

Feb. 6, 1968

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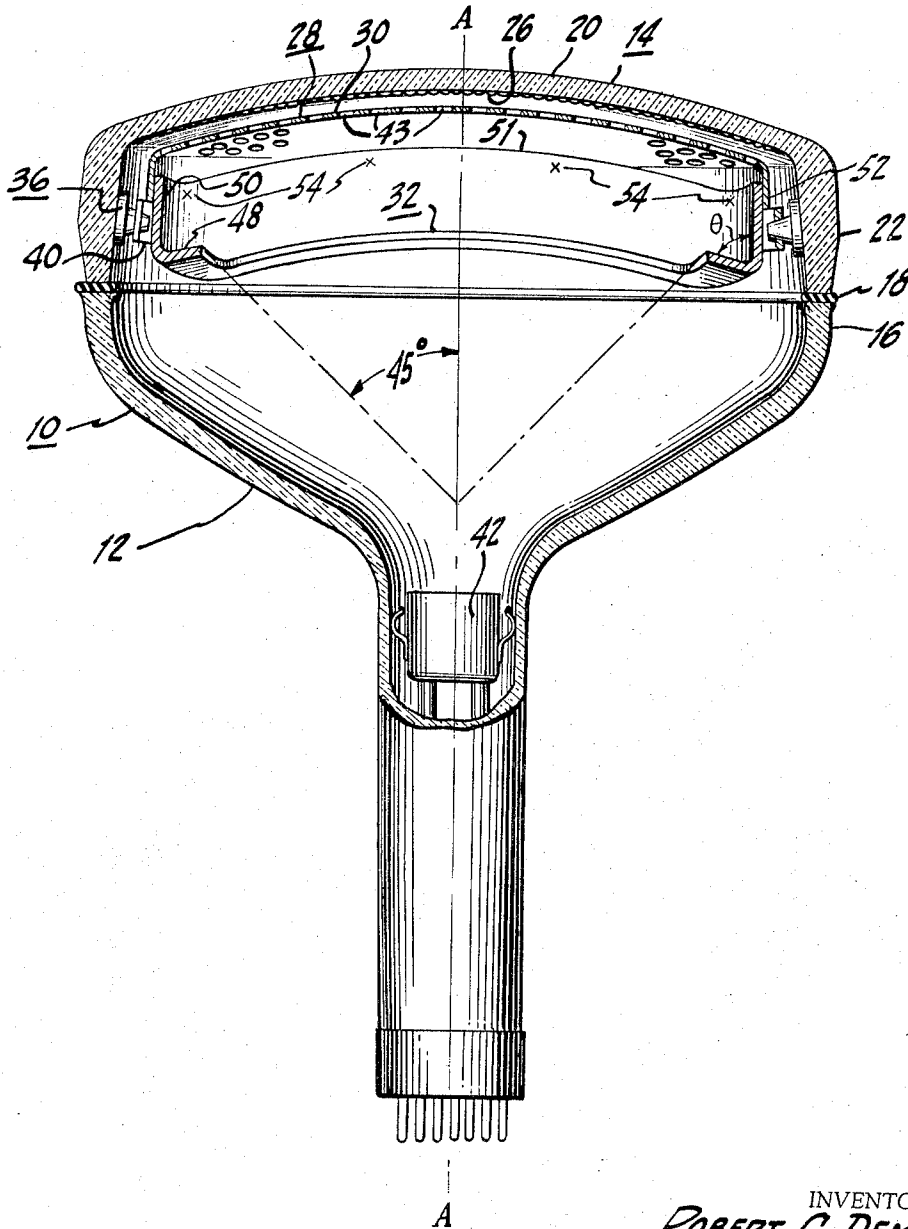
3,368,098

SHADOW MASK WELDED TO FRAME AT TWELVE POINTS

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3 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

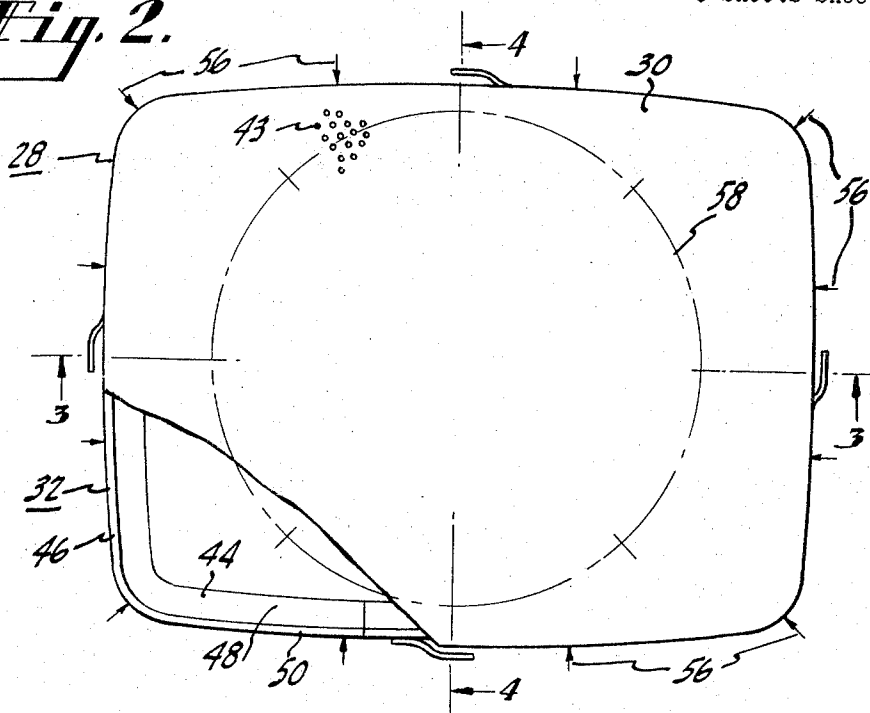


Fig. 3.

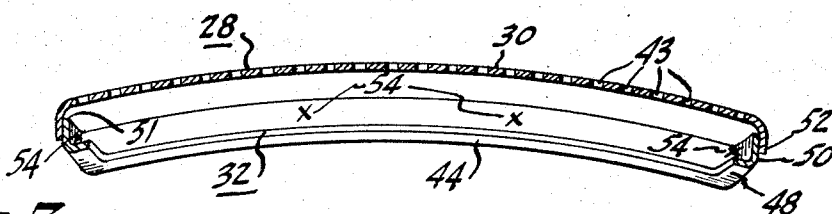
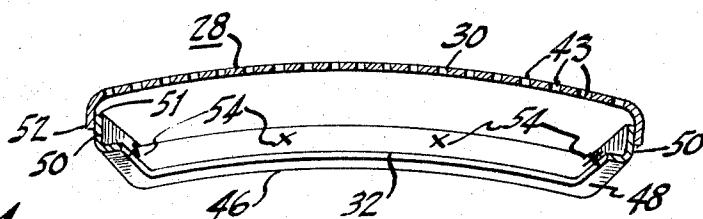


Fig. 4.



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Fig. 5.

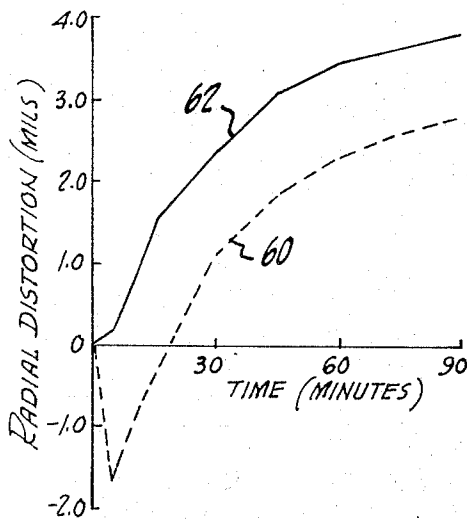


Fig. 8.

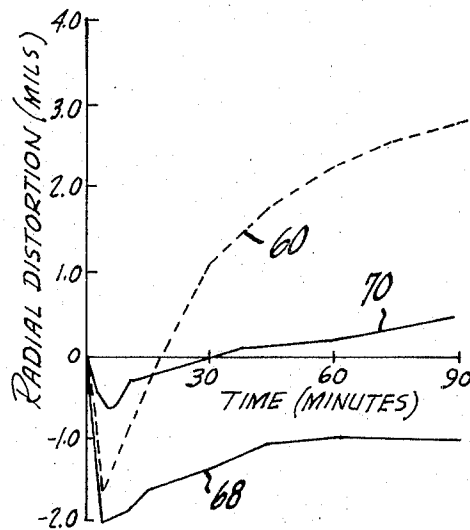


Fig. 7.

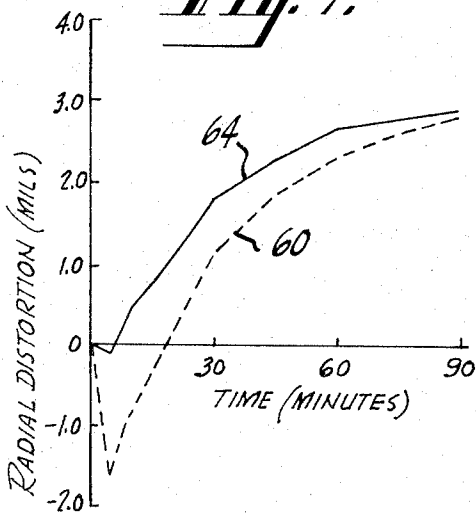
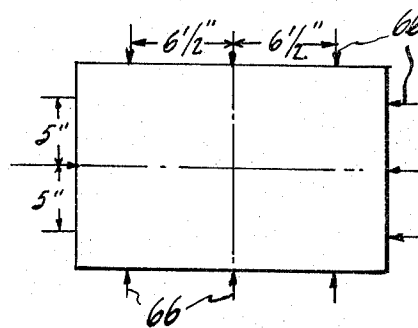


Fig. 6.



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SHADOW MASK WELDED TO FRAME AT TWELVE POINTS

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2 Claims. (Cl. 313—85)

ABSTRACT OF THE DISCLOSURE

The multi-apertured mask of a rectangular shadow mask cathode ray tube is welded to its reinforcing frame at a limited number of points, e.g. 8 to 14, to permit slight movement of the mask periphery relative to the frame during tube warm-up and thereby minimize picture distortion due to misalignment of the mask apertures and the elements of a mosaic phosphor screen. The preferred arrangement is one in which the mask is welded to the frame at twelve points distributed three on each side of the rectangle, with one weld at the midpoint of the side and the other two spaced closer to the corner than to the midpoint, at approximately two-thirds of the distance between the midpoint and the corner.

This invention relates to shadow mask color cathode ray tubes and particularly to the shadow mask electrode thereof and a method of fabricating the electrode.

Shadow mask cathode ray tubes usually comprise a mosaic screen of phosphor dots, electron gun means for exciting the screen, and a shadow mask electrode interposed between the gun and screen. The shadow mask electrode usually includes a thin, multi-apertured sheet of metal disposed adjacent to, co-extensive with, and substantially parallel to the mosaic screen, with the apertures thereof positioned in a systematic relationship with dots of the screen.

In herein describing a mask electrode as being parallel to the phosphor screen, it is not intended to exclude a mask-screen spacing relationship which varies from parallelism by a controlled amount for the purpose of obtaining a desired register of the electron beams on the phosphor dots.

In one form of shadow mask cathode ray tube, the mosaic screen and the shadow mask electrode are generally rectangular with rounded corners and outwardly bowed sides. The major surfaces of the screen and mask electrode are curved, e.g., approximately spherically curved. For the sake of brevity, such a mosaic screen and shadow mask electrode will hereinafter be referred to simply as rectangular and curved, or domed.

One form of prior art rectangular, domed shadow mask electrode comprises a domed, multi-apertured, thin metal sheet mounted across a considerably heavier rectangular frame. The frame is formed by a deep-drawing process. The frame has an L-shaped cross-section with two flanges perpendicular to each other. One flange of the L extends toward the screen and has its edge contoured to generally conform thereto. The other flange of the L is substantially planar. Consequently, the width of the contoured flange varies along the length of the frame, thus giving the frame a non-uniform cross-section. This two-piece mask electrode, when heated by electron bombardment during operation of the tube, becomes somewhat distorted to an equilibrium during the operation because of the non-uniformity of the frame cross-section. This distortion, in turn, results in a distortion of the multi-apertured sheet metal masking member. This distortion may adversely affect the color purity of the image displayed on the screen. In an improved form of shadow

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mask cathode ray tube having a domed, rectangular phosphor screen, disclosed and claimed in my application Ser. No. 374,588, filed June 12, 1964, and assigned to the same assignee, the shadow mask electrode comprises a rectangular frame of relatively thick material and a relatively thin multi-apertured sheet metal masking member mounted thereacross. The frame has an approximately L-shaped cross-section whose shape and size are substantially uniform along the length of the frame. The four sides of the rectangular frame are curved so that they are substantially parallel to the phosphor screen. The multi-apertured, sheet metal masking member is domed to also generally conform to the curvature of the screen. The uniformity of cross-section of the frame reduces the distortion of the frame and masking member with changes in temperature.

Tests on shadow mask tubes using the improved masking member frame show the existence of another form of distortion which occurs invariably during the warm-up period. The color phosphor dot pattern of the screen mosaic is normally deposited on the face plate using the mounted apertured masking electrode in the conventional "lighthouse" process when the parts are at room temperature. Thus, the electrons passing through the apertures in the masking electrode will impinge the desired phosphor dots at the beginning of operation of the tube. However, as the mask heats up by electron bombardment it expands much faster than the frame on which it is rigidly mounted because the frame is ten to fifteen times as thick as the mask and also has a smaller area exposed to beam bombardment. This causes the mask to dome out toward the mosaic screen. At the center and extreme edge of the mask, this initial distortion produces no picture distortion. However, in intermediate regions the effect is to move the apertures radially inward relative to the color phosphor dots, causing misalignment of the beam electron paths with respect to the color dots. If the electron spots were all centered on the phosphor dots under normal conditions, some misalignment due to mask distortion could be tolerated without producing color dilution in the picture, because the phosphor dots are about 16.5 mils in diameter compared with about 10 mils aperture diameter. However, for other reasons, the spots are not all centered on the phosphor dots, so that very little misalignment can be tolerated. This inward aperture distortion is arbitrarily called a negative distortion. After about five minutes the mask frame warms up and expands outwardly sufficient to begin to overcome the initial negative distortion. After about twenty minutes the distortion becomes positive as the frame expansion causes the apertures to move outwardly beyond the normal or aligned position. The positive distortion increases with time up to a maximum after about ninety minutes. The positive maximum is roughly twice the negative maximum. Since this distortion is radial it could be corrected at any desired time interval by moving the deflection yoke of the tube axially. However, since both positive and negative distortions occur, any correction in one direction would increase the distortion in the other direction, and thus, be undesirable.

An object of the present invention is to provide a domed shadow mask electrode which when heated by electron bombardment will undergo aperture position distortion substantially in only one direction during the warm-up period.

In accordance with the present invention, the apertured masking member of the shadow mask cathode ray tube is welded to its frame at not less than eight points and not more than fourteen points. Preferably, twelve welds are provided at spaced points distributed along the periphery of the mask electrode.

In the drawings:

FIG. 1 is a longitudinal view partially in section of a shadow mask color cathode ray tube embodying the invention;

FIG. 2 is a plan view of the shadow mask electrode of the tube of FIG. 1 with a part broken away;

FIGS. 3 and 4 are sections taken respectively along lines 3—3 and 4—4 of FIG. 2;

FIG. 5 is a graph showing the distortion of the shadow mask electrode with time during warm-up of the tube of FIGS. 1—4;

FIG. 6 is a sketch showing an arrangement of welds different from that of FIGS. 1—4;

FIG. 7 is a graph showing the mask distortion for the embodiment of FIG. 6; and

FIG. 8 is a graph showing the mask distortion in a tube having a masking member and frame of different materials.

Referring to the drawings, a cathode ray tube 10 includes an envelope 12 having a central longitudinal axis A—A. The envelope 12 comprises a shallow bowl-like faceplate panel 14 sealed by a frit seal 18 at its open end to a mating open end of a funnel member 16. The faceplate panel 14 comprises a rectangular, domed, faceplate 20 and a peripheral side-wall 22.

A domed, rectangular mosaic luminescent screen 26 comprising a multiplicity of elemental dot-like deposits of different color-emitting phosphors is disposed on the internal surface of the faceplate 20. The screen 26 may be aluminized according to known techniques.

A shadow mask electrode 28 is disposed adjacent to, substantially co-extensive with, and approximately parallel to the mosaic phosphor screen 26. The shadow mask electrode 28 comprises a cap-shaped domed, rectangular multi-apertured sheet metal masking member 30 telescoped with a rectangular frame 32.

A plurality of (e.g., four) electrode support studs 36 extend from the internal surface of the panel side-wall 22 at locations nearly midway between the four corners thereof.

A plurality of leaf spring support straps 40 are fixed at their one ends to the shadow mask electrode frame 32. The support straps 40 are provided with suitable apertures near their other (free) ends into which the support studs 36 are received so as to provide a detachable, readily removable and replaceable shadow mask electrode 28 within the panel 14. The spring support straps 40 are such that their apertured free ends may be depressed toward the frame 32 to permit the shadow mask electrode 28 to be mounted onto or removed from the studs 36. Such mounting of the mask electrode 28 is useful to permit quick removal and remounting of the mask electrode 28 during the manufacture of the mosaic phosphor screen 26 in accordance with known screening practices.

An electron gun assembly 42 is disposed within the neck portion of the funnel member 16. The gun assembly 42 is adapted to project a plurality of electron beams through the apertures 43 of the masking member 30 and onto the mosaic phosphor screen 26.

The frame 32 preferably comprises an endless strip of metal formed in a generally rectangular shape having two long side lengths 44 and two short side lengths 46. The strip has a generally L-shaped cross-section which is of substantially uniform size along the strip. The L is oriented with a transverse flange 48 extending inwardly toward the axis A—A from the rear edge of an axial flange 50 extending toward the screen 26.

The cross-sectional uniformity of the frame 32 results in more uniform thermal expansion characteristics than exhibited by prior art deep-drawn, variable cross-section frames. Accordingly, with the frame 32 there is less undesirable distortion of the masking member 30 than is the case with prior art deep-drawn frames.

Each of the four sides of the rectangular frame 32 is bowed both outwardly (FIG. 2) away from the central

longitudinal axis A—A of the tube 10 and along (FIGS. 3 and 4) the axis A—A toward the phosphor screen 26. The bow of the four sides 44 and 46 of the rectangular frame is such as to dispose the forward (distal, or remote from the gun) edge 51 of the axial flange 50 substantially parallel to the phosphor screen 26, i.e., the curvature of the frame sides 44 and 46 conform generally to that of the faceplate 20. Because of the bow of the frame sides 44 and 46, the transverse flange 48 is non-planar. Preferably, the transverse flange 48 is formed at an acute angle θ to the axial flange 50 so that the flange 48 is approximately parallel, that is, its major surfaces are parallel to the phosphor screen 26.

The frame 32 is of considerably thicker material than the masking member 30. It may be as much as about 15 or more times as thick. For example, in one embodiment of the shadow mask electrode 28, the frame has been made of 0.093 inch thick material whereas the masking member has been made of 0.006 inch thick material. A relatively thin masking member 30 is very desirable from a practical standpoint because it minimizes electron interception by the side walls of the apertures 43 therein. However, the thin masking member 30 is sufficiently rigid to maintain its domed shape without external support. The provision of a relatively thick, massive frame is highly desirable so as to provide a good heat sink to stabilize the operational temperature of the shadow mask electrode 28 and prevent temperature fluctuations and attendant dimensional fluctuations of the thin masking member 30. Preferably, the masking member and frame are both made of cold rolled steel which is relatively inexpensive, as compared with lower thermal expansion materials such as Invar.

As shown in FIGS. 1, 3 and 4, the masking member 30 is cap-shaped, with an axially-extending peripheral flange 52 telescoped with the upwardly extending flange 50 of frame 32. It has been the practice in the past to spot weld the flange 52 to the outside of the frame 32 at a large number of points, say fifty or more, in order to attach the two together substantially continuously along the periphery thereof.

In accordance with the present invention, I have discovered that if the number of welds is reduced to about twelve, the negative distortion of the mask during the warm-up period of tube operation is either eliminated entirely or reduced to a very small amount. Twelve weld points are indicated in FIGS. 1—4 by x marks 54 and arrows 56. In the embodiment shown there is one weld at each of the four corners, and two on each side substantially uniformly spaced apart. Preferably, each weld is substantially at or below the midpoint of the overlap of the masking member 30 and frame 32, to permit slight radial movement of the masking member 30 away from the outer edge of the flange 50 on thermal expansion and contraction of the parts during warm-up. The masking member 30 and frame 32 are manufactured with tolerances such that any inside dimension of the periphery 52 of the member 30 is equal to or up to 30 mils greater than the corresponding outside dimension of flange 50 of the frame 32. Thus, the outer edge of the flange 50 is normally initially spaced a few mils from the adjacent surface of the periphery 52 of member 30.

FIG. 5 is a graph showing the effect of the distortion of certain portions of the masking member 30 with time during the first ninety minutes of operation. The ordinate is the measured radial movement, in mils, of the electron spots, caused by movement of the apertures 43, relative to the phosphor dots of screen 26, at various times after the tube is turned on, as measured at predetermined points on a 25 inch rectangular tube with 90° deflection. These measurements were made at eight points on a circle 58 of seven inch radius shown on FIG. 2, at 12:00 o'clock 1:30, 3:00, etc., positions. The ordinate of each point on the curves in FIG. 5 is the average of the eight measurements at a particular time. The dotted curve 60 shows

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the average aperture distortion during the first ninety minutes of operation of the standard 25 inch rectangular 90° tube having a mask electrode 28 with about fifty welds. The curve 60, which is the statistical average for a large number of tubes, shows the typical initial negative distortion to a maximum of about 1.8 mils, followed by a positive distortion leveling off at about 3 mils.

The solid curve 62 in FIG. 5 shows the average aperture distortion at the seven inch radius for a tube as shown in FIGS. 1-4 having twelve welds instead of the usual fifty. It can be seen that the drastic reduction in the number of welds entirely eliminated the negative distortion which usually occurs during the first fifteen or twenty minutes. The resulting distortion is all positive, representing only outward movement of the apertures. Although the positive maximum is somewhat higher for the improved mask than for the standard mask, this can be tolerated, or corrected for. By moving the deflection yoke axially, the aperture distortion can be made zero at any desired time, as for example, at thirty minutes, since there is no negative dip to contend with.

While it is not known exactly why the use of a limited number of welds eliminates the initial negative aperture distortion, it appears that the major effect of the improved arrangement is to reduce the initial constraint of the frame on the mask. Moreover, the fact that the outer edge of the frame is spaced slightly from the mask probably contributes to the improved results by introducing more thermal isolation between the mask and frame than is present in the standard tube with about 50 welds.

I have also made and tested tubes identical to that of FIGS. 1-4 except for having eight welds (one at each corner and one at the midpoint of each side) and ten welds (with two on each long side), obtaining distortion curves very similar to curve 62 of FIG. 5 with little or no negative distortion. The use of less than eight welds does not appear practical because there is insufficient support for the masking member on the frame. Similarly, tests on tubes having fourteen welds, the same as in FIGS. 1-4 except for one extra weld on each long side, showed only about one half mil of initial negative aperture distortion during warm-up.

FIG. 7 shows the aperture distortion curve 64 obtained for a 25 inch rectangular tube identical to that of FIGS. 1-5 except for having twelve welds 66 arranged as shown in FIG. 6. As shown, instead of welding at each corner, the welds were located three on each side with one weld, at the midpoints and two at distances therefrom of 6½ inches on the long sides and 5 inches on the short sides. As shown in FIG. 6, the two outer welds are located at approximately two-thirds of the distance between the midpoint and the corner. Although the curve 64 shows a slight negative dip, the final positive maximum is little if any higher than for the standard tube, curve 60. Therefore, this arrangement is superior to that of FIGS. 1-4 having the same number of welds. The reason for this is not known.

In addition to the experiments described above on 25 inch 90° rectangular shadow mask tubes, I have also used a twelve point weld in a 19 inch 90° rectangular shadow mask tube of similar construction, and obtained an aperture distortion curve almost identical with curve 64 in FIG. 7.

In the standard 21 inch round shadow mask color cathode ray tubes, with 70° deflection that have been in use for several years, the amount of negative aperture distortion during warm-up is so small that it can be tolerated. However, in new round tubes with 90° deflection, the negative aperture distortion during warm-up is almost as large as that shown in curve 60 for 25 inch rectangular tubes. Thus, the present invention is useful in round tubes with large deflection angle, as well as in rectangular tubes.

While welding was used to attach the masking member 30 to the frame 32 in the tubes described above, it

should be understood that other forms of attachment could be used, such as riveting.

Previous tests on tubes like that of FIGS. 1-4 having as few as twenty-four welds showed no appreciable improvement over curve 60 for the standard fifty weld tube. Thus, there was no indication that further reduction in the number of welds would produce any significant improvement. Moreover, it was thought that a relatively large number of welds was necessary to produce a satisfactory rigid mount for the masking member on its frame. The present invention resulted indirectly from tests I made on a similar tube having a frame 32 of Invar and a masking member 30 of cold rolled steel. The lower solid curve 68 in FIG. 8 shows the aperture distortion measured for such a tube. This curve shows an initial negative distortion even greater than for the standard tube (curve 60), having cold rolled steel frame 32 and masking member 30, followed by a partial decrease and leveling off at a negative distortion of about -1.0 mil after the low expansion Invar frame warmed up to its equilibrium operating temperature. Examination of the mask electrode after such operation showed that the periphery of the masking member 30 adjacent to the frame 32 had become permanently distorted by buckling and crimping as a result of the constraint placed upon the masking member by the Invar frame. I discovered that this buckling could be avoided by using a small number of welds. Tests on a tube having an Invar frame with twelve welds produced the aperture distortion curve 70 of FIG. 8, which is very satisfactory. However, the use of Invar for the frame is not economical. Because of these tests with tubes with Invar frames, I decided to try using only twelve welds in the standard tube, with the unexpected results described above.

What is claimed is:

1. A shadow mask cathode ray tube comprising:

- (a) an envelope comprising an outwardly domed generally rectangular faceplate,
- (b) a mosaic phosphor screen disposed on the internal surface of said faceplate,
- (c) electron gun means for projecting electrons toward said screen, and
- (d) a domed generally rectangular shadow mask electrode mounted adjacent to said screen in the paths of said electrons,
- (e) said electrode comprising a rigid metal frame and a multi-apertured domed thin sheet metal masking member mounted across said frame,
- (f) said masking member including a peripheral edge portion attached to said frame at only twelve points located three on each side and spaced from the corners of the rectangle, one of said three points being located near the midpoint of the side and the other two points being located respectively nearer the corners than the midpoint of the side at approximately two-thirds of the distance between the midpoint and the corner.

2. A shadow mask cathode ray tube comprising:

- (a) an envelope comprising an outwardly domed generally rectangular faceplate,
- (b) a mosaic phosphor screen disposed on the internal surface of said faceplate,
- (c) electron gun means for projecting electrons toward said screen, and
- (d) a domed generally rectangular mask electrode mounted adjacent to said screen in the paths of said electrons,
- (e) said electrode comprising a rigid metal frame and a multi-apertured domed thin sheet metal masking member mounted across said frame,
- (f) said masking member including a peripheral edge portion attached to said frame at a limited number of points, the portion of each of the four sides of said masking member between the corners thereof being attached to said frame at three points only,

one of said three points being located near the midpoint of the side and the other two points being located respectively nearer the ends than the midpoint of the side at approximately two-thirds of the distance between the midpoint and the corner.

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