May 5, 1970 G. A. BURDICK 3,509,802

CATHODE RAY TUBE EXPOSURE OPTICS

Filed Dec. 29, 1966 7 Sheets-Sheet 1

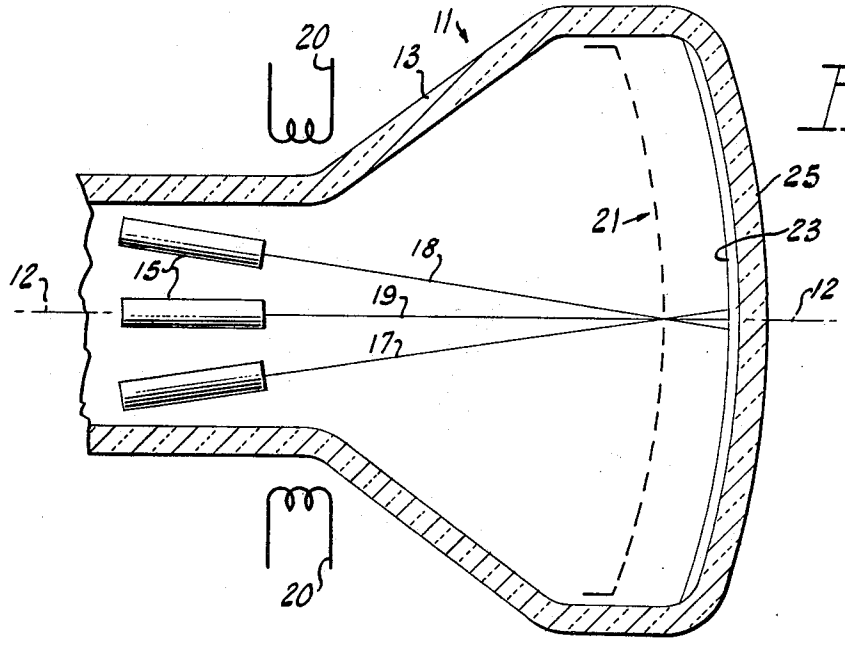


Fig. 1

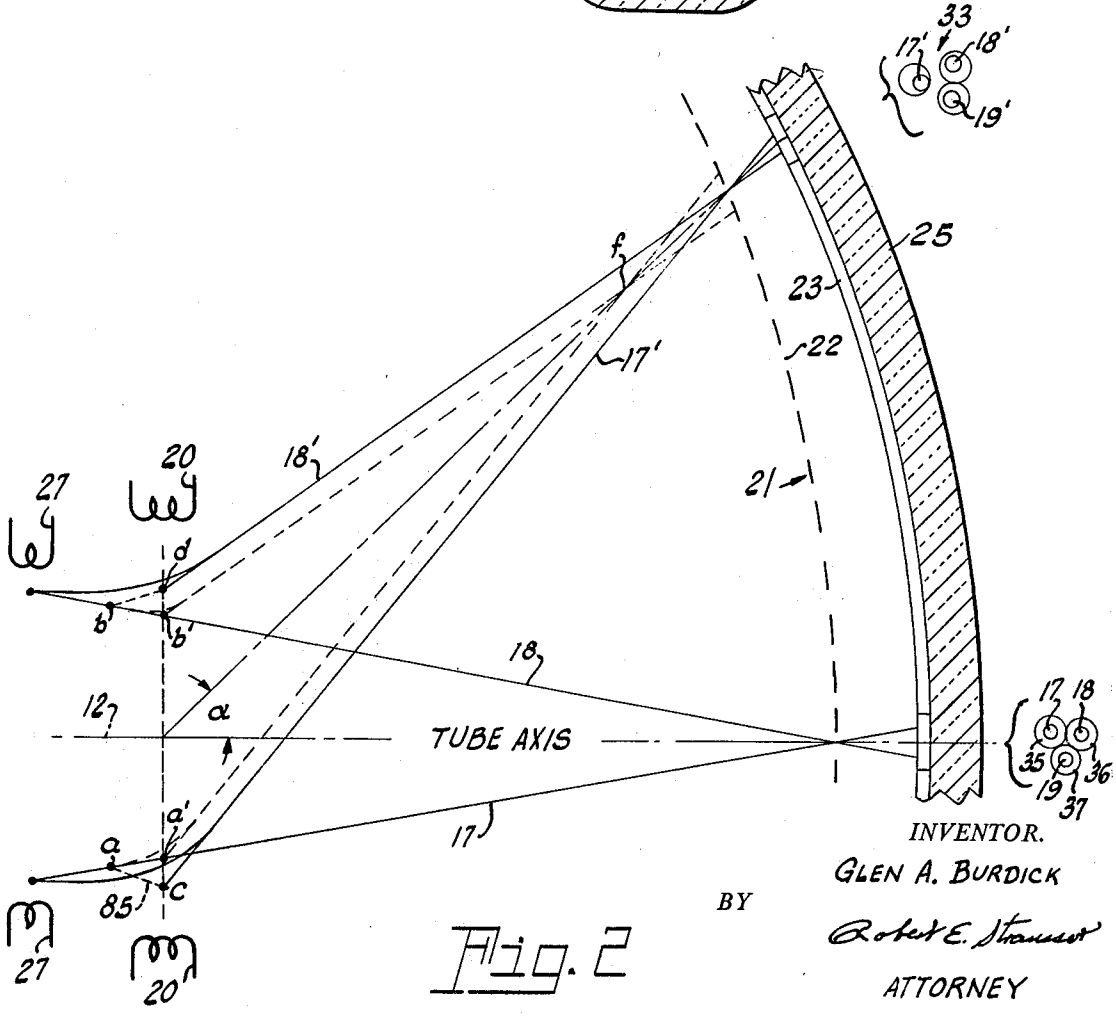


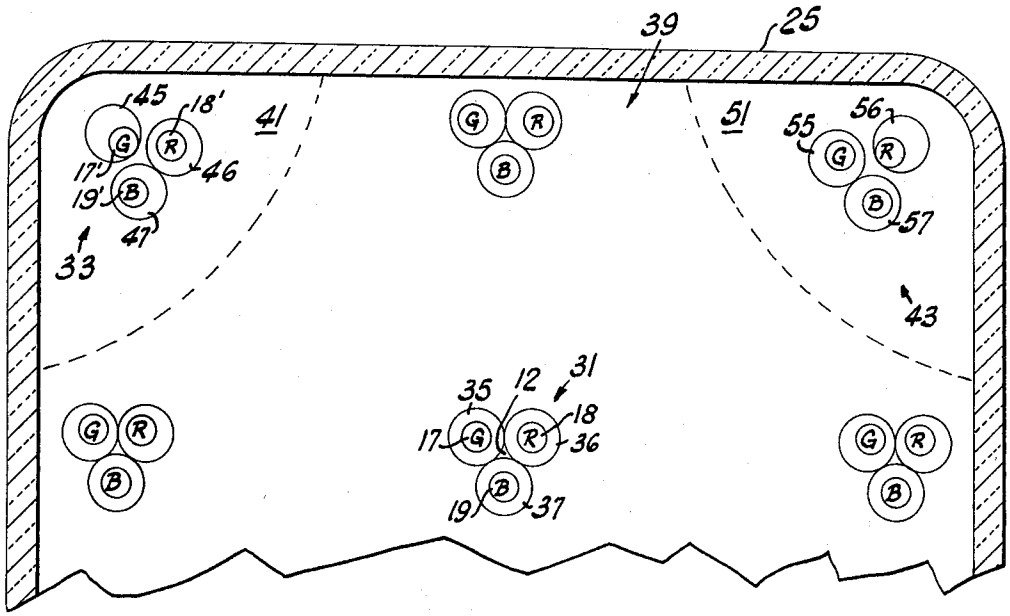
Fig. 2

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CATHODE RAY TUBE EXPOSURE OPTICS

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Prior Art

Fig. 3

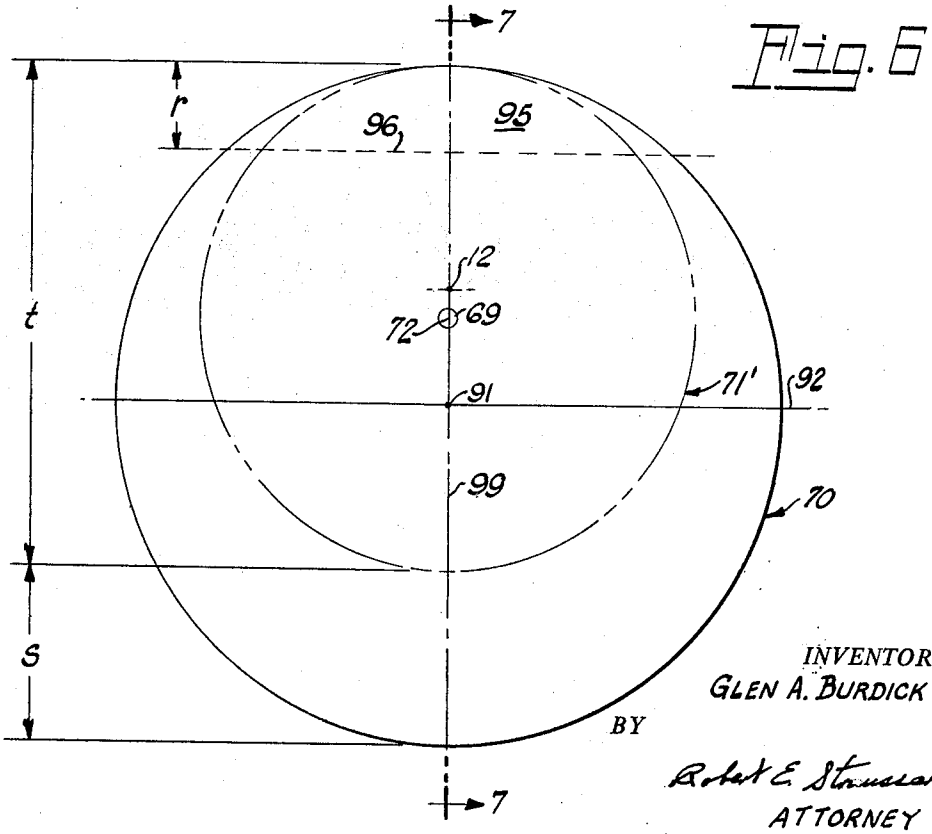


Fig. 6

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CATHODE RAY TUBE EXPOSURE OPTICS

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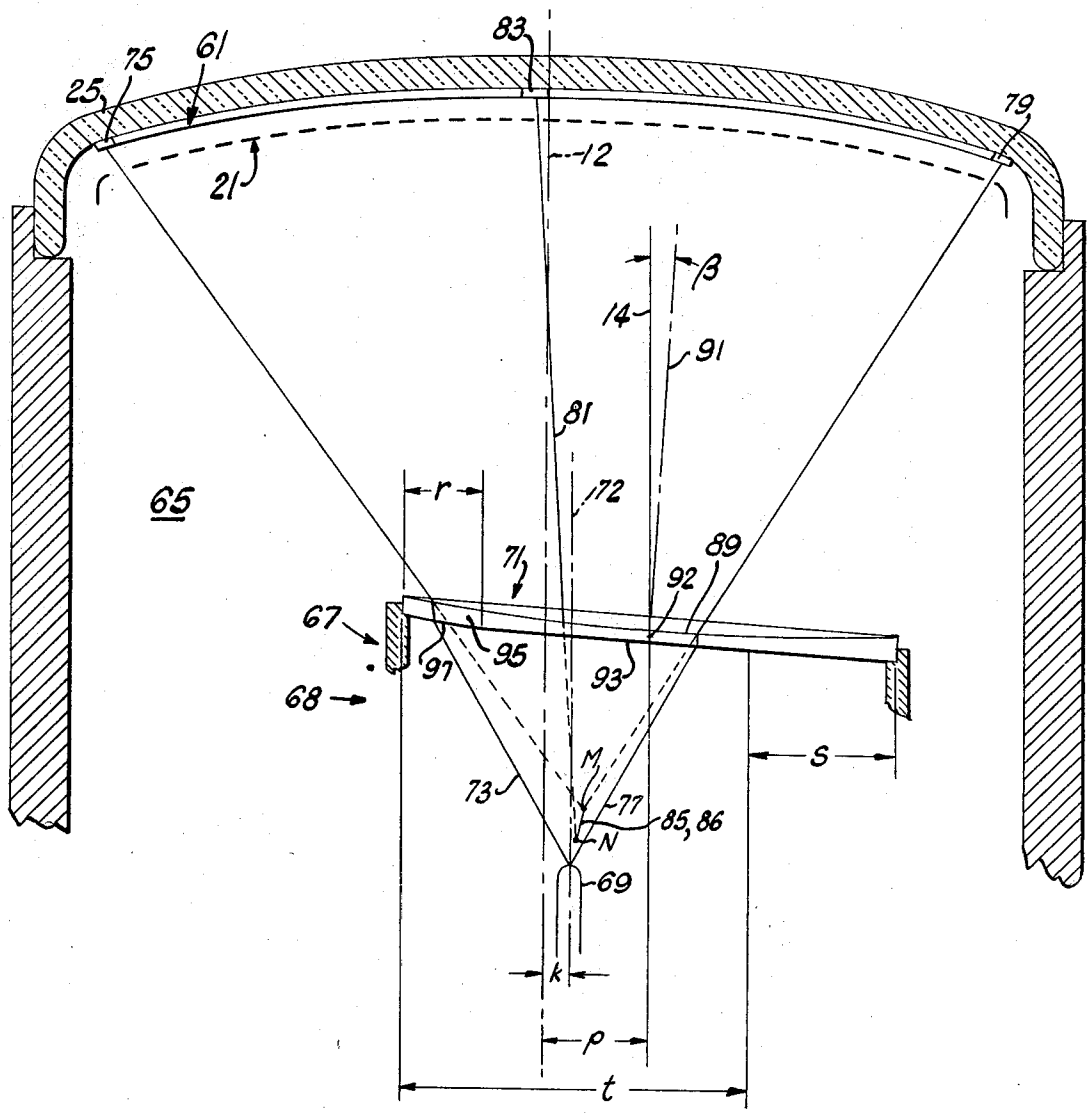


Fig. 4

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CATHODE RAY TUBE EXPOSURE OPTICS

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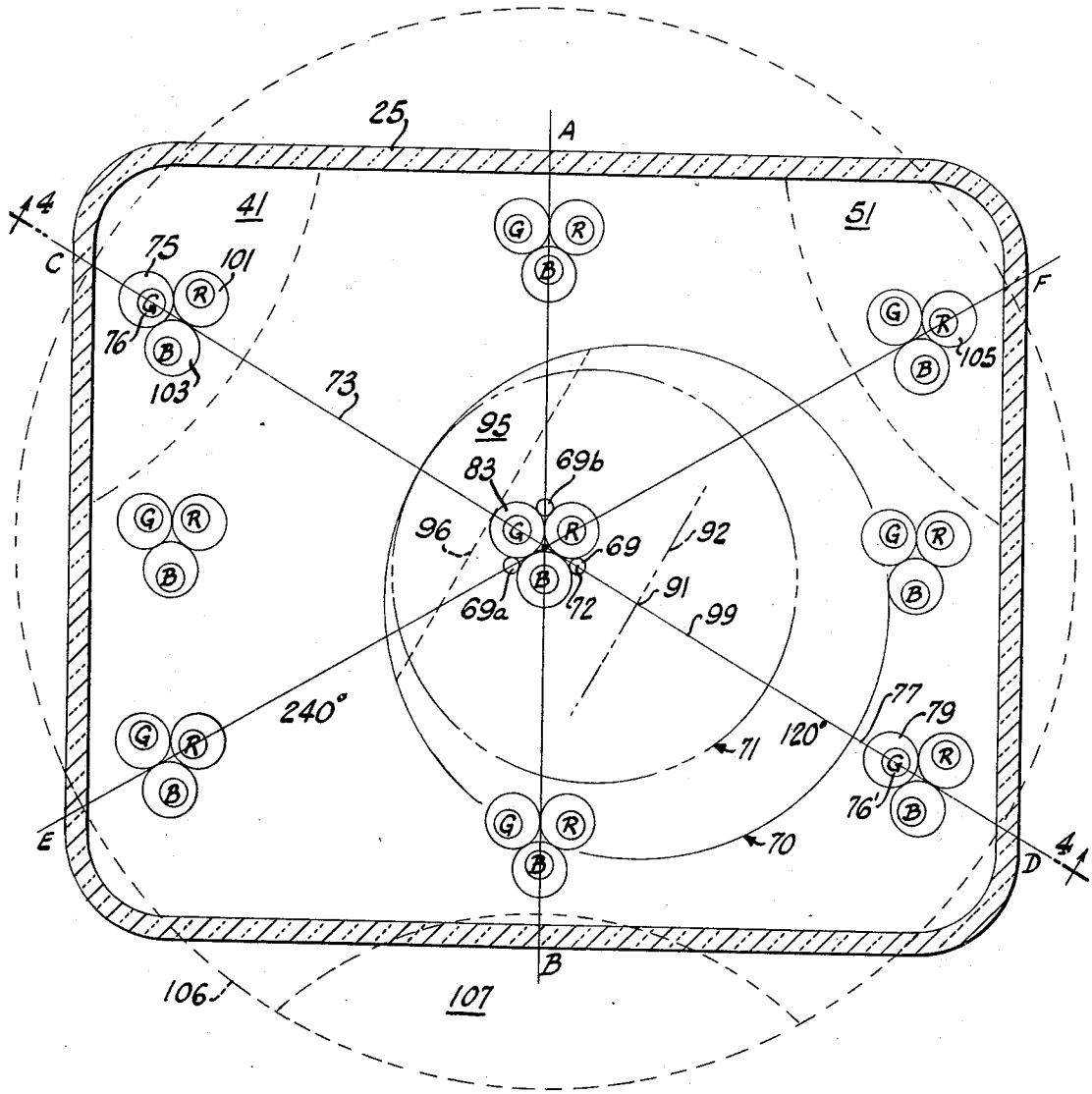


Fig. 5

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CATHODE RAY TUBE EXPOSURE OPTICS

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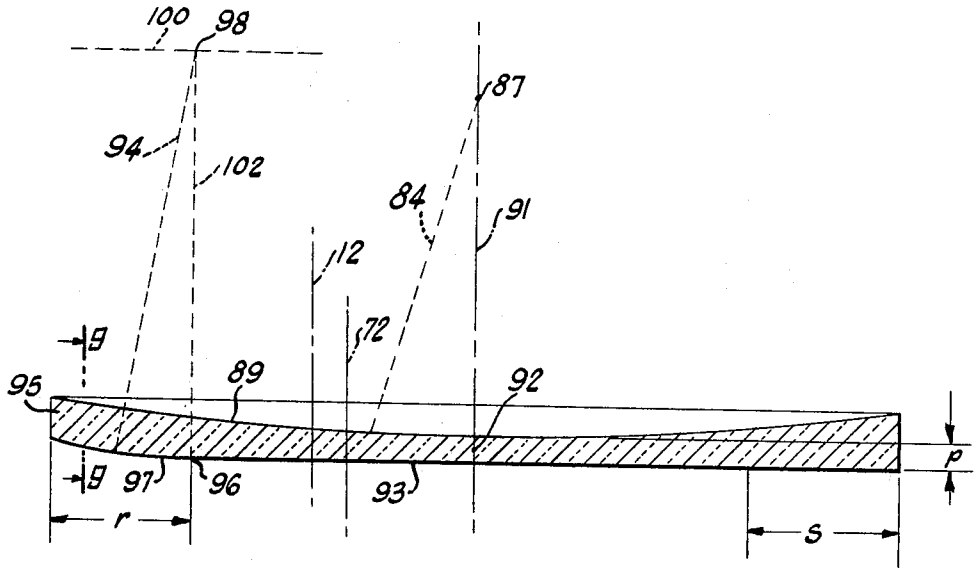


Fig. 7

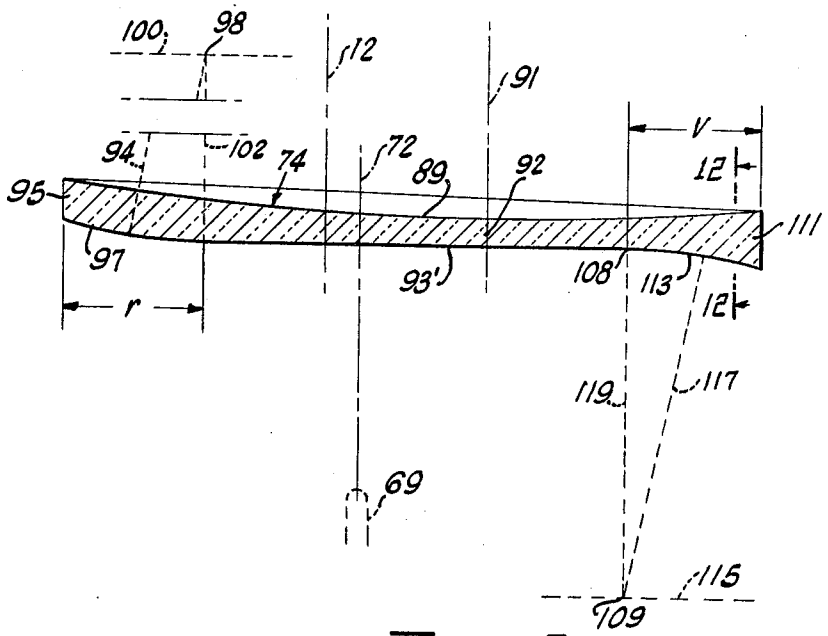


Fig. 8

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CATHODE RAY TUBE EXPOSURE OPTICS

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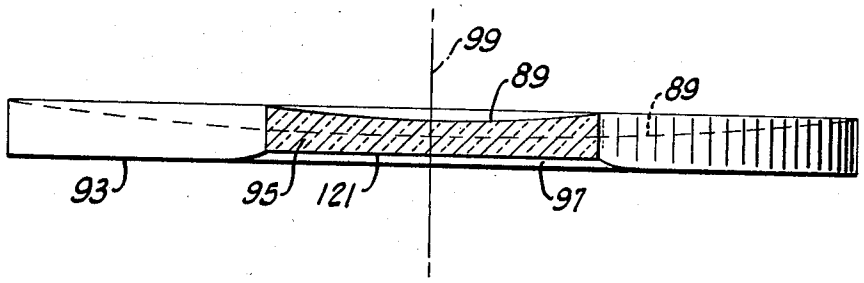


Fig. 9

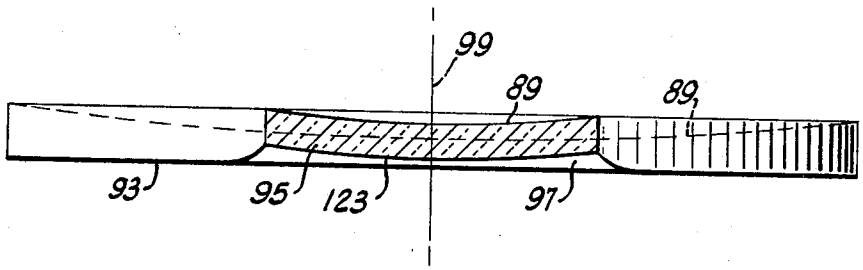


Fig. 10

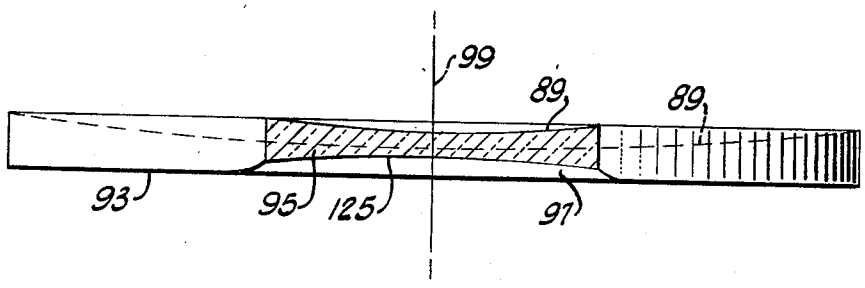


Fig. 11

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CATHODE RAY TUBE EXPOSURE OPTICS

Filed Dec. 29, 1966 7 Sheets-Sheet 7

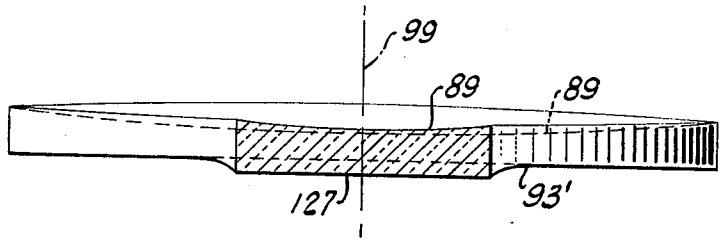


Fig. 12

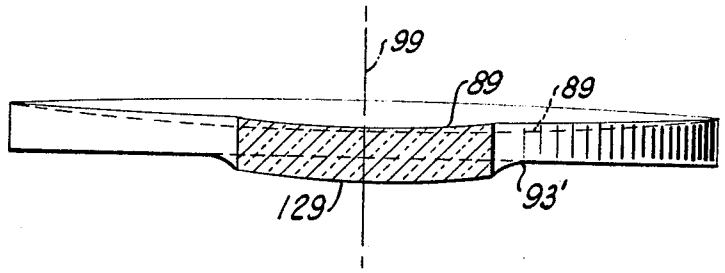


Fig. 13

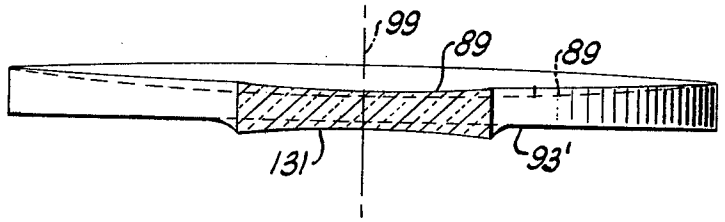


Fig. 14

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United States Patent Office 3,509,802
Patented May 5, 1970

3,509,802

CATHODE RAY TUBE EXPOSURE OPTICS

Glen A. Burdick, Waterloo, N.Y., assignor to Sylvania Electric Products Inc., a corporation of Delaware

Filed Dec. 29, 1966, Ser. No. 605,783
Int. Cl. G03b 41/00
U.S. Cl. 95—1 14 Claims

ABSTRACT OF THE DISCLOSURE

An optical system utilized for providing a tri-dot patterned color cathode ray tube screen having phosphor patterns of improved symmetry. The optical system is predeterminately positioned to expose a sensitized screen panel through an associated apertured mask. A portion of the exposure light radiation is refracted by a modified plano-concave lens having at least one modified plano chordal portion whereby improved exposure is provided for one or more specific peripheral quadrantal portions of the screen to effect substantially improved equilateral phosphor dot pattern formation thereon.

This invention relates to cathode ray tubes and more particularly to improved patterned screens and a method and optical apparatus utilized in forming said improved screens for color cathode ray tubes.

Cathode ray tubes employed as display devices in color television applications conventionally utilize one or more electron guns to provide the required electron beam or beams which are accelerated, focused and modulated by voltages applied to the gun. When a plurality of guns are used in a related manner, convergence electrodes or pole pieces are usually included as part of the electron gun structure. The modulated electron beams are discretely deflected across the screen to provide electron impingement upon selected color fluorescing materials disposed in patterned configurations on the viewing panel of the tube to reproduce the transmitted color image. It is conventional practice to position a grid or grids or an apertured mask intermediate the electron gun or guns and the cathodoluminescent screen to provide focusing and deflection of the electron beams or selected masking of the screen.

Color cathode ray tubes, of the type generally utilized for color television, usually have screens consisting of multitudinous dot, bar or stripe patterned formations of green, blue, and red color fluorescing phosphors. Various methods have been employed to form the respective screens, for example, one conventional process makes use of a photoprinting technique. By this procedure, the tube viewing panel is coated with a light sensitive substance and one of the desired electron-responsive phosphor materials and then exposed to a point source of light through an appropriate negative master. Subsequent development produces a first phosphor pattern of desired configurations. The process is repeated for each of the remaining different color electron-responsive phosphors comprising the patterned screen. In each instance, the point source of light is appropriately offset during the exposure operation to provide individual phosphor patterns that are properly displaced from one another to form the desired screen.

One difficulty encountered with photo-disposed screens is caused by the electrons not following the same beam-paths during tube operation as the light rays travel during the screen forming procedures. Consequently, there are areas of the screen where the electron beams do not properly impinge the desired patterned configurations during tube operation. This condition of misregister results in the display image having color impurity.

The inherent nature of the electron beam is a factor affecting the aforementioned misregister. Since the electrons projected toward the screen have mass and charge, their paths of travel are altered by the electron gun and tube geometry and by various electrostatic and magnetic fields existing in and around the tube. It has been found that the center of deflection, or the location within the deflection yoke from which the electrons appear to come, moves as the electron beam scans the screen. In addition, when several electron guns are utilized to effect a plurality of electron beams the phenomena resulting from the dynamic convergence of the several beams causes a departure of the beams from their normal paths of travel.

Various procedures and devices for reducing the amount of misregister between the electron beam or beams and the fluorescent pattern configurations have been employed. Auxiliary devices have been used internally and externally of the tube and on and about the tube components in an effort to compensate for the excursion of the electron beams from the desired trajectories. In the screen exposure devices, several light optical systems have been devised to consummate the photodeposition of the desired screen pattern. For example, in tubes having a discretely dotted screen pattern formed relative to a foraminous shadow mask wherein a triad of dots of differing cathodoluminescent phosphors are related to each aperture in the mask, several types of lens components have been incorporated into the light optical system. For instance, in color tubes having a 70 degree angle of deflection, it has been found that use of a spherical symmetrical planar-concave lens, properly tilted and offset, provides light optics which substantially duplicate the electron optics of the operating tube as effected by the axial motion of the center of deflection and dynamic convergence. Screen exposure systems of this type are described and claimed in Pat. No. 2,986,080 issued to Glen A. Burdick, and Pat. No. 2,936,683 issued to Glen A. Burdick et al., both of which are assigned to the same assignee as the present invention.

In the manufacture of screens for color tubes having angles of deflection greater than 70 degrees, for instance, rectangular tubes having 90 degree deflection, it has been discovered that use of the aforementioned lens does not achieve the desired register relationship between light optics and electron optics. In at least two areas of the screen, in substantially the upper right and upper left hand corner areas, the desired equilateral dot patterns are not fully realized. A related lack of symmetry exists in the 70 degree tube exposure optics, but due to the smaller angle of deflection the effect is not significant in magnitude, and the dot pattern-beam registration is acceptable for all areas of the screen. For the most part, in the screen of the 90 degree tubes, the dot and beam patterns are substantially in desired registry for all parts of the screen except in the areas of the two mentioned upper corner regions of the viewed screen. In the upper right corner areas the dots of one color tend to be displaced in an outward radial direction in their triad patterns, and in the upper left corner area dots of another color are affected in a similar manner.

Accordingly, it is an object of the invention to reduce the aforementioned difficulties and to provide an improved color cathode ray tube.

Another object is to provide a color cathode ray tube screen having a dot pattern of improved symmetry.

Still another object is to provide an improved shadow mask color cathode ray tube having improved register of electron beam impingement on the phosphor dot pattern.

A further object is to provide an improved method and optical system for producing color screens having dot patterns of improved symmetry.

The foregoing objects are achieved in one aspect of the invention by the provision of an improved method and an associated optical system for use in a light exposure device for photo-fabricating an improved color cathode ray tube screen having a patterned mask in spaced adjacency therewith. The light radiation for screen exposure is discretely refracted by a modified plano-concave lens having non-symmetrical optical aberration positioned between a light source and the masked sensitized panel. Improved light refraction is achieved by utilizing the modified lens in a manner that the modified portion of the plano surface formed as at least one substantially chordal area is oriented to provide desired correction of light ray refraction and direction to a discrete area of the screen to thereupon effect the optical imprinting of a screen pattern having improved symmetry.

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 accompanying drawings in which:

FIG. 1 is a cross sectional view of a color cathode ray tube of the shadow mask type employing plural electron beams;

FIG. 2 is a section view showing the manner in which the electron beams are converged in the tube;

FIG. 3 is a partial plan view illustrating a prior art rectangular screen wherein the dots and beam landings are exaggerated in size;

FIG. 4 is a section plan view of a type of apparatus utilized in photo-disposing patterned cathode ray tube screens taken along the line **4**—**4** of FIG. 5;

FIG. 5 is a top plan view looking down through the panel into the apparatus;

FIG. 6 is a plan view showing the optically utilized portion of the refractive medium;

FIG. 7 is a sectional view of the refractive medium taken along the line **7**—**7** of FIG. 6;

FIG. 8 is a sectional view showing another embodiment of the invention;

FIG. 9 is a sectional view showing the transverse profile of the modified first chordal portion taken along the line **9**—**9** of FIG. 7;

FIGS. 10 and 11 are sectional views showing alternate embodiments of the transverse profile of the modified first chordal portion taken along the line **9**—**9** of FIG. 7;

FIG. 12 is a sectional view showing the transverse profile of the modified section chordal portion taken along the line **12**—**12** of FIG. 8; and

FIGS. 13 and 14 are sectional views showing alternate embodiments of the transverse profile of the modified second chordal portion taken along the line **12**—**12** of FIG. 8.

With reference to the drawings, FIG. 1 illustrates a conventional plural beam shadow mask type of color cathode ray tube **11** having a central axis **12** therethrough. Suitably disposed within the neck portion of the envelope **13** are three electron emitters **15** oriented, for example, substantially 120 degrees apart equally spaced about axis **12** to provide a delta arrangement of electron beams **17**, **18** and **19**. Coil means in the form of yoke **20** positioned external of the envelope, are utilized to deflect the electron beams over the raster area. It is desirable that the several beams converge at the mask **21** and pass through apertures **22** therein to discretely impinge the patterned cathodo-luminescent screen **23** therebeneath. The screen comprises a multitude of triadically arranged dot or elements of green, blue and red color electron responsive fluorescing materials formed on the interior surface of the viewing panel **25**. While a tri-gun shadow mask color tube is illustrated in FIG. 1, it is not intended to be limiting as the invention to be described in this specification is also applicable in other types of image reproduction devices employing plural beams of radiant energy excitation.

Since the tube axis, the panel axis and the electron gun system axis are substantially coincidental, it seems expedient for clarification in this description to henceforth denote these several reference axes as the central axis **12**.

To achieve the desired convergence or crossover of the several beams at the mask apertures, external dynamic convergence means **27** are normally utilized. With reference to FIG. 2, two of the three beams, **17** and **18**, respectively, are shown to illustrate the aspects of dynamic convergence. The static convergence beam paths, **17** and **18**, passing through points *a* and *b*, respectively, in the deflection region, proceed at an angle with the tube axis to converge or crossover at the apertured mask **21** and thence impinge the patterned screen **23**. In deflecting the beams to an angle alpha (α) without the influence of the dynamic convergence means **27**, the beams appear to come from points *a'* and *b'* and undesirably effect convergence short of the mask at point *f*. Employment of the dynamic convergence means provides magnetic fields which move the beam positions **17'** and **18'** radially outward in the deflection region to cause the beam positions **17'** and **18'** to appear to come from points *c* and *d* to provide the desired convergence crossover at the apertured mask. It will be observed that as the angle of deflection increases, the deflected electron beam appears to emerge from the deflection region at a point closer to the screen. For example, as the electron beam path **17** is deflected from the static position to the convergence deflected beam path **17'**, the dotted line between *a* and *c* defines the locus of motion **85** of the apparent center of deflection. In like manner, movement of the related beam from static beam path **18** to the convergence deflected path **18'** defines the locus of motion of the apparent center of deflection as being along the dotted line between *b* and *d*. The apparent center of deflection and locus of motion thereof is different for each electron beam because of the respective electron gun orientation within the tube.

Screen **23** is comprised of multitudinous triadical groupings of electron responsive phosphor dots **35**, **36**, and **37**, respectively. Two of such triadical groupings are illustrated in FIG. 2, namely, an axial grouping **31** and a radial grouping **33**. The geometry of the tube is such that the three electron beam landings form a substantially equilateral triadical formation at the center of the screen and a radially compressed triadical formation at the peripheral region thereof. With the optical system conventionally utilized for screen exposure, the photo-disposed triadical phosphor dot patterns, while substantially equilateral over a major portion of the screen area, depart significantly from equilaterality in certain peripheral areas. This departure is particularly noticeable in tubes having wide angles of deflection in excess of 70 degrees, as for example 90 degree deflection in rectangular screen tubes. Such is shown in FIG. 3 wherein fragmentary portion of a prior art rectangular screen **39** is portrayed from the viewpoint of an observer facing the viewing panel **23**. Illustrative groupings of dots and beam landings are shown in exaggerated size. The axial dot grouping **31** has substantially equilateral placement of phosphor dots **35**, **36**, and **37**. When the electron beams **17**, **18**, and **19** pass through the mask and make landings on the electron-responsive dots, the areas of impingement fluoresce in a color characteristic of the particular phosphor, such as green (G), red (R), and blue (B), respectively. In the upper left screen region **41**, the illustrated radial grouping **33** shows an outward radial displacement of the phosphor dot **45** with reference to adjacent dots **46** and **47**. The criticalness of this displacement is evidenced when the deflected beam **17'** makes a peripheral G landing thereon. A similar situation erists in the upper right screen region **51** where an exemplary upper right radial triad **43** has the red phosphor dot **56** radially displaced.

It has been found that correction of the misplaced dots in the aforementioned corner regions of rectangular screens can be achieved by utilizing the method and the

specialized optical system of the invention during screen exposure.

An optical exposure apparatus, such as that depicted in FIG. 4, is utilized in the method to form the aforementioned dot patterned screen. It is desired to directly dispose the triadical dot patterns in a manner that the subsequent electron beam landings will be in register therewith and have the largest possible minimum border of fluorescent material around each beam impinging position. Prior to the exposure of each of the several patterns comprising the screen, the screen-bearing surface, in this instance the inner surface of the viewing panel **25**, is coated with a light hardenable photosensitive substance and a desired electron responsive color cathodoluminescent phosphor material, one for example being zinc-cadmium sulfide which fluoresces green, to form a photosensitive phosphor-associated film **61** thereover. Next, the apertured mask is temporarily positioned in spaced adjacency with the sensitized panel, whereupon the mated mask-panel assembly is suitably oriented on the exposure apparatus **65**. Within this apparatus, there are means **67** for predeterminately positioning an optical system **68** comprising a point light source **69** and a light refractive medium in the form of a modified plano-concave lens **71** wherein a portion of the plano surface is distinctly modified. In the exposure step, discrete areas of the coated panel are subjected to light radiating from the point light source **69** which is refracted in a predetermined manner by the lens **71** and directed through the mask apertures **22**. The discrete areas of the photosensitive film **61** which are exposed to the light radiation become hardened and adhere to the surface of the glass panel forming an imprint of a first screen pattern of dots. Sequentially, a screen developing step removes the intervening unexposed portions of the film shadowed by the solid portions of the mask structure wherein the panel is treated with a suitable solvent or developing fluid. The above-described procedure is twice repeated to dispose the required blue and red phosphor dot patterns of the complete screen combination. For the separate exposure of each screen pattern, the light source and lens are properly positioned and offset from the central axis, the optical system being shifted substantially 120 degrees about the central axis for each subsequent pattern exposure.

With reference to FIG. 4, 5, 6, and 7 the essentials of the optical system **68** are shown in greater detail wherein a light refractive medium such as a modified plano-concave lens **71** of high UV transmissive optical glass is positioned intermediate the point light source **69** and the apertured shadow mask **21**. As previously described, the locus of motion of the apparent center of deflection in the operating tube appears to move forward toward the screen as the angle of deflection increases. In a like manner the apparent origin of the light source appears to follow a similar locus due to the optical aberrations designed into the lens. Of the light emanating from source **69**, a ray **73** designated as a single line is selected for illustration. Upon being incident upon and refracted by lens **71**, subject ray is directed to a particular portion of the mask **21** to pass through an aperture therein and light expose a phosphor dot area **75** of the screen. The electron beam for the same deflection angle appears to originate at point M, which also appears to be the apparent light source for ray **73**. Another light ray **77**, directed to an opposite portion of the screen to expose phosphor-dot area **79** is likewise refracted to have an apparent light source at M. With N designating the apparent light source for a ray **81** beamed to the center dot area **83**, the apparent locus **86** of motion of the light source is along the line M–N. Although the light rays **73** and **77** originate at the point source **69**, they appear to come from a point on locus **86**, when viewed from the screen, due to refraction of the modified lens **71**. Thus (with reference to FIG. 2 and 4) the optical system of the exposure device as utilized in the method of the invention produces the desired special relationship between the respective local of motion **85** and **86** of the apparent center of electronic beam deflection and the loci of the apparent origins of the light beams to effect the desired register between the prosphor dot screen pattern and respective electron beam impingements thereon. The optical system illustrated is, for example, capable of photo-disposing the green fluorescing screen pattern whereof a dot in substantially the upper left corner of 10 o'clock area of the viewed screen is designated as **75** and one at suzstantially the lower right corner or 4 o'clock area thereof as **79**. The relationship of subsequent electron beam impingement on these respective phosphor dots is indicated in FIG. 5 as 76 and 76'.

The design of the modified plano-concave lens and the positioning of the lens relative to the masked panel, the central axis and the light source may be adequately achieved in several ways: by mathematical calculation, by empirical experimentation, or by a judicious combination of the two.

The modified plano-concave lens **71** as utilized in the improved optical system of the invention for photo-disposing the screen of a 25 inch rectangular shadow mask tube having substantially 90 degree deflection, has corrective qualities for optical aberration substantially equivalent to the length of the locus of motion of the apparent center of deflection for all angles included within the subject 90 degree deflection. By way of illustration, the basic circular lens **70** has a symmetrical concave portion or spherical concavity **89** having a radius of curvature **84** of approximately 83.500 inches determined from a point **87** on the basic lens axis **91** which is also referred to as the quasi-axis of symmetry. The thickness of the lens p at this quasi-axis is approximately 0.200 inch. In this example the lens plano portion **93** has a modified chordal section **95** shaped as a substantially circular cylindrical section with the surface **97** thereof transitionally tangent to the plano surface along a substantially linear region of demarcation **96**. The axis **98** of the substantially cylindrical section is spacedly oriented from the concave surface **89** in a plane **100** substantially parallel to the plano lens surface **93**, the axis **98** of the cylindrical section being substantially parallel to the substantially linear region of demarcation **96** and in a plane **102** therewith perpendicular to the plano surface **93**. The radius **94** of the substantially cylindrical surface, as determined from the axis **98**, is in the order of 85.00 inches. Thus, a slight convex curvature is imparted to the chordal area in a direction toward the spherical concavity which effects a gradual reduction in the refractive thickness of the lens. It has been found that this chordal modification improved the refraction of the light rays directed to the upper left region of the screen and brings the ray landings radially inward for desirably disposing the green phospher dots.

It has been found that the orientation of the optical system to produce the desired aforedescribed dot placement in the 25 inch rectangular panel can be accomplished by orienting the several axes of related elements of the system in a common vertical plane. For example, there is contained in subject common plane the central axis **12** wherefrom the axis **72** of the point light source **69** is laterally offset by a distance k of approximately 0.180 inch; and wherein there is also located the quasi-axis **91** of the lens component **71** which is offset from the central axis by a distance p of approximately 1.938 inches. Optimizing of the angles of incidence and refraction is effected by imparting a slight tilt to the lens which is achieved by tilting the quasi-axis thereof at an angle (β) of substantially .5 degree from a line **14** parallel with the central axis **12** and oriented in the common vertical plane therewith. Consummation of the lens tilt is accomplished about a lateral axis of placement **92** which perpendicularly intersects the quasi-axis **91** and the lens plane of symmetry **99**. The amount of offset and tilt of the modified lens **71** are inter-related in a compensating manner whereof an increase in offset will permit a reduction in tilt and vice-versa to achieve the desired results.

It will be noted that the basic lens **70** is offset in the exposure device in a manner that only a portion of the spherical concavity **89**, removed or shifted eccentrically from said quasi axis, is optically utilized as a non-symmetrical spherical concavity. The concavity in conjunction with a portion of the plano surface **93** and the chordal area **95** constitute the elements of utilized light refractive medium **71**. In addition, it will be noted that the quasi-axis is retained therein. The portion of the basic lens **70** designated by *s* is not optically utilized in the application, and if desired can be removed by forming a smaller optical unit therefrom embodied by the dimension *t* in the form of refractive medium **71'** which contains the optical essentials for the application previously designated by refractive portion **71** of basic lens **70**. Henceforth, in this description, to enhance clarity, the utilized refractive medium will continue to be referred to as **71** and the extraneous portions of basic lens structure **70** will be disregarded. Due to the rectangular screen shape, differing portions of the refractive medium **71** are utilized to expose the dot pattern of each respective color producing phosphor.

With particular reference to FIG. 5, looking into the panel **25** positioned atop exposure apparatus **65**, positioning planes utilized in orienting the optical system for photodisposing the several color fluorescing phosphor patterns are indicated. For example, the green dot pattern is formed by positioning the optical system in plane CD which substantially corresponds to the 4–10 o'clock panel diagonal, being removed clockwise from the 12 o'clock position in ordinate plane AB by 120 degrees. The plane of symmetry **99** of refractive medium **71** is positioned coincident with plane CD. This plane of lens symmetry bisects the first chordal portion **95** in a manner perpendicular to said substantially cylindrical section and has the quasi-axis **91**, the light source axis **72**, and the central axis **12** contained therein. The light irradiation directed to the upper left or 10 o'clock quadrantal area **41** of the screen is refracted in an improved manner by the chordal lens portion **95** to pull the light beam impingement radially toward the central axis **12**. This refractive improvement photo-disposes the green dots **75** in that screen area in an improved equilateral triadical position with the contiguous red and blue dots **101** and **103**, respectively. The maximum correction of dot placement is in the chordal effected area along the plane CD. Correction diminishes in a gradual manner on either side therefrom. The unmodified portion of the plano-concave lens effects light radiation refraction to provide substantially equilateral dot pattern exposure for the remaining area of the sensitized screen panel.

In photo-disposing the red dot pattern the optical system is positioned along plane EF which substantially corresponds to the 2–8 o'clock panel diagonal, being removed clockwise from the 12 o'clock position by 240 degrees. In FIG. 5 while the whole optical system is shifted to coincide with plane EF only light source **69***a* is shown to avoid confusion in the drawing. In this position, the first chordal portion **95** effects refractive improvement for the red dot pattern in the upper right or 2 o'clock quadrantal area **51** of the screen bringing the red dot positions **105** radially inward into an improved triadical position so that the subsequent electron beam impingement will be better centered thereon.

For blue dot deposition the optical system is oriented in the AB ordinate plane wherein light source **69***b* is indicated. With the optical system so positioned, the refractive improvement effected by the first chordal portion falls within an area **107** which is substantially outside of the rectangular panel and needs no correction, but in a round panel **106** correction of blue dot orientation would be desired in said area. Thus, in a rectangular screen the first chordal lens portion affords improved dot positioning for each of two color patterns in substantially a specific area of the screen for each. This facilitates a subsequent color display of improved color purity since the color dot patterns are more desirably positioned in these certain screen areas to be in better register with electron beam impingement. The various subsequent electron beam landings are designated in FIG. 5 to indicate the improvement produced.

Since the optical system **68** may be tilted with reference to the central axis **12** or the distance of offset of the lens or light source may be varied therefrom or the angle of lens tilt varied, it may be expedient to modify a second portion of the plano surface of the lens. A second embodiment of the invention as shown in FIG. 8 allows a change in the lens tilt-lens offset relationship wherein a second chordal portion **111** is modified to make correction to dot placement in the screen areas oriented substantially opposite the influence of the first chordal portion **95**. The modified plano-concave lens **74**, which has a usable refractive portion similar to that exhibited by refractive medium **71'**, as illustrated in cross-section in FIG. 8, has a first modified chordal portion **95** with a substantially cylindrical surface **97** as previously described for the initial embodiment. In addition, there is a second modified chordal portion **111** substantially diametrically opposed to the first chordal portion **95** with an intervening substantially unmodified plano portion **93'** therebetween; the second chordal portion being oriented substantially opposite the non-symmetrical spherical concavity **89**. This section chordal portion, substantially involving the section *v*, is formed as a second substantially cylindrical surface **113** transitionally tangent to the plano surface **93** at a second substantially linear region of demarcation **108** to impart a slightly opposed concave curvature in a direction away from said spherical concavity and effect a gradual increase in the refractive thickness of the light refractive medium **74** in a second selected peripheral area thereof. The axis **109** of the second substantially cylindrical section is spacedly oriented from the plano surface **93** in a plane **115** substantially parallel thereto, the axis **109** being substantially parallel to the linear region of demarcation **108** and in a plane **119** therewith perpendicular to the plano surface **93**. The radius **117** of the second substantially cylindrical surface, as determined from axis **109**, is of a value to effect the required arcuate surface for consummating the desired refraction. The plane of symmetry of this refractive medium bisects both chordal portions and is oriented in the optical system as for the previously described embodiment. The utilization of this second light refractive medium facilitates dot placement compensation in diagonally opposite areas of the screen when such is desired.

While the modified first and second chordal portions of the plano lens surface have been described as being substantially circular cylindrical sections, optical requirements may necessitate forming the chordal surface in accordance with sequentially differing radii **94** and/or **117** in effecting peripheral contours other than circular. If such be the case for either or both chordal surfaces, the planes **100** and/or **115** containing the respective axes **98** and **109** may be parallelly shifted in spaced relationship to the plano lens surface according to radial requirements. In addition, it may be desirable for optical considerations to effectuate a departure from cylindricity in all or a portion of each or both of the modified chordal surfaces. For example, with reference to FIGS. 7, 9, 10 and 11, the profile substantially cylindrical general surface **97** of the first chordal portion **95**, as transversely defined by lines of intersection between planes parallel with the perpendicular plane **102** and the general chordal surface **97**, may be a substantially straight surface as indicated by the substantially straight profile **121** as shown in the embodiment illustrated in FIG. 9. Optical requirements may necessitate the formation of a slightly curved surface, as for example, an arcuately ellipsoidal surface as characterized by the elliptic line **123** in the embodiment shown in FIG. 10, or an arcuately hyperboloidal surface as depicted by the hyperbolic line **125** in the embodiment illustrated in FIG. 11, or the pro-

file surface may be a blended combination of the aforementioned surface embodiments. Similarly, with reference to FIGS. 8, 12, 13 and 14, the profile of the substantially cylindrical general surface **113** of the second chordal portion **111** as transversely defined by lines of intersection between planes parallel with the perpendicular plane **119** and the general chordal surface **113** may be a substantially straight surface as indicated by the substantially straight profile **127** as illustrated in the embodiment shown in FIG. 12. As with the first chordal profile, a slightly curved surface may be optically advantageous for the second chordal portion, such as that portrayed in the embodiment in FIG. 13, wherein an arcuately ellipsoidal surface is indicated by the elliptic line **129**, or an arcuately hyperboloidal surface as shown in the embodiment of FIG. 14 by the hyperbolic line **131**, or a blended combination of the several surface embodiments. Thus, the term "substantially cylindrical" as used in this specification with reference to either or both of the modified chordal lens portions is intended to encompass peripheral surface contours transitionally ranging from substantially right cylindrical to cylindroidal manifestations and transverse profiles ranging from substantially straight to arcuate or respective combinations thereof.

Use of the improved method and associated optical system for patterned screen exposure has markedly improved color screen quality and has provided for the desired register of the dot patterns with electron beam impingement in tubes having deflections in excess of 70 degrees. Thus, a patterned cathodoluminescent screen is produced wherein the phosphor dots in substantially all portions of the screen are in contiguous abutment. This disposure arrangement forms an expansive substantially regular tessellation of dots which are discretely oriented as a multiplicity of similar triadical phosphor groupings. A screen so formed produces a vastly improved display having significantly enhanced color purity.

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 optical system for use in a light exposure device utilized in the fabrication of a patterned cathodoluminescent screen for a color cathode ray tube having a central axis and at least one electron gun positionally related thereto from which emanates an electron beam capable of being deflected from a static path to scan said patterned screen through an intermediately positioned grid mask spaced adjacent to said screen, said optical system being positioned relative to said static beam path to discretely beam light through said mask to photo-dispose said screen pattern on a related screen-bearing panel, said system comprising:

a point source of light radiation having an axis and being directionally oriented relative to said masked coated panel to provide processing illumination thereto;

a modified plano-concave lens having a plane of symmetry with a quasi-axis of symmetry therein and a lateral axis of placement perpendicularly intersecting said quasi-axis and said plane of symmetry, said lens having the concave surface formed as a spherical concavity whereof the portion substantially utilized is a section eccentrically removed from but containing said quasi-axis defining a non-symmetrical spherical concavity, said plano surface being modified in at least one substantially chordal area thereof to provide improved light exposure for at least one specific peripheral quadrantal portion of said screen, said lens being predeterminately positioned intermediate said light source and said masked panel with said concave surface being oriented toward said masked panel and said modified plano surface being oriented toward said point light source to provide non-symmetrical optical aberration for said light radiation; and

means for predeterminately positioning said light source and said lens relative to said masked panel to provide a locus of motion of apparent light beam origin that is substantially coincident with the locus of motion of the apparent center of said electron beam deflection.

2. An optical system according to claim **1** wherein said modified plano surface has a first modified portion substantially opposite said non-symmetrical spherical concavity portion to form a first substantially chordal portion, said first chordal portion being shaped as a first substantially cylindrical section with the surface thereof tangent to said plano surface at a first substantially linear region of demarcation to impart a slight convex curvature to said modified surface in a direction toward said spherical concavity and effect a gradual reduction in the refractive thickness of said lens in a first selected substantially peripheral area thereof.

3. An optical system according to claim **2** wherein said lens is positioned in a manner that said plane of symmetry of said lens bisects said first chordal portion in a manner perpendicular to said substantially cylindrical section and has said quasi-lens axis, said light source axis, and said central axis contained therein.

4. An optical system according to claim **2** wherein said substantially cylindrical section of said first chordal portion of said lens has an axis spacedly oriented from said concave surface in a plane substantially parallel to said plano lens surface, said axis of said substantially cylindrical section being substantially parallel to said first substantially linear area of demarcation and in a plane perpendicular to said lens plane of symmetry.

5. An optical system according to claim **4** wherein said axis of siad first substantially cylindrical section is substantially parallel to said first substantially linear area of demarcation and in plane therewith perpendicular to said plano surface.

6. An optical system according to claim **2** wherein said modified plano surface of said lens has a second modified portion oriented substantially opposite said non-symmetrical spherical concavity to form a second chordal portion being substantially diametrically opposed to said first chordal portion, said second chordal portion being shaped as a second substantially cylindrical section the axis whereof is substantially parallel to the axis of said first substantially cylindrical section and tangent to said plano surface at a second substantially linear region of demarcation to impart a slight opposed concave curvature to said second chordal surface in a direction away from said spherical concavity and effect a gradual increase in the refractive thickness of said lens in a second selected peripheral area thereof.

7. An optical system according to claim **6** wherein said lens is positioned in a manner that the plane of symmetry of said lens bisects said first and second chordal portions in a manner perpendicular to said substantially cylindrical sections and has said quasi-lens axis, said light source axis, and said central axis coincident therewith.

8. An optical system according to claim **6** wherein said substantially cylindrical section of said second chordal portion of said lens has an axis spacedly oriented from said plano surface in a plane substantially parallel thereto, said axis of said second substantially cylindrical section being substantially parallel to said second substantially linear region of demarcation and in a plane perpendicular to said lens plane of symmetry.

9. An optical system according to claim **8** wherein said axis of said second substantially cylindrical section is substantially parallel to said second linear region of demarcation and in a plane therewith perpendicular to said plano surface.

10. An optical system according to claim 3 wherein said optical system is supported at a position offset from said central axis.

11. An optical system according to claim 3 wherein said optical system is supported at a position tilted from said central axis.

12. An optical system according to claim 3 wherein said optical system is supported at a position offset and tilted from said central axis.

13. An optical system according to claim 3 wherein said optical system is supported with said lens offset from said central axis.

14. An optical system according to claim 3 wherein said optical system is supported with said lens offset from said central axis and tilted with reference to said lateral axis of placement.

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