Furthermore, the curved surface of the shadow mask can be formed at high precision, thereby decreasing occurrence of a defective product in the shadow mask manufacturing process.

Claims

1. A color cathode ray tube comprising:

   an envelope including a substantially rectangular panel (12) having an inner surface defined by a concave curved surface, a funnel (13) connected to said panel (12), and a neck (21) extending from said funnel (13); a phosphor screen (14) formed on an effective region of said inner surface of said panel (12); and a shadow mask (15) which is substantially rectangular, has long and short sides, and is fixed in said panel (12), said shadow mask (15) having an effective region defined by a curved surface opposing said phosphor screen (14) and having minor and major axes, and a plurality of slit type aperture arrays, each of which is obtained by arranging a plurality of slit type apertures in an array in a direction of the minor axis of said effective region, and which are aligned in a direction of the major axis, characterized in that a difference $d(k) = PL(k) - PC(k)$ between an array interval $PL(k)$ of the slit type aperture arrays at a peripheral portion on said long side of said shadow mask (15) and an array interval $PC(k)$ of the slit type aperture arrays on the major axis is made to have a maximum within a distance range of 0.4h to 0.9h from the minor axis, where h is 1/2 a length of said effective region of said shadow mask (15) in the direction of the major axis, and an array interval of the slit type aperture arrays at an end of the major axis is formed to be larger than an array interval of the slit type aperture arrays at a corner.

2. A color cathode ray tube according to claim 1, characterized in that an array interval of the slit type aperture arrays at an end of the minor axis is substantially equal to an array interval of the slit type aperture arrays at a central portion of said shadow mask (15).

Patentansprüche

1. Farbkathodenstrahlröhre mit:

   einen Kolben mit einer im wesentlichen rechteckförmigen Frontplatte (12), die eine durch einen konkaven gekrümmte Oberfläche definierte Innenfläche hat, einem Trichter (13), der mit der Frontplatte (12) verbunden ist, und einem Hals (21), der sich von dem Trichter (13) erstreckt, einem Leuchttubeschirm (14), der auf einem wirksamen Bereich der Innenfläche der Frontplatte (12) gebildet ist, und einer Schattenmaske (15), die im wesentlichen rechteckförmig ist, lange und kurze Seiten aufweist und in der Frontplatte (12) festgelegt ist, wobei die Schattenmaske (15) einen wirksamen Bereich, der durch eine gekrümmte Oberfläche gegenüber zu dem Leuchttubeschirm (14) festgelegt ist und Neben- und Hauptachsen hat sowie mehrere Öffnungssarrays des Schlitzytyp aufweist, deren jedes durch Anordnen einer Vielzahl von Schlitzytyp-Öffnungen in einem Array in einer Richtung der Nebenachse des wirksamen Bereiches erhalten ist und die in einer Richtung der Hauptachse ausgerichtet sind, dadurch gekennzeichnet, daß eine Differenz $d(k) = PL(k) - PC(k)$ zwischen einem Arrayintervall $PL(k)$ der Schlitzytyp-Öffnungssarrays an einem Randteil auf der langen Seite der Schattenmaske (15) und einem Arrayintervall $PC(k)$ der Schlitzytyp-Öffnungssarrays auf der Hauptachse gestaltet ist, um ein Maximum innerhalb eines Abstandbereiches von 0,4 h bis 0,9 h von der Nebenachse zu haben, wobei $h_{1/2}$ einer Länge des wirksamen Bereiches der Schattenmaske (15) in der Richtung der Hauptachse ist, und wobei ein Arrayintervall der Schlitzytyp-Öffnungssarrays an einem Ende der Hauptachse größer gestaltet ist als ein Arrayintervall der Schlitzytyp-Öffnungssarrays an einer Ecke.

2. Farbkathodenstrahlröhre nach Anspruch 1, dadurch gekennzeichnet, daß ein Arrayintervall der Schlitzytyp-Öffnungssarrays an einem Ende der Nebenachse im wesentlichen gleich zu einem Arrayintervall der Schlitzytyp-Öffnungssarrays an einem Mittelteil der Schattenmaske (15).
Revendications

1. Tube à rayons cathodiques couleur comportant:
   une enveloppe comprenant un panneau (12) substantiellement rectangulaire et présentant une surface intérieure définie par une surface courbe concave, un entonnoir (13) relié àudit panneau (12) et un col (31) s’étendant à partir dudit entonnoir (13);
   un écran phosphorescent (14) formé sur une région utile de ladite surface intérieure dudit panneau (12); et
   un cache d’ombre (15) qui est substantiellement rectangulaire, qui présente un grand côté et un petit côté, et
   qui est fixé dans dudit panneau (12), dudit cache d’ombre (15) présentant une région utile définie par une surface courbe située en face dudit écran phosphorescent (14) et présentant un grand axe et un petit axe et une pluralité de groupements d’ouvertures du type fente, dont chacun est obtenu en disposant une pluralité d’ouvertures du type fente en un groupement dans le sens du petit axe de ladite région utile et en alignant les groupements dans le sens du grand axe, caractérisé par le fait
   qu’une différence \( d(k) = PL(k) - PC(k) \) entre l’intervalle \( PL(k) \) des groupements d’ouvertures du type fente, mesuré sur la portion périphérique du grand côté du cache d’ombre et l’intervalle \( PC(k) \) des groupements d’ouvertures du type fente, mesuré sur le grand axe est prévue pour valoir au maximum entre 0,4h et 0,9h, compté à partir du petit axe, selon la direction du grand axe, où \( h \) est la demi-longueur de la région utile dudit cache d’ombre (15) dans le sens du grand axe et un intervalle des groupements d’ouvertures du type fente à une extrémité du grand axe est prévu être supérieur à un intervalle des groupements d’ouvertures du type fente à un angle.

2. Tube à rayons cathodiques couleur selon la revendication 1, caractérisé par le fait qu’un intervalle des groupements d’ouvertures du type fente à une extrémité du petit axe est substantiellement égal à un intervalle des groupements d’ouvertures du type fente en une portion centrale dudit cache d’ombre (15).