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CATHODE-RAY TUBE HAVING AN
IMPROVED SHADOW MASK CONTOUR

5 This invention relates to shadow mask type cathode-ray tubes (CRT's) and, particularly, to the contour of shadow masks in such tubes.

There are two basic faceplate panel contours utilized for rectangular commercial CRT's over about a 9-inch (22.9 cm) diagonal screen size: spherical, and cylindrical. It appears that the future trend in CRT
10 design will be toward faceplate panel contours having less curvature than present CRT's. Along with this decrease in panel curvature is a corresponding decrease in shadow mask curvature. Such decrease in shadow mask curvature increases a problem known as doming. Doming occurs when
15 certain parts of the shadow mask become hotter than other parts and move outwardly from the general contour of the mask.

The present invention provides a shadow mask contour for use in CRT's having reduced faceplate
20 curvature which reduces the above-mentioned doming problem.

In accordance with the invention, a cathode-ray tube includes a shadow mask mounted therein which has curvatures along its major and minor axes, of which that
25 along the major axis is greater at the sides of the mask than at the center of the mask.

In the drawings:

FIGURE 1 is a plan view, partly in axial section, of a shadow mask color picture tube in which one
30 embodiment of the present invention is incorporated.

FIGURE 2 is a front view of the faceplate panel of the tube of FIGURE 1, taken at line 2-2 of FIGURE 1.

FIGURES 3, 4 and 5 are cross-sections of the faceplate panel of FIGURE 2 taken at lines 3-3, 4-4 and
35 5-5 respectively, of FIGURE 2.

FIGURE 6 is a compound view showing the exterior surface contours of the faceplate panel at the cross-sections of FIGURES 3, 4 and 5.

FIGURE 7 is a compound view showing the exterior surface contours of a faceplate panel of another tube embodiment.

FIGURE 8 is a plan view of a shadow mask that may be used with the faceplate panel of FIGURE 7.

FIGURE 9 is a compound view showing cross-sections of the shadow mask contours taken at lines 9a-9a, 9b-9b and 9c-9c of FIGURE 8.

FIGURE 10 is a side view of another shadow mask embodiment.

FIGURE 1 shows a rectangular cathode-ray tube (CRT), in the form of a color picture tube 10 having a glass envelope 11, comprising a rectangular faceplate panel 12 and a tubular neck 14 connected by a funnel 16. The panel comprises a viewing faceplate 18 and a peripheral flange or sidewall 20, which is sealed to the funnel 16 by a glass frit 17. A rectangular three-color phosphor screen 22 is carried by the inner surface of the faceplate 18. The screen is preferably a line screen, with the phosphor lines extending substantially parallel to the minor axis Y-Y of the tube (normal to the plane of FIGURE 1). Alternatively, the screen can be a dot screen. A multi-apertured color selection electrode or shadow mask 24 is removably mounted within the faceplate panel 12 in predetermined spaced relation to the screen 22. An inline electron gun 26, shown schematically by dotted lines in FIGURE 1, is centrally mounted within the neck 14 to generate and direct three electron beams 28 along coplanar convergent paths through the mask 24 to the screen 22. Alternatively, the electron gun can have a triangular or delta configuration.

The tube 10 of FIGURE 1 is designed to be used with an external magnetic deflection yoke, such as the yoke 30 schematically shown surrounding the neck 14 and

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funnel 16 in the neighborhood of their junction, for
subjecting the three beams 28 to vertical and horizontal
magnetic flux, to scan the beams horizontally in the
direction of the major axis (X-X) and vertically in the
5 direction of the minor axis (Y-Y), respectively, in a
rectangular raster over the screen 22.

FIGURE 2 shows the front of the faceplate panel
12. The periphery of the panel 12 forms a rectangle with
slightly curved sides. The border of the screen 22 is
10 shown with dashed lines in FIGURE 2. This border is
rectangular.

The specific contours along the minor axis
(Y-Y), major axis (X-X) and the diagonal are shown in
FIGURES 3, 4 and 5, respectively; and a comparison of the
15 relative contours of the exterior surface of the faceplate
panel 12 along the minor axis, major axis and diagonal is
shown in FIGURE 6. The exterior surface of the faceplate
panel 12 is curved along both the major and minor axes,
with the curvature along the minor axis being greater than
20 the curvature along the major axis, at least in the center
portion of the panel 12. The surface curvature along the
diagonal is selected to smooth the transition between the
different curvatures along the major and minor axes. In a
preferred embodiment, the curvature along the minor axis
25 is at least $4/3$ greater than the curvature along the major
axis, at least in a central portion of the faceplate. In the preferred
embodiment, the contour along the diagonal from center to corner of
the faceplate has at least one sign change of its second derivative
(that is, the second derivative of the equation defining the curvature
30 of the contour) such as shown in FIGURES 5 and 6.

Because of the differing curvatures along the
major and minor axes and along the diagonal, the height A
of the panel skirt 20 can be made constant around the
periphery of the panel 12, as illustrated in FIGURES 3 to
35 5. In order to achieve such constant skirt height, it is
necessary to properly smooth the faceplate contour between
the edge of the screen and the skirt. If such smoothing
presents difficulties, skirt height will vary slightly

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around the tube periphery in a scallop fashion; i.e., it will be slightly higher at the diagonal than at the ends of the major and minor axes. The present invention encompasses both such skirt alternatives.

5 Because of the differing curvatures along the major and minor axes, the points on the exterior surface of the panel directly opposite the edges of the screen 22 substantially lie all in the same plane P. These substantially planar points, when viewed from the front of
10 the faceplate panel 12, as in FIGURE 2, form a contour line on the exterior surface of the panel that is substantially a rectangle superposed on the edges of the screen 22. Therefore, when the tube 10 is inserted into a television receiver, a uniform width border mask or
15 bezel can be used around the tube. The edge of such a bezel that contacts the tube at the rectangular contour line also is substantially in the plane P. Since the periphery border of a picture on the tube screen appears to be planar, there is an illusion created that the
20 picture is flat, even though the faceplate panel is curved along both the major and minor axes.

 In one tube embodiment, the faceplate panel is formed from two smoothed cylindrical surfaces, the axes of which are perpendicular. The radii of the two cylindrical
25 surfaces are chosen so that, when the two surfaces are made tangent at the center of the panel, there is a plane perpendicular to the Z axis that intersects the surfaces and forms a rectangle at the intercept therewith. The following equation can be used to determine the geometric
30 parameters of the panel surface contour along the major and minor axes:

$$R_1 - 1/2 \sqrt{4R_1^2 - l_1^2} = R_2 - 1/2 \sqrt{4R_2^2 - l_2^2},$$

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where:

R_1 = radius of curvature along the major (X)

axis;

R_2 = radius of curvature along the minor (Y) axis; .

l_1 = cord length of the panel in the major (X) axis direction; and

l_2 = cord length of the panel in the minor (Y) axis direction.

The actual panel contour is described by segments of circles parallel to the X-Z plane and having radii varying from one value on the X axis to a relatively large value at the ends of the minor axis, and by segments of circles parallel to the Y-Z plane and having radii varying from another value on the Y axis to another relatively large value at the ends of the major axis. The radius on the minor (Y) axis is shorter than the radius on the major (X) axis, wherefore there is greater curvature along the minor axis than along the major axis.

The radii of the circular segments at the ends of the major and minor axes are sufficiently large that, when the faceplate is viewed at normal viewing distances, portions of the faceplate at the edges of the screen appear as straight lines. Such radii could be infinite, whereby the periphery border of the panel would be truly planar, or very long, whereby the sides of the periphery border would bow slightly out of a plane but still be considered to be substantially planar.

The contour of the interior surface of the faceplate 18 of the panel 12 is slightly different from the exterior surface contour. This is because a certain amount of wedging must be added to the faceplate thickness to optimize the strength-to-weight ratio of the faceplate panel, such as shown in FIGURE 5. The faceplate 18, therefore, increases in thickness from its center to its edges. In most embodiments, a larger amount of wedging occurs along the minor axis (Y-Y) than along the major axis (X-X). The amount of wedging required varies with tube size and other design considerations. Generally, the wedging required is of the order of approximately 1 to 3

mm. In another embodiment, it has been found desirable to include a faceplate panel which is thicker at its corners than at the ends of its major and minor axes.

5 The curvature of the shadow mask 24 somewhat parallels the curvature of the interior surface of the faceplate 18. However, one deviation from such parallel relationship is well known in the art, e.g., from U. S. Patent 4,136,300, issued to A. M. Morrell on January 23, 1979. The mask deviations of that patent, as well as the
10 aperture spacing variations taught therein, can be applied to the present inventive tube structure.

The faceplate surface curvature variation of another inventive CRT is shown in FIGURE 7. In this embodiment, the curvature along the minor axis is similar
15 to that of the embodiment of FIGURE 6. The curvature along the major axis, however, is much less in the central portion of the faceplate and increases near the edges of the faceplate. In this embodiment, the curvature along the major axis, near the edges of the faceplate, is
20 greater than the general curvature along the minor axis. With this design, the central portion of the faceplate becomes flatter, while the points of the faceplate exterior surface at the edges of the screen substantially remain in a plane P and define a rectangular contour line,
25 as in the previously described embodiment.

The corresponding shadow mask for the CRT faceplate panel of FIGURE 7 is somewhat similar in contour to the panel. The contour of such a shadow mask can be generally obtained by describing the major (X) axis
30 curvature as a large radius circle over about the central 75% portion of the major axis, and a smaller radius circle over the remainder of the major axis. The curvature parallel to the minor (Y) axis is such as to smoothly fit the major axis curvature to the required mask periphery
35 and can include a curvature variation as is used along the major axis.

FIGURE 8 shows a plan view of one embodiment of such a inventive shadow mask 32. The dashed lines 34 show

the border of the apertured portion of the mask 32. The surface contours along the major (X) and minor (Y) axes of the mask 32 are shown by the curves 9a and 9b, respectively, in FIGURE 9. The mask 32 has a different curvature along its major axis than along its minor axis. The contour along the major axis has a slight curvature near the center of the mask and greater curvature at the sides of the mask. Such mask contour exhibits some improved doming characteristics because of the increased curvature near the ends of the major axis.

In an alternative embodiment, a shadow mask has the same curvature along both the major and minor axes in the central portion of the mask, but greater curvature at the ends of the major axis. The curvatures along the edges of the mask that parallel the major axis are less at the sides of the mask than is the curvature along the major axis, and, as shown in FIGURE 10, the second derivative of the contour 36 along the minor axis is opposite in sign to that of the second derivative of the contour 38 at the sides of the mask 40 which are parallel to the minor axis.

As with the above-described faceplate panels, the contours along the shadow mask diagonals must be smoothed to compensate for the different curvatures. Such smoothing results in a center-to-corner contour along the diagonals which has at least one sign change in its second derivative, such as contour 9c in FIGURE 9.

It should be appreciated that the present invention is applicable to a wide variety of CRT's, including shadow mask color picture tubes of line or dot screen types.



1 CLAIMS:

1. A cathode-ray tube including a shadow mask mounted within said tube, said shadow mask including a substantially rectangular active apertured portion through which electron beams pass, and said mask within said active apertured portion having curvatures along its major and minor axes, wherein the curvature along the major axis is greater at the sides of said active apertured portion than at the center of said mask.

2. A tube as defined in Claim 1, wherein said shadow mask has a different curvature along its major axis than along its minor axis.

3. A tube as defined in Claim 1, wherein the curvatures along the edges of the shadow mask paralleling the major axis are less at the sides of the mask than the curvature along the major axis at the sides of the mask.

4. A tube as defined in Claim 1, wherein the center-to-corner contour of said shadow mask has at least one sign change of its second derivative.

5. A tube as defined in Claim 1, wherein the second derivative of the contour along the minor axis is of opposite sign to the second derivative of the contour at the sides of the mask paralleling the minor axis.

6. A tube as defined in Claim 1, wherein the curvature in each of planes parallel to the minor axis is greater at the sides of said mask than near the major axis thereof.



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1 7. A cathode ray tube having a shadow mask
substantially as hereinbefore described with reference
to Figures 8 and 9 or Figure 10 of the accompanying
drawings.

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8. A cathode ray tube having a faceplate
substantially as hereinbefore described with reference
to Figures 3-7 of the accompanying drawings and a shadow
mask as in any preceding claim.

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