

PATENT SPECIFICATION

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(54) METHOD AND APPARATUS FOR EXPOSURE OF PHOSPHOR SCREEN

(71) We, HITACHI LTD., a Japanese Body Corporate of 5-1, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

5 This invention relates to the art of exposure of the phosphor screen of a color picture tube or CRT (cathode-ray tube) of the stripe phosphor screen type, and more particularly to an exposure method and apparatus for forming phosphor stripes, having a width narrower than the slot width of the shadow mask, on the inner surface of the face plate of a color picture tube of the type above described.

10 In a color picture tube of the stripe type, phosphor stripes having a width narrower than the slot width of the shadow mask are generally formed on the inner surface of the face plate in order to increase the landing allowance of the electron beams. As a means for forming such phosphor stripes of narrow width, a method is commonly known in which two linear light sources are used, and the exposure profiles of the individual light sources are arranged to overlap each other during exposure. In such a known method an extra high pressure mercury lamp is frequently used as each individual light source. This known method has however been defective in that the effective distance between the light sources is limited due to the bulb outer diameter of the mercury lamps and also due to the requirement for provision of cooling means, resulting in impossibility of providing the practically most suitable center-to-center distance of 1 to 3mm.

20 Another method which obviates such a defect is also commonly known in which a single linear light source is sequentially moved for alternate exposure between two positions. This method has also been defective in that a light source moving mechanism of complex structure is required, and the impossibility of simultaneous exposure reduces the effect of a photoresist material of reciprocity law failure type.

25 In an effort to obviate such prior art defects, the inventors have previously proposed a method of exposure in which a prism device is combined with a single linear light source so that two virtual linear light sources can be observed when viewed from the side of the face plate. This proposed method has however been completely unsatisfactory since only one of the two virtual linear light sources is visible when observed from some points of the side of the face plate.

30 It is therefore a primary object of the present invention to provide an improved method of exposing the face plate to light directed from a single linear light source so that two virtual light sources can be always observed in the entire area of the face plate and also to provide an apparatus preferably used for the practice of such a method.

35 According to the invention there is provided a method of exposure for forming a phosphor screen on an inner surface of a face plate of a color picture tube, comprising the steps of: disposing a single linear real light source at a position spaced apart by a predetermined distance from the inner surface of the face plate of the color picture tube so that the axis of said linear real light source is parallel to the inner surface of said faceplate; disposing a prism device between said linear real light source and the inner surface of said face plate, said prism device comprising a plurality of prisms each including a base surface substantially parallel with the inner surface of said face plate and at least two light-refracting surfaces disposed at a predetermined angle with respect to said base surface, said prisms being juxtaposed such that the juxtaposed light-refracting surfaces of adjacent

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ones of said prisms in the direction of the length of said linear real light source are oppositely inclined with respect to the base surface and directing light from said linear real light source toward said face plate through said prism device, whereby said single linear real light source may be observed as a plurality of virtual linear light sources at every point on said face plate.

According to another aspect of the invention there is provided an exposure apparatus for forming a phosphor screen on the inner surface of a face plate of a color picture tube, comprising a single rear linear light source disposed at a position spaced apart by a predetermined distance from the inner face of the face plate of the color picture tube while extending in parallel therewith, and a prism device disposed between said linear light source and the inner surface of said face plate, said prism device including a plurality of prisms closely arranged so as to constitute a means for causing said single linear real light source to be observed as a plurality of virtual linear light sources from every point on said face plate.

The above-mentioned and various preferred features of this invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings, in which:

Figure 1 is a diagrammatic view illustrating the exposure path according to a prior art method using a prism device as described hereinbefore.

Figure 2 is a schematic front elevational view of one form of a prism device employed in an embodiment of the method according to the present invention;

Figure 3a is a schematic front elevational view of prisms arranged in individual sections of the prism device shown in Figure 2 for producing two virtual linear light sources;

Figure 3b is a schematic sectional view taken along the line IIIb-IIIb in Figure 3a;

Figure 4 illustrates the two virtual linear light sources produced in discontinuous fashion by the prisms shown in Figure 3a;

Figure 5 is a diagrammatic view illustrating the most suitable length of the linear light source;

Figure 6a is a schematic front elevational view of prisms arranged in individual sections of the prism device shown in Figure 7;

Figure 6b is a schematic sectional view taken along the line VIb-VIb in Figure 6a;

Figure 6c is a schematic sectional view taken along the line VIc-VIc in Figure 6a;

Figure 7 is a schematic front elevational view of another form of a prism device employed in another embodiment of the method according to the present invention;

Figure 8 illustrates the two virtual linear light sources produced in discontinuous fashion by the prisms shown in Figure 6a; and

Figure 9 illustrates the four virtual linear light sources produced in discontinuous fashion by slightly inclining the entire prism device relative to the axis of the single linear light source.

For a better understanding of the present invention, the exposure path according to the prior art method using a prism will be described with reference to Figure 1 before describing the present invention in detail.

According to this prior art method, a prism 3 is disposed in the exposure path between a face plate 1 and a linear light source 2 as shown in Figure 1. Thus, when the linear light source 2 is observed from a point 4 on the face plate 1, two virtual linear light sources 6 and 7 are observed due to the refraction of light by the prism 3, so that the single light source 2 is observed virtually as two separate light sources. This prior art method is however defective in that the virtual light source 7 only can be observed when the light source 2 is viewed from another point on the face plate 1, such as a point shown by the numeral 8 in Figure 1.

The present invention provides a novel and improved method and apparatus which obviate the above defect. An embodiment of the method according to the present invention will now be described in detail with reference to the drawings.

Figure 2 is a schematic front elevational view of a prism device employed in the practice of the method according to the present invention. Although a linear light source is not shown in Figure 2, this light source is located on the back side of the sheet surface to extend in a vertical direction in parallel with the sheet surface in Figure 2. For instance, the prism device is divided into at least 130 small sections as seen in Figure 2, each of which is provided with a plurality of prisms each having a taper plane inclined in a different direction at a same angle. Each individual section may be in the form of a square, a rectangle, a rhombic shape or the like, and the one side (H) and the other side (W) of the entire prism device are about 145 mm and about 185 mm respectively.

Figure 3a is a front elevational view to show the shape of the prisms used in the method of the present invention so that a single linear light source can produce two virtual light sources. Oblique lines are shown in Figure 3a to indicate that the prisms are tapered alternately in opposite directions. The portions 12 having the oblique lines sloping toward the left are tapered toward the left, and the portions 13 having the oblique lines sloping

toward the right are tapered toward the right. In other words, when individual prism blocks constituting a prism assembly 10 are denoted by the reference numeral 11 in Figure 3a, the tapered face 12 of one prism block 11 has a direction of inclination opposite to that of the tapered face 13 of the adjacent prism block 11, and these tapered faces 12 and 13 are tapered toward the left and right respectively on opposite sides of the ridgeline 14. Many of these prism blocks 11 are closely arranged side by side in such a relation that the direction of inclination of their tapered faces changes alternately in the lateral direction. Thus, the tapered faces 12 and 13 of the laterally adjacent prism blocks 11 are contiguous at their boundary, but those of the longitudinally adjacent prism blocks 11 are discontinuous or stepped at their boundary since the associated tapered faces have the different directions of inclination in the lateral direction.

In each of the 130 sections of the prism device shown in Figure 2, a vertical pair of prism blocks 11 shown in Figure 3a are disposed. Referring to Figure 3b showing a cross-section taken along the line IIIb-IIIb in Figure 3a, and then since the length of the light source is much longer as compared with that of each prism block disposed in one section, there are provided two virtual light sources which are observed through the prism face tapered toward the right and also observed through the prism face tapered toward the left, and are displaced in an opposite direction to each other respectively. Thus, when viewed from the side of face plate, a single linear light source 15 directing light toward the face plate through the tapered prism face is observed virtually as two discontinuous linear light sources 15 as shown in Figure 4. In general, the taper angle θ_1 of the prisms in the same section of the prism device is the same. However, the prisms in all the sections ranging from the central area to the peripheral area of the prism device have not the same taper angle, and the taper angle θ_1 changes continuously at a slight rate. In the case of exposure of the face plate of, for example, a 22-inch 110°-deflection cathode-ray tube of the post-deflection focus type, it is said that the most suitable center-to-center distance between the virtual light sources when viewed from the central area of the face plate is about 1 mm, and that when viewed from the peripheral area (spaced apart by 250 mm from the center) of the face plate is about 2 mm. Thus, the prism device is disposed at a position spaced apart by 95 mm from the light source, and the prisms in a section in the central area of the prism device have a taper angle θ_1 of about 0.009 radians, while those in a section spaced apart from the center of the prism device by 70 mm toward the right and 45 mm toward the top have a taper angle θ_1 of about 0.005 radians.

In accordance with the present invention, even when exposure is effected with such two discontinuous virtual linear light sources the distribution of intensity of light on the face plate along a direction orthogonal to the axes of the discontinuous virtual linear light sources is approximately the same as when exposure is effected with two continuous virtual linear light sources.

The essential condition for forming continuous stripes of predetermined constant width is to maintain constant the distribution of intensity of light in the axial direction of the stripes.

This essential condition will be discussed with reference to Figure 5. Suppose that ℓ , P , Q and B_p in Figure 5 designate the length of the linear light source 15, the distance between the light source 15 and the shadow mask 16, the distance between the shadow mask 16 and the face plate 17, and the slot pitch of the shadow mask 16, respectively. Then, the length ℓ of the linear light source 15 providing the constant distribution of intensity of light in the axial direction of the stripes is expressed as follows:

$$\ell = B_p \times (P + Q)/Q \quad \dots (1)$$

Thus, in order that the single linear light source 15 can be observed as two virtual linear light sources, and the distribution of the intensity of light in the axial direction of the stripes can be constant, the prism assembly 10 disposed between the light source 15 and the shadow mask 16 must satisfy the following equation:

$$PM \cdot 2n \cdot (P+Q)/(P+Q-PL) = \ell \quad \dots (2)$$

where n is an integer, PM is the length of each prism block, and PL is the distance between the light source 15 and the prism assembly 10.

In the case where the equation (2) is satisfied, the light source will be observed as being two virtual linear light sources and consequently the light intensity distribution in a direction lengthwise of the stripe will be kept constant. However, generally such a value of PM capable of satisfying the equation (2) does not exist, but the light intensity distribution may be improved by vibrating the entire prism device in a direction lengthwise of the stripe. By the use of the prism assembly 10 satisfying the equation (2), exposure by the two virtual linear light sources can be satisfactorily effected, and the continuous stripes having the

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width narrower than the slot width of the shadow mask can be formed.

In Figures 3a and 3b, the prism assembly 10 is shown composed of prism blocks 11 which have rectangular prism faces of alternately changing taper. However, the present invention is in no way limited to the specific prism configuration shown in Figures 3a and 3b. For example, each of the prisms constituting the prism assembly 10 may be in the form of a pyramid 18 having a rhombic bottom face as shown in Figure 6a, and one of the diagonals of the rhombus may be disposed in parallel with the axis of the single linear light source. In that case, the whole structure of the prism device is that as shown in Figure 7, and the light source may be observed as being the respective virtual light sources 19a, 19b, 19c, and 19d as shown in Figure 8 with respect to the respective planes 18a, 18b, 18c and 18d of the pyramid 18, but the respective virtual light sources 19a and 19b are superposed by the respective virtual light sources, so that the virtual light sources may be observed as being two light sources. Further, this diagonal of the rhombus may be slightly inclined relative to the axis of the single linear light source, so that as shown in Figure 9 this single light source may be observed as four virtual linear light sources.

The taper of the prism is suitably selected depending on the position of the prism assembly 10 in the exposure system so as to provide the center-to-center distance of 1.0 to 3.0 mm between the two virtual linear light sources. When the prism assembly 10 is arranged to provide four virtual linear light sources, the center-to-center distances of the adjacent virtual light sources may be selected to be 0.2 to 0.8 mm, 1.0 to 2.5 mm and 0.2 to 0.8 mm respectively. The taper angle of these prisms changes continuously from a section in the central area toward a section in the peripheral area of the prism device, as in the case of Figures 3a and 3b.

Referring to Figures 6b and 6c showing sections taken along the lines VIb-VIb and VIc-VIc in Figure 6a respectively, the taper angle of the prisms in a section in the central area of the prism device is, for example, about 0.007 radians, and that in a section spaced from the center of the prism device by 70 mm toward the right and 45 mm toward the top is, for example, about 0.004 radians.

It will be understood from the foregoing detailed description of the present invention that a single linear light source can act as a plurality of virtual linear light sources during exposure in the entire area of the face plate, and the center-to-center distance between these virtual linear light sources can be selected to be most suitable for the exposure purpose. Further, the present invention eliminates the prior art necessity for light source moving means.

WHAT WE CLAIM IS:

1. A method of exposure for forming a phosphor screen on an inner surface of a face plate of a color picture tube, comprising the steps of: disposing a single linear real light source at a position spaced apart by a predetermined distance from the inner surface of the face plate of the color picture tube so that the axis of said linear real light source is parallel to the inner surface of said face plate; disposing a prism device between said linear real light source and the inner surface of said face plate, said prism device comprising a plurality of prisms each including a base surface substantially parallel with the inner surface of said face plate and at least two light-refracting surfaces disposed at a predetermined angle with respect to said base surface, said prisms being juxtaposed such that the juxtaposed light-refracting surfaces of adjacent ones of said prisms in the direction of the length of said linear real light source are appositely inclined with respect to the base surface; and directing light from the said linear real light source toward said face plate through said prism device, whereby said single linear real light source may be observed as a plurality of virtual linear light sources at every point on said face plate.

2. A method as claimed in claim 1, wherein said angle changes depending on a distance from the center of said prism device to the location of said each prism and according to a predetermined function of said distance.

3. A method as claimed in claim 1 or 2, wherein said light-refracting surfaces are rectangular in shape.

4. A method as claimed in claim 1, 2 or 3, wherein each of said prisms is in the form of a pyramid and said base surface has the shape of a rhombus.

5. A method as claimed in claim 4, wherein one of the diagonals of said rhombus extends in parallel with the axis of said linear real light source.

6. A method as claimed in claim 4, wherein one of the diagonals of said rhombus is slightly inclined relative to the axis of said linear real light source so that said single linear real light source is observed as four virtual linear light sources at every point on said face plate.

7. A method as claimed in claim 3, wherein the number of said virtual light source is two and the center-to-center distance of said two virtual light sources is 1.0 to 3.0 mm.

8. A method as claimed in claim 6, wherein the center-to-center distances of said four

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width narrower than the slot width of the shadow mask can be formed.

In Figures 3a and 3b, the prism assembly 10 is shown composed of prism blocks 11 which have rectangular prism faces of alternately changing taper. However, the present invention is in no way limited to the specific prism configuration shown in Figures 3a and 3b. For example, each of the prisms constituting the prism assembly 10 may be in the form of a pyramid 18 having a rhombic bottom face as shown in Figure 6a, and one of the diagonals of the rhombus may be disposed in parallel with the axis of the single linear light source. In that case, the whole structure of the prism device is that as shown in Figure 7, and the light source may be observed as being the respective virtual light sources 19a, 19b, 19c, and 19d as shown in Figure 8 with respect to the respective planes 18a, 18b, 18c and 18d of the pyramid 18, but the respective virtual light sources 19a and 19b are superposed by the respective virtual light sources, so that the virtual light sources may be observed as being two light sources. Further, this diagonal of the rhombus may be slightly inclined relative to the axis of the single linear light source, so that as shown in Figure 9 this single light source may be observed as four virtual linear light sources.

The taper of the prism is suitably selected depending on the position of the prism assembly 10 in the exposure system so as to provide the center-to-center distance of 1.0 to 3.0 mm between the two virtual linear light sources. When the prism assembly 10 is arranged to provide four virtual linear light sources, the center-to-center distances of the adjacent virtual light sources may be selected to be 0.2 to 0.8 mm, 1.0 to 2.5 mm and 0.2 to 0.8 mm respectively. The taper angle of these prisms changes continuously from a section in the central area toward a section in the peripheral area of the prism device, as in the case of Figures 3a and 3b.

Referring to Figures 6b and 6c showing sections taken along the lines VIb-VIb and VIc-VIc in Figure 6a respectively, the taper angle of the prisms in a section in the central area of the prism device is, for example, about 0.007 radians, and that in a section spaced from the center of the prism device by 70 mm toward the right and 45 mm toward the top is, for example, about 0.004 radians.

It will be understood from the foregoing detailed description of the present invention that a single linear light source can act as a plurality of virtual linear light sources during exposure in the entire area of the face plate, and the center-to-center distance between these virtual linear light sources can be selected to be most suitable for the exposure purpose. Further, the present invention eliminates the prior art necessity for light source moving means.

WHAT WE CLAIM IS:

1. A method of exposure for forming a phosphor screen on an inner surface of a face plate of a color picture tube, comprising the steps of: disposing a single linear real light source at a position spaced apart by a predetermined distance from the inner surface of the face plate of the color picture tube so that the axis of said linear real light source is parallel to the inner surface of said face plate; disposing a prism device between said linear real light source and the inner surface of said face plate, said prism device comprising a plurality of prisms each including a base surface substantially parallel with the inner surface of said face plate and at least two light-refracting surfaces disposed at a predetermined angle with respect to said base surface, said prisms being juxtaposed such that the juxtaposed light-refracting surfaces of adjacent ones of said prisms in the direction of the length of said linear real light source are appositely inclined with respect to the base surface; and directing light from the said linear real light source toward said face plate through said prism device, whereby said single linear real light source may be observed as a plurality of virtual linear light sources at every point on said face plate.

2. A method as claimed in claim 1, wherein said angle changes depending on a distance from the center of said prism device to the location of said each prism and according to a predetermined function of said distance.

3. A method as claimed in claim 1 or 2, wherein said light-refracting surfaces are rectangular in shape.

4. A method as claimed in claim 1, 2 or 3, wherein each of said prisms is in the form of a pyramid and said base surface has the shape of a rhombus.

5. A method as claimed in claim 4, wherein one of the diagonals of said rhombus extends in parallel with the axis of said linear real light source.

6. A method as claimed in claim 4, wherein one of the diagonals of said rhombus is slightly inclined relative to the axis of said linear real light source so that said single linear real light source is observed as four virtual linear light sources at every point on said face plate.

7. A method as claimed in claim 3, wherein the number of said virtual light source is two and the center-to-center distance of said two virtual light sources is 1.0 to 3.0 mm.

8. A method as claimed in claim 6, wherein the center-to-center distances of said four



adjacent virtual light sources are 0.2 to 0.8 mm, 1.0 to 2.5 mm and 0.2 to 0.8 mm, respectively.

- 5 9. A method as claimed in any preceding claim, further comprising the step of oscillating said prism device in the direction of the length of said linear light source, thereby to provide uniform distribution of intensity of light at any point on said face plate. 5

- 10 10. An exposure apparatus for forming a phosphor screen on the inner surface of a face plate of a color picture tube, comprising a single real light source disposed at a position spaced apart by a predetermined distance from the inner face of the face plate of the color picture tube while extending in parallel therewith, and a prism device disposed between 10 said linear light source and the inner surface of said face plate, said prism device including a plurality of prisms closely arranged so as to constitute a means for causing said single linear real light source to be observed as a plurality of virtual linear light sources from every point on said face plate. 10

- 15 11. Exposure apparatus according to claim 10, wherein said prisms are juxtaposed such that light-refracting surfaces of prisms, adjacent to each other in the direction of the length of said linear real light source, are appositely inclined with respect to the base surface. 15

12. Exposure apparatus according to claim 11, wherein said refracting surfaces are rectangular in shape.

- 20 13. Exposure apparatus according to claim 11, wherein each of said prisms is a pyramid having a rhombus shaped base. 20

14. Exposure apparatus according to claim 13, wherein said rhombus shaped base has one diagonal that extends parallel to the length of said linear real light source.

- 25 15. Exposure apparatus according to claim 13, wherein said rhombus shaped base has one diagonal which is slightly inclined relative to the axis of said linear real light source so that said single linear real light source is observed as four virtual linear light sources at any point on said face plate. 25

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