

COLOR PICTURE TUBE HAVING SHADOW MASK
WITH IMPROVED APERTURE SPACING

This invention relates, generally, to color picture tubes of a
5 type having shadow masks for use with dot screens, wherein the
shadow mask apertures are round, nearly round, elliptical or
nearly elliptical and are usually aligned in staggered rows and
columns; and, particularly, to an improved spacing between the
rows and columns of such apertures.

10 Several factors may cause misregistry of an electron beam
with a phosphor element on a color picture tube screen. One of
these factors is the thermal expansion of a shadow mask of the
tube, when the mask is heated by electron beams from an
electron gun of the tube that strike the mask. The shadow mask
15 is usually attached to a peripheral frame that surrounds the mask.
During tube operation, heat from the mask flows into the frame,
creating a differential in temperatures between the center and
peripheral portions of the mask. Because of this differential, the
mask center, mask periphery and frame expand at different rates.
20 These different expansion rates result in an arching or doming of
the shadow mask. Because of such doming, the electron beams
passing through the mask misregister with the phosphor elements
of the tube screen. One method of compensating for mask doming
is taught in U.S. Patent 4,136,300, issued to A. M. Morrell on
25 January 23, 1979. That patent discloses the desirability of
increasing the curvature of a mask to reduce electron beam
misregister caused by mask doming. The patent also teaches that,
with the increased curvature, the horizontal center-to-center
spacing between shadow mask apertures should be increased
30 from the center of the mask to the ends of the horizontal axis.

In the design of dot screen type color picture tubes that can
be used in video displays, it is desirable to utilize greater mask
curvature along with variable aperture spacing, in order to gain
the advantage of reduced misregister as well as the additional
35 advantages of being able to use higher anode power, providing
simpler manufacturability, increased mask strength and reduced

microphonics. However, a problem exists, relating to how aperture spacing should be varied in order to obtain a screen with uniformly straight parallel rows of phosphor dots, to minimize moiré.

5 In accordance with the present invention, an improved color picture tube includes a shadow mask and a dot screen, wherein the mask is rectangular and has two horizontal long sides and two vertical short sides. The long sides parallel a central major axis of the mask, and the short sides parallel a central minor axis of the
10 mask. The mask includes an array of apertures arranged in vertical columns and horizontal rows. Apertures in one row are in different columns than are the apertures in adjacent rows. The vertical spacing between apertures in the same column is the vertical pitch of the apertures, and the horizontal spacing between
15 apertures in the same row is the horizontal pitch of the apertures. The improvement comprises the horizontal pitch of the apertures increasing from the minor axis to the short sides of the mask and decreasing from the major axis to the long sides of the mask. Also, along the major axis, the vertical pitch of the mask decreases
20 from the center to the short sides of the mask and, adjacent the long sides of the mask, it increases from the minor axis to the corners of the mask.

In the drawings:

FIGURE 1 is a partially sectioned axial side view of a color
25 picture tube embodying the present invention.

FIGURE 2 is a front plan view of a shadow mask-frame assembly of the tube of FIGURE 1.

FIGURE 3 is a small section of the shadow mask of the assembly of FIGURE 2, used for illustrating aperture pitch.

30 FIGURE 4 is a small section of a dot screen of the tube of FIGURE 1, illustrating dot pitch.

FIGURE 5 is an upper right quadrant of the shadow mask of FIGURE 2, showing the curvatures of various rows and columns of apertures in the mask and presenting horizontal and vertical
35 pitches for a particular embodiment of the mask.

FIGURE 6 is an upper right quadrant of the shadow mask embodiment of FIGURE 5, showing the horizontal pitches between apertures within rows at four locations.

FIGURE 7 is an upper right quadrant of the shadow mask embodiment of FIGURE 5, showing the vertical pitches between apertures within columns at four locations.

FIGURE 8 is an upper right quadrant of the viewing screen of the tube of FIGURE 1, associated with the shadow mask of FIGURE 5, showing the horizontal center-to-center spacing between the centers of phosphor dot triads at four locations.

FIGURE 9 is an upper right quadrant of the viewing screen of the tube of FIGURE 1, associated with the shadow mask of FIGURE 5, showing the vertical center-to-center spacing between the centers of phosphor dot triads at four locations.

FIGURE 1 shows a rectangular color picture tube 10 having a glass envelope 11 comprising a rectangular faceplate panel 12 and a tubular neck 14 connected by a rectangular funnel 15. The funnel 15 has an internal conductive coating (not shown) that extends from an anode button 16 to the neck 14. The panel 12 comprises a viewing faceplate 18 and a peripheral flange or sidewall 20, which is sealed to the funnel 15 by a glass frit 17. A three-color phosphor screen 22 is carried by the inner surface of the faceplate 18. The screen 22 is a dot screen, with the phosphor dots arranged in triads, each triad including a phosphor dot of each of three colors. A multi-apertured color selection electrode or shadow mask 24 is removably mounted, by conventional means, in predetermined spaced relation to the screen 22. An electron gun 26, shown schematically by dashed lines in FIGURE 1, is centrally mounted within the neck 14, to generate and direct three electron beams 28 along convergent paths through the mask 24 to the screen 22.

The tube of FIGURE 1 is designed to be used with an external magnetic deflection yoke, such as the yoke 30 shown in the neighborhood of the funnel-to-neck junction. When activated, the yoke 30 subjects the three beams 28 to magnetic fields which cause the beams to scan horizontally and vertically in a

rectangular raster over the screen 22. The initial plane of deflection (at zero deflection) is at about the middle of the yoke 30. Because of fringe fields, the zone of deflection of the tube extends axially from the yoke 30 into the region of the gun 26.

5 For simplicity, the actual curvatures of the deflected beam paths in the deflection zone are not shown in FIGURE 1.

The shadow mask 24 is part of a mask-frame assembly 32 that also includes a peripheral frame 34. The mask-frame assembly 32 is shown positioned within the faceplate panel 12 in
10 FIGURE 1. The shadow mask 24 includes a curved apertured portion 25, an imperforate border portion 27 surrounding the apertured portion 25, and a skirt portion 29 bent back from the border portion 27 and extending away from the screen 22. The mask 24 is telescoped within (or, alternatively, over) the frame
15 34, and the skirt portion 29 is welded to the frame 34.

The shadow mask 24, shown in plan view in FIGURE 2, has a rectangular periphery with two long sides and two short sides. The mask 24 has a major axis X, which passes through the center of the mask and parallels the long sides, and a minor axis Y, which
20 passes through the center of the mask and parallels the short sides. The mask 24 includes an array of round apertures 36, arranged in staggered vertical columns 38 and horizontal rows 40, as shown in detail in FIGURE 3. The columns 38 approximately parallel the minor axis Y, and the rows 40 approximately parallel
25 the major axis X. The apertures in one row are in different columns than the apertures in the adjacent rows. The vertical spacing between adjacent apertures in the same column is defined as the vertical pitch a_v of the apertures, and the horizontal spacing between adjacent apertures in the same row is defined as
30 the horizontal pitch a_h of the apertures.

The screen 22 includes a pattern of phosphor dots 42 arranged in staggered vertical columns 44 and horizontal rows 46, as shown in FIGURE 4. The columns 44 approximately parallel the minor axis Y, and the rows 46 approximately parallel the major
35 axis X. The vertical spacing between adjacent dots in the same column is defined as the vertical pitch D_v of the dots, and the

horizontal spacing between dots in the same row that emit light of the same color is defined as the horizontal pitch D_h of the dots.

The aperture pitch at any location on a mask can be determined by calculating either the vertical or horizontal spacing between two adjacent apertures at the location. This calculation can be performed by using the following equations (1) and (3) for the vertical position Y_n of an aperture in row n and for the horizontal position X_m of an aperture in column m , of the mask, respectively.

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$$Y_n = Y_{0n} + A_1 Y_{0n} x^2 + A_2 Y_{0n}^3 x^2 + A_3 Y_{0n}^5 x^2 + A_4 Y_{0n} x^4 + A_5 Y_{0n}^3 x^4 + A_6 Y_{0n}^5 x^4 \quad (1)$$

where x is the horizontal distance of the aperture from the minor axis, along row n ;

where A_1, A_2, A_3, A_4, A_5 and A_6 are coefficients that are related to the relative curvatures of the faceplate panel and shadow mask; and

where Y_{0n} is the minor axis intercept of aperture row number n , which is determined by the equation,

$$Y_{0n} = C_1 n + C_2 n^2 + C_3 n^3 + C_4 n^4, \quad (2)$$

where C_1, C_2, C_3 and C_4 are coefficients that are related to the relative curvatures of the faceplate panel and shadow mask and n is a row number for a particular aperture row.

$$X_m = X_{0m} + B_1 X_{0m} y^2 + B_2 X_{0m}^3 y^2 + B_3 X_{0m}^5 y^2 + B_4 X_{0m} y^4 + B_5 X_{0m}^3 y^4 + B_6 X_{0m} y^6 \quad (3)$$

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where y is the vertical distance of the aperture from the major axis, along column m ;

where B_1, B_2, B_3, B_4, B_5 and B_6 are coefficients that are related to the relative curvatures of the faceplate panel and shadow mask; and

where X_{0m} is the major axis intercept of aperture column m , which is determined by the equation,

$$X_{0m} = D_1 m + D_2 m^2 + D_3 m^3 + D_4 m^4 + D_5 m^5 \quad (4)$$

5

where D_1, D_2, D_3, D_4 and D_5 are coefficients that are related to the relative curvatures of the faceplate panel and shadow mask and m is a column number for a particular aperture column.

10 The vertical pitch $a_v(76-74)$ between rows 74 and 76 is determined by solving the vertical position equation Y_n twice, once for $n = 74$ and once for $n = 76$. Note that row 75 does not contain an aperture that is in the same column as are the apertures in rows 74 and 76. The vertical pitch $a_v(76-74)$ then is
15 equal to $Y_{76} - Y_{74}$. Similarly, the horizontal pitch $a_h(80-78)$ between columns 78 and 80 is determined by solving the horizontal position equation X_m twice, once for $m = 78$ and once for $m = 80$. The horizontal pitch $a_h(80-78)$ then is equal to $X_{80} - X_{78}$.

20 In one particular embodiment the coefficients for the above equations are as follows, with all dimensions in millimeters (mm). These coefficients were selected to assure that the vertical pitch D_v of the screen dots remains constant over the entire screen.

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	$C_1 = 0.461 \times 10^0$
	$C_2 = -0.765 \times 10^{-6}$
	$C_3 = 0.632 \times 10^{-7}$
	$C_4 = -0.294 \times 10^{-10}$
5	$A_1 = -0.382 \times 10^{-6}$
	$A_2 = 0.244 \times 10^{-11}$
	$A_3 = 0.284 \times 10^{-15}$
	$A_4 = 0.321 \times 10^{-11}$
	$A_5 = -0.174 \times 10^{-15}$
10	$A_6 = 0.545 \times 10^{-20}$
	$D_1 = 7.844 \times 10^{-1}$
	$D_2 = 7.818 \times 10^{-6}$
	$D_3 = 3.858 \times 10^{-7}$
	$D_4 = 9.233 \times 10^{-10}$
15	$D_5 = -9.557 \times 10^{-13}$
	$B_1 = -1.703 \times 10^{-6}$
	$B_2 = 2.394 \times 10^{-12}$
	$B_3 = 2.412 \times 10^{-16}$
	$B_4 = 5.072 \times 10^{-11}$
20	$B_5 = -2.453 \times 10^{-15}$
	$B_6 = 3.059 \times 10^{-16}$

FIGURE 5 shows the horizontal and vertical pitches, a_h and a_v , respectively, at selected locations on an upper right quadrant of a mask, that were calculated using the specific coefficients above in the preceding equations. The pitch variations between the center, sides and corner of the mask 24 of FIGURE 5 are shown in FIGURES 6 and 7. FIGURE 6 shows that the mask horizontal pitch a_h increases from the minor axis Y to the short sides of the mask, and decreases from the major axis X to the long sides of the mask. FIGURE 7 shows that the mask vertical pitch a_v increases from the major axis X to the long sides of the mask; but, along the major axis X, it decreases from the center to the short sides of the mask and, adjacent the long sides, it increases from the minor axis Y to the corners of the mask. The increase in vertical pitch a_v

from the major axis X to the long sides of the mask usually occurs when the sides of the screen are outwardly bowed.

By using the mask specified above, a screen may be obtained that has the horizontal and vertical pitches D_h and D_v , shown in FIGURES 8 and 9, respectively. Although the screen horizontal pitch D_h increases from the minor axis Y to the short sides of the screen and decreases from the major axis X to the long sides of the screen, there is no variation in the screen vertical pitch D_v over the entire screen. Because the vertical pitch of the screen is constant over the screen, moiré is minimized.

CLAIMS

1. A color picture tube having a shadow mask and a dot screen, said mask being rectangular and having two horizontal long sides and two vertical short sides, said long sides paralleling
5 a central major axis of said mask and said short sides paralleling a central minor axis of said mask, said mask including an array of apertures arranged in vertical columns and horizontal rows, apertures in one row being in different columns than are the apertures in adjacent rows, the vertical spacing between adjacent
10 apertures within a column being the vertical pitch of the apertures and the horizontal spacing between adjacent apertures within a row being the horizontal pitch of the apertures; wherein said horizontal pitch increases from said minor axis to the short sides of said mask and decreases from said major axis to the
15 long sides of said mask, and

said vertical pitch decreases from the center of said mask to the short sides of said mask, along said major axis, and increases from said minor axis to the corners of said mask, adjacent the long sides of said mask.

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2. The tube as defined in claim 1, wherein said screen includes vertical columns and horizontal rows of phosphor dots, the vertical dot pitch on said screen being the vertical distance between two adjacent dots within the same column, comprising
25 the vertical dot pitch being essentially the same over the entire screen.

3. The tube as defined in claim 1, wherein said screen has sides that bow outwardly, comprising said vertical pitch
30 increasing from said major axis to the long sides of said mask.

