United States Patent [19]

Robbins et al.

[11] **3,777,204**

[45] **Dec. 4, 1973**

[54] **TRI-COLOR CATHODE RAY TUBE EMPLOYING A SHADOW MASK HAVING ELONGATED APERTURES**

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[22] Filed: **Mar. 30, 1972**

[21] Appl. No.: **239,514**

[52] **U.S. Cl.** ..... **313/85 S,** 313/92 B

[51] **Int. Cl.** **H01j 29/06**

[58] **Field of Search** ..... 313/85 S, 82 NC, 313/92 B, 92

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Attorney—Norman J. O'Malley et al.

[57] **ABSTRACT**

An improved aperture mask-screen combination is provided for use in a shadow mask color cathode ray tube employing three in-line electron beams. The mask having elongated apertures therein is utilized in the formation and subsequent operation of a patterned screen including repetitive arrays of three dot-type elongated phosphor areas. The multitude of elongated apertures, dimensioned by the interstitial webbing of the mask member, effect a display of enhanced brightness having a minimum of moire pattern distraction. The elongated apertures are discretely arrayed in a plurality of parallel horizontal rows with the apertures in alternate rows being aligned in similar columns.

13 Claims, 3 Drawing Figures

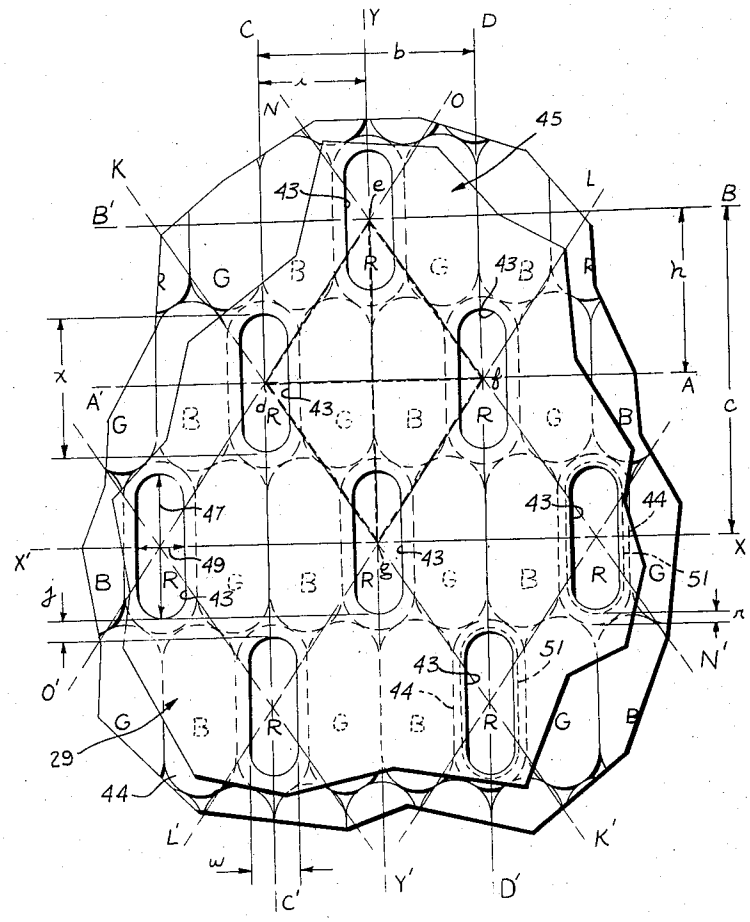


Fig. 1
PRIOR ART

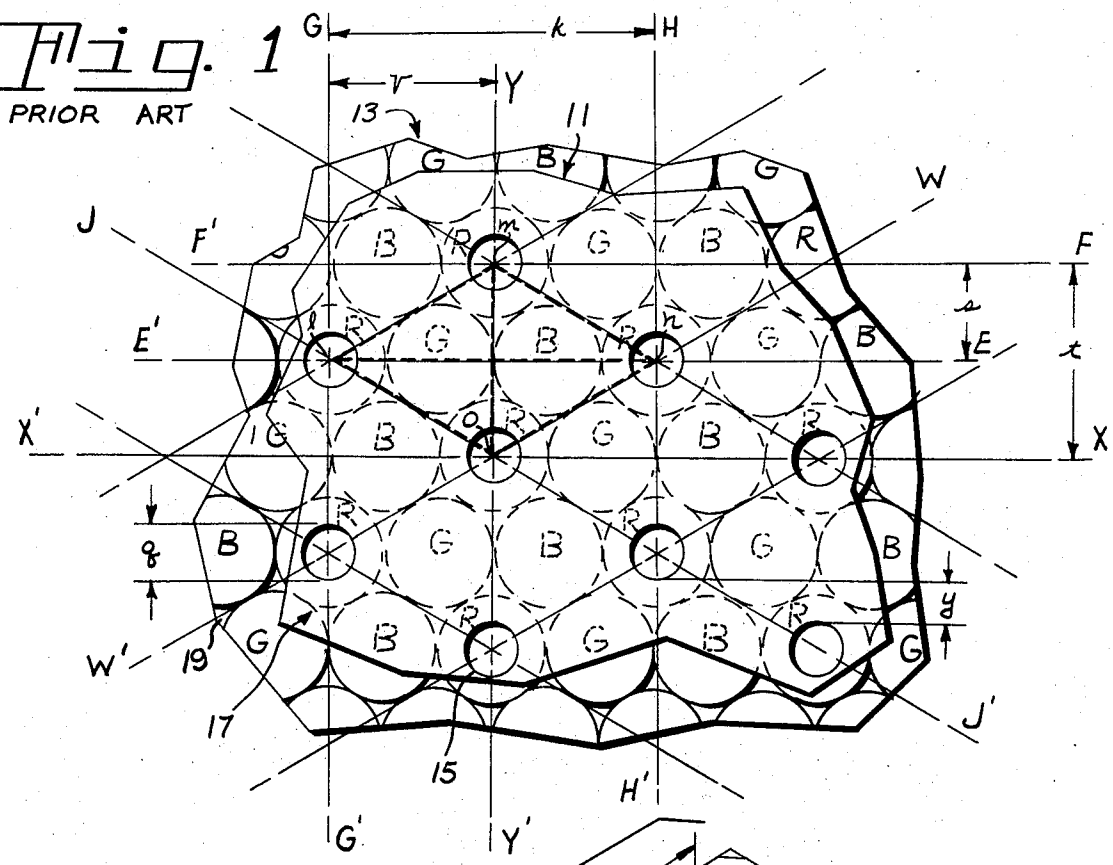
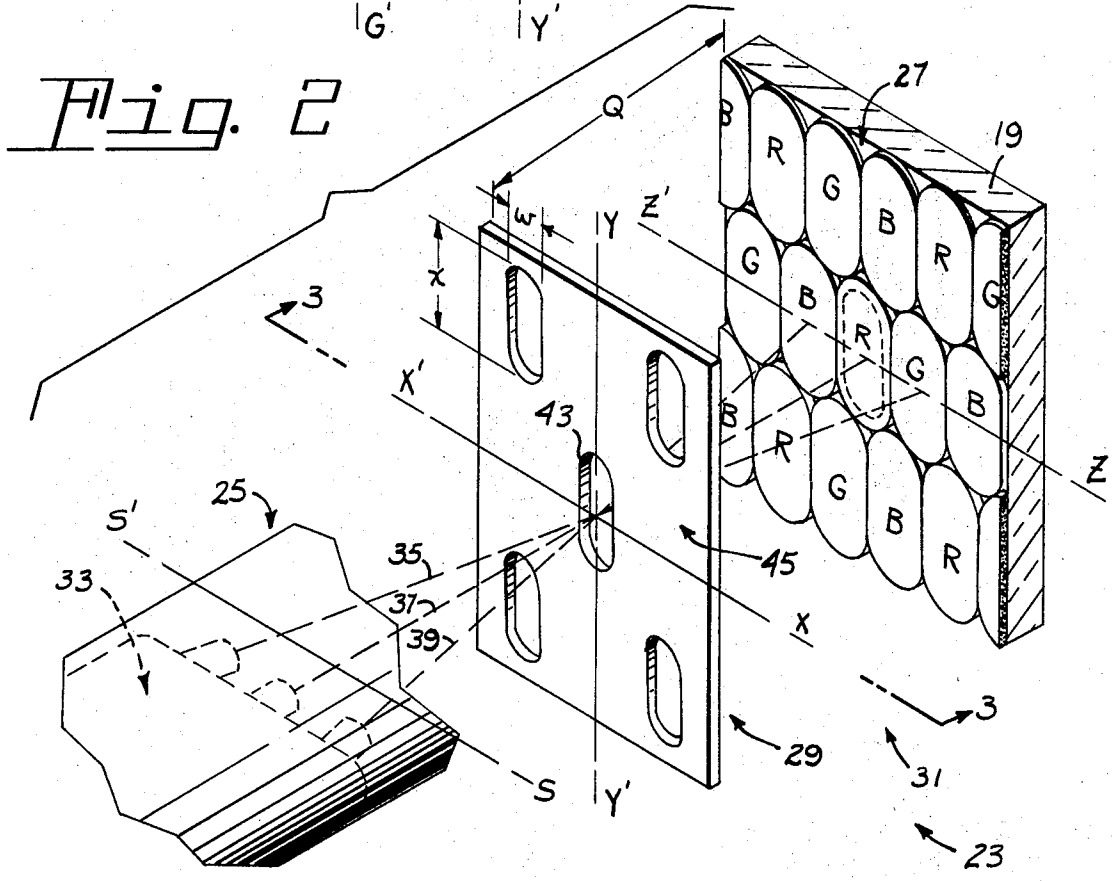


Fig. 2



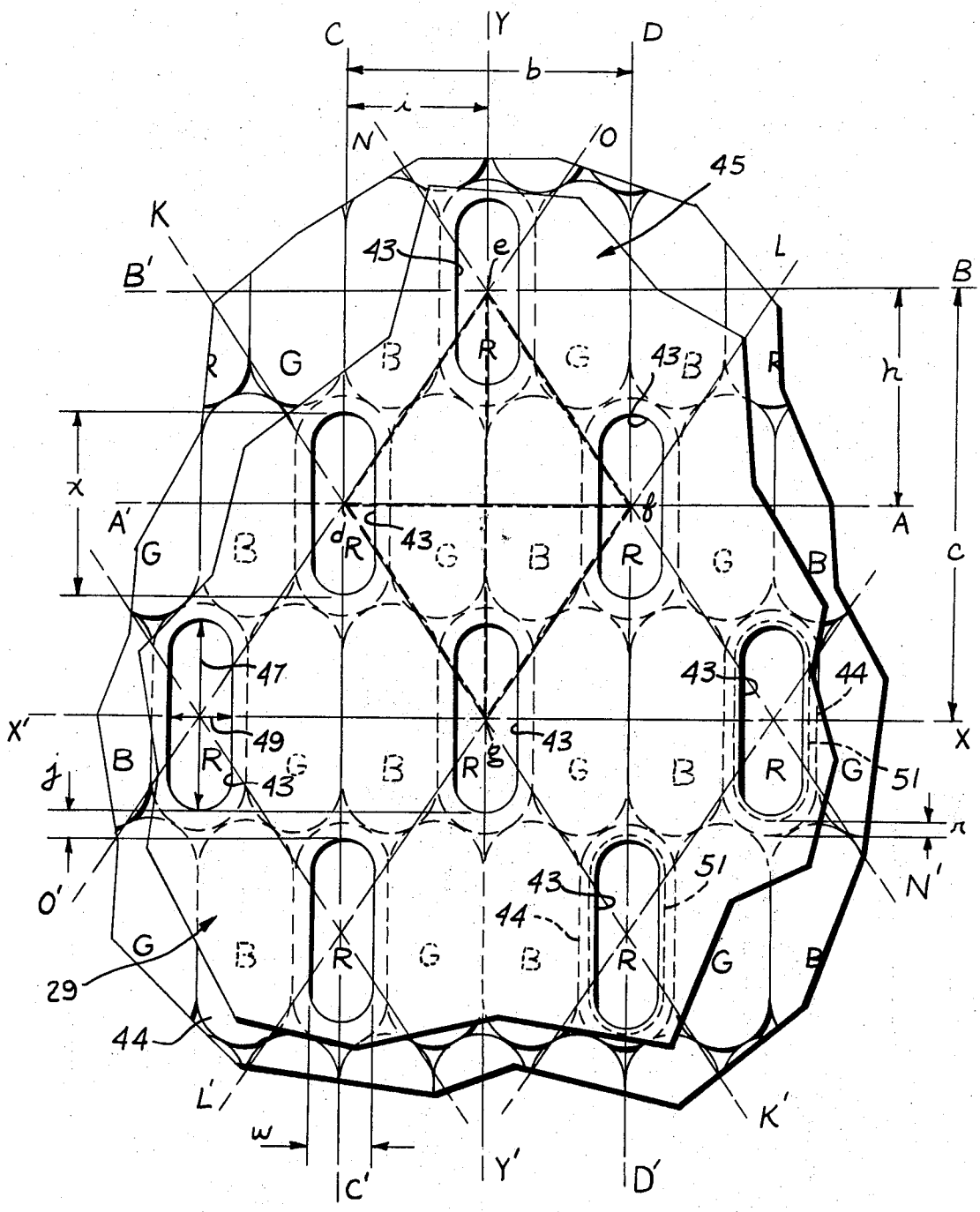

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Fig. 3

TRI-COLOR CATHODE RAY TUBE EMPLOYING A SHADOW MASK HAVING ELONGATED APERTURES

BACKGROUND OF THE INVENTION

This invention relates to color cathode ray tubes and more particularly to tri-color cathode ray tubes of the type employing a plurality of in-line electron beams and a shadow-mask construction having a multitude of elongated apertures therein.

Color cathode ray tubes utilizing gun structures emitting a plurality of in-line electron beams have employed a variety of shadow mask constructions and associated cathodoluminescent screen patterns. Cylindrical type masks or grills have been formed of parallel wires or thin strips of metal or slats to provide narrow parallel openings or slots for use with parallel striped screens. Masks of such construction tended to exhibit structural and thermal instability which became more pronounced in larger screen sizes. Since the parallel wire or strip type masks are not adaptable to spherical forming, as such, a multiplicity of narrow cross bridgings were added in attempts to strengthen the slot construction, but success was limited in this endeavor.

Shadow masks, of the conventional foraminous type, having circular apertures or holes therein have also been used in inline gun tubes along with dot-pattern screens. While the round hole mask is much more readily formed in a spherical or domed shape and exhibits structural strength and stability, the web-pattern of the opaque mask material defining the round apertures intercepts an appreciable amount of the respective electron beams. Thus, the round-hole mask inherently reduces the resultant screen brightness over that exhibited by a slat type mask and striped screen combination.

Furthermore, during operation of the tube, the temperature of the round aperture mask tends to elevate due to electron beam impingement of the webbing causing expansion of the mask. This, in turn, aggravates mis-registration of the apertures in the mask with the phosphor dots of the screen pattern, a condition which degrades the color purity of the display. The inherent nature of the round aperture mask, and its associated round-dot screen pattern, limits the variability of registration, and as such, is susceptible to the mis-registration influences of the earth's magnetic field.

An additional disadvantage of the round apertured mask and its associated dot pattern screen is the evidence of visually disturbing moire patterns which may occur in the operating tube. This distraction is due to the development of an interference pattern related to the distance differential between successive scanning lines and the spacing between successive round apertures in the mask.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the invention to reduce the aforementioned disadvantages and to provide an improved shadow mask for an inline plural beam tri-color cathode ray tube to effect a display of improved brightness.

A further object is to provide a bright cathode ray tube display that exhibits a minimum of moire pattern.

Additional objects are to provide a cathode ray tube shadow mask having improved electron transmission, dependable structural stability, reduced operating temperature in the tube environment, and one that provides a tube less susceptible to influences of the earth's magnetic field.

The foregoing objects are achieved in one aspect of the invention wherein an improved shadow mask, for use in a color cathode ray tube employing three in-line electron beams and a dot-type patterned screen including a repetitive array of three phosphor areas, exhibits a discrete elongated aperture arrangement. The mask member which provides greater transmission and improved brightness comprises a multitude of elongated apertures defined by the interstitial webbing and arrayed in a substantially uniform pattern effecting a plurality of parallel horizontal rows wherein the apertures in alternate rows are vertically aligned in similar columns. The dimensional aspects relating to the elongated apertures are referenced in terms of an equilateral parallelogram or rhombus having definitive vertices formed at the centers of four mutually adjacent apertures located in three sequential horizontal rows. The horizontally oriented vertices of the rhomboidal parallelogram are joined by a first diagonal thereacross to define the center-to-center spacing between horizontally adjacent apertures having an unbroken area of interstitial webbing therebetween. The vertically oriented vertices of the rhombus are joined by a second diagonal thereacross to define the center-to-center spacing between vertically adjacent apertures that is greater than the center-to-center spacing between horizontally adjacent apertures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an enlarged fragmentary plan view illustrating a prior art relationship of round mask apertures with the associated round-dot patterned screen;

FIG. 2 is a partial perspective view of a tube embodying the invention showing the relationships of the screen, the shadow-mask and the plural in-line electron beams employed therein; and

FIG. 3 is an enlarged fragmentary plan view illustrating the patterned screen and the elongated mask aperture relationship of the invention taken along the line 3—3 in FIG. 2 as viewed from the orientation of the source of the electron beams.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For a better understanding of the present invention, together with other and further objects, advantages and capabilities thereof, reference is made to the following specification and appended claims in connection with the aforedescribed drawings.

The descriptive phraseology "in-line plural beam tri-color cathode ray tube" refers to a tube employing three separate electron beams emanating in a substantially horizontal plane and beamed through shadow mask apertures to impinge a patterned cathodoluminescent screen comprising a repetitive array of three dot-type phosphor areas. Each of the phosphor areas is made up of one or more phosphor materials which, when excited, emits a distinctive hue. Simultaneous excitation of two or more of the phosphor areas produces an additive composite hue. The electron-responsive phosphor dots of each tri-dot grouping are denoted as blue "B," red "R" and green "G" respectively.

With reference to the drawings, there is shown in FIG. 1 an enlarged fragmentary plan view of substantially the center portion of a prior art aperture mask 11

and associated patterned screen **13** as viewed from the source of the plural in-line electron beams within the tube. The foraminous shadow mask member **11** has therein a multitude of circular apertures **15** defined by the opaque interstitial webbing **17** and presents an aperture array as employed in a conventional tri-color or tri-dot plural in-line beam color cathode ray tube. The round aperture array of the prior art mask is directly related to the X and Y axes of the mask and the associated diagonals associated with the apertures forming a plurality of related horizontal rows and vertical columns whereof the apertures in alternate horizontal rows are vertically aligned. The horizontal rows are parallel with the X axis and the vertical columns parallel with the Y axis. The adjacent horizontal rows of apertures are arranged to have a center-to-center spacing *s* and a vertical clearance separation between-rows of *y*. The relationship of apertures is noted, for example, by four mutually adjacent apertures **15** oriented in three sequential horizontal parallel rows F–F′, E–E′, and X–X′, having centers *l*, *m*, *n*, and *o*, which form an equilateral parallelogram or rhombus *lmno* wherein all four sides are of equal lengths. The rhombus has acute angular vertices formed at centers *l* and *n* of adjacent apertures **15** along horizontal row E–E′ which is parallel to the X axis; to avoid confusion these vertices are also denoted as *l* and *n* respectively. These acute vertices *l* and *n* of the rhombus are joined by a first diagonal *ln* thereacross which is horizontally oriented to define center-to-center spacing *k* between horizontally adjacent apertures. The obtuse angular vertices *m* and *o* of the same rhomboidal parallelogram are joined by a second diagonal *mo* thereacross, vertically oriented along vertical axis Y–Y′, to define the center-to-center spacing *t* between vertically adjacent apertures. In this prior art round aperture mask the acute vertices *l* and *n* of the rhomboidal layout are equal angles of substantially 60 degrees. The adjacent aperture spacings as defined by diagonals *ln* and *mo* indicate that the horizontal spacing *k* between apertures in the round hole mask is greater than the vertical spacing *t* relationship therebetween. In similar manner, the spacings *v* between adjacent parallel columns of apertures oriented in the Y axial direction, are greater than the spacings *s* between adjacent horizontal rows of apertures oriented in the X axial direction.

The tri-color screen **13** formed on the glass substrate or viewing panel **19** and operationally associated with the prior art round hole mask **11** is comprised of groupings of substantially round "B," "R," and "G" dot-type phosphor areas.

With reference to FIG. **2**, a partial perspective view illustrates discrete portions of a cathode ray tube **23** enclosed in a fragmentarily shown envelope **25** wherein substantially the center portion of the spherical viewing panel **19** is portrayed as comprising a tri-color screen pattern **27** in the form of repetitive groupings of "B," "R" and "G" elongated phosphor areas disposed in rows thereon. A spherical or domed metallic foraminous shadow mask **29** having elongated apertures **31** therein, is spatially positioned relative to the screen **27** being directly associated with the formation and subsequent operation of the patterned screen. In usage, the apertured shadow mask **29** and screened viewing panel **19** are considered as a combination assembly **31**, and as such are conventionally spatially affixed by means not shown. Additionally, predeterminately positioned within the envelope **25** is an electron beam generating structure **33** oriented in a manner to direct three separate in-line electron beams **35, 37** and **39** toward the apertured shadow mask **29** and the related screen **27**. As shown, the three in-line beams **35, 37,** and **39** converge at the mask **29** passing through an elongated aperture **43** therein and thence selectively impinging and exciting separate elongated phosphor areas on the screen **27** to provide a luminescent display.

There is illustrated in FIG. **3** an enlarged fragmentary plan view of substantially the center portion of the spherical shadow mask **29** of the invention, wherein the array of elongated apertures **43** is shown in overlay relationship with the elongated phosphor areas **44** comprising the "B," "R" and "G" screen pattern therebeneath.

In greater detail, reference is made to FIGS. **2** and **3** wherein the shadow mask **29** having X and Y axes therethrough comprises a multitude of elongated apertures **43** defined by the opaque interstitial webbing **45**; each having longitudinal and transverse axes **47** and **49** therethrough intersecting at the center thereof. These apertures are arrayed in a substantially uniform pattern wherein the longitudinal axes **47** of the apertures **43** are oriented relative to the vertical or Y axis and the transverse axes **49** are oriented relative to the horizontal or X axis of the mask. The elongated aperture pattern array is substantially defined by the orientation of adjacently related apertures to form a plurality of interrelated horizontal rows, as for example, X–X′, A–A′, and B–B′, and vertical columns, e.g., C–C′, Y–Y′, and D–D′, whereof the apertures in alternate horizontal rows, e.g., X–X′ and B–B′ are vertically aligned such as in column Y–Y′. The spacings between apertures in the horizontal and vertical relationships of the pattern array additionally effect linear diagonal pitch associations between adjacent apertures **43** in adjacent horizontal rows to also form an array of intersecting diagonal rows, e.g., O–O′, L–L′, N–N′, and K–K′. The rows of apertures in a given directional orientation are substantially parallel, for example X–X′ and A–A′, O–O′ and L–L′, N–N′ and K–K′, and a similar parallel relationship also holds for exemplary columns C–C′ and Y–Y′.

The related dimensional aspects of the elongated apertures **43** are referenced in terms of an equilateral parallelogram or rhombus formed, for example, by four mutually adjacent apertures oriented in three sequential horizontal parallel rows B–B′, A–A′, and X–X′, whereof the centers *d*, *e*, *f* and *g* of the respective apertures form the vertices of the equilateral parallelogram *defg*. The quadrilateral thus formed has its sides oriented coincident with the diagonals N–N′, K–K′, O–O′, and L–L′ of the aperture pattern. The obtuse angular vertices also denoted as *d* and *f* are formed at the centers *d* and *f* of adjacent elongated apertures **43** along horizontal row A–A′ which is parallel to the X axis. Joining these obtuse vertices *d* and *f* is a first diagonal *df* thereacross which is horizontally oriented to define the center-to-center spacing *b* between horizontally adjacent apertures **43** in row A–A′, for instance. These adjacent horizontally related apertures are horizontally separated by an unbroken area of interstitial webbing therebetween that has a height at least equalling the lengths of the separated apertures. In accordance with this relationship, the vertical spacing *j* between the ends of apertures in adjacent horizontal rows may in

certain instances approach zero value. The acute angular vertices *e* and *g* of the aforementioned rhomboidal parallelogram are joined by a second diagonal *eg* thereacross which is vertically oriented along the vertical Y axis to define the center-to-center spacing *c* between vertically adjacent apertures in the same column. In this parallelogrammatic layout, the spacings between adjacent elongated apertures, as defined by the diagonals *df* and *eg* denote that the horizontal spacing *b* between apertures is less than the vertical spacing *c* relationship therebetween. Like-wise, the horizontal spacings *i* between adjacent parallel columns of apertures, oriented in the Y axial direction, are less than the vertical spacings *h* between adjacent horizontal rows of elongated apertures oriented in the X axial direction. These dimensional relationships are reverse of those evidenced in the aforedescribed prior art round-aperture mask **11.**

It is preferred that the elongated apertures **43** have rounded ends as such facilitates a desired nesting of the elongated phosphor dots **44** comprising the screen pattern **27,** and additionally enhances the strength of the mask structure in the regions where the ends of the apertures approach one another in an alternate relationship. The round ends of the elongated apertures each have a radius substantially equalling one-half of the width of the aperture.

The improved shadow mask **29** of the invention has elongated aperture areas **43** larger than those of the round apertures **15** in the described prior art mask **11,** and as such relates to greater mask transparency. Thus, the improved mask, having a reduced amount of opaque webbing therein, permits the passage of a greater number of exciting electrons therethrough.

While various combinations of elongated aperture width, length and spacing are possible, in considering structural and display requirements, it has been found that a longitudinal to transverse aspect dimensional ratio *x:w* for the elongated apertures is desirably within the range of substantially 2:1 to 20:1 and more preferably within the range of 3:1 to 10:1. The width dimension *w* of each elongated aperture **43** is of a value smaller than one-third of the horizontal center-to-center spacing *b* between adjacent apertures in the same row. The aperture length or height *x* is of a value smaller than the vertical center-to-center spacing *h* between adjacent horizontal rows of apertures, e.g., A–A′, B′B′ to preferably allow for guard bands *r* in the nested phosphor areas comprising the screen structure. The relationship of the vertical center-to-center spacing *h* between adjacent horizontal rows of apertures, e.g., A–A′, B′B′ and the horizontal center-to-center spacing *b* between adjacent apertures is expressed as a ratio *h:b* exceeding 5:1.

To minimize moire pattern effect, the vertical spacing *h* between adjacent horizontal rows of elongated apertures should be of a value other than that substantially resultant from dividing the vertical dimension of the usable mask area by the number of active electron beam scan lines utilized in scanning the display area of the mask. For example, a mask employed in a 15 inch 90° in-line tube has a vertical dimension of the usable mask area, utilized in the subsequent display, of substantially 8.78 inches. When in operational usage, the mask is sequentially scanned by an electron beam having a scan rate of, for instance, 525 lines per raster frame, the number of visible scan lines is in the order of substantially 480. Thus,

$$\frac{\text{Vertical height of mask}}{\text{Visible scan lines of raster}} = \frac{8.78}{480}$$

$$= .183 \text{ inch unfavorable value of center-to-center spacing "}h\text{" between rows.}$$

Multiples of the exemplary **.183** inch spacing, i.e., 0.366 and 0.549 inches are also undesirable when considering moire pattern interference. As referenced in the Figures, the areas of the elongated phosphor dots **44** are desirably larger than the mask apertures **43,** being so formed during the screen forming process. While the mask aperture determines the area of the beam traversing the mask **29,** the landing area **51** of the electron beam on the phosphor dot area **44** is larger than the aperture area **43** because of several interrelated factors in the geometric optics affecting the electron beam, e.g., the mask-to-screen spacing "Q," the distance from the screen to the plane of deflection (not shown), and the sectional area of the electron beam at the plane of deflection. Because of these factors, the area of beam landing **51** on the dot is normally 10 to 15 percent larger than the area of the associated aperture **43.** The perimetric area of the phosphor dot **44** that is formed to extend beyond the impinging beam landing area is referenced as the guard band *r* of each respective phosphor area. The extra phosphor provided by this guard band, which has a representative width of 0.001 of an inch or more, allows for shifting of the impinging electron beam while maintaining a comparable area of luminescent excitation.

It has been found that a color cathode ray tube employing the shadow mask **29** of the invention, having the aforedescribed elongated apertures **43** therein, is less critical for vertical registration than the conventional round aperture mask. It has been further discovered that, in a tube utilizing the elongated aperture mask, a beneficial compromise between brightness and guard band can be achieved; for example, a slight reduction in the elongated aperture area and an increase in guard band width improves color purity and lessens sensitivity to the influences of the earth's magnetic field, particularly in the 3 and 9 o'clock regions of the screen. Thus, in-line shadow mask tubes utilizing the elongated apertures **43** not only evidence enhanced brightness over the round-apertured mask, but they also are less critical for operational set-up.

The elongated aperture has an added advantage over the round aperture in that the area of the round aperture varies as the square of the diameter whereas the area of the elongated aperture is predominantly a linear change with respect to the width of the elongation. Thus, any change in aperture width dimension more drastically affects the area of the prior art round aperture than it does that of the elongated aperture. Such is particularly evidenced in the transmission of a graded mask wherein the aperture dimensions predeterminately vary from center to edge. Thus, when attempting to maintain a substantially constant guard band across the screen pattern, the deleterious fall-off in brightness from center to edge, resultant from the use of a graded hole mask, is more pronounced for the prior art round aperture than it is for the elongated aperture mask construction.

In considering the greater transparency or mask transmission "G" of the improved mask **29**, attention is directed to FIG. **3** wherein the aforedescribed parallelogrammatic area *defg* is referenced as a definitive area of the shadow mask encompassing the total portions of an individual representative elongated aperture **43** and the surrounding interstitial webbing **45** associated therewith. This improved mask as aforedescribed herein provides a center transmission factor exceeding substantially **18** percent per unit of mask area. For purposes of example, the following values are ascribed for one embodiment of a elongated aperture mask utilized in a 15 inch 90° in-line tube, the apertures having a dimensional longitudinal to transverse ratio of *x:w* equalling substantially 2.5:1 :

Apert. width "*w*" (center)..... .0103 in.
Apert. height "*x*" (center)..... .0257 in.
Horiz. spacing between apert. "*b*"..... .0440 in.
Vert. spacing between adjacent horiz. rows "*h*"..... .0282 in.
Area of round end elongated aperture

$$= wx - w^2\left(1 - \frac{\pi}{4}\right)$$

Area of parallelogram "*defg*" = *bh*

Mask trans. factor "*G*" (center)

$$= \frac{\text{Area of elongated aperture}}{\text{Area of parallelogram "}defg\text{"}} \times 100$$

$$= \frac{wx - w^2\left(1 - \frac{\pi}{4}\right)}{ab} \times 100$$

$$= \frac{.0103 \times .0257 - .0103^2(1 - .7854)}{.0440 \times .0282} \times 100$$

Trans. Factor "G" of Elongated Apert. Mask (center) = 19.5 percent

For comparison, values such as the following are ascribed to the prior art parallelogrammatic relationship *lmno* for the round aperture mask shown in FIG. **1**:

Apert. dia. "*q*" (center)..... .0103 in.
Horiz. spacing between apert. "*k*"..... .04330 in.
Vert. spacing between adjacent horiz. rows "*s*"..... .0125 in.
Area of round aperture = $.7854 \times q^2$
Area of parallelogram "*lmno*" = *ks*

Mask trans. factor "*G*" (center)

$$= \frac{\text{Area of round aperture}}{\text{Area of parallelogram "}lmno\text{"}} \times 100$$

$$= \frac{.7854 \times q^2}{ks} \times 100$$

$$= \frac{.7854 \times .0103^2}{.04330 \times .0125} \times 100$$

Trans. Factor "G_o" of Prior Art Round Apert. Mask (center) = 15.4 percent

Thus, on the basis of comparative dimensions, the aperture mask **29** of the invention provides improved mask transmission of the electron beams which, from that aspect alone, enhances brightness of the screen display and effects a reduction in the operational temperature of the mask thereby improving mask-aperture-screen-pattern registration.

In considering temperature reduction, the mask **29** with the elongated apertures **43** intercepts less beam current than the prior art round aperture mask **11**, therefore it absorbs less energy and aS a result does not elevate to the same level Of operating temperature. For example, the precent reduction in absorbed watts for the elongated hole mask **29** over the prior art mask **11** is substantially as follows:

Round apert. trans. "G_o" = 15.4%, absorbed beam current = 84.6%
Elongated apert. trans. "*G*" = 19.5%, absorbed beam current = 80.5%
Watts = *E C*
where *E* = anode voltage
C = average beam current

Percent reduction in absorbed watts

$$= \frac{(.846C)E - (.805C)E}{(.846C)E} \times 100 = 4.8\%$$

With reference to FIGS. **2** and **3**, the tri-color nested phosphor screen pattern **27** comprises a repetitive array of three elongated phosphor areas or dots **43** disposed in accordance with the elongated aperture array of the mask **29**. These elongated phosphor areas are conventional cathodoluminescent materials such as those that emit blue "B," red "R," and green "G" luminous hues when electron excited. In the X axis directional relationship of the mask **29**, the phosphor rows in the screen pattern **27** are oriented in a manner that the linear transverse axis Z–Z′ of the elongated dot screen pattern is substantially coincidental with the X–X′ axis of the aperture mask.

As shown, and as previously mentioned in this specification, the elongated phosphor areas of the screen pattern **27** are preferentially larger than the areas of the elongated apertures **43**. Such diametrical relationship is not intended to be limiting, as the phosphor areas may also be of a size equal to those of the apertures and still be in keeping with the concept of the invention, as there may be instances when it is desirous to form a screen pattern array of like aperture sizing; for example, one wherein the individual phosphor areas are disposed in substantially spaced-apart relationship. Such alteration of the pattern spacing could necessitate a proportional modification of the parallelogrammatic dimensions between the apertures in the mask, however, the dimensional relationships therebetween would remain in keeping with the teaching of the invention.

In FIG. **2**, the in-line electron generating structure **33** is assembled in a manner to provide and direct the three separate in-line electron beams **35**, **37**, and **39** to the mask-screen portion **31** of the tube **23**. As indicated, the directional line of scan S–S′ of the three in-line beams is substantially parallel with the X–X′ axial orientation of the mask apertures **43**.

Thus, there is provided a color cathode ray tube shadow mask having a discrete elongated aperture array, that has greater electron transmission, dependable structural stability and reduced operating temperature in the tube environment. This mask, when utilized in conjunction with a compatible screen pattern, provides for a display of improved brightness, exhibits a minimum of moire pattern and effects a tube that is less susceptible to influences of the earth's magnetic field.

While there have been shown and described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims:

What is claimed is:

1. An apertured shadow mask for use in a color cathode ray tube utilizing a defined number of scan lines per raster frame employing a plurality of three related in-line electron beams wherein said mask having vertical and horizontal axes is utilized in the formation and subsequent operation of a discretely patterned cathodoluminescent screen having a plurally repetitive array of dot-like elongated phosphor areas disposed in substantially horizontal rows therein, said mask comprising:

a metallic foraminous member having a multitude of elongated apertures having substantially rounded ends defined by the interstitial webbing of said mask member to facilitate contiguity of the elongated phosphor dots comprising said screen pattern; each of said elongated apertures having longitudinal and transverse axes therethrough intersecting at the center thereof; said elongated apertures being arrayed in a substantially uniform pattern with the longitudinal axes of said apertures oriented relative to the vertical axis of said mask and the transverse axes of said apertures oriented relative to the horizontal axis of said mask; the aperture pattern array of said mask being defined by the orientation of said apertures to form a plurality of inter-related horizontal rows and vertical columns whereof the apertures in alternate horizontal rows are vertically aligned; the spacings between the apertures in the horizontal and vertical relationship of the pattern array additionally effecting linear diagonal pitch associations between adjacent apertures in adjacent horizontal rows to also form an array of intersecting diagonal rows; said rows in a given directional orientation being substantially parallel; the dimensional aspects relating to said elongated apertures being referenced in terms of an equilateral parallelogram having definitive acute and obtuse angular vertices formed at the centers of four mutually adjacent apertures located in three sequential horizontal rows, said parallelogram having the obtuse vertices joined by a first diagonal thereacross horizontally oriented to define the center-to-center spacing between horizontally adjacent apertures, said horizontally related apertures having an unbroken area of interstitial webbing therebetween of a height at least equalling the lengths of said apertures, said parallelogram having the acute vertices joined by a second diagonal thereacross vertically oriented to define the center-to-center spacing between vertically adjacent apertures that is greater than the center-to-center spacing between horizontally adjacent apertures, and wherein the vertical center-to-center spacing between adjacent horizontal rows of apertures is of a value substantially other than that resultant from dividing the vertical dimension of the usable mask area by the number of scan lines utilized in scanning said usable area to minimize subsequent moire pattern effect.

2. An apertured shadow mask according to claim **1** wherein said elongated apertures have a longitudinal to transverse aspect ratio ranging substantially from 2:1 to 20:1.

3. An apertured shadow mask according to claim **1** wherein said elongated apertures have a longitudinal to transverse aspect ratio ranging substantially from 3:1 to 10:1.

4. An apertured shadow mask according to claim **1** wherein the elongated apertures provide a center transmission factor exceeding substantially **18** percent per unit of mask area.

5. An apertured shadow mask according to claim **1** wherein the relationship of the vertical center-to-center spacing between adjacent horizontal rows of apertures and the horizontal center-to-center spacing between adjacent apertures is expressed by a ratio exceeding 0.5 to 1.

6. An apertured shadow mask according to claim **1** wherein said elongated apertures have length and width dimensions wherein the aperture length is a value smaller than the vertical center-to-center spacing between adjacent horizontal rows of apertures, and wherein the aperture width is a value smaller than one-third of the horizontal center-to-center spacing between adjacent apertures.

7. An improved shadow mask according to claim **1** wherein the vertical spacing between adjacent horizontal rows of apertures is of a value other than that substantially resultant from dividing the vertical dimension of the usable mask area by the number of visible electron beam scan lines utilized in scanning the display area of the mask to minimize subsequent moire pattern effect.

8. A color cathode ray tube utilizing a defined number of scan lines per raster frame comprising:

an envelope formed as an integral enclosure medium having a face panel with adjoined funnel and neck portions;

an integrated electron gun structure positioned within said envelope neck portion in a manner to beam a plurality of three ultimately converging in-line electron beams toward said panel;

a shadow mask member having a multitude of elongated apertures formed therein and vertical and horizontal axes thereacross; said mask being oriented forward of said electron gun structure in spaced adjacency to the interior surface of said face panel at the convergence position of said plural in-line electron beams, each of said elongated apertures having substantially rounded ends defined by the interstitial webbing of said mask has longitudinal and transverse axes therethrough in-

tersecting at the center thereof; said elongated apertures being arrayed in a substantially uniform pattern with the longitudinal axes of said apertures oriented relative to the vertical axis of said mask and the transverse axes of said apertures oriented relative to the horizontal axis of said mask; the aperture pattern array of said mask being defined by the orientation of said apertures to form a plurality of inter-related horizontal rows and vertical columns whereof the apertures in alternate horizontal rows are vertically aligned; the spacings between the apertures in the horizontal and vertical relationships of the pattern array additionally effecting linear diagonal pitch associations between adjacent apertures in adjacent horizontal rows to also form an array of intersecting diagonal rows; said rows in a given directional orientation being substantially parallel; the dimensional aspects relating to said elongated apertures being referenced in terms of an equilateral parallelogram having definitive acute and obtuse angular vertices formed at the centers of four mutually adjacent apertures located in three sequential horizontal rows, said parallelogram having the obtuse vertices joined by a first diagonal thereacross horizontally oriented to define the center-to-center spacing between horizontally adjacent apertures, said horizontally related apertures having an unbroken area of interstitial webbing therebetween of a height at least equalling the lengths of said apertures, said parallelogram having the acute vertices joined by a second diagonal thereacross vertically oriented to define the center-to-center spacing between vertically adjacent apertures that is greater than the center-to-center spacing between horizontally adjacent apertures the vertical center-to-center spacing between adjacent horizontal rows of apertures being of a value substantially other than that resultant from dividing the vertical dimension of the usable mask area by the number of scan lines utilized in scanning said usable area to minimize subsequent moire pattern effect, and

a cathodoluminescent screen having a repetitive patterned array of substantially contiguous nesting phosphor areas formed in substantially horizontal rows on the interior surface of said face panel adjacent to said mask, said phosphor areas being of round-ended elongated shapes similar to the elongated apertures in said mask having been formed by the utilization of said apertures.

9. A color cathode ray tube according to claim **8** wherein said plurality of electron beams emanate as three beams in a horizontal in-line arrangement whereof the in-line plane substantially corresponds with the horizontal axis of said mask.

10. A color cathode ray tube according to claim **8** wherein the elongated apertures in said shadow mask member having a longitudinal to transverse aspect ratio ranging substantially from 2:1 to 20:1.

11. A color cathode ray tube according to claim **8** wherein the elongated apertures in the shadow mask evidence a spacing relationship whereof the vertical spacing between adjacent horizontal rows of apertures and the horizontal spacing between adjacent apertures is expressed by a ratio exceeding 0.5 to 1.

12. A color cathode ray tube according to claim **8** wherein the elongated apertures of the shadow mask have length and width dimensions wherein the aperture length is of a value smaller than the vertical center-to-center spacing between adjacent horizontal rows of apertures, and wherein the aperture width is of a value smaller than one-third of the horizontal center-to-center spacing between adjacent apertures.

13. A color cathode ray tube according to claim **8** wherein the elongated apertures of said shadow mask provide a center transmission factor exceeding substantially 18 percent per unit of mask area.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,777,204 Dated December 4, 1973

Inventor(s) John D. Robbins and Louis R. Wanner

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, Line 55: "5:1" should read -- .5:1 ---

Column 7, Line 57: "G" should read -- G_o ---

Signed and sealed this 30th day of April 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents