June 24, 1969 R. J. LINDEMAN 3,452,234

MOUNTING FOR A SHADOW MASK ASSEMBLY IN A COLOR CATHODE RAY TUBE

Filed Sept. 15, 1967 Sheet 1 of 3

FIG. 1

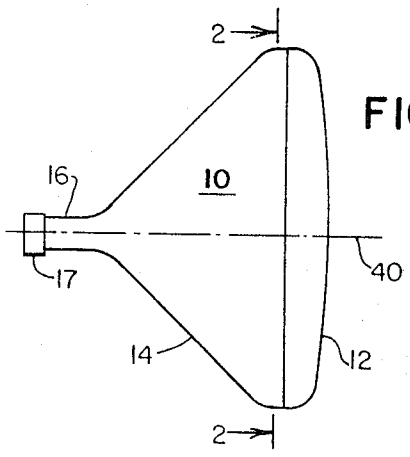
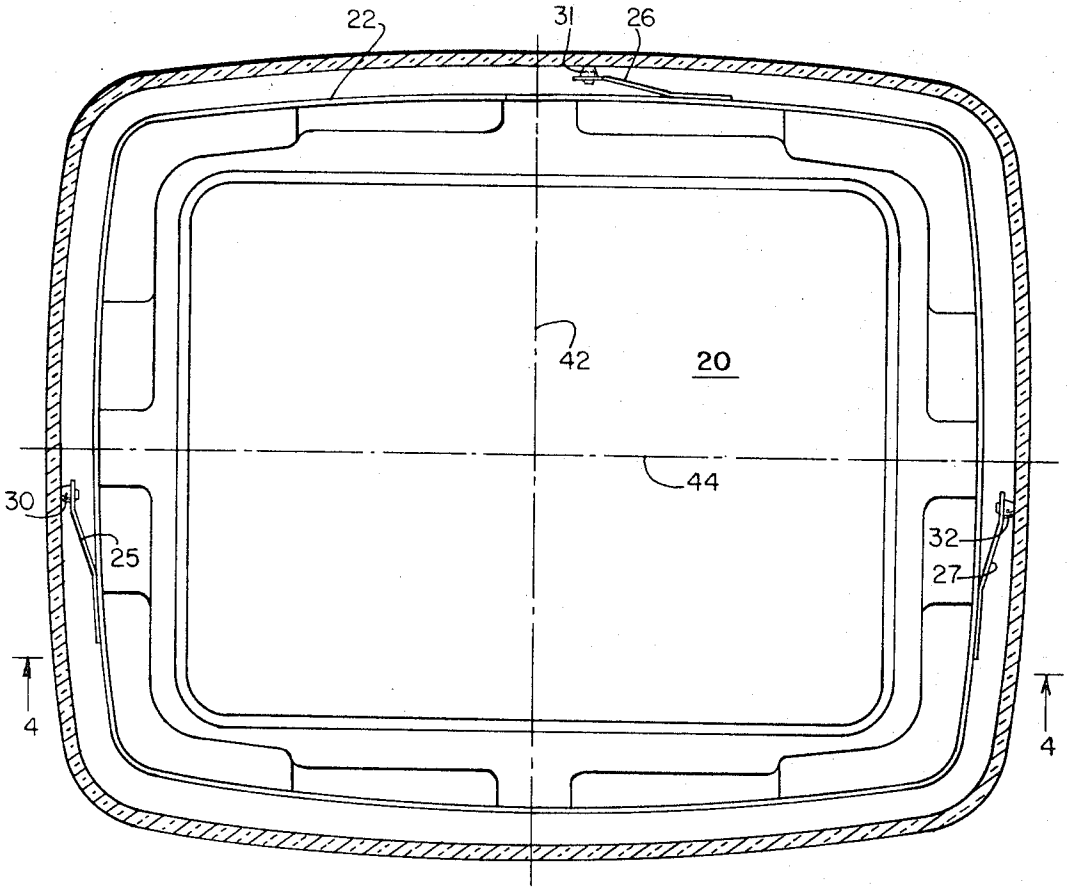


FIG. 2



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FIG. 3

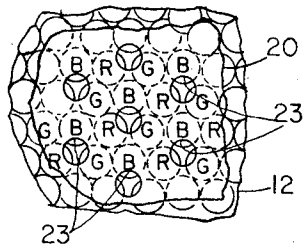


FIG. 4

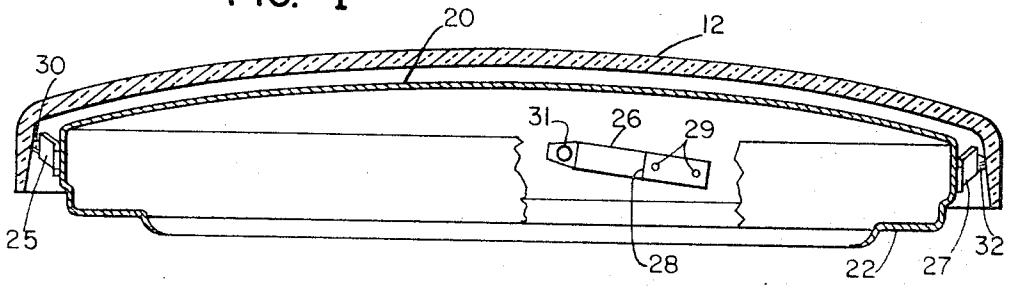


FIG. 5

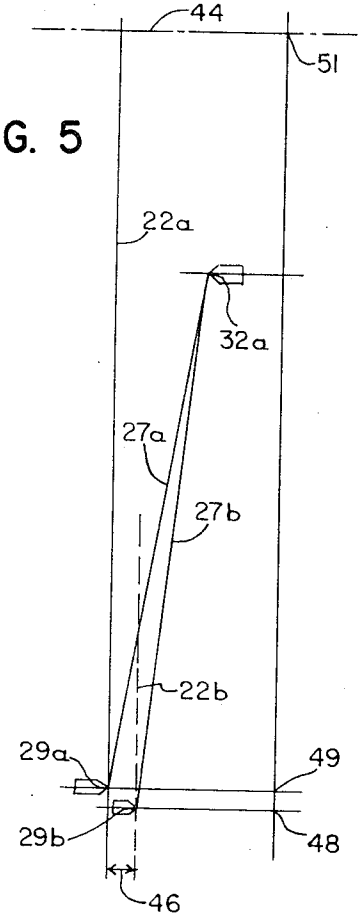
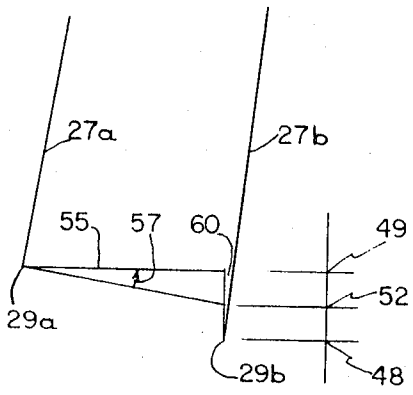


FIG. 6



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FIG. 7

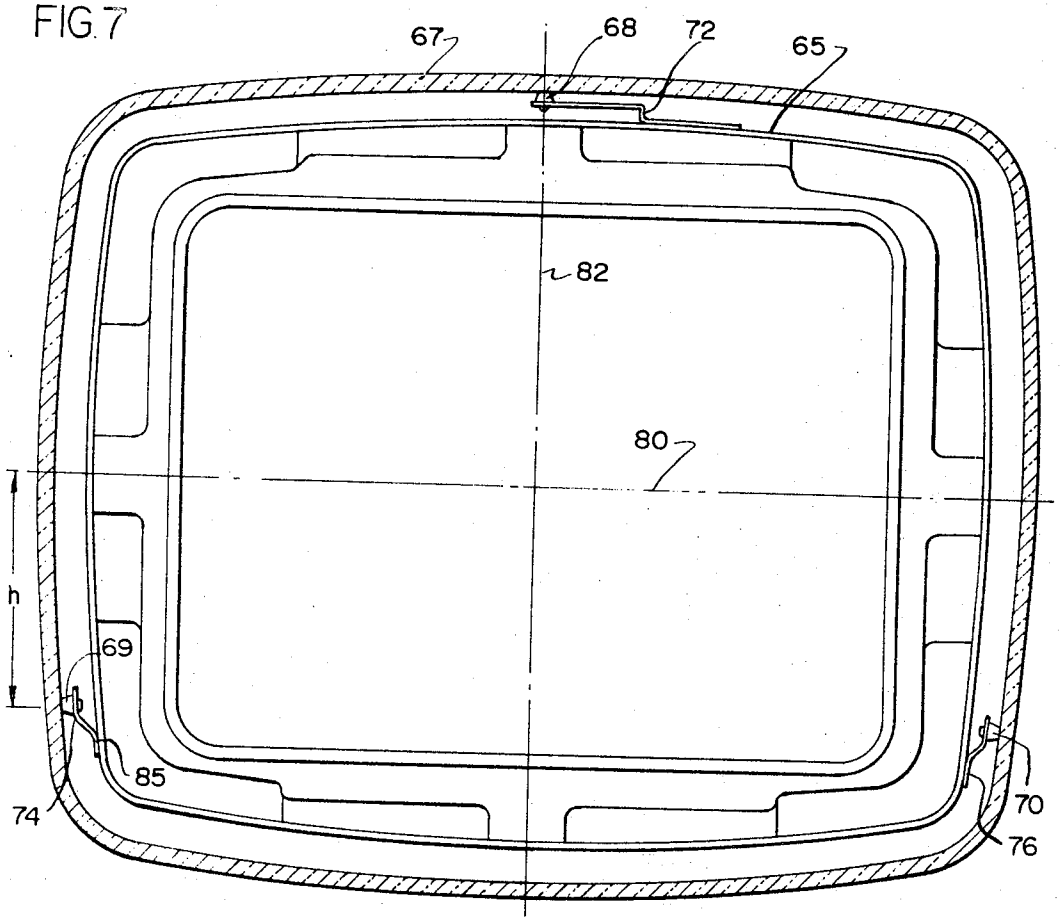
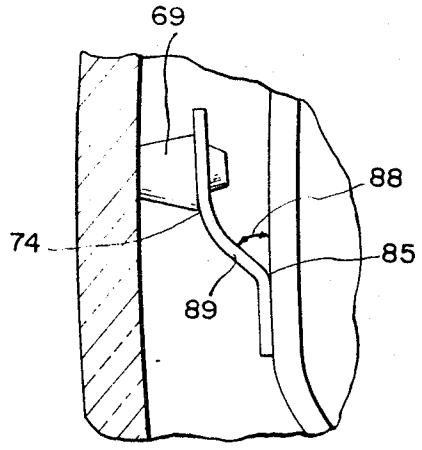


FIG. 8



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MOUNTING FOR A SHADOW MASK ASSEMBLY IN A COLOR CATHODE RAY TUBE

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Continuation-in-part of application Ser. No. 573,599, Aug. 19, 1966. This application Sept. 15, 1967, Ser. No. 672,413

Int. Cl. H01j 29/46, 19/50, 1/46

U.S. Cl. 313—85

4 Claims

ABSTRACT OF THE DISCLOSURE

A three point support for a shadow mask screen within the faceplate panel of a color cathode ray tube is provided by three studs embedded in the glass side walls of the panel and spring mounting members which are connected to the shadow mask frame and fastened to respective studs. The stud which forms the apex of a triangle formed by the three mounting studs is located on the central vertical axis. The remaining two studs forming the base of the triangle are positioned well beneath the horizontal radial axis, and are mirror images of one another. The angle between the springs connected to the two studs and the shadow mask frame is chosen so that upon tube warmup expansion of the shadow mask assembly in a direction parallel to the horizontal radial axis will cause the screen to rotate about the studs to compensate for the thermal expansion of the shadow mask assembly normal to the horizontal radial axis.

Cross reference to related application

This application is a continuation-in-part of application Ser. No. 573,599, filed Aug. 19, 1966, and assigned to the assignee of this application.

Background of the invention

This invention relates to cathode ray tubes and more particularly to the mounting structure for the electron beam mask in a shadow mask-type cathode ray tube for producing images in color.

In the widely used tri-beam cathode ray tube, a beam intercepting shadow mask has a large number of apertures, each one aligned with a triad of phosphor dots on the screen of the tube so that the selected angle of each beam passing through the apertures causes the beam to impinge only on an associated one of the phosphor dots. The three electron beams are associated respectively with red, blue and green colors of the composite image and the triads of phosphor dots are each associated with an aperture of the shadow mask so that by proper relative energization of the dots in a triad a picture element of a desired color can be produced. The overall image or picture is, of course, composed of a great number of the picture elements made up by triads of the phosphor dots.

Since the electron beams are at a high energy level in order to produce a bright image, considerable heat is generated as the beams are scanned across the shadow mask so that the mask, in intercepting the beam, will expand by a substantial amount in relation to the precision of the phosphor dot to mask aperture alignment, and in relation to the very small size of the mask apertures and phosphor dots. Proper support of the shadow mask within the faceplate panel of the tube envelope requires several spaced spring mounting members to hold the relatively heavy mask in its frame and to provide desirable resilience for this thermal expansion. The mounting members also permit removal and reinsertion of the

mask in the faceplate panel during the several process steps to form the triad phosphor dot pattern.

In the case of such cathode ray tubes having a rectangular viewing screen, wide spacing of three or four cantilever mounting springs can retain the shadow mask to satisfy the above relationships. However, lack of symmetry of the mask, as compared to a tube having a circular faceplate panel, for example, can result in nonuniform beam landing errors as the shadow mask heats up and shifts in its spring mounting. If the thermal expansion can be limited to a uniform pattern outwardly from the center of the shadow mask, the central screen area will not change in beam landing characteristic on warmup, and shadow mask areas outwardly of the center which do shift radially upon warmup can be more satisfactorily compensated to maintain improved alignment of the mask apertures with the triads of phosphor dots on the tube screen.

Summary of the invention

An object of this invention is to reduce shadow mask thermal shift in the central portion of a mask in a rectangular color picture tube and to limit the non-central thermal shift of the mask to movement in radial direction.

Another object is to achieve the above thermal shift improvement while maintaining proper shadaw mask support and stability, as well as necessary mask removability.

In a particular form of the invention, shadow mask supports, for example metallic studs, are fixed in the walls of the faceplate panel of the tube and mounting members in the form of cantilever springs fixed to the side of the shadow mask frame engaging the studs to support the mask with its apertures properly aligned with the phosphor dot pattern of the tube screen. Thermal expansion of the mask upon impingement by the electron beams causes radial mask growth tending to shift the mask at the junction point thereof with a mounting spring. This shift tends to become a slight rotation of the spring and mask frame junction about the stud engaging the spring. Since the mounting spring is generally not parallel to the side of the mask frame, this shift is partly translated into a shift normal to the central radial axis of the face of the mask. Simultaneously, the spring mounting member may change in length as its temperature rises thus tending also to cause a mask shift normal to the radial axis. These two mentioned shifts can be compensated by locating the stud support in the faceplate so that mask expansion between its junction point with the spring mounting member and the radial axis is equal and opposite to the resultant of the first two mentioned shifts. In this way the thermal movement of the central portion of the mask is reduced or eliminated and the non-central portions of the shadow mask expand radially in a manner that can be compensated more easily than in the case of non-radial shifts.

Description of the drawings

FIG. 1 is a side elevational view of a tri-beam cathode ray tube;

FIG. 2 is a sectional view along the line 2—2 of FIG. 1 illustrating the faceplate panel and shadow mask structure of the invention;

FIG. 3 is a greatly enlarged representation of a portion of the mask and screen of FIG. 2;

FIG. 4 is a sectional view of the faceplate panel and shadow mask assembly taken along the line 4—4 of FIG. 2;

FIG. 5 is a a schematic representation of a portion of the shadow mask mounting assembly, some of which is enlarged greatly out of proportion for illustrative purposes;

FIG. 6 is a still further enlarged representation of a portion of the diagram of FIG. 5;

FIG. 7 is a view similar to FIG. 2 of a further embodiment of this invention; and

FIG. 8 is an enlarged view of a portion of the device shown in FIG. 7.

Detailed description

The cathode ray tube **10** of FIG. 1 includes a faceplate panel **12** joined to a funnel portion **14** which merges into a tube neck **16**. Suitable connectors for the electrodes within the tube project from the tube base **17**. In accordance with known color picture tube consruction the neck **16** includes three different electron guns each producing a beam associated with the production of one of three colors making up the composite image.

As seen in FIG. 2 the faceplate panel **12** contains within its rearwardly projecting walls a shadow mask assembly including the apertured mask **20** and the shadow mask frame **22**. The mask **20** includes apertures **23** (FIG. 3) each of which is precisely aligned with a triad of phosphor dots marked R, B and G in FIG. 3. The phosphor dots are deposited in accordance with known techniques on the back side of the face of panel **12**. As can be understood by consideration of FIG. 3, the approach angle of electron beams directed at the mask **20** results in one beam striking only the dots marked B to produce blue light and the other two beams similarly striking the dots marked R and G to produce respectively red and green light. As previously stated relative energization of the dots in each triad will produce a picture element of the desired color.

The shadow mask **20** and its associated frame **22** are mounted within the faceplate panel **12** by means of cantilever mounting members or springs **25**, **26** and **27**. (FIGS. 2 and 4.) The springs **25–27** are secured to the shadow mask frame at appropriate weld spots **29** (FIG. 4) and have bent lines **28** across them adjacent one weld. Cantilever spring members **25–27** are each apertured at their free ends and these apertures fit over the respective mounting studs **30**, **31** and **32**. The studs **30–32** are embedded in the glass side walls of the faceplate panel **12** to become fixed mounting supports. Accordingly, the shadow mask assembly **20**, **22** is suspended within the faceplate panel **12** by means of the spring mounting member and there is some resilience in the mounting structure to allow for jarring of the tube, thermal expansion of the mask, and the like. Additionally the shadow mask can be removed, when the panel **12** is separated from the funnel **14**, by depressing the members **25–27** toward the mask frame **22** to release them from the mounting studs. This procedure is carried out several times during the formation of the phosphor dot pattern as shown in FIG. 3 which may, for example, be formed by a photo process known in the art.

The longitudinal axis **40** (FIG. 1) is intended to represent an imaginary line intersecting the vertical radial axis **42** and the horizontal radial axis **44** which divide the mask and faceplate assembly into four substantially equal quadrants. Relatively wide spacing of the springs **25**, **26** and **27** will afford improved mechanical support of the shadow mask and frame **20**, **22** which may be of substantial weight, for example, three pounds. Accordingly, it is preferable that the springs **25** and **27** join the shadow mask frame **22** in different quadrants from one another and different from the quadrant in which spring **26** is secured to the mask frame. However, when decentered, non-symmetrical spacing is used for desired mechanical stability it will result in poor registry of the electron beams passing through the apertures **23** for their intended phosphor dots (FIG. 3), because of the increased non-radial thermal expansion of the metallic mask and frame **20**, **22** with respect to longitudinal axis **40**.

In FIG. 5, **22***a* represents the side of the shadow mask frame **22**. This side is shown straight, whereas in practice it may have some curvature but that has minimal effect on the following analysis. The reference **27***a* represents a schematic showing of the mounting member **27**. This is shown extending from a support point **32***a* established at the stud **32** and a junction point **29***a* established at the side of the mask frame. The support point **32***a* will remain relatively fixed during operation of the tube and heating of the shadow mask **20** due to impingement by the electron beams. While there will be thermal expansion of the glass walls of the faceplate panel **12** tending to move the point **32***a* parallel to axis **44**, this can be neglected if the mask expansion is considered relative to the faceplate panel.

Consider that the cathode ray tube is initially at a normal room temperature with the mask frame at **22***a* and that the tube is operated for a substantial period of time to become established at an elevated operating temperature, then the relative thermal expansion of the mask outwardly from the intersection of the radial axes **42**, **44** will result in the frame side **22***a* moving to position **22***b* (FIG. 5). This shift is represented as an expansion distance **46** generally parallel to the radial axis **44**. At the same time the shadow mask and frame become heated, the mounting member **27** will also become heated and of increased length (assuming that it is made of material having a positive temperature coefficient). Since the support point **32***a* is a relatively fixed reference, the warmup of the shadow mask and frame, along with the warmup of the mounting spring, will result in a net movement of the juncture point **29***a* to the juncture point position **29***b*. This is effectively a slight rotation of the spring **27** about its associated mounting stud **32**.

The shift of the juncture point from **29***a* to **29***b* involves both movement in the direction parallel to the lateral symmetrical axis **44** and some movement in the direction normal to this axis, this latter distance being represented by the distance between points **48** and **49**. It may be seen that for a similar spring mounting, movement of the juncture point **29***a* parallel to the axis **44** will be matched by an equal and opposite movement on the other side of the shadow mask frame so that for this shift direction the central portion of the mask at axis **42** will tend to remain stationary. However, the shift normal to axis **44**, represented by the distance **48**, **49**, will also be produced by a similar amount in the case of spring **25** so that the overall effect is a downward shift of the shadow mask.

To compensate for this shift transverse to the axis **44**, whether due either to triangulation of the shift components produced by expansion **46**, or by longitudinal change due to the thermal response of spring **27**, or to both of these, the spring mounting assembly is positioned at a selected distance from the axis **44**. The distance between juncture point **29***a* and the axis **44** is represented in FIG. 5 by the distance between point **49** and **51**. This distance encompasses a portion of the shadow mask **20** which will expand in response to mask heating in a direction upwardly from point **29***a*. Accordingly the distance **49**, **51** is selected to produce a thermal shift normal to axis **44** in FIG. 5 which is equal and opposite to the thermal shift defined by the distance **48**, **49**. In this way the three expansions that take place can be grouped to compensate one another so that there is a minimum or complete absence of vertical shift at the central symmetrical axis **44**. It should be clear that the spring mounting structure including member **25** and stud **30** is constructed in a manner corresponding to the description given in connection with **27** and **32** and in effect a mirror image thereof, so that vertical shift of the shadow mask during warmup is compensated.

The above analysis is also valid with respect to lateral shift, that is shift normal to the axis **42**, caused with respect to the spring **26** and mounting stud **31**. These members are constructed and located in accordance with the above analysis to reduce or eliminate shift in the direction normal to the axis **42**.

Attention is invited to FIG. 6 to illustrate in greater detail the approximate make-up of the shift of the mask frame between juncture points **29***a* and **29***b*. The downward shift of the mask normal to axis **44** due to the triangulation effect of the spring mounting position **27***a* is represented as the distance **49, 52**. While the spring **27** will, in a more accurate consideration, move in an arcuate path, the relatively small movement thereof can be considered in connection with the right triangle showing that a lateral mask expansion of the length **55** produces a net vertical displacement (**49, 52**) approximately equal to the distance **55** times the tangent of the angle **57**, which is also equal to the angle of **27***a* with respect to the vertical.

Similarly, thermal expansion of the spring **27** will contribute a vertical shift approximately equal to the distance **48, 52** which is very nearly equal to the longitudinal expansion of the spring member itself. More accurately, this distance is substantially equal to the cosine of the angle **60** which **27***b* makes with the vertical times the linear expansion of the member **27**.

In order to appreciate the exaggeration of the representations of FIGS. 5 and 6, and at the same time understand the permissible simplification of the geometry depicted in those figures, represented practical measurements for an operating cathode ray tube constructed in accordance with the invention are as follows:

	Inches
Diameter of shadow mask apertures **23**	.010
Diameter of phosphor dots R, B and G	.016
Distance **46** relative to point **32***a* (for 30° C. temperature rise and a tube mask of 13" x 17")	.002
Distance **49, 52**	.0004
Distance **48, 52** (stainless steel)	.0007

As the spring members **25–27** are made shorter, their rigidity may increase, but at the same time the amount of error introduced due to thermal expansion and triangulation can increase. However, it is possible within the teachings hereof to have the spring member short enough to be desirably rigid, while at the same time compensate for transverse shift of the mask normal to either or both of the axes **42, 44**.

In the above description, it has been assumed that the coefficient of thermal expansion of the shadow mask assembly **20, 22**, as well as that of the spring members **25–27** has a positive temperature coefficient. If, in any particular construction, they have temperature coefficients that are negative, or if the spring members have a zero coefficient, then the same analysis is used, although the directions of shift can be reversed and the distances of the shifts may change, but the desired resultant shift compenation can still be achieved.

The significance of this invention may be more clearly seen by referring to FIGS. 7 and 8. In FIG. 7, a shadow mask frame **65** is shown mounted to a faceplate panel **67** with a three point support provided by studs **68, 69** and **70** embedded in the glass sidewalls of the panel, and spring mounting members **72, 74** and **76**, which are connected to the frame **65** and are fastened to their respective studs. The three point support of a shadow mask frame within the faceplate panel of a color television tube is one of the most economical and satisfactory ways of supporting the shadow mask. The three points of a triangle establish a single plane to provide for very accurate alignment of the frame assembly within the faceplate panel. This may be contrasted to color tubes which have their shadow mask assemblies supported at four or more points around the faceplate panel. In this type of tube, it is very difficult for the shadow mask screen to be aligned with the glass because the multiple stud path may define more than one plane, or the mounting means might not define a plane which mates with the stud plane. Furthermore, it is obviously a more expensive mounting because more studs have to be inserted into the walls of the faceplate panel and more spring mounting members have to be used, with smaller manufacturing tolerances.

In the early development of the three point method for supporting a shadow mask screen, location of the studs as shown in FIG. 7 resulted in large non-symmetrical shifts of the screen during tube warmup. To overcome this problem it was recognized that the studs could be located near the horizontal radial axis of the tube, but this approach resulted in a substantially weaker support structure. To overcome this problem, a four point support was developed, but it had the aforementioned drawbacks.

This invention, however, has made it practical to use a three point support in which the studs are relatively removed from the horizontal radial axis **80**. The advantage of this can be immediately seen. With the studs placed towards the bottom of the faceplate panel (FIG. 7), (in one model they were located 2½ inches from the axis **80**) the sides of the triangle forming the three point support for the shadow mask screen are lengthened, thereby providing stronger support for the shadow mask assembly, in addition to providing a single plane for alignment.

Correction for the relatively large shift of the shadow mask screen due to location of the studs near the bottom of the faceplate panel is provided in accordance with the teachings of this invention. With stud **69** positioned in the faceplate panel, the distance *h*, which is measured from point **69**, where the spring member **74** contacts the stud, to the horizontal radial axis **80**, is determined. With this distance and the thermal coefficient of expansion of the shadow mask screen element known, the amount the shadow mask assembly **65** will expand above the point **69** normal to axis **80** may be calculated for a given increment of temperature change. Knowing this amount of movement, and in accordance with the precepts of this invention, the angle **88**, which portion **89** of the spring member **74** makes with the shadow mask assembly **65** (this corresponds to the angle **57** in FIG. 6) can be selected such that the expansion of the shadow mask assembly parallel to axis **80** creates a change in the angle, which produces a movement normal to axis **80** that is just equal and opposite to the thermal expansion of the mask assembly **65** normal to axis **80**.

The thermal expansion of mask assembly **65** normal to axis **80** is made up of expansion of the shadow mask assembly between points **80** and **85** minus the thermal expansion of the spring assembly between points **69** and **85**. However, the difference in the thermal coefficient of expansion for cold roll steel, which is used in shadow mask assemblies, and for spring materials is so small that the expansion normal to axis **80** can be defined as the thermal expansion of the shadow mask between axis **80** and stud mounting point **69**.

Typical differential values of thermal coefficient between the mask assembly and springs is on the order of 3×10^{-6} inch/inch/° F. This would result in a shift between point **69** and **85** under normal operating conditions with a 40° F. rise in the temperature of the mask, of approximately .0001 to .0002 inch, as compared to a shift of .001 inch for distance *h*.

Because of the small differential expansion between springs and shadow mask assembly, it is possible to mount the top stud **68** on the end of the central vertical axis **82**. The spring **72** which is parallel to the shadow mask frame **65** creates minimal shifts of .0001 to .0002 inch which can be ignored.

In summary, therefore, if given the known thermal expansion for the shadow mask assembly and the distance between the position of the stud and the horizontal radial axis of the shadow mask assembly, it is possible to predict the angle between the mounting spring and the shadow mask assembly such that expansion of the shadow mask assembly in a direction parallel to the central radial axes will cause the screen to rotate about the studs to compensate for the thermal expansion of the shadow mask assembly normal to the central radial axis.

I claim:

1. In a cathode ray tube including an enclosing envelope, a front panel having a discrete pattern of light emitting phosphors thereon, and an apertured beam masking device having a radial axis of symmetry passing through a central portion thereof and being suspended in the tube by three cantilever mounting springs secured to the masking device in different quadrants and connected to respective studs mounted in the tube envelope adjacent the screen, with the central portion aligned in a predetermined position with respect to the phosphor pattern, the combination including, first and second cantilever springs being positioned in opposite quadrants and extend upwardly from the masking device to the respective studs transverse to the radial axis of symmetry of the masking device, each said spring being secured to the masking device at a preselected angle whereby thermal responsive dimensional change of the masking device in a direction parallel to the radial axis of symmetry causes the central portion of the masking device to move in one direction normal to said radial axis of symmetry an amount depending on said preselected angle, said angle being selected so that the movement in said one direction is substantially equal to the thermal responsive dimensional change of the masking device between the stud mounting point and said radial axis of symmetry in a direction normal thereto and opposite in direction to said one direction thereby maintaining the central portion of the masking device in substantially the same predetermined position with respect to the phosphor pattern.

2. The cathode ray tube of claim 1 wherein the value of said preselected angle is determined by the formula

$$\tan \theta = \Delta O / \Delta A$$

wherein

θ=said preselected angle

ΔO=the thermal responsive dimensional change of the masking device between the stud mounting point and said radial axis of symmetry in a direction normal thereto; and

ΔA=the thermal responsive dimensional change of the masking device in a direction parallel to said radial axis of symmetry.

3. The cathode ray tube of claim 2 wherein the thermal responsive dimensional change of the masking device between the stud mounting point and said radial axis of symmetry is determined by the formula:

$$\Delta h = k \Delta t h$$

where

Δh=thermal responsive dimensional change of the masking device between the stud mounting point and said radial axis of symmetry;

k=thermal coefficient of expansion for the masking device;

Δt=change in temperature of the masking device; and

h=distance between the stud mounting point and the radial axis of symmetry.

4. In a cathode ray tube including an enclosing envelope and a faceplate panel having a discrete pattern of light emitting phosphors thereon, the combination of

apertured beam masking means having a radial axis of symmetry passing through a central portion thereof,

mask support means fixed with respect to the tube envelope,

mounting means including a pair of mounting members on opposite radial sides of said masking means extending between respective junction points of said masking means and said mask support means to suspend said masking means with the central portion thereof aligned in a predetermined position with respect to the phosphor pattern,

said mounting members each joining said masking means at respective predetermined angles at said respective junction points and extending substantially transverse to the radial axis of symmetry of said masking means,

said masking means being of a construction such that a thermal responsive dimensional change takes place therein substantially parallel to the radial axis tending to cause a first shift of said central portion of said masking means about said mask support means engaged by each of said mounting members in a direction substantially normal to the radial axis and in an amount determined by said predetermined angles,

said mounting members each tending to cause a predeterminable second shift of said central portion of said masking means substantially normal to the radial axis by an amount dependent on the thermal coefficient of expansion of each said mounting member,

said junction points being positioned a given distance from the radial axis, said given distance encompassing a portion of said masking means having a thermal responsive dimensional change tending to cause a third predeterminable shift of said central portion of said masking means substantially normal to the radial axis,

at least one of said first, second and third shifts associated with each of said mounting members being in the opposite direction from another thereof,

and said predetermined angles, said thermal coefficient of expansion of each said mounting member, and said given distance from the radial axis to each of said junction points being selected so that said shifts in opposite directions from one another compensate each other thereby maintaining the central portion of said masking means in substantially the same predetermined position with respect to the phosphor pattern.

References Cited

UNITED STATES PATENTS

3,370,194 2/1968 Schwartz et al.

ROBERT SEGAL, *Primary Examiner.*

U.S. Cl. X.R.

313—286, 292