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HETEROGENEOUS LENS FOR FORMING PHOSPHOR PATTERNS ON COLOR KINESCOPE

Filed Oct. 5, 1967

FIG. 1

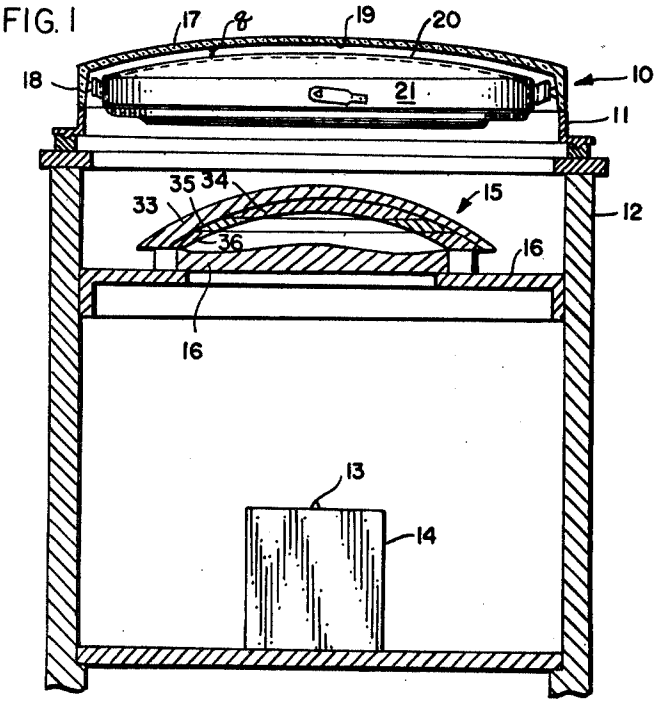


FIG. 2

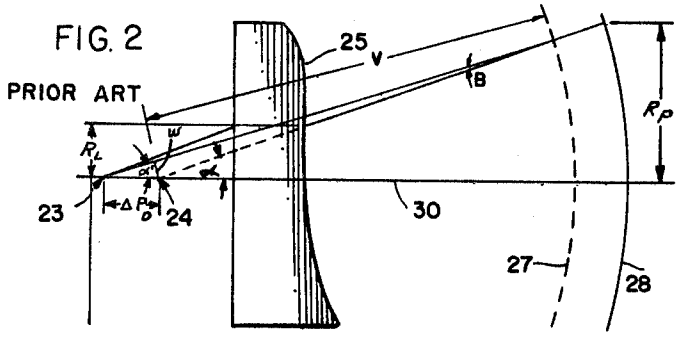


FIG. 3

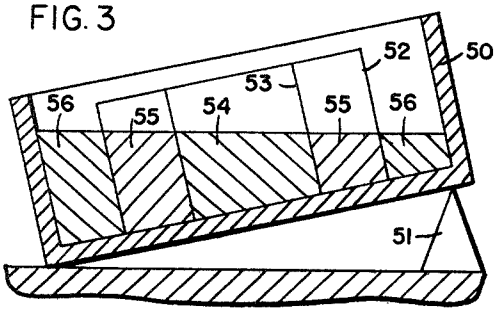
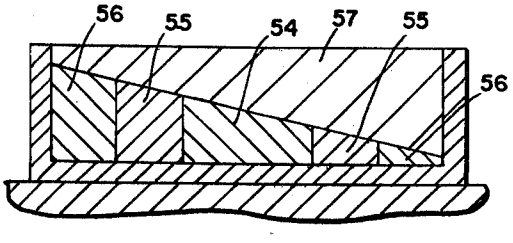


FIG. 4



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HETEROGENEOUS LENS FOR FORMING PHOSPHOR PATTERNS ON COLOR KINESCOPE

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U.S. Cl. 95—1 5 Claims

ABSTRACT OF THE DISCLOSURE

A continuous surface lens is fabricated from materials having different indexes of refraction such that the composite or effective index of refraction of the lens is a predetermined function of the distance from the axis or center of the lens. The lens is used in depositing the phosphor dot pattern on the viewing area of a color television kinescope of the kind which uses an apertured shadow mask. The lens overcomes misconvergence errors in compensating for the grouping caused by the reduced spacing between the shadow mask and faceplate panel at the periphery of the viewing screen.

Background

This invention relates to color kinescopes; and more particularly to the forming of the phosphor dot pattern on the viewing area of a color kinescope adjacent to an apertured shadow mask mounted therein.

In color kinescopes of the type which employ shadow masks, three separate electron beams are deflected across the viewing area in a raster. Each beam is intensity-modulated with a separate video signal representing a color component (red, blue or green) of the composite picture. Three different sets of phosphor dots are deposited on the viewing area, and each set of dots produces an image of a different primary color when excited by its associated electron beam. The three images are so closely spaced that they appear as a composite image. Desired colors in the image are reproduced by relative excitement of different color-producing phosphors at each elemental area of the reproduced image.

An apertured shadow mask is placed adjacent to the phosphor pattern on the viewing area for selective excitation of the dots. The mask has of the order of 300,000 apertures. Each of the apertures is associated with one triad, that is, one dot of each color-producing phosphor. Each of the beams converges at the aperture in the shadow mask and they cross over as they pass through the mask so that each beam impinges only on its associated phosphor dot to the exclusion of adjacent dots.

Extreme precision is required in the construction of the tubes so that the electron beams do not strike dots associated with a different beam which would generate incorrect color or dilute the color.

According to prevailing practice, the dots are deposited in three separate operations. First, the viewing area of the faceplate of the tube is coated with a solution of phosphor "dust" or powder supported by a substrate consisting in substantial part of polymeric material such as polyvinyl alcohol. In the first operation, the particular phosphor will generate green light when excited by an electron beam. The shadow mask is then inserted in the faceplate, and they are placed on a "lighthouse." The coating is a photographic emulsion which records the mosaic pattern impressed thereon by actinic light passing through the apertures of the shadow mask emanating from a point source of light placed at the virtual source of the electron beam which is modulated by the green video signal. Hence, only those selected areas which the electron gun

modulated by the green video signal can "see" are deposited with the green-producing phosphor.

Next, the undeposited emulsion is washed away and the same process is repeated with an emulsion carrying the red-producing phosphor; and the light source is then switched to a position corresponding to the virtual source of the electron beam modulated by the red video signal. A similar process is repeated for the deposition of the blue-producing phosphor dots with the source of light placed at the virtual source of the electron beam modulated by the blue video signal.

There are two primary sources of color dilution in color television tubes using shadow masks. These problems are known in the art and various systems have been proposed for solving them. The first problem has to do with the differential effect when deflecting the electron beams in a wide angle; and it is of principal importance when the deflection angle approaches 90°. It will be appreciated that the guns generate parallel beams which are arranged triangularly in the neck of the tube. The electron beams travel from their respective guns along the neck of the tube parallel to the axis of the constricted neck portion until deflected by the main deflection yoke. The path of the beams then curves smoothly outwardly as they travel through the yoke; and thereafter the beam moves in a straight line toward the image area.

When this deflection angle is relatively wide, the differential deflection mentioned above is particularly pronounced because the curvature of the beam is greater as it passes through the yoke with the result that the plane of deflection is the plane transverse of the axis of the tube which marks the apparent source of a beam as determined by its impact angle on the phosphor pattern. Hence, the deflection plane moves forward from the virtual center of the source of light which was used to deposit the phosphor dots. Resulting error is caused by misconvergence of the electron beams as they pass through the shadow mask and impinge on the screen at a location which is displaced radially outwardly from their associated phosphor dots. It will be remembered that each set of phosphor dots was deposited by means of a common point source of light. This "radial" error is corrected by means of an optical lens called a "radial lens." The other similar error due to wide deflection angle is the separation or misconvergence of the beams.

The differential deflection error is alleviated by dynamic convergence correction. Independent of the electromagnetic field which causes deflection of the beams as they scan through a raster, the beams are subjected to a dynamic convergence force to focus or converge the beams at the shadow mask. The dynamic convergence signals are derived from, and synchronized with, the horizontal and vertical scanning signals; and they are applied to the windings of an external convergence yoke.

The dynamic convergence field developed during scanning shifts the beams radially outwardly from the tube axis by an amount dependent upon the deflection angle. Since the spacing between the beam spots on the screen is approximately a constant demagnification of the spacing between the beams in the plane of deflection, such an increase in radial spacing during scanning results in a separating or "degrouping" of the electron beams with respect to the phosphor dot triads. In other words, the triangle defined by the centers of the beam spots enlarges relative to the triangle defined by the centers of a triad of phosphor dots. This is highly undesirable in that it tends to cause an additional deterioration of color purity most predominant in the peripheral areas of the screen.

One method for correcting for degrouping error is suggested in Epstein, et al., U.S. Patent No. 3,109,116, is-

sued Oct. 29, 1963. In this patent, correction was made for the dynamic convergence error by providing that the spacing between the convex surface of the shadow mask and the opposing concave of the faceplate (sometimes referred as the q distance) be increasingly less proceeding from the axis of the tube to the peripheral or marginal portions. In this system, the electron beams spots resulting from the incident of the beams on the image area would substantially coincide with the phosphor dots throughout the scanning operation. However, by decreasing this spacing between the shadow mask and faceplate panel, the triads of dots are "grouped" during the deposition process. The amount of grouping of the dots is an increasing function of the radial distance from the axis of the tube.

Some compensation for the grouping of the phosphor dots caused by decreasing the q distance may be accomplished by interposing an aspherical optical lens between the point source of light and the faceplate assembly, including its shadow mask, during the screen plotting operation. However, as will be explained more fully below, this type of optical lens can correct only in one dimension, whereas for true compensation it is desirable that the compensation be only a function of the radial distance from the axis of the tube, and not the angular location along the face of the tube.

Summary

The present invention contemplates correcting for the degrouping error produced by dynamic convergence of the electron beams at the shadow mask. A lens is provided having a heterogeneous refraction index which is an increasing function of the distance from the axis of the lens. Thus, when depositing the phosphor emulsion during the manufacture of the faceplate panel, the trajectories of the actinic light causing deposition of the phosphor dots more closely approximates the actual trajectory of the scanning electron beams and compensates for degrouping.

Other features and advantages of the instant invention will be obvious to persons skilled in the art from the following detailed description accompanied by the attached drawing.

Drawing

FIG. 1 is a schematic illustration of a lighthouse employing one embodiment of the inventive lens;

FIG. 2 schematically illustrates a one-dimensional corrective system used in the prior art; and

FIGS. 3 and 4 illustrate an alternative embodiment of a lens having a heterogeneous refraction index according to the present invention.

Detailed description

The amount of the grouping of the dots caused by decreasing q is an increasing function of the radial distance from the axis of the tube. An empirical formula defining the correction needed to degroup the phosphor dots is:

$$\Delta P_D = 0.011\ (R_L)^2 \qquad (1)$$

where P_D is the amount of decrease in the virtual distance of the light source from the center of the shadow mask and R_L is the radius of the lens at any given point for a predetermined spacing of the lens plane from the actual light source.

Turning first to FIG. 1, there is shown a schematic illustration of a lighthouse with a faceplate panel and shadow mask assembly during deposition of the phosphor dots. The faceplate panel and shadow mask assembly are generally designated **10**, and they rest on a shoulder **11** which is seated on the housing **12** of the lighthouse.

A point source of light **13** is located in a mechanism which is designed to shift the point source of light **13** to either of the three positions representative of the virtual source of the three electron beams. The mechanism **14** is conventional, and in this respect it may be substituted by any number of such devices, and it need not be discussed in greater detail.

A lens generally designated **15** rests on a bracket **16** intermediate the faceplate assembly **10** and the point source of light **13**.

The faceplate assembly **10**, in more detail, includes a concave image area **17** and an integral, depending peripheral flange **18** which comprise the faceplate panel. The phosphor pattern is deposited on the interior concave surface of the viewing area as at **19**. An apertured shadow mask **20** is secured by a frame **21** which is conventionally mounted to the peripheral flange **18** of the faceplate panel by means of a three-point, flexible, flat steel spring suspension system.

Referring now to FIG. 2, the conventional method for compensating for the differential deflection error in a single dimension is schematically illustrated. The actual source of light is represented by reference numeral **23** and the virtual source of light by reference numeral **24**. A lens **25** is interposed between a shadow mask **27** which has a contour generally conforming to the concave interior surface **28** of a viewing screen. This type of optical system is used to compensate for grouping of the dots by interposing a lens of a type shown to move the virtual source of light forward as a function of the distance R_P from the axis of the tube which is represented in the drawing by the line **30**. With this type of system it is possible to compensate for dot grouping in one dimension only.

Various systems could be proposed for accomplishing the desired result wherein the surface of the lens has a discontinuous surface; however, it is not feasible to make lenses of the quality required here with discontinuities in their surfaces.

Rather than require discontinuous lens surfaces, the present invention concentrates on changing the index of refraction of the material in such a way that it increases with the radius of the lens and wherein the index of refraction bears a relationship to the radius of the lens so that it produces the proper displacement of the image according to Equation 1.

Equation 1, of course, is only a first-order approximation to the degrouping problem, and for completeness it is noted that the full degrouping has to be calculated by including the effects of the degrouping of the dots, ΔP_D, with the degrouping of the triad, ΔP_T, where

$$\Sigma\Delta P = \Delta P_T \pm \Delta P_D \qquad (2)$$

In Equation 2, ΔP_T may be expressed empirically as follows:

$$\Delta P_T = 0.091(R_L - 1)(1 - e^{-R_L}) + 0.0045e^{-25(R_L - 0.9)^2} \qquad (3)$$

In order to establish a relationship between the degrouping and the refraction angle, B, we let

$$W = \Delta P_D \sin \alpha \qquad (4)$$

where α is the angle which a ray of light makes with the axis of the tube in the lighthouse. From this relationship, and from Snell's Law, the following relationship is derived:

$$\sin B \cong (n_{R_{Lx}} - n_{R_{Lo}}) \sin \varphi \qquad (5)$$

Equation 5 thus establishes a relationship between the change in refraction index $(n_{R_{Lx}} - n_{R_{Lo}})$ as a function of the radius of the lens, where x is the distance along the radius, that is, the radius of the lens (R_L) can be calculated for various prism angles, φ.

The following Table 1 illustrates the results of a sample calculation using this technique.

TABLE 1

R_P	13	11.3	9.6	7.5	5.4	3.6	1.9
R_L	3.5	3.0	2.5	2	1.5	1.0	0.5
ΔP_D	0.133	0.099	0.062	0.044	0.025	0.011	0.003
ΔP_T	0.23	0.18	0.136	0.091	0.023	0.004	0.000
$\Sigma\Delta P$	0.333	0.279	0.198	0.135	0.048	0.015	1.003
W	0.037	0.067	0.038	0.023	0.010	0.003	0.0007
α	47°	43°	38°	32°	25°	17°	9°
V	13.1	11.2	11.5	10.6	9.9	9.5	9.3
B	0.42	0.31	0.19	0.13	0.06	0.018	0.004

In one embodiment of the present invention it is contemplated that the factor ($n_{RL_x}-n_{RL_o}$) may be compensated for in a single lens with homogeneous refraction index n_{RL_o}, and an identical prism which is located to have an effect complementary to that of the lens. This is shown in FIGS. 3 and 4 and is disclosed in greater detail below.

In the situation in which the deposition of the phosphor dots is caused by actinic light from a true point source of light, the lens may take the form of a hemispherical configuration as seen in FIG. 1. Even if it is not, however, columnating and decolumnating lens system may be used for the lens profile may be changed to compensate for the nonperpendicular light impinging.

Referring then to the lens **15** of FIG. 1, it can be seen that this lens comprises an external layer **33** having an index of refraction n_0. Fastened to the concave surface of the external layer **33**, are a plurality of conforming segments **34**, **35** and **36**, which are defined by horizontally extending planes; and the section **34** has an index of refraction n_0, section **35** has an index of refraction n_1, and the section **36** has an index of refraction n_2. In this relationship, n_2 is greater than n_1 and n_1 is greater than n_0

Any conventional glass glue may be used to fill the interstitial gaps between the surfaces of the components of the lens, or cedar oil or other suitable optical fluid may be used. As shown in FIG. 1, the various internal sections of the lens **15** are defined by a horizontal plane; however, adjacent boundaries may also be radial, that is, the boundaries between the sections could be defined by planes perpendicular to the page of FIG. 1 and passing through the center of the lens at various angles. Beneath the lens **15**, is a radial lens **16**, and in a particular example, the index of refraction $n_0=1.5$; the index of refraction of $n_1=1.6$, and the index of refraction of $n_2=1.8$. The radius of the lens is approximately 7.2" and the height of the lens is 2.6". The radial thickness of the internal segments is 0.25" and the radial thickness of the external covering is 0.15". The degrouping lens may be located beneath the radial lens as well.

Another embodiment of the invention contemplates as illustrated in FIG. 3 and FIG. 4, and it contemplates using plastics which are transparent to ultra-violet light. The embodiment illustrated in FIGS. 3 and 4 is for a degrouping lens for parallel light, and it uses a number of plastic materials with different refraction indexes. A circular mold **50** is tilted at an angle by means of a stand **51**, and concentric ring molds of **52** and **53** have cylindrical side surfaces as shown, and they are placed concentric with the cylindrical external mold **50**. Next, three separate plastics, **54**, **55** (which takes annular form), and **56** (which also is annular) are poured into the areas defined by the mold. The plastic materials **54**, **55** and **56** have respectively refraction indexes which are increasingly greater and will be represented by n_0, n_1, and n_2.

Before the plastic has completely set, the ring molds **52** and **53** are removed so that the different plastics will sag to contact each other and blend into each other, thereby forming a continuous lens. After this has solidified, the stand **50** is removed and the remaining top section of the mold is filled with a plastic **57** having an index of refraction n_0 equal to that of the plastic **54**.

As an example, a lens was made using type 100 and type 650 "glass resin" of Owens-Illinois Company, with refraction indexes 1.42 and 1.49 respectively for the inner cylinder **54** and the outer ring **56**. The intermediate ring **55** was formed of a proper ratio mixture of these two materials, including seven parts per weight of the 650 material and one part per weight of the 100 plastic. A prism angle having a tangent of 0.1 was employed.

Having thus described a preferred embodiment of an inventive lens for a point source of light and a preferred embodiment of a lens having heterogeneous index of refraction for use with parallel light for depositing the phosphor pattern in the viewing area of the faceplate panel in a color television kinescope, it will be appreciated that certain modifications of the structure and equivalent materials may be used while continuing to practice the principle of the invention. It is therefore intended that all such equivalents and modifications be covered as they are embraced within the spirit and scope of the appended claims.

I claim:

1. For use with a lighthouse including a point source of light for depositing the phosphor pattern on the viewing area of a color television kinescope having an apertured shadow mask mounted adjacent to viewing area; a lens assembly placed intermediate the light source and the faceplate panel, said lens having a heterogeneous index of refraction which is an increasing function of the distance from the center of the lens for correcting for differential deflection errors in said kinescope.

2. The structure of claim **1** wherein said lens comprises an external layer having an index of refraction n_0, and a plurality of horizontal sections conforming to the spherical shape of the external layer and having increasing indexes of refraction proceeding from the center of said layer to its periphery.

3. The structure of claim **2** wherein the said internal sections are defined by horizontal planes and further including a radial lens beneath said spherical lens.

4. The structure of claim **1** wherein said lighthouse is adapted to generate parallel light for depositing said phosphor patterns, and wherein said lens comprises a central cylindrical portion, an annular portion about said cylindrical portion and an external annular portion integral with the external periphery of the first annular portion, all of said annular portions being defined by a first plane perpendicular to their common axes and a second plane angularly disposed relative to said axis, said lens further comprising a prism section for complementing the shape thereof so that said lens forms a right circular cylinder.

5. The structure of claim **4** wherein said indexes of refraction of said concentric rings is an increasing function of radius of the ring.

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