

[54] METHOD OF PRODUCING A STRIPED
CATHODE RAY TUBE SCREEN

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[51] Int. Cl. G03c 5/00

[58] Field of Search..... 96/36.1, 36, 35;
117/33.5 CM, 33.5 C, 33.5 CP; 313/92 B, 92
PD, 92 F, 92 PH, 92 CS

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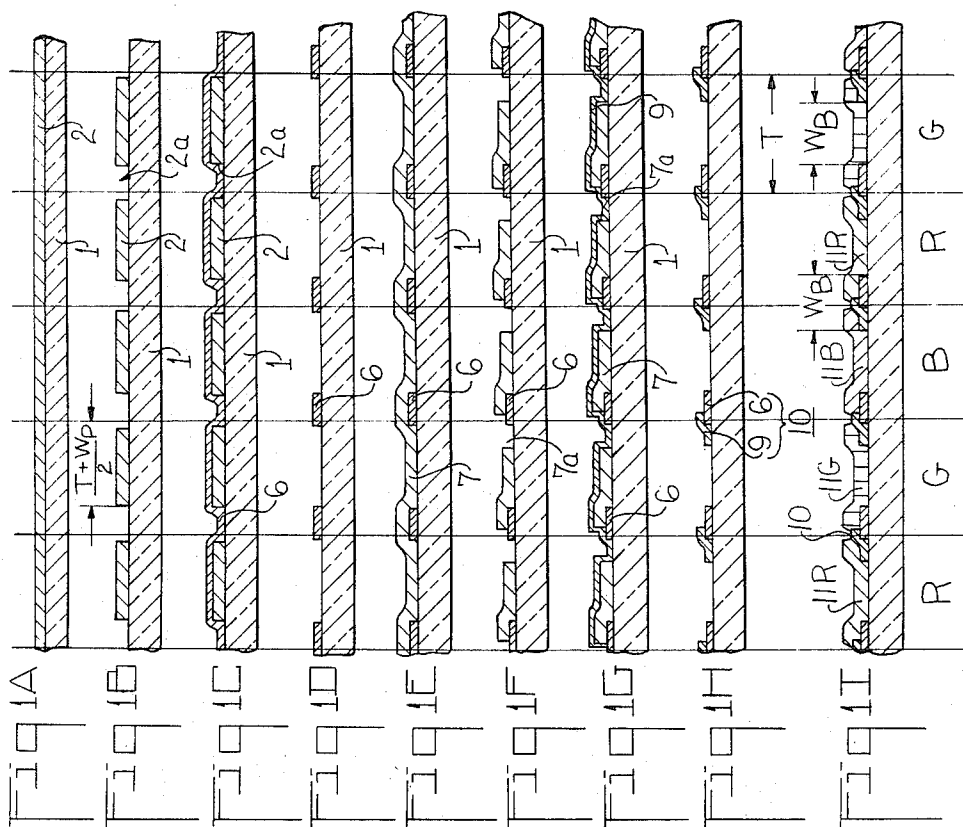
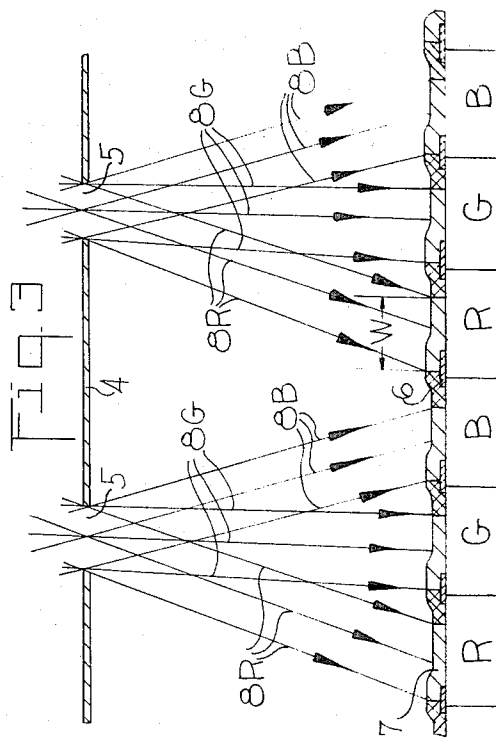
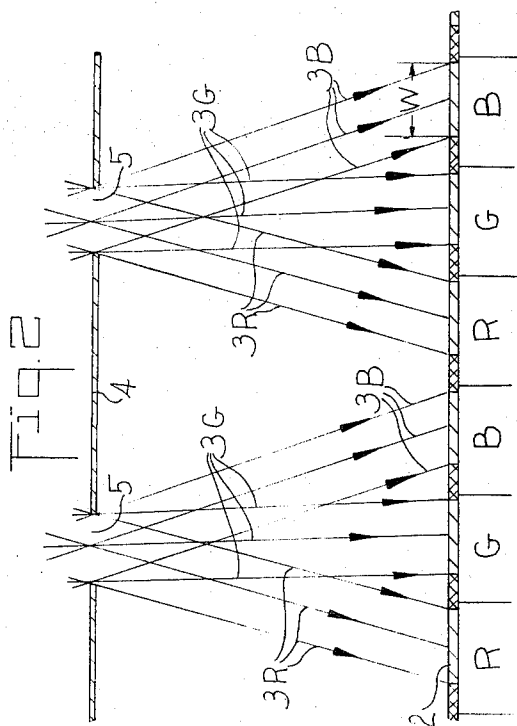
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Assistant Examiner—Edward C. Kimlin
Attorney—Lewis H. Eslinger et al.

[57] ABSTRACT

A photographic method of forming light-absorbing stripes on a color cathode ray tube screen between light-emitting phosphor stripes by an optical shadowing technique in which the light-absorbing stripes are wider than the opaque parts of the shadow mask used to create the optical image. In order to create wider shadows, one set of exposures of the photosensitized screen is made from one set of positions of the light sources, and photographic and deposition steps are carried out to produce a first set of light-absorbing stripes. One edge of each stripe is in the desired location. The exposure process is repeated with the light sources slightly displaced so that, upon further development and deposition steps, a second set of light-absorbing stripes is produced that overlaps the first set so that the width of each stripe is correct and both edges are properly located. The space for light emission between adjacent stripes is therefore narrower than the beams that can strike these stripes by passing through the openings in the shadow mask.

7 Claims, 7 Drawing Figures



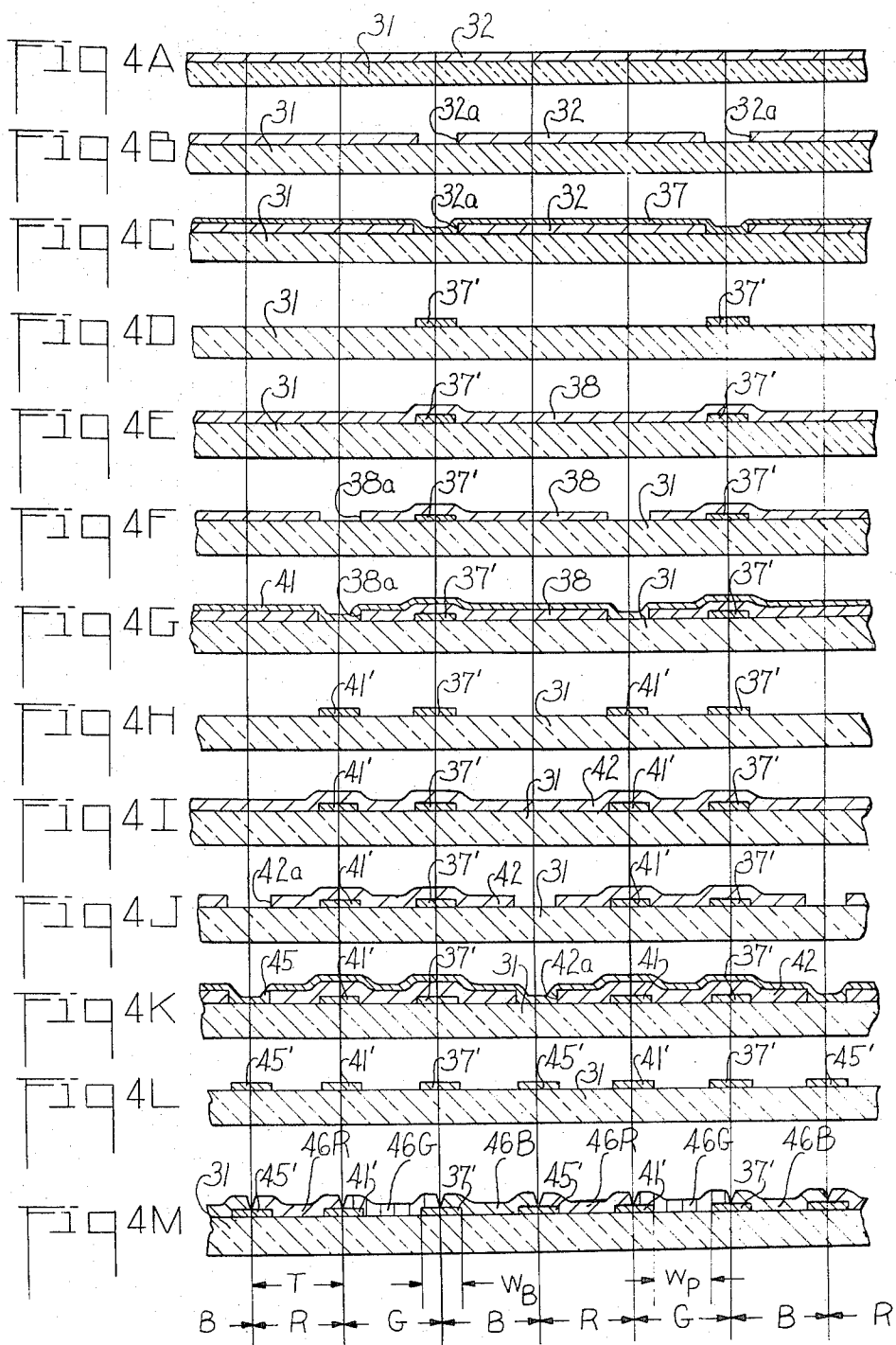


Fig. 5

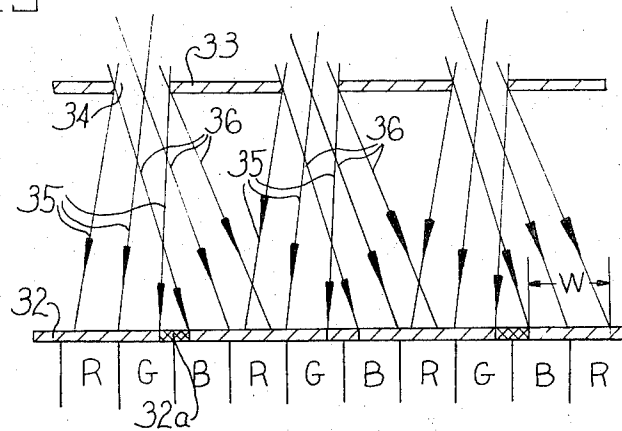


Fig. 6

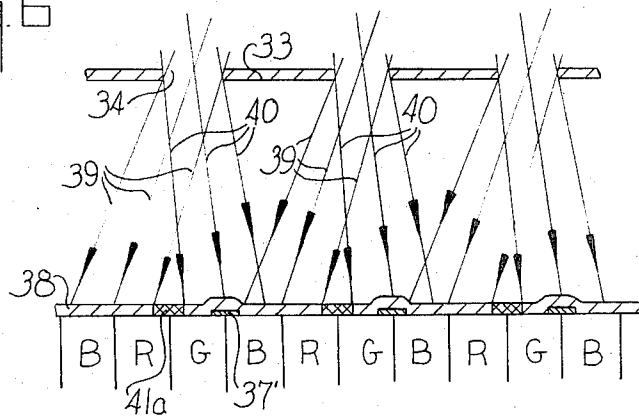
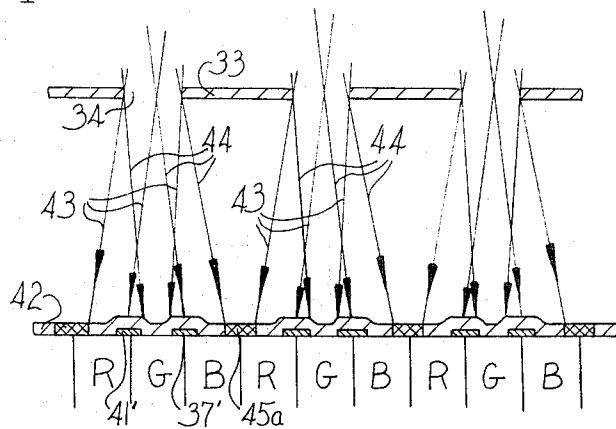


Fig. 7



METHOD OF PRODUCING A STRIPED CATHODE RAY TUBE SCREEN

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of color cathode ray tubes and particularly to a photographic method for making light-absorbent stripes for a striped color cathode ray tube phosphor screen.

2. The Prior Art

In color cathode ray tubes of the type in which the fluorescent screen is divided into elemental areas of fluorescent material that emit light in the primary colors and are spaced across the surface of the screen according to a regular pattern, these elemental areas may theoretically be formed so that they are contiguous with each other. If the beam-selecting structure, which is usually a shadow mask, is perfectly aligned with the screen and with the electron gun structure, electrons that are intended for only one of the sets of elemental areas corresponding to one color will be energized and other areas that are not intended to be electronically excited will not be energized. However, perfect alignment between the various parts of the color cathode ray tube is difficult to achieve, and other means have come into use to prevent electrons from exciting phosphor material that emits light of the wrong color.

One technique to prevent such color contamination is to surround each elemental light-emitting area with an outline of light-absorbing material, such as graphite. Of course, such a light-absorbing outline occupies part of the area that might be used to generate light, but this is not objectionable as long as the remaining light-emitting area can furnish enough brightness.

Since the fluorescent screens of color cathode ray tubes are usually made by a photographic process that involves successively applying elemental areas of the different phosphors to proper locations on the screen, it is desirable to form the light-absorbing barrier photographically. The elemental light-emitting phosphor areas are usually produced by exposing a photo-sensitive material, usually a photo-resist, to an image formed by passing light from selected points of origin through the shadow mask that is to be used with that particular tube. The final resultant image is essentially a negative of the shadow mask since the phosphors are caused to adhere to the supporting structure, which is usually a glass face plate, only in those areas that correspond to the openings in the shadow mask.

The light-absorbing material must be placed in areas that correspond to a positive reproduction of the shadow mask except that, in order to obtain the advantage of the light-absorbing material, the width of the light-absorbent areas has to be greater than the true shadow of the corresponding portion of the mask. Such a result may be obtained by making the shadow mask so that its apertures are narrower than they will be in the finished tube, and using the mask with the narrowed apertures to make the optical exposures as a preliminary step to applying the phosphor materials to the screen. Thereafter, the light-absorbing material is caused to adhere to the areas of the screen surrounding each of the phosphor areas, and the mask is re-etched to increase the size of the apertures.

However, it is difficult in re-etching a shadow mask to enlarge the apertures without distorting them in some way. In addition, the thickness of the mask is

likely to be changed in a non-uniform manner, thus causing the mask to twist. Both of these effects cause mislanding of the electron beams.

The size of the areas exposed may also be controlled by controlling the intensity of light striking the photo-resist material.

It is one of the objects of the present invention to provide a method of applying light-absorbing material to the screen of a color picture tube by direct optical shadowing technique but in such a way that the areas of the light-absorbent material will be wider than the opaque areas of the shadow mask used in the optical imaging part of the process.

Other objects will become apparent from the following specification together with the drawings.

BRIEF STATEMENT OF THE INVENTION

In accordance with the present invention, stripes of light-absorbing material are formed on the screen of a color cathode ray tube by a photographic process using direct shadowing of light passing through a striped mask that is to be incorporated with that screen in a color cathode ray tube. The mask is first illuminated from selected positions to form a shadow image on a layer of photo-sensitive material on the support structure for the screen. The mask and screen are substantially parallel to each other and the light sources are far enough away so that the shadow image has stripes that are substantially the same width as the opaque strips of mask material. However, the light sources are offset somewhat to one side of the position corresponding to the effective origins of the electron beams. The offset is enough so that one edge of each shadow stripe corresponds to the proper position for one edge of each of the final stripes of light-absorbing material in the finished screen. However, the width of each of the shadow stripes is not as great as is required for the stripes of light-absorbing material.

After the photo-resist material has been thus exposed, it is developed and the unexposed stripe areas are washed away. A suitable light-absorbing material is then coated over the screen and adheres to the screen in the uncoated areas between adjacent exposed stripes. Thereafter, the exposed photo-resist material is dissolved, carrying with it any excess light-absorbing material and leaving stripes of light-absorbing material in the areas that correspond to the original shadows of the mask.

The striped screen is again coated with a photo-resist and is again exposed with the same set of light sources. However, in this second exposure, or set of exposures, the light sources are placed in slightly different locations so that the shadows formed in the second exposure do not precisely overlap the original stripes of light-absorbing material. The photo-resist is developed a second time and the unexposed portions are washed away leaving stripes of photo-resist material, one edge of each of which overlaps one edge of each of the stripes of light-absorbing material on the screen. The overlapped edge of each of these stripes is the one that is in the proper position for the completed screen. Light-absorbing material is again coated onto the exposed and developed surface and adheres to the clean areas of the screen and overlaps the second edge of each of the original stripes of light-absorbing material. Thereafter, the exposed photo-resist material is dissolved, carrying away with it the light-absorbing mate-

rial that was coated on it. This leaves stripes of light-absorbing material that are wider than the original stripes and have opposite edges that are correctly located as desired for the final cathode ray tube. Stripes of suitable phosphors for emitting light of the proper colors may then be coated on the areas between adjacent stripes of light-absorbing material and, in fact, overlapping such adjacent stripes.

In a modified method the screen coated with a layer of photo-resist material is exposed to light through the shadow mask but the light passes along paths that are overlapping at the screen except for shadow areas which correspond to the locations of every third stripe of light-absorbing material in the completed screen. The unexposed photo-resist material is washed away, a layer of light-absorbing material is applied over the exposed stripes of photo-resist material and the stripe areas therebetween, the exposed photo-resist material is dissolved, and the entire process is repeated again but with the sources of light shifted to form shadows corresponding to a second set of light-absorbing stripes. Thereafter, the process is repeated another time with the sources of light shifted to still another location to form shadows corresponding to the third set of stripes of light-absorbing material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A-1I illustrate the steps of one method of preparing light-absorbing stripes for a color cathode ray tube screen according to the present invention.

FIGS. 2 and 3 show fragmentary cross-sectional views of a color screen and mask during exposure to light in the manufacture of light-absorbing stripes on the screen.

FIGS. 4A-4M illustrate the steps of an alternative method of producing light-absorbing stripes on a color cathode ray tube screen.

FIGS. 5-7 are fragmentary cross-sectional views of a color screen and mask showing the optical exposure at selected times during the process illustrated in FIGS. 4A-4M.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The method of forming stripes of light-absorbing material will first be described with reference to FIGS. 1A-1I and FIGS. 2 and 3.

The first step of the method of forming light-absorbing stripes on a screen for a color cathode ray tube is shown in FIG. 1A, in which a glass panel 1 has one of its surfaces coated with a photo-sensitive resist layer 2, such as polyvinyl alcohol or another suitable material.

The second step of the method is to expose the resist layer to an optical image of a mask 4 that is to be used in the same color cathode ray tube as the screen. The relative locations of the coated glass panel 1 and the mask are illustrated in FIG. 2. The mask 4 is substantially parallel to the glass panel 1 and is in the same relative position that this panel and mask will later occupy in a completed color cathode ray tube. Light from three specific locations is directed onto the mask 4 and passes through slit apertures 5 formed in the mask. The locations of the light sources are such that a clear shadow image of the mask 4 is formed on the photo-sensitive resist 2. Light strikes the resist by following different paths through the aperture 5, depending on

the location of the sources of the light. A central light beam 3G passes almost, but not quite, perpendicularly through the mask 4, at least at the center of the mask, and strikes the surface of the resist 2. The area struck by the light beam 3G corresponds substantially to the area that will later be coated with phosphor that emits green light when excited by an electron beam. Two other beams of light rays 3R and 3B also pass through the apertures 5 along paths that are angularly displaced from the path of the beam 3G. However, the locations of the light ray beams 3R and 3B are such that they strike areas equally displaced on each side of the area struck by the beam 3G. Since all of the beams pass through the same apertures and the mask 4 is substantially parallel to the panel, 1, the beams 3R, 3G and 3B illuminate stripes of equal width W in the photo-resist material 2.

These beams 3R, 3G, and 3B may be produced by simultaneously turning on three separate light sources of the type suitable for exposing the photo-sensitive material used in making color cathode ray tube screens, or they may be produced by using a single light source as the radiation source and placing it in three proper locations in sequence. In either case, the radiation must reach the surface 2 by passing through the apertures 5 along a correct set of angles, as described.

The next step in the method is to develop the exposed photo-sensitive material 2. In so doing, the unexposed stripes are washed away leaving open areas 2a as shown in FIG. 1B between the remaining stripes of the exposed photo-sensitive material 2.

The vertical lines in FIGS. 1A-1I illustrate the repetitive spacing of the stripes on a color cathode ray tube screen. This spacing is referred to as the pitch T. In accordance with the present invention the open areas 2a have been so formed that the left-hand edge of each of the remaining stripes 2 of exposed photo-resist material are located a distance $(T + W_p)/2$. The significance of this spacing is that the total width of each of the final light-emitting stripes will be W_p as illustrated in FIG. 1I. The procedure to this point has established the location of the left-hand edge of each of these light-emitting stripes, and this left-hand edge is located a distance T/2 plus a distance $W_p/2$ from the right-hand boundary marked by one of the vertical lines. However, it will be noted that the spaces 2a are off center with respect to the boundaries marked by the vertical lines.

The next step in the process is illustrated in FIG. 1C and is to coat, with a layer of light-absorbing material 6, the entire upper surface of the exposed photo-resist material 2 and the uncovered area of the panel 1 in the openings 2a. The material 6 may comprise a liquid mixture of graphite and water glass. After drying the mixture, the photo-resist material 2 is removed by use of hydrogen peroxide H_2O_2 , which leaves only stripes of light-absorbing material 6 on the panel 1 as shown in FIG. 1D.

The entire process is then repeated, beginning with the application of another photo-resist layer 7 covering the exposed surface of the panel and the upper surface of the light-absorbing stripes 6, as shown in FIG. 1E. This second coating of photo-resist material is then exposed to light passing along a second set of angles through the apertures 5 in the mask 4, as shown in FIG. 3. The difference between the angles of travel of the light beams in FIG. 2 and the angle of travel of the light beams 8R, 8G and 8B in FIG. 3 is that the beams 3R,

3G and 3B in FIG. 2 tilt to the left while the beams 8R, 8G and 8B tilt to the right. The angle of tilt is preferably equal but opposite to that in FIG. 2. Furthermore, the width W of the stripes exposed by the light beams 8R, 8G and 8B is the same as the width W in FIG. 2. As may be seen, the exposed photo-sensitive material 7 includes some that overlaps the stripes 6 of light-absorbing material, but the overlap is not complete.

The next step is to develop the photo-sensitive material 7, thereby leaving openings 7a as shown in FIG. 1F. The width of each of these openings is, of course, the same as the width of each of the stripes 6 of light-absorbing material since both were formed as a result of the shadow image of the same opaque portions of the shadow mask.

Thereafter, more light-absorbing material 9 is applied at least to the openings 7a, although in practice, the light-absorbing material 9 may also cover the remaining photo-resist material 7. The light-absorbing material on the photo-resist material is excess and is then washed away when the photo-resist material is removed in the next step of the process by the use of hydrogen peroxide, as before. This leaves only the light-absorbing material stripes 6 and 9 as shown in FIG. 1H. Since these stripes coalesce, they may be referred to as the stripes 10. It will be noted that these stripes are now symmetrical with respect to the vertical lines, and, of course, are wider than the original stripes 6, alone.

Thereafter, by standard photographic techniques, suitable stripes of light-emitting phosphors of the proper colors may be placed on the exposed surface of the panel 1, as shown in FIG. 1I. These light-emitting stripes are identified as 11R, 11G and 11B in which the suffix letter designates the color of light emitted by that stripe. FIG. 1I also indicates that the total width of each of the stripes of light-absorbing material 10 is W_p and, as stated above, that the width of the stripes 11R, 11G, and 11B from which light can actually be emitted is W_p .

The screen in its final form as shown in FIG. 1I, is ready to be excited by electron beams passing through the same mask 4 shown in FIG. 2 and 3. Thus, the widths of the electron beams that actually strike the screen will be the same as the widths W of the light beams 3R, 3G and 3B in FIG. 2. This width W is greater than width W_p shown in FIG. 1I and is indicated by the following relationship:

$$W_p < W \leq T + W_p/2$$

A modified method will be described with reference to FIGS. 4A-4M and FIGS. 5-7.

In the modified method the surface of a glass panel 31 is coated with a layer of photo-resist material 32. Then the photo-resist material is exposed to light beams passing through a mask 33 as shown in FIG. 5. These light beams pass through slit apertures 34 in the mask 33 and form separate beams 35 and 36.

Contrary to the exposure arrangement in FIGS. 2 and 3, the exposure in FIG. 5 requires only two light sources which are placed so that the beams 35 and 36 passing through the apertures 34 overlap in one set of locations which happens in FIG. 5 to be the location that will later be occupied by phosphor material that emits red light. More significant is that a stripe that overlaps the areas that will later emit green and blue light is in the shadow of opaque portions of the mask 33 and is not struck by either the light beams 35 or the

light beams 36. This is not a direct shadow of the opaque portions of the mask and so can be made as wide as necessary for the formation of light-absorbing stripes.

After the material 32 has been exposed to light, it is developed, and the parts that were in shadow are washed away to form the open areas 32a which are the same width as the light-emitting stripes required for this structure.

The next step in the process is to apply light-emitting material 37 as shown in FIG. 4C, at least in the open areas 32a, but normally over the entire surface. Thereafter the remaining photo-resist material 32 is dissolved, carrying with it the excess material 37 and leaving only the light-absorbing stripes 37' as shown in FIG. 4D.

The stripes 37' in FIG. 4D are of the proper width but there are only one-third as many as are necessary. Thus the whole process must be carried out two more times in order to form the correct total number of light-absorbing stripes.

FIG. 4E shows the step of re-coating the entire surface with another layer of photo-resist material 38. This material is then exposed to light but, of course, the light must reach different areas than in the first instance. The second exposure is illustrated in FIG. 6 in which the two light sources are moved so that their beams 39 and 40 overlap in a different set of locations, which leaves shadows in stripe areas that overlap the areas that will later emit red and green light.

The next step of the process, as illustrated in FIG. 4F, is to develop the exposed photo-resist material 38, thereby washing away the material in stripe areas to leave openings 38a. Then, a layer of light-absorbing material 41 is applied over the entire surface or at least over the areas 38a, as shown in FIG. 4G, and the photo-resist material 38 is subsequently removed, leaving only the light-absorbing stripes 37' and 41', as shown in FIG. 4H.

The process must be repeated a third time in order to form the remaining required set of stripes of light-absorbing material. Thus, as shown in FIG. 4I, the entire surface is again coated with photo-resist material 42 and this material is exposed to light emanating from a different set of locations as illustrated in FIG. 7. The light passes through the openings 34 in the mask 33 and leaves in shadow stripe areas that overlap sections of the screen that will later emit blue and red light. Although the set of angles that characterize the beam directions for the beams 43 and 44 are different from the sets of angles that characterize the beams 35 and 36 in FIG. 5, and the beams 39 and 40 in FIG. 6, these angles are not entirely different from those that have been used before. To be specific, the beams 43 strike the same areas as the beams 35 in FIG. 5, and the beams 44 strike the same areas as the beams 40 in FIG. 6. Thus, it is not necessary to have as many positions for the lights that provide these beams as might at first be supposed.

After exposure of the photo-resist material, it is developed to cause stripe openings 42a to be formed as shown in FIG. 4J. The surface is again coated with light-absorbing material 45 as shown in FIG. 4K, after which the photo-resist material is removed. This leaves a complete set of light-absorbing stripes 37', 41' and 45' as shown in FIG. 4L. Thereafter, stripes of appropriate phosphors 46R, 46G and 46B shown in FIG. 4M

may be applied to overlap the light-absorbing stripes 37', 41' and 45', as shown in FIG. 4M.

The area that must be eliminated in carrying out the second method just described requires, as shown in FIG. 4B, for example, that a stripe of the barrier of the photo-resist 32, slightly less than 3T wide, must be exposed. The width of each stripe of the photo-resist 32 that remains after exposure and development is less than 3T by half the width W_B on each side of each of the stripes of the material 32. In order to expose a stripe of the material 32 of the proper width, the width W of each of the beams 35 and 36 in FIG. 5 or the corresponding beams in FIGS. 6 and 7, must cover at least one half of the width of such an exposed stripe. On the other hand, the width of each of the beams 35 and 36 cannot be greater than the total width of such an exposed stripe of the photo-resist 32. Using the same designations as before, the total width of the exposed stripe of the material 32, as shown in FIG. 4B, is $3T - W_B/2$. However, since the width T is equal to the sum of W_B and W_p , this expression for the width of the stripe of photo-resist 32 may be rewritten as:

$$2T + W_p$$

This is the maximum width W of a light beam 35 or 36 if the beams totally overlap.

The minimum widths W of each of the beams 35 and 36 if there is no overlap is:

$$3T/2 - W_B/2$$

This may be rewritten as:

$T + W_p/2$ The complete expression is, therefore:

$$T + W_p/2 \leq W \leq 2T + W_p$$

What is claimed is:

1. In the manufacture of a striped screen for a color cathode ray tube, the method comprising the steps of:
 - A. coating a photo-resist material on one surface of a support panel;
 - B. making a first exposure of the coated material to radiation that reaches said material along a first set of paths at a first set of angles through a shadow mask comprising a plurality of slots between opaque strips;
 - C. removing unexposed photo-resist material from said surface;
 - D. coating with light-absorbing material at least a portion of said surface from which said unexposed material has been removed;
 - E. removing the photo-resist material from said surface leaving first stripes of light-absorbing material on said surface;
 - F. recoating said surface with photo-resist material;
 - G. making a second exposure of said re-coated sur-

face to radiation passing through said slots in said mask along a different set of angles than said first exposure to leave different striped areas of said surface in the shadow of opaque portions of said mask;

- H. removing the unexposed material from said re-coated surface;
- I. applying a layer of light-absorbing material to those areas from which said last-named unexposed material has been removed; and
- J. removing the remaining exposed photo-resist material.

2. The method of claim 1 in which said second exposure causes said different striped areas to overlap said first stripes of light-absorbing material, whereby the total width of stripes of light-absorbing material following the step of removing the remaining exposed photo-resist material is greater than the width of shadows of said opaque strips of said shadow mask.

3. The method of claim 1 in which said radiation is directed through said slots along three angularly separate sets of paths to strike three sets of striplike areas of equal width and equal spacing, and the central one of said sets of paths is substantially, but not precisely, perpendicular to said surface at the center thereof, whereby each of said first stripes is displaced laterally in one direction less than its width.

4. The method of claim 3 in which said different set of angles causes each of said different striped areas to be displaced laterally in the opposite direction a distance less than its width.

5. The method of claim 4 in which said different set of angles is equal and opposite to said first set of angles.

6. The method of claim 1 in which radiation for said first exposure reaches said surface along two sets of paths and at least partially overlaps at a first set of locations on said surface.

7. The method of claim 6 in which radiation for said second exposure reaches said surface along two different sets of paths and overlaps at a second set of locations on said surface, and said method comprises the additional steps of:

- A. coating said surface a third time with photo-resist material and making a third exposure thereof by radiation along a third pair of sets of paths to overlap at a third set of locations of said surface and leave a third set of striped areas in the shadow;
- B. removing those portions of said last-named coating in shadow;
- C. applying a layer of light-absorbing material to those portions of said surface from which the last-named coating has been removed; and
- D. removing the remaining portions of said last-named material.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,779,760 Dated December 18, 1973

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:

In The Heading insert:

--Priority: October 5, 1971
Japan
78216/71 and 78217/71--.

Signed and sealed this 11th day of June 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents