June 24, 1969 MICHIO TAMURA 3,451,812

METHOD OF MAKING COLOR SCREEN FOR CATHODE RAY TUBE

Filed Jan. 26, 1966 Sheet 1 of 3

Fig. 1

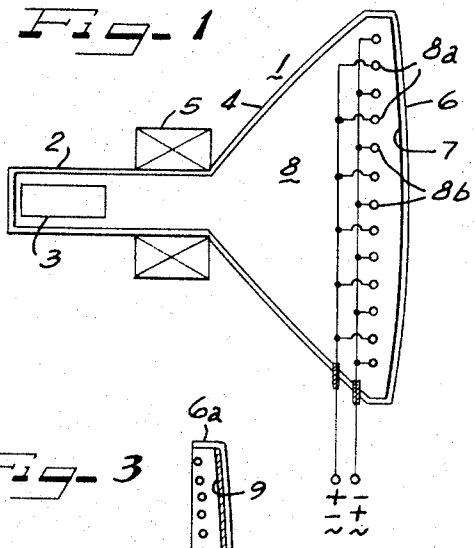


Fig. 2

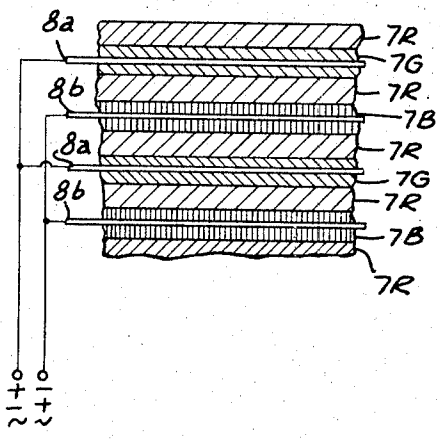


Fig. 3

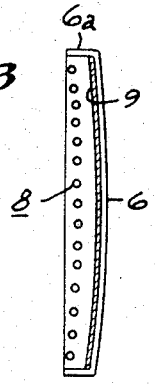
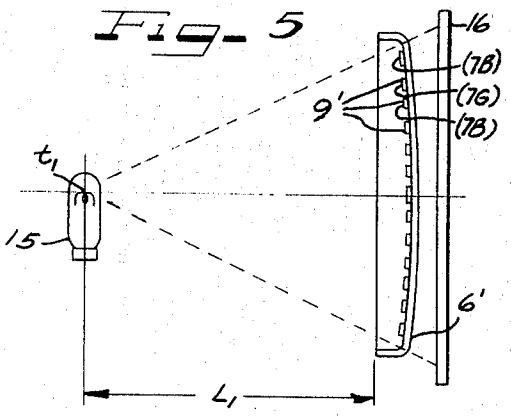


Fig. 5



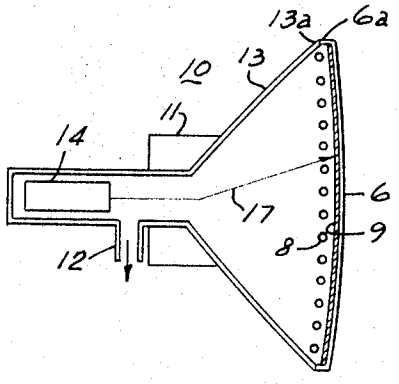


Fig. 4

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METHOD OF MAKING COLOR SCREEN FOR CATHODE RAY TUBE

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Fig-6

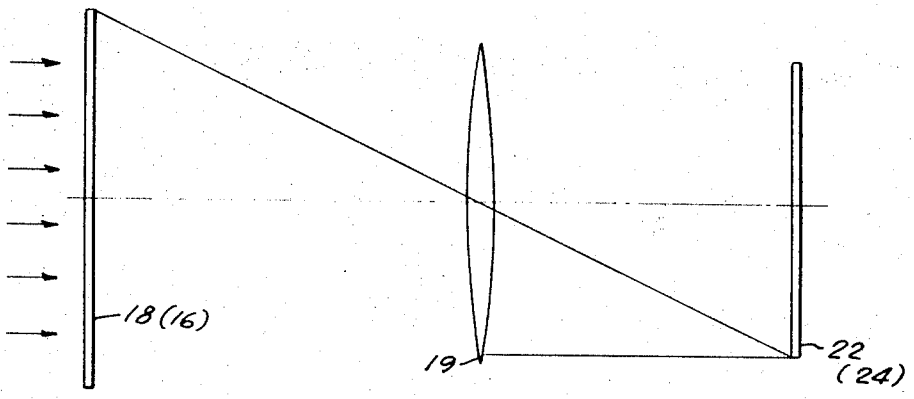


Fig-7

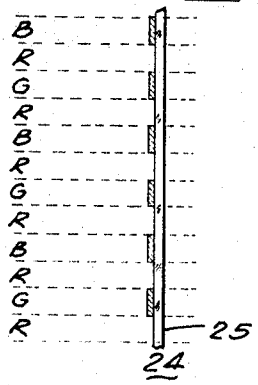


Fig-8

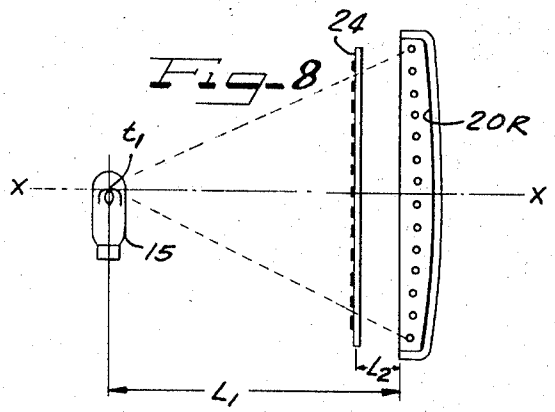
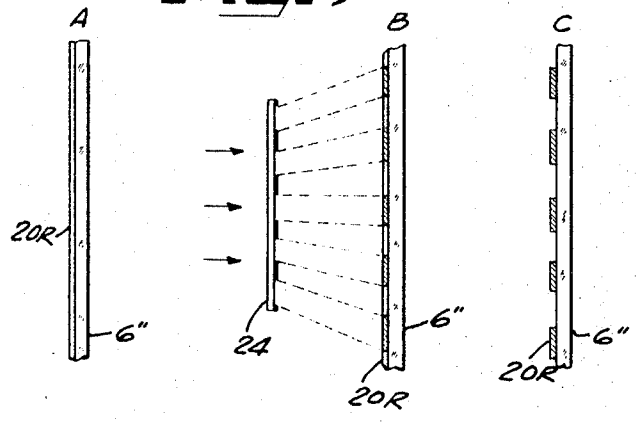


Fig-9



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METHOD OF MAKING COLOR SCREEN FOR CATHODE RAY TUBE

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Fig. 10

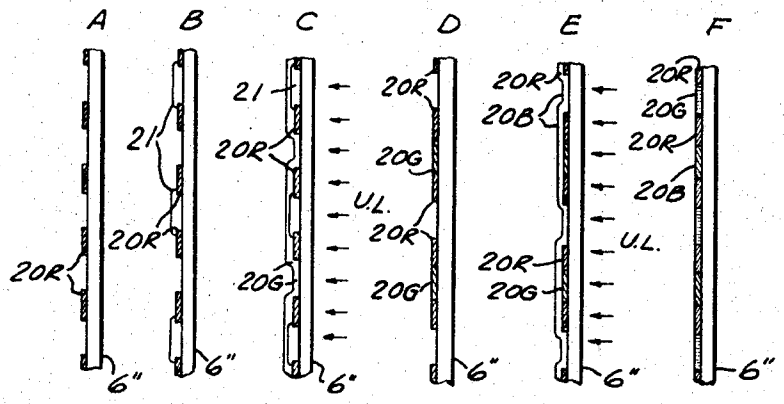
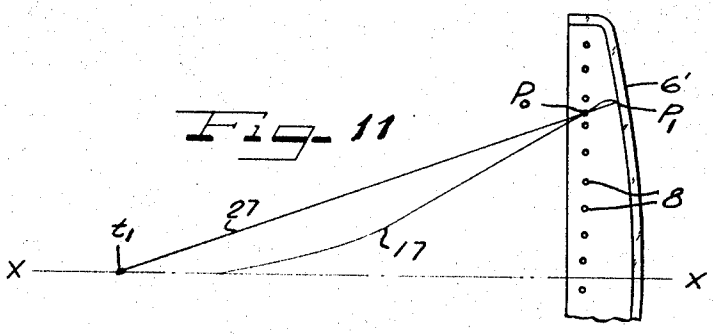


Fig. 11



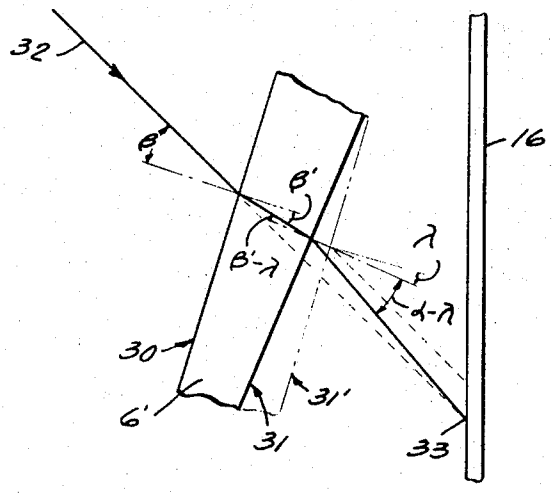


Fig. 12

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3,451,812

METHOD OF MAKING COLOR SCREEN FOR CATHODE RAY TUBE

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Claims priority, application Japan, Jan. 29, 1965, 40/4,657
Int. Cl. G03c 7/04
U.S. Cl. 96—36.1
4 Claims

ABSTRACT OF THE DISCLOSURE

A method for forming a cathode ray tube for the reproduction of color and having an electron gun and grid elements adjacent the screen of the tube comprising exposing a master face panel having photosensitive materials by the electron beam, and deflecting the beam by first and second color deflection voltages corresponding to first and second colors and then developing the master face panel to leave void areas corresponding to a third color. A photo-plate is formed by exposing it through the master face panel and a photo-mask is formed from the negative photo-plate formed from the master face panel. The mask and master face panel are mounted relative to the light source and positioned so that the shadow of the mask and the image of the master face panel are aligned. The master face panel is then removed and a face panel to be constructed is positioned in the same place as the master face panel and is exposed through the mask. The face panel is then developed forming the third color phosphor on the panel. First and second color phosphors are then deposited between alternative strips of the third phosphor material.

This invention relates to methods for producing color screens for cathode ray tubes used in color television reception, and particularly to the manufacture of striped screen surfaces of the type used in post-deflection-focusing type cathode ray tubes.

There have heretofore been proposed many color cathode ray tubes such as a shadow-mask tube, post-deflection-focusing type shadow-mask tube, beam-indexing tube, post-deflection-focusing type tube having color-switching grids. In any types of such color cathode ray tubes electron beams, which are emitted from the electron gun and density-modulated by a signal corresponding to a predetermined chrominance signal, must accurately be impinged upon selected phosphor strips which give off a color in accordance with the chrominance signal. To perform this, a phosphor dot screen for the shadow-mask tube is usually manufactured by an optical printing method, utilizing a shadow mask as an optical mask. That is, the shadow mask is placed in the same relative position that the mask and screen will occupy in the finished tube and a light source is located in the deflection center of electron beams, after which the inner face of the face plate coated with a photosensitive material is exposed to irradiation by light beams through the mask, thereafter being subjected to a developing process. This sequence of operation is carried out for each of the colors involved in the screen to produce the multicolor phosphor screen. However, the optical printing method cannot be used for the other types of coolr cathode ray tubes, which is due to the fact that the actual path of the electron beams from their deflection center to the screen is not straight. To remove the difficulty encountered in this method, the so-called electron beam printing method has been proposed such that a screen coated with an organic photosensitive material is subjected to

impingement by the beam of electrons under substantially the same operative condition as that of the finished cathode ray tube and phosphor deposits each emitting a predetermined color are formed in predetermined positions on the screen.

According to this method, since the electron beam printing is carried out in a tube evacuated to the pressure which will be employed in actual operation of the television receiver, the so-called "fog" is caused in the photosensitive material under the influence of dust or the like within the tube, and hence stable electron beam printing cannot be accomplished. Further, the evacuation and electron beam printing are naturally required at least twice or more because a multicolor phosphor screen is produced. Hence, this conventional method inevitably involves many steps in the manufacturing process thereof and is consequently not suitable for mass production.

Accordingly, it is one object of this invention is to provide a method of manufacturing color phosphor screens comprising providing a photograph corresponding to a screen face formed by the electron beam printing method, forming an optical mask confronting the screen face from said photograph and making a multicolor phosphor screen utilizing the optical mask, thereby obtaining a multicolor phosphor screen with a single evacuation.

It is another object of this invention to provide a method for the manufacture of color phosphor screens which utilizes the advantages of both of the electron beam printing method and the optical printing method.

Other objects, features and advantages of this invention will become apparent from the following description taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic cross-sectional view of a "Chromatron" type cathode ray tube, for explaining one example of the method for the manufacture of a color screen according to this invention;

FIGURE 2 is a partial enlarged cross-sectional view of the screen of the tube, showing the relative arrangement of color phosphor strips and grids;

FIGURE 3 is a schematic cross-sectional view of the face of a cathode ray tube to be employed for the manufacture of a color phosphor screen according to this invention;

FIGURES 4 to 6, inclusive, are schematic diagrams illustrating, by way of example, a sequence of manufacturing processes according to this invention;

FIGURE 7 is a schematic diagram illustrating one example of a photographic image obtained during the manufacturing processes of the method of this invention;

FIGURE 8 is a schematic diagram illustrating one example of an optical printing process of this invention;

FIGURES 9 and 10 respectively show steps in the latter half of the manufacturing process of this invention; and

FIGURES 11 and 12 are schematic diagrams for explaining this invention.

Referring now to the drawings, the present invention will be described as applied to the manufacture of a multicolor phosphor screen for the "Chromatron" type cathode ray tube.

As clearly seen from FIGURE 1, the "Chromatron" type color cathode ray tube, generally designated by the reference numeral **1**, comprises an electron gun device **3** positioned in a neck portion **2** of the cathode ray tube **1**, a deflection coil **5** provided on the outer side of the conical portion **4** of the tube **1**, multicolor phosphor screen **7** formed on the inner face of the face plate panel **6** of the tube **1** and a post-deflection-focusing grid device **8** interposed between the deflection coil **5** and the color phosphor screen **7**. The electron gun device **3** is usually formed to produce a single electron beam and signals corresponding to red, green and blue colors are sequentially applied to

the device 3, and a density-modulated electron beam is obtained correspondingly. In FIGURE 2 there is illustrated one example of the color phosphor screen 7 which is composed of red, green and blue phosphor strips 7R, 7G and 7B laid down in a repeating cyclic order of red-green-red-blue. The grid device 8 consists of two groups of grid elements 8*a* and 8*b* disposed opposite the blue and green phosphor strips 7B and 7G, respectively, correspondingly positioned elements being connected together. Between the grid elements 8*a* and 8*b* a switching signal is applied in accordance with the color signal applied to the electron gun device 3. The switching signal is, for example, a rectangular wave voltage or sine wave voltage having a subcarrier frequency of 3.58 mc./s. With such an arrangement, a red color is produced by impingement of the electrons of a beam upon the red phosphor strips 7R when the grid elements 8*a* and 8*b* are at the same potential. When the grid elements 8*a* are made positive relative to the grid elements 8*b* and the electrons of the beam impinge upon the green phosphor strips 8G. Under the opposite conditions with the grid elements 8*a* negative and the grid elements 8*b* positive, the electrons of the beam impinge upon the blue phosphor strips 7B. The aforementioned grid device 8 is usually framed and precisely mounted detachably in opposing relation to the phosphor screen 7. In this case, it is of prime importance to position the grid device 8 relative to the face panel 6 as accurately as possible.

Now, description will be made in connection with the manufacture of such a phosphor screen for the "Chromatron" type color cathode ray tube. A face plate panel 6 is prepared such as shown in FIGURE 3. In the first step of the process, the entire inner face of the face panel 6 is first coated with a photosensitive material layer 9 which becomes hard by exposure to electron beams. Then, a framed grid device 8, similar to the aforementioned one, is positioned adjacent the inner face of the face panel 6 precisely in the position which it will occupy in the finished cathode ray tube.

The face panel 6 is then attached to the conical portion 13 of a demountable cathode ray tube 10 as an electron beam irradiation apparatus, as illustrated in FIGURE 4. The demountable cathode ray tube 10 is substantially the same in structure as the finished cathode ray tube except that it has an exhaust pipe 12. Accordingly, the tube 10 is provided with at least an electron gun device 14, a deflection coil 11 and the exhaust pipe 12. In attaching the face panel 6 to the tube 10, an abutting face 6*a* of the face panel 6 is joined to an end portion 13*a* of the conical portion 13 of the tube 10. Then, the tube is evacuated through the exhaust pipe 12. In such a case, it is preferred to apply a sealing material such as grease to the abutting faces 6*a* and 13*a* so as to make an air-tight joint between the face panel 6 and the tube 10. The cathode ray tube 10 is held under a pressure such, for example, as 5×10^{-5} mm. Hg which will be employed in actual operation of the television receiver. Under such conditions an accelerating voltage and a deflection voltage are applied respectively to the electron gun device 14 and the deflection coil 11. In this case, however, it is not necessary to apply to the electron gun device 14 voltages in accordance with the red, green and blue color signals but the electron gun device 14 is adapted to produce an electron beam of a certain density at all times. Further, the grid device 8 is adapted to be supplied selectively with the voltages which will be employed in the finished tube.

With such an arrangement, a potential is applied to the grid device 8 such that the grid elements 8*a* are made positive and grid elements 8*b* negative to cause an electron beam 17 to impinge upon the coated inner face of the face panel 6 at locations which are to be occupied ultimately by green phosphor strips 7G, creating green latent image areas.

Next, a second electron beam printing is carried out by applying to the grid device 8 a potential such as to

make the elements 8*a* negative and the elements 8*b* positive similarly to cause the electron beam 17 to impinge upon the coated inner face of the face panel 6 in positions which blue phosphor strips 7B will occupy in the finished tube, producing blue latent image areas.

Thereafter, air is introduced into the tube 10 through the exhaust pipe 12 and the face panel 6 with the grid device 8 is disassembled from the conical portion 13 of the tube 10. The grid device 8 is also removed from the face panel 6. Then, the inner face of the face panel 6 is subjected to a developing process which consists in rinsing the entire inner face of the face panel 6 with, for example, water to wash away selectively the photosensitive material layer 9 of the those areas which has not been exposed to the electron beam. This leaves void areas which are to form the red phosphor strips 7R in the finished cathode ray tube 1 such as illustrated in FIGURE 1. As illustrated in FIGURE 5, this selective removal of the photosensitive material layer 9 results in the production of a face panel 6′ having the photosensitive material strips 9′ which have become hard at positions to be occupied ultimately by the blue and green phosphor strips 7B and 7G.

After a sequence of these processes to obtain the face panel 6′, a mask is produced for optical printing use as will hereinbelow be described.

A light source 15 is first disposed in the apparent deflection center t_1 in opposing relation to the inner face of the face panel 6′, while a photographic plate 16 is positioned opposite the outer face of the face panel 6′. As clearly seen from FIGURE 11, the apparent deflection center t_1 is that point at which the straight line 27 crosses the axis X—X of the face panel 6′, the line 27 joining the point P_0 between the grid elements, through which the electron beam 17 deflected by the deflection coil 11 is caused to pass, with the point P_1 on the inner face of the face panel 6′ upon which the electron beam 17 is caused to impinge after finally being deflected by the focusing voltage present between the grid device 8 and the conductive layer of the face panel 6′ or the metal-backing layer thereof. The photosensitive material strips 9′ are previously painted opaque with a suitable paint, if necessary. Under such conditions, the photographic plate 16 is exposed to irradiation by light from the light source 15 through the face panel 6′ having deposited thereon the photosensitive material strips 9′, creating on the photographic plate 16 latent image areas in acocrdance with the striped pattern formed by the strips 9′ on the inner then subjected to a developing process to obtain a negative plate 18.

The next step consists in producing a mask for optical printing use by making use of the negative plate 18. That is, the negative plate 18 and a photographic plate 22 are disposed opposite with a lense 19 positioned therebetween, as illustrated in FIGURE 6, and the photographic plate 22 is subjected to irradiation by light from the outside of the negative plate 18 as indicated by the arrows, printing on the plate 22 the photographic image of the negative plate 18. The photographic plate 22 is then developed to obtain an optical mask 24. The mask 24 is used for forming red phosphor strips as will be described later, and this mask 24 is opaque at places corresponding to blue and green phosphor strips B and G which will be deposited on the screen of the finished cathode ray tube, but transparent at places corresponding to red phosphor strips R ultimately occupying on the screen, as illustrated in FIGURE 7. Reference numeral 25 indicates a transparent base film of the mask 24.

Following this, the mask 24 is placed adjacent the inner face of the face panel 6′ and the light source 15 is disposed in the apparent deflection center t_1 spaced a distance L_1 from the face panel 6′ as illustrated in FIGURE 8. Under such conditions the mask 24 is moved along the axis X—X of the face panel 6′ so as to define a distance L_2 between the face panel 6′ and the mask 24 such that the

striped pattern of the mask **24** exactly coincides with that of the photosensitive material strips **9'** previously formed on the face plate panel **6'**.

Then, a phosphor slurry which consists of a red phosphor and a photosensitive lacquer is deposited over the entire inner face of another face panel **6''**, as illustrated in FIGURE 9A at **20R**, on which are to be formed the phosphor strips. The deposition of this red phosphor slurry layer **20R** may take place by means of any desired conventional methods. The face panel **6''** is placed in exactly the same position as the face panel **6'** relative to the mask **24** and the light source **15**. The photosensitive lacquer may be a mixture composed of polyvinyl alcohol, ammonium dichromate, water glass and so on.

The coated inner face of the face panel **6''** is then exposed to irradiation by light through the mask **24** from the light source placed behind the mask **24**, as indicated by the arrows. The photosensitive material is usually highly sensitive to ultraviolet light, so that a xenon lamp, a mercury-arc lamp or the like is employed as the light source **15** in this case. As seen from FIGURE 9B, during this exposure to the light only some portions of the red phosphor slurry layer **20R** are exposed to the light since the other remaining portions of the layer **20R** are masked by the opaque portions of the mask **24**. The red phosphor slurry on those areas which have been exposed to the light is hardened. In the next stage the excess phosphor layer which has not been exposed to the light is washed off by rinsing with water, leaving the hardened red phosphor strips **20R** in spaced relation at predetermined intervals, as illustrated in FIGURE 9C.

Next, the red phosphor strips **20R** are colored to be opaque and a material **21**, such, for example, as wax or enamel which is a light transmitting inhibitor and is readily removed by a solvent, is deposited in every other void area between the red phosphor strips **20R** as illustrated in FIGURE 10B. This deposition may take place by means of any desired methods such as spraying, since the red phosphor strips **20R** are spaced apart a considerable distance from adjacent ones. Then, a green phosphor slurry is deposited over the entire inner face of the face panel **6''** as illustrated in FIGURE 10C at reference numeral **20G**. This coated face is exposed to irradiation by light from the convex side of the face panel **6''**, after which the coated face is rinsed with water to remove selectively those areas which have not been exposed to the light and then the material **21** previously deposited on the void areas between the red phosphor strips **20R** is removed by rinsing with toluene or acetone. As a result of this, the green phosphor strips **20G** are deposited between the red phosphor strips **20R** in alternating relation, as illustrated in FIGURE 10D. After the formation of the green phosphor strips **20G**, the red and green phosphor strips **20R** and **20G** deposited on the inner face of the face panel **6''** are colored to be opaque and the entire face is given a coating with a blue phosphor slurry as seen from FIGURE 10E at reference numeral **20B** and then subjected to irradition by light from the convex side of the face panel **6''**. During this exposure, the portions of the blue phosphor slurry coated in the remaining void areas between the red phosphor strips **20R** are hardened by exposure to the light, while the remaining portions of the blue phosphor slurry coated on the red and green phospher strips **20R** and **20G** are masked from the effects of the irradiation by these strips. As in the preceding process, the inner face of the face panel **6''** is then rinsed with water, leaving blue phosphor strips **20B** as illustrated in FIGURE 10F. In this manner, a phosphor screen is produced which consists of the red, green and blue phosphor strips sequentially arranged in the order of red-green-red-blue-red-green etc.

In the foregoing, alternate void areas between the red phosphor strips **20R** are masked from the light by the light transmitting inhibitor material such as wax or the like for the production of the blue or green phosphor strips in the process shown in FIGURES 9A to 9C. In such a case, however, only specified portions of the blue or green phosphor slurry coating can be exposed to the light by changing the relative position of the mask **24** to the face panel **6''** without using the wax.

Now, refraction of light due to the glass of the face panel **6'** in the case of producing the negative plate **18** will be discussed. Where the screen surface of the face panel **6'** is plane, substantially the same deflection due to the refraction of light is caused over the entire surface so that the refraction does not matter. In fact, however, since the screen surface of the face panel **6'** is curved, the refraction of light naturally differs throughout the screen surface. To avoid this, the outer face of the face panel **6'** is formed to be a non-spherical lens by means of, for example, grinding. FIGURE 12 is schematic diagram for explaining the principle of the correction. Reference numeral **30** indicates the inner face of the face panel **6'**. Reference numerals **31** and **31'** respectively identify the outer faces of the face panel **6'** after and before correction. A light **32** having reached the inner face **30** at an incidence angle of β is refracted at the inner face **30** so as to be transmitted through the face panel **6'** at an angle of β'. Thus, the light **32** reaches the outer face **31** at an incidence angle of $(\beta-\lambda)$ and then it is refracted with a refraction angle of $(\alpha-\lambda)$ so as to be projected on the photographic plate **16** at a point **33** thereof.

Where the angle λ represents an acute angle between the outer faces **31** and **31'**, and n indicates the refraction index of the face panel **6'**, the following equations hold true:

$$\frac{\sin\beta}{\sin\beta'}=n,\ \frac{\sin(\alpha-\lambda)}{\sin(\beta'-\lambda)}=n$$

From these equations, the following expressions can be derived:

$$\tan\lambda=\frac{\sin\beta-\sin\alpha}{\sqrt{n^2-\sin^2\beta}-\cos\alpha}$$

The angle λ can be obtained from the angles β and α. In this case the point **33** on the photographic plate **16** through which the refracted light from the outer face **31** of the face panel **6'** passes lies on the extension line of the incident light **32**. Accordingly, the outer face of the face panel **6'** is corrected so as to satisfy the angle λ and consequently the influence of the refraction of the face panel **6'** can be removed. It is preferred to grind the face panel **6'** after the electron beam printing, since the face panel **6'** is mechanically weakened by the grinding. Further, the influence of the refraction of the face panel **6'** can be removed by carrying out the process shown in FIGURE 5 in a container filled with a liquid of the same refractive index as that of the glass of the face panel **6'**.

As has been described in the foregoing, according to this invention the evacuation of the tube is necessary only once for the electron beam printing in the production of the mask **24** and the color phosphor screen is manufactured by optical methods without requiring further evacuation, so that the method of this invention requires less fabrication process than the conventional method employing the electron beam printing all throughout the process thereof. Therefore, the method of this invention is suitable for mass-production of the color phosphor screen for the cathode ray tubes.

Furthur, the present invention is applicable to the manufacture of the color phosphor screens for wide angle deflection and bipotential cathode ray tubes.

It is considered possible to produce an optical mask by exposing a photographic plate to irradiation by light from the front of the face panel **6'** in the process shown in FIGURE 5 with such arrangements that a lens is placed between the light source **15** and the photographic plate is exposed to the light through the lens so as to obtain the pattern of the photosensitive layer **9'**. In such a case, however, since the solid angle at the apparent deflection center l_1 subtending to the screen is very large in the

color phosphor screen of the wide angle deflection or bipotential cathode ray tubes, a very wide angle lens is required and a mask having a predetermined striped pattern is practically difficult to obtain due to distortion of the lens. According to this invention, however, no lens is used in the exposure of the photographic plate **16** to the irradiation by light and the reduction degree of the striped pattern of the face panel **6'** obtained on the mask **24** from the negative plate **18** is small, as compared with the case in which lens is employed, so that a distortionless lens having a long focal length can be employed in this invention. Consequently the color phosphor screen for the wide angle deflection or bipotential cathode ray tubes can precisely be produced.

In the foregoing, the color screen is produced before locating the grid device **8** to be attached to the face panel **6''**, but it is preferred that the grid device **8** is previously positioned and thereafter the color phosphor screen is produced in accordance with the positioning thereof. In such a case, the face panel **6''** having attached thereto the grid device **8**, the mask **24** and the light source **15** are arranged in the same relative positions as those shown in FIGURE 8 before exposing the red phosphor slurry layer **20R** coated on the inner face of the face panel **6''** to the irradiation by light through the mask **24**. Thereafter, the mask **24** is rotated about the axis X—X until a spurious pattern or a moiré pattern resulting from interference due to disagreement between the striped patterns of the mask **24** and the grid device **8** becomes a predetermined symmetrical pattern. Following this positioning, the grid device **8** is disassembled from the face panel **6''** and the red phosphor slurry layer **20R** is exposed to light through the mask **24** and thereafter the same processes as those described in the foregoing are carried out. After the production of the color screen, the grid device **8** is atatched to the face panel **6''** at the predetermined position thereof, permitting the grid device **8** to be attached to the color screen at the predetermined position.

Although the present invention has been described with reference to the manufacture of the multicolor phosphor screen for the "Chromatron" type color cathode ray tube, the invention can be applied to the color phosphor screen for the post-deflection-focusing, shadow-mask and other types of color cathode ray tubes.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel concepts of this invention.

What I claim is:

1. The method of forming a color screen for a cathode ray tube type having an electron gun and grid elements

comprising, exposing a master face panel having photosensitive material by applying first and second color deflection voltages to said grid elements to expose areas with said electron beam of said master face panel corresponding to said first and second colors, developing said master face panel to leave void areas corresponding to a third color, exposing a posotive photo-plate from the developed master face panel by passing a light source through said master face panel onto said photo-plate, forming a photo mask which comprises a negative photo-plate from said positive photo-plate, mounting said mask between said master face panel and a light source and positioning the mask and light source until the pattern image of the mask aligns with the pattern image of the master face panel, applying photosensitive material of a third color to an unexposed face panel, placing the unexposed face panel in the exact position of the master face panel relative to the mask and light and exposing it, developing the exposed face panel and placing phosphor of the first color between alternate strips of the third color, and placing phosphor of the second color between the remaining strips of the third color.

2. The method of claim **1** wherein the phosphor of the first color is placed between alternate strips of the third color by spraying light transmitting inhibiting material into every other void area between the strips of said third color and filling the remaining void areas with phosphor of the first color and then exposing to light the phosphor of said first color.

3. The method of claim **2** wherein the phosphor of the second color is placed between the remaining strips of the third color by filling the areas between remaining strips of the third color with phosphor of the second color and then exposing to light the phosphor of said second color.

4. The method of claim **3** wherein the phosphors of the first, second and third colors are exposed to light passing through the face panel.

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J. R. EVERETT, *Assistant Examiner.*

U.S. Cl. X.R.

117—335