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Miyaoka [45] Aug. 6, 1974

[54] **EXPOSURE APPARATUS FOR THE DIRECT PHOTOGRAPHIC PRODUCTION OF A PHOSPHOR SCREEN ON THE FACE-PLATE OF A COLOR PICTURE TUBE**

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[73] Assignee: **Sony Corporation,** Tokyo, Japan

[22] Filed: **Nov. 12, 1973**

[21] Appl. No.: **415,219**

[52] **U.S. Cl.** ..... **354/1,** 313/92 B, 350/175 R
[51] **Int. Cl.** **G03b 27/00**
[58] **Field of Search** ..... 95/1 R; 313/92 B; 350/175 R

[56] **References Cited**
UNITED STATES PATENTS

3,279,340	10/1966	Ramberg et al.	95/1 R
3,628,850	12/1971	Yamazaki	95/1 R X
3,738,234	6/1973	Barten et al.	95/1 R

Primary Examiner—Richard M. Sheer
Attorney, Agent, or Firm—Lewis H. Eslinger, Esq.; Alvin Sinderbrand, Esq.

[57] **ABSTRACT**

In an exposure apparatus or lighthouse for use in the direct photographic production of a phosphor screen on the face-plate of a color picture tube or kinescope of the type having a mask with apertures therein associated with the phosphor screen, and in which the face-plate and mask are held in predetermined relation to each other during the selective exposure through apertures of the mask of a photosensitive layer on the face-plate by means of light rays passing through a correcting lens from a light source; such light source is linear so that light rays from locations along the light source reach each selectively exposed portion of the photosensitive layer, and the correcting lens, whose effective surface consists of a plurality of refractive surface sections having discontinuous borderlines, is arranged with such discontinuous borderlines extending at angles to the direction of the linear light source for avoiding the casting of shadows on the photosensitive layer by the discontinuous borderlines.

8 Claims, 15 Drawing Figures

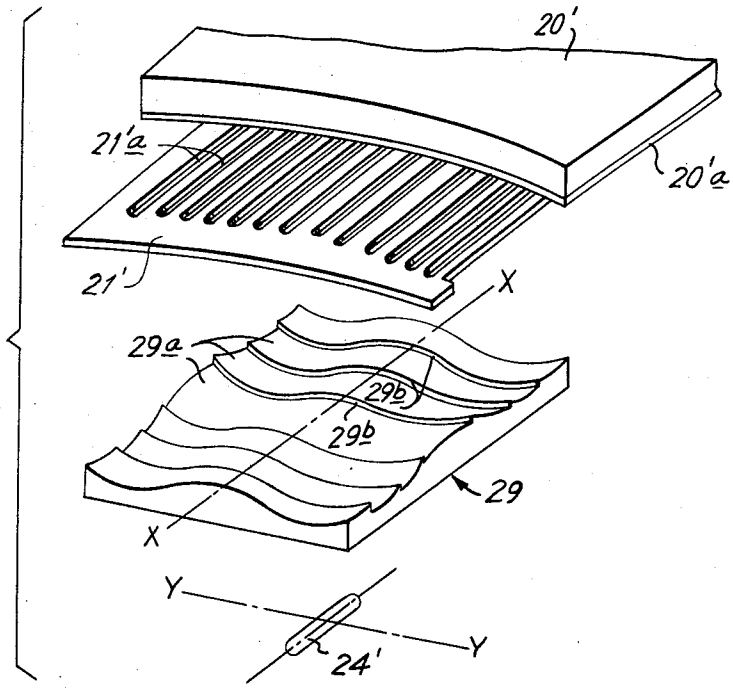


FIG. 1
PRIOR ART

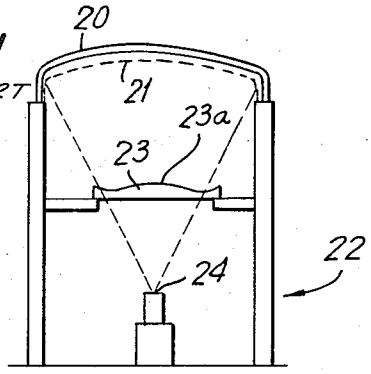


FIG. 2
PRIOR ART

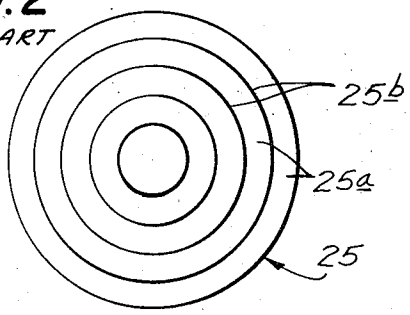


FIG. 3 PRIOR ART

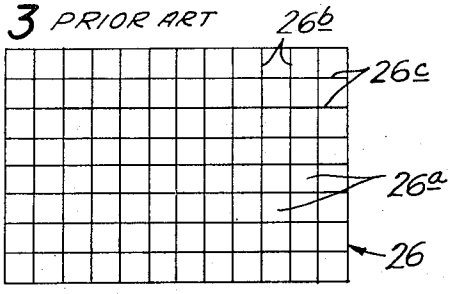
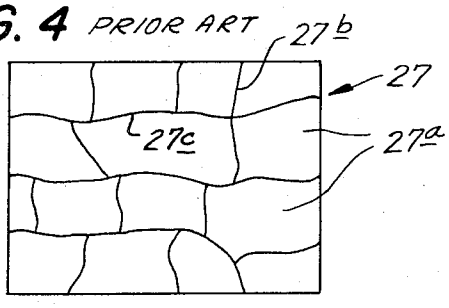


FIG. 4 PRIOR ART



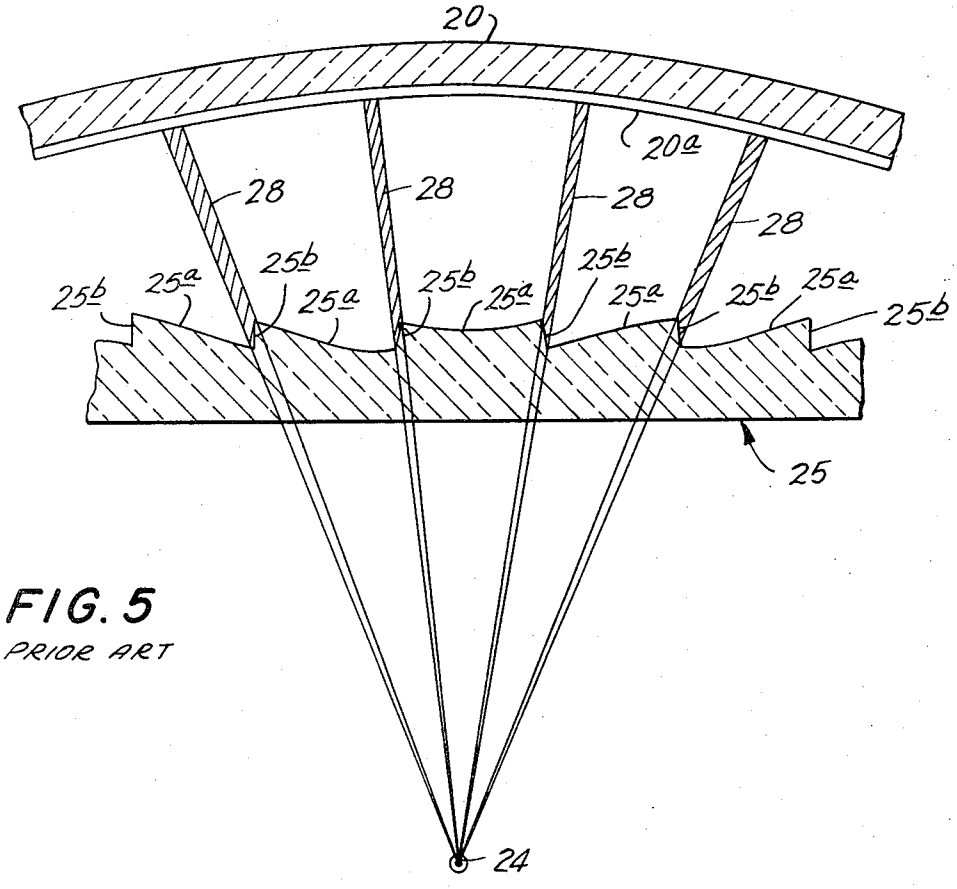
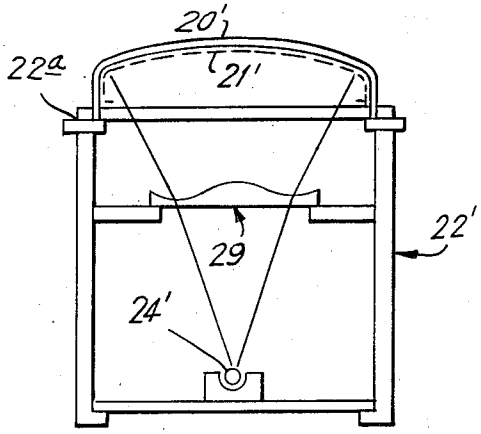


FIG. 5
PRIOR ART

FIG. 6



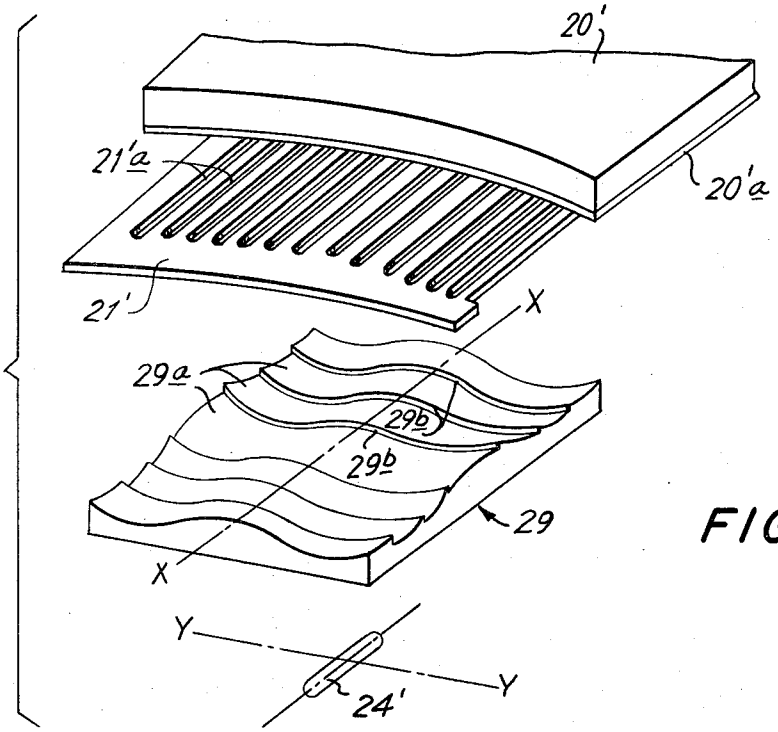


FIG. 7

FIG. 8

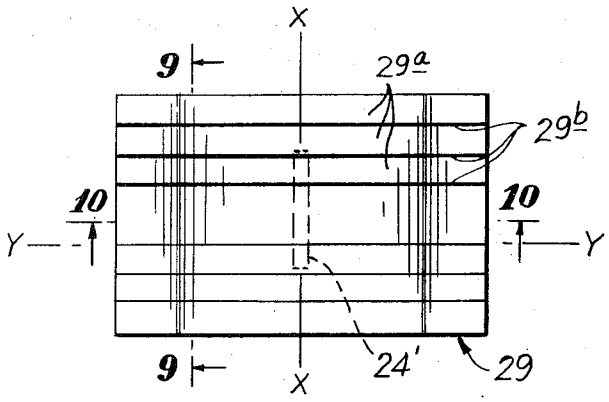


FIG. 9

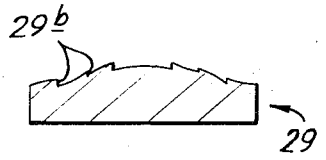
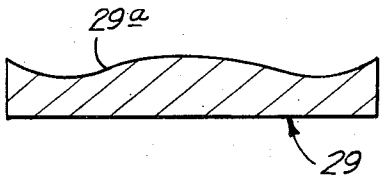


FIG. 10



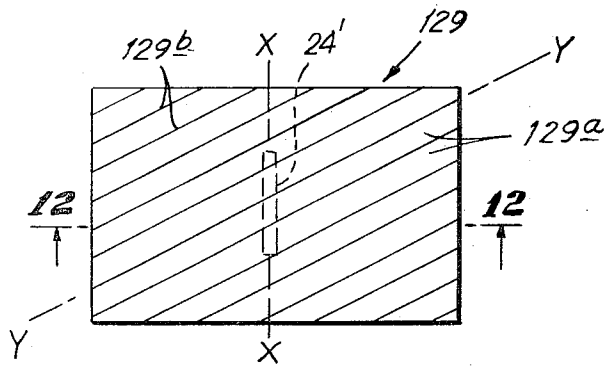


FIG. 11

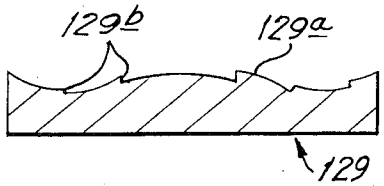


FIG. 12

FIG. 13

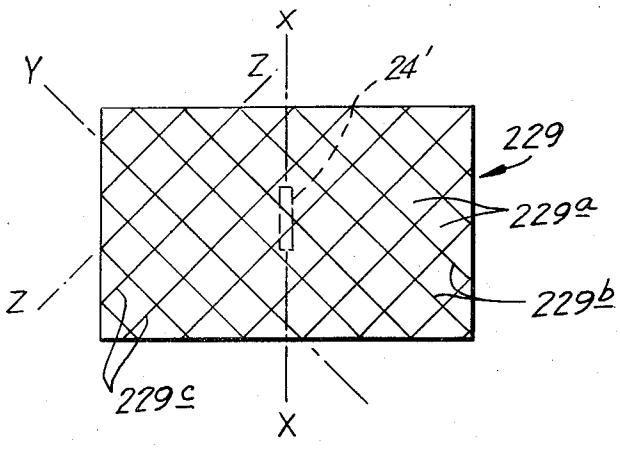
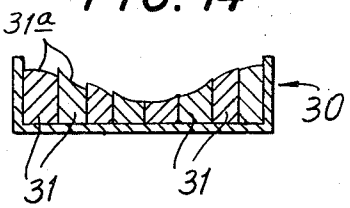


FIG. 14



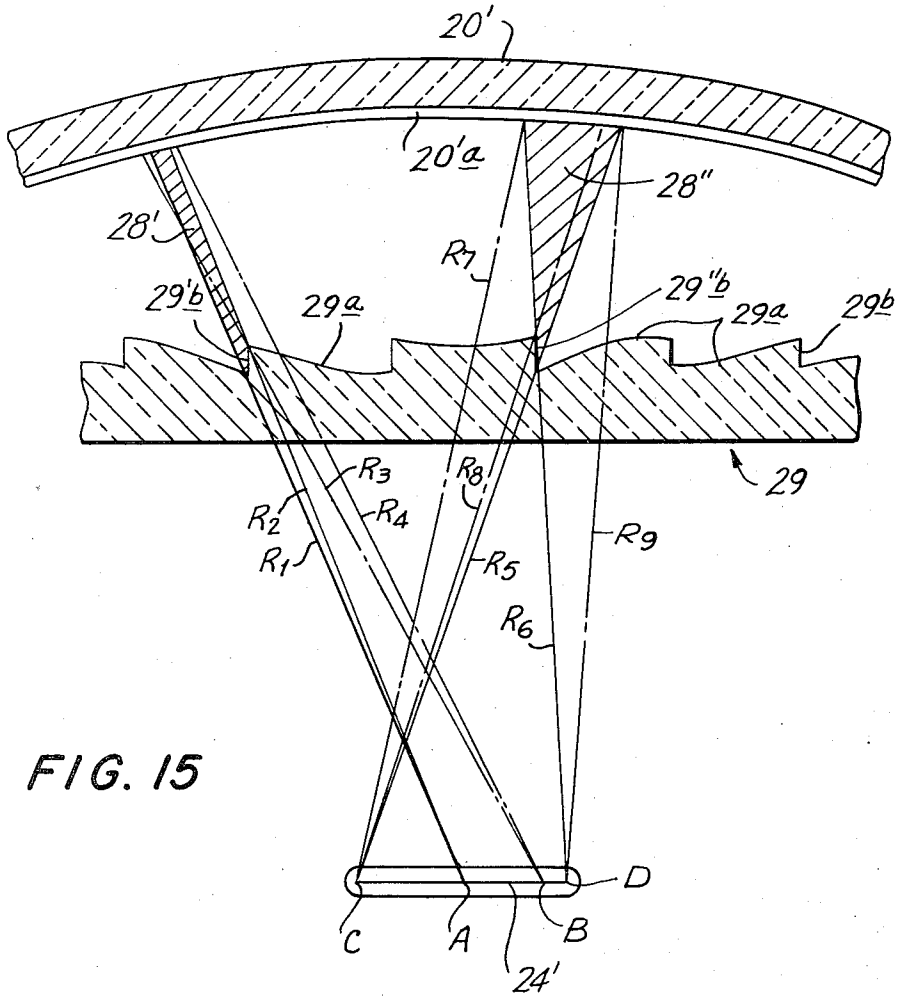


FIG. 15

EXPOSURE APPARATUS FOR THE DIRECT PHOTOGRAPHIC PRODUCTION OF A PHOSPHOR SCREEN ON THE FACE-PLATE OF A COLOR PICTURE TUBE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to an exposure apparatus or so-called lighthouse for use in the direct photographic production of a phosphor screen on the face-plate of a color picture tube or kinescope of the type having an apertures shadow mask or grill associated with its phosphor screen.

2. Description of the Prior Art

In producing the phosphor screen on the face-plate of a color picture tube or kinescope of the type having an apertured mask or grill, it is the common practice to employ the so-called direct photographic method. In practicing that method, a photosensitive layer for producing the areas of the phosphor screen emitting green, red or blue light is applied to the face-plate and the latter and the mask or grill are then held in predetermined relation to each other on an exposure apparatus or lighthouse. In such exposure apparatus or lighthouse, the photosensitive layer or emulsion on the face-plate is selectively exposed, through the apertures of the associated mask or grill, by means of light rays passing through a lens system from a point source of light which is positioned to correspond to the location of the deflection center of the respective electron beam in the completed color picture tube. After developing and fixing the exposed photosensitive layer to provide the areas of the phosphor screen for emitting light of one color, the foregoing process is repeated, but with the point source of light being shifted, in each case, to a position that corresponds to the deflection center of the electron beam by which the respective phosphor screen areas are to be excited.

In the completed or operating color picture tube or kinescope, the deflection centers of the three electron beams for respectively exciting the green, red and blue light-emitting areas of the phosphor screen shift in dependence on the angles of deflection of the electron beams during scanning of the phosphor screen. Accordingly, in exposing each photosensitive layer or emulsion in the lighthouse, it is necessary to employ a lens system that includes one or more correcting lenses for bringing thepaths of the light rays used for exposing the photosensitive layer through each aperture of the mask or grill more or less into correspondence with the path of the respective electron beam when passing through that aperture during operation of the color picture tube. In the absence of such correcting lens or lenses, the locations of the areas of the phosphor screen for emitting light of different respective colors, as produced by the direct photographic process, will not precisely correspond to the landing spots of the respective beams on the phosphor screen, particularly at the peripheral portions of the screen, with resulting impairment of the quality of the produced color picture.

Various correcting lenses have been proposed for minimizing such picture defects occasioned by lack of register of the electron beam spots with the respective phosphor screen areas produced as aforesaid. For example, in U.S. Pat. No. 2,885,935, issued May 12, 1959, a correcting lens is disclosed having a continuous

effective surface with complex curvatures. However, it is very difficult to mold a correcting lens with an effective surface having such complex curvatures, and difficulties are also encountered in polishing the effective surface with its complex curvatures. Further, the continuous effective surface, even with its complex curvatures, cannot achieve the desired correspondence of the light ray-paths with the electron beam-paths over the entire extent of the phosphor screen.

In order to avoid the foregoing disadvantages of the correcting lens with a continuous effective surface having complex curvatures, it has been proposed, for example, in U.S. Pat. No. 3,279,340, issued Oct. 18, 1966, and U.S. Pat. No. 3,628,850, issued Dec. 21, 1971, to provide a correcting lens having an effective surface which is a composite of a plurality of refractive surface sections or elements formed with independently predetermined curvatures or other configurations and having discontinuous boundries or borderlines, such as steps, between the adjacent surface sections or elements. Thus, for example, in certain of these previously proposed correcting lenses having a composite effective surface, the discontinuous borderlines or steps are circular so that each surface section or element is continuous in the circumferential direction, and the discontinuities or steps occur in the radial direction of the composite surface. In others of the porposed correcting lenses with a composite effective surface, at least one of the refractive surface sections or elements has discontinuous borderlines extending in at least two directions. These correcting lenses with composite effective surfaces are similar to FRESNEL lenses and have the advantage of permitting the designing of each refractive surface section or element so as to achieve the optimum correction over the full extent of the phosphor screen. Further, a correcting lens with an effective surface which is a composite of refractive surface sections or elements having discontinuous borderlines can be relatively easily produced by molding the lens in a mold made up of an assemblage of mold elements which are individually formed with respective surfaces corresponding to the desired shapes of respective surface sections or elements of the correcting lens.

However, when a Fresnel-type correcting lens, as described above, is employed for the selective exposure of the photosensitive layer or emulsion in the direct photographic production of a phosphor screen, the discontinuous borderlines or steps between the refractive surface sections of the composite effective surface cast shadows on the photosensitive layer being exposed, with the result that defects occur in the phosphor screen at the regions of such shadows and the quality of the color picture provided by the color picture tube or kinescope is impaired. It has been proposed to eliminate such shadows, or at least to reduce the deleterious effect thereof, by either vibration reciprocating or oscillating of the correcting lens or the light source relative to the other in a plane normal to the central axis of the light house. Effecting the vibratory reciprocation or oscillation of the correcting lens or light source gives rise to complications in the construction and operation of the lighthouse. Further, in the case of a color picture tube or kinescope of the shadow mask type having circular holes or apertures associated with dot-shaped color phosphors making up the phosphor screen so that a point source of light is used during the exposure step

of the direct photographic process, the described vibratory reciprocation or oscillation is not effective to eliminate the shadows cast by the discontinuous borderlines of the correcting lens.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide an exposure apparatus or lighthouse for use in the direct photographic production of a phosphor screen on the face-plate of a color picture tube or kinescope, and which is free of the above discussed disadvantages and problems associated with apparatus previously proposed for that purpose.

More specifically, it is an object of this invention to provide an exposure apparatus, as aforesaid, employing a correcting lens whose effective surface is a composite of refractive surface sections or elements having discontinuous borderlines for obtaining optimum correspondence of the light ray-paths with the electron beam-paths over the entire extent of the phosphor screen, and in which the casting of shadows by discontinuous borderlines is simply and effectively eliminated.

In accordance with an aspect of the invention, an exposure apparatus, as aforesaid, employs a linear light source so that rays from locations along the light source reach each selectively exposed portion of the photosensitive layer or emulsion, and the correcting lens having an effective surface which is a composite of refractive surface elements or sections with discontinuous borderlines is arranged with such discontinuous borderlines extending at angles to the direction of the linear light source.

The above, and other objects, features and advantages of the invention, will be apparent in the following detailed description of illustrative embodiments which is to be read in connection with the accompanying drawings:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic sectional view of an exposure apparatus or lighthouse according to the prior art for use in producing the phosphor screen of a color picture tube or kinescope;

FIGS. **2, 3** and **4** are plan views of various correction lenses proposed in the prior art for use in the exposure apparatus of FIG. **1**;

FIG. **5** is a diagrammatic view to which reference will be made in explaining how shadows are cast on the photosensitive layer being exposed in the apparatus according to the prior art;

FIG. **6** is a view similar to that of FIG. **1,** but showing an exposure apparatus according to this invention;

FIG. **7** is a fragmentary perspective view showing the relationship of the essential elements in the exposure apparatus according to this invention;

FIG. **8** is a plan view of a correcting lens that may be used in an exposure apparatus according to this invention and showing its relationship to the light source of such apparatus;

FIGS. **9** and **10** are sectional views taken along the lines **9—9** and **10—10,** respectively, on FIG. **8**;

FIG. **11** is a view similar to FIG. **8,** but showing another correcting lens usable in the exposure apparatus according to this invention;

FIG. **12** is a sectional view taken along the line **12—12** on FIG. **11**;

FIG. **13** is a view similar to FIG. **8,** but showing still another correcting lens usable in the exposure apparatus according to this invention;

FIG. **14** is a schematic view illustrating a mold in which a correcting lens usable in the exposure apparatus according to this invention can be economically and conveniently formed; and

FIG. **15** is a diagrammatic view similar to that of FIG. **5,** but illustrating the manner in which the casting of shadows is eliminated in the apparatus according to this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings in detail, and initially to FIG. **1** thereof, it will be seen that, in producing the phosphor screen on the faceplate of a color picture tube or kinescope of the type having an apertured or shadow mask, by means of the so-called direct photographic method, a photosensitive layer or emulsion for providing the areas or phosphor dots of the screen emitting green, red or blue light is applied to the faceplate **20,** whereupon such faceplate and the shadow mask **21** are held in predetermined relation to each other on an exposure apparatus or lighthouse **22.** In the exposure apparatus or lighthouse **22,** the photosensitive layer or emulsion on faceplate **20** is selectively exposed, through the apertures of mask **21,** by means of light rays passing through a lens system **23** from a point source of light **24** which is positioned to correspond to the location of the deflection center of the respective electron beam in the completed color picture tube. After such exposure of the photosensitive layer, the latter is developed and fixed to provide the phosphor dots of the phosphor screen for emitting light of a respective color, whereupon the foregoing steps are repeated, but with the point source of light **24** being shifted, in each case, to a position that corresponds to the deflection center of the electron beam by which the respective phosphor dots are to be excited.

In operation of a color picture tube or kinescope, the deflection centers on the three electron beams for respectively exciting the green, red and blue light-emitting phosphor dots of the phosphor screen shift in dependence on the magnetic deflection of the electron beams during scanning of the phosphor screen. Accordingly, in exposing each photosensitive layer or emuslion in the exposure apparatus or lighthouse **22,** it is necessary that the lens system **23** of the latter include one or more correcting lenses by which the paths of the light rays used for exposing the photosensitive layer through each aperture of mask **21** are made to more or less correspond with the path of the respective electron beam when passing through that aperture during operation of the color picture tube. If the correcting lens is provided with a continuous effective surface having complex curvatures, for example, as indicated at **23***a* on FIG. **1** and as disclosed in U.S. Pat. No. 2,885,935, it is very difficult to mold the correcting lens with the necessary complex curvatures of its continuous effective surface and to polish such surface, and, furthermore, a continuous effective surface, even with complex curvatures, cannot achieve the desired correspondence of the light ray-paths with the electron beam-paths over the entire extent of the phosphor screen. In order to avoid the foregoing problems, correcting lenses have been provided with an effective surface

which is a composite of a plurality of refractive surface sections or elements formed with independently predetermined curvatures or other configurations and having discontinuous boundries or borderlines, such as steps, between the adjacent sections or elements of the composite surface. Thus, for example, as shown on FIG. 2 and as disclosed specifically in U.S. Pat. No. 3,279,340, it has been proposed to use a correcting lens **25** having an effective surface which is a composite of annular surface sections or elements **25***a* having discontinuous borderlines or steps **25***b* therebetween which are concentric circles so that each surface section or element **25***a* is continuous in the circumferential direction and the discontinuities or steps occur in the radial direction of the composite surface. In order to further simplify the manufacture of the correcting lens and to make possible the more precise correction of the paths of the light rays, it has been proposed, for example, as shown on FIGS. **3** and **4** and as disclosed in U.S. Pat. No. 3,628,850, to provide the correcting lens with a composite effective surface made up of refractive surface sections or elements having discontinuous borderlines extending in at least two directions. For example, such a correcting lens **26** (FIG. **3**) may have its composite effective surface made up of surface sections or elements **26***a* having discontinuous borderlines **26***b* and **26***c* extending at right angles to each other, or a correcting lens **27** (FIG. **4**) may be provided with an effective surface which is a composite of surface sections or elements **27***a* with discontinuous borderlines **27***b* and **27***c* extending irregularly in various directions.

Referring now to FIG. **5**, it will be seen that, when any of the above described correcting lenses, for example, the correcting lens **25** of FIG. **2**, is used in the exposure apparatus or lighthouse **22** having a point source of light **24** according to the prior art, the discontinuous borderlines or steps **25***b* between the refractive surface sections **25***a* of the composite effective surface cast shadows, as indicated by the shaded regions **28**, on the photosensitive layer **20***a* applied to faceplate **20**. As a result of such shadows **28**, defects occur in the produced phosphor screen at the regions of the shadows, and the quality of the color picture produced with the color picture tube or kinescope is impaired.

Referring now to FIGS. **6** and **7**, it will be seen that the exposure apparatus or lighthouse **22'** according to this invention, as there illustrated, is particularly adapted to eliminate the casting of such shadows during the direct photographic production of the phosphor screen for a color picture tube or kinescope of the type in which the phosphor screen is made up of phosphor stripes, rather than dots, and is associated with an aperture grill **21'** having elongated apertures or slits **21'***a* extending parallel to the phosphor strips and through which the electron beams pass for exciting the respective phosphor strips, for example, as disclosed in U.S. Pat. No. 3,573,528, issued Apr. 6, 1971, or U.S. Pat. No. 3,638,063, issued Jan. 25, 1973, both of which have a common assignee herewith. In accordance with this invention, the exposure apparatus **22'** having a support **22'***a* for holding the faceplate **20'** and aperture grill **21'** in predetermined relation to each other is further provided with a rectilinear light source **24'** having its longitudinal axis X—X (FIG. **7**) extending parallel to the elongated apertures or slits **21'***a* of the aperture grill, and with a correction lens **29** having an effective surface composed of refractive surface sections or elements **29***a* with discontinuous borderlines or steps **29***b* therebetween which extend in the direction Y—Y at an angle to the longitudinal axis X—X of the light source **24'**. The several refractive surface sections **29***a* are shaped to provide the desired corrections of the light ray-paths for correspondence of the latter to the electron beam-paths in the actual color picture tube or kinescope.

The correcting lens **29** used in the exposure apparatus **22'** according to this invention may have all of its discontinuous borderlines **29***b* extending parallel to each other in the direction Y—Y at right angles to the longitudinal axis X—X of the linear light source **24'**, as shown on FIGS. **7–10**. In that case, each refractive surface section **29***a* is continuous in the direction Y—Y at right angles to the longitudinal axis of the linear light source, as is apparent particularly on FIG. **10**, and the discontinuities **29***b* in the composite surface of the correcting lens **29** occur in the direction along the axis of the linear light source, as is apparent on FIG. **9**.

Alternatively, as shown on FIGS. **11** and **12**, the correcting lens **129** used in the exposure apparatus **22'** may have all of the discontinuous borderlines **129***b* between its surface sections or elements **129***a* extending parallel to each other in the direction Y—Y which is; at an angle other than a right angle in respect to the longitudinal axis of linear light source **24'**. Still another embodiment is shown on FIG. **13**, in which the correcting lens **229** is there illustrated to have a composite surface made up of refractive surface sections or elements **229***a* having a first group of parallel discontinuous borderlines **229***b* extending in the direction Y—Y at an angle to the longitudinal axis X—X of linear light source **24'** and a second group of parallel discontinuous borderlines **229***c* extending in the direction Z—Z which is also at an angle to the longitudinal axis X—X. Preferably, as shown, the longitudinal axis X—X of the linear light source **24'** is arranged to substantially bisect the angle between the directions Y—Y and Z—Z of the discontinuous borderlines **229***b* and **229***c*, respectively.

The correcting lens **29**,**129** or **229** used in the exposure apparatus **22'** according to this invention is advantageous in that it can be conveniently and economically formed with the optimum correction characteristics in the manner disclosed in U.S. Pat. No. 3,628,850. More specifically, as shown on FIG. **14**, a metal mold **30** for use in producing the correcting lens **29**,**129** or **229** may consist of an assemblage of mold elements or blocks **31** which have had their upper end surfaces **31***a* individually shaped to correspond to the necessary configuration of a respective surface section or element **29***a*,**10**-**29***a* or **229***a* of the correcting lens to be produced. After the blocks **31** have been assembled together to form the mold **30**, the material of the desired correcting lens, for example, a solution of an acrylic resin or the like, is poured onto mold **30**. After the resin has set and cured, the resulting correcting lens blank may be suitably polished.

Further, by reason of the use of a linear light source **24'** rather than a point source of light, and by reason of the above described disposition of the discontinuous borderlines **29***b*, **129***b* or **229***b* and **229***c* at angles in respect to the longitudinal axis of the linear light source **24'**, the exposure apparatus **22'** according to this invention avoids the casting of shadows of such discontinuous borderlines on the photosensitive layer **20'***a*

during the exposure of the latter. The foregoing advantage will be apparent from FIG. **15** in which it will be seen that the region **28**, that would be in shadow between light rays R_1 and R_2 emanating from a point A along linear light source **24'** and passing through one of the discontinuous borderlines or steps **29'***b*, receives light from the point B along the linear light source **24'**, for example, as represented between the light rays R_3 and R_4 emanating from point B and passing through a surface section or element **29***a*. Similarly, if one considers the shadowed region **28''** that would be defined between the light rays R_5 and R_6 extending from points C and D, respectively, at opposite ends of linear light source **24'** through the discontinuous borderline **29''***b*, it will be seen that the bundle of light rays between the rays R_7 and R_8 emananting from point C and the bundle of light rays between the rays R_6 and R_9 emanating from point D will all deliver light to such shadowed region through surface sections **29***a* of the correcting lens surface. Thus, the shadows are substantially lightened or eliminated to avoid any interference thereof with the proper exposure of the photosensitve layer **20'***a*.

Although illustrative embodiments of the invention have been described in detail herein with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention.

What is claimed is:

1. An exposure apparatus for use in the direct photographic production of a phosphor screen on the faceplate of a color picture tube of the type having a mask with apertures therein associated with the phosphor screen; comprising support means for holding the faceplate and mask in predetermined relation to each other, a linear light source positioned for directing rays of light from locations therealong through said apertures of the mask to said face-plate, and correcting lens means disposed between said linear light source and said mask and defining an effective surface consisting of a plurality of refractive surface sections at least some of which have discontinuous borderlines, all of said discontinuous borderlines extending at angles in respect to the direction of said linear light source.

2. An exposure apparatus as in claim **1**; in which said apertures of the mask are elongated in directions extending parallel to said direction of the linear light source.

3. An exposure apparatus as in claim **2**; in which said light source is rectilinear.

4. In an exposure apparatus for use in the direct photographic production of a phosphor screen on the faceplate of a color picture tube of the type having a mask with apertures therein associated with the phosphor screen, and in which the face-plate and mask are held in predetermined relation to each other during the selective exposure of a photosensitive layer on said faceplate by light rays passing from a light source through a correcting lens and then through the apertures of said mask; the improvement comprising said light source being linear so that said light rays selectively exposing any portion of said photosensitive layer are derived from locations along said linear light source, said correcting lens defining an effective surface consisting of a plurality of refractive surface sections at least some of which have discontinuous borderlines, and all of said discontinuous borderlines extending at angles in respect to the direction of said linear light source so as to avoid the casting of shadows on said photosensitive layer by said discontinuous borderlines.

5. The exposure apparatus as in claim **4**; in which the apertures of said mask are elongated in directions extending parallel to said direction of the linear light source.

6. The exposure apparatus as in claim **5**; in which said light source is rectilinear.

7. The exposure apparatus as in claim **6**; in which said discontinuous borderlines extend parallel to each other and are at the same angle in respect to said direction of the rectilinear light source.

8. The exposure apparatus as in claim **6**; in which said discontinuous borderlines include a first group of parallel borderlines and a second group of parallel borderlines at an angle to, and intersecting said borderlines of the first group, and said direction of the rectilinear light source substantially bisects said angle between the discontinuous borderlines of said first and second groups.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,828,358 Dated August 6, 1974

Inventor(s) Senri Miyaoka

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

(30) Foreign Application Priority Data

November 17, 1972 115307/72 --- Japanese

November 17, 1972 115308/72 --- Japanese

Signed and sealed this 17th day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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