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PATENT SPECIFICATION

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(54) EXPOSURE DEVICE FOR MANUFACTURING A DISPLAY SCREEN OF A COLOUR DISPLAY CATHODE-RAY TUBE

(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33, Gutter Lane, London, E.C.2, a British Company, 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:—

10 THIS INVENTION relates to an exposure device for manufacturing a colour display cathode-ray tube of the shadow mask type, comprising a light source having an elongate light-emissive part, a correction lens or lens system and a diaphragm having an aperture in the form of a slot, said diaphragm being present between the light source and the correction lens or lens system.

15 One such device is known from United States Patent Specification No. 3,587,417.

20 A colour television display tube manufactured with such a device usually comprises means for producing three electron beams, a display screen comprising a large number of triplets of phosphor dots, and a shadow mask (colour selection mask) at a short distance from and substantially parallel to the display screen. The shadow mask has a large number of apertures, each corresponding to one triplet. Each triplet usually comprises phosphor dots which luminesce in red, green and blue, respectively, when an electron beam is incident upon them. Deflection means cause the three electron beams to collectively scan the shadow mask, convergence means causing them to intersect each other in the proximity of the shadow mask. As a result of the angle which the electron beams make with each other, the electrons of the three beams which pass through the apertures in the shadow mask are each incident upon different phosphor dots. As a result of this it is possible to divide colour information about the picture to be displayed into the three above-mentioned colours and to have each controlled by a separate electron beam.

45 Since the pattern of the phosphor dots on

the screen must accurately correspond to the pattern of the holes in the shadow mask, that shadow mask which is eventually present in the finished tube is usually also used in the manufacture of the display screen thereof. The patterns of red, green and blue phosphor dots are each individually provided by exposing a photosensitive layer in known manner through the shadow mask which is in the same position relative to the display screen as it is afterwards in the finished tube. The light source which is used for the exposure is given a different position for each colour corresponding to the three different deflection points of the electron beams in the deflection field produced by the deflection means. (A deflection point is the intersection of an extension forwards of the axis of an undeflected electron beam with an extension backwards of the axis of that beam after deflection.)

It is known that the deflection point of a beam moves with increasing deflection angle. This displacement consists of an axial displacement which results from the action of the deflection means and a radial displacement which results mainly from the action of the convergence means. (The axial direction is the direction parallel to the axis of the tube. A radial direction is a direction at right angles to and cutting the axis of the tube.) The radial displacement for each beam is in the direction of its eccentricity relative to the axis of the tube. During manufacture of the screen the said displacement of the deflection point of each electron beam should be imitated with a corresponding virtual displacement of the light source, which displacement depends upon the deflection angle so that the pattern of phosphor dots corresponds accurately to the impact positions of the electron beams on the screen in operation. For this purpose the U.S. Patent Specification No. 3,504,599 discloses a correction lens which produces both the axial and the radial virtual displacements of the light source. However, it can be proved that a correction

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[Price 25p]

Price 75p

lens which produces both an axial and a radial virtual displacement of the light course as a function of the deflection angle also produces a virtual azimuthal displacement of the light source. (An azimuthal direction is a direction at right angles to both the axial and a radial direction.) As a result of the azimuthal displacement, the virtual light source rotates about the axis of the tube. Said virtual azimuthal displacement, which also depends upon the direction in which the electron beams are deflected, i.e. on the position on the display screen from which the light source is observed, is detrimental because it does not correspond to a corresponding azimuthal displacement of the deflection point of the electron beam. The virtual azimuthal displacement of the light source produces an elongation of the triplets of phosphor dots on the display screen along a line through the screen centre. As a result of this the screen is not filled with phosphor dots as completely as is desirable. It should be noted that compression of the triplets of phosphor dots also occurs as a result of the curvature of the display screen so that it is possible in principle to use this to compensate for a part of the elongation. However, this is only possible to a limited extent.

It is an object of the invention to provide an exposure device which produces substantially no virtual azimuthal displacement of the light source or only so much as is necessary to obtain optimum filling of the screen or to compensate for other detrimental effects.

The invention provides an exposure device for manufacturing a colour display cathode-ray tube of the shadow mask type, comprising a light source having an elongate light-emissive part, a correction lens or lens system and a diaphragm having an aperture in the form of a slot, said diaphragm being present between the light source and the correction lens or lens system, the slot being curved so that at its centre it is directed substantially at right angles to the longitudinal direction of the light-emissive part of the light source and at both ends it is directed at an acute angle to said longitudinal direction.

It has now been recognised that the required virtual displacement can be achieved partly by means of a real displacement of that quasi-punctiform part of an elongate light source, which is effectively used for the exposure of each part of the display screen. It has been found that this part of the displacement can be chosen to be such that the part of the displacement which has still to be obtained by means of the correction lens or lens system does not result in any undesirable virtual azimuthal displacement. The part of the light source which is effectively used for the exposure of a given part of the screen is determined by the slot-like aperture of the diaphragm which, viewed

from a given position on the display screen, transmits light only from a quasi-punctiform part of the elongate source. The position of this quasi-punctiform part depends upon the shape of the slot and the position on the display screen from which it is viewed.

The diaphragm may coincide either with a flat surface or with a cylindrical surface which extends parallel to the longitudinal direction of the light-emissive part of the light source. In the latter case, as will be demonstrated with reference to an embodiment to be described hereinafter, the diaphragm preferably coincides with a circular cylindrical surface the axis of which coincides with the longitudinal axis of the light-emissive part of the light source and the distance of the projection of any point of the slot onto said axis from the projection of the centre of the slot onto said axis is preferably substantially proportional to

$$\sin^2 \beta / \cos \beta,$$

where β is the angle between the two projection directions. The correction lens system may then comprise the combination of a cylindrical lens and a rotationally symmetrical lens which, as a result of the real displacement of the effective light source, need not cause any virtual azimuthal displacement. In order to obtain a light distribution over the whole display screen which is as homogeneous as possible, the width of the slot preferably decreases from the centre of the slot to each of the two ends thereof.

An embodiment of the invention will be described in greater detail, by way of example with reference to the accompanying diagrammatic drawings in which

Fig. 1 shows an exposure device,

Fig. 2 shows a diaphragm for the device of Fig. 1 drawn in a rectangular system of coordination, and

Fig. 3 is a perspective view of the diaphragm of Fig. 2.

In fig. 1 an exposure device 1 has a cathode ray tube window 2 secured thereto by means not shown. A shadow mask is fixed in the window 2 also by means not shown. The shadow mask 3 has a very large number of apertures of which a few are shown, not to scale, and one of which is denoted by 4.

A photosensitive layer (not shown) is provided on the window 3 on the side thereof which faces the shadow mask 3, for manufacturing a display screen on the window 2 by the usual photochemical method. In this method the photosensitive layer is exposed to a light source 5 through the holes 4 in the shadow mask 3. The light source 5 is the quasi-linear light-emissive portion of a tubular gas discharge lamp and is arranged in a semicircular cylindrical screen or diaphragm 6 having a slot 7. The axes of the

screen or diaphragm 6 and the light source 7 lie in the plane of the drawing. A quasi-punctiform part 18 of the light source 5 is seen from any arbitrary point on the shadow mask 3. One light ray is denoted by 8 and makes a deflection angle φ with the axis 9 of the display screen to be manufactured. The light ray 8 passes through a correction lens system 10. It will be seen already from fig. 1 that the position of the said quasi-punctiform part 18 of the source 5 depends upon φ and the deflection direction, as will be explained in detail with reference to fig. 2. The correction lens system 10 gives part of the required virtual displacement of the light source, this part being such that zero or only a small azimuthal displacement occurs. Although the correction lens system 10 is shown as (and may be) one lens it may alternatively consist of several lenses. For example, it may consist of one cylindrical lens and one rotationally symmetrical lens. The diaphragm 6 and the correction lens system 10 are slightly eccentric relative to the axis 9 because of the eccentric arrangement of the electron guns in the colour television display tube to be manufactured.

Fig. 2 shows a rectangular co-ordinate system having axes X, Y and Z. The axis Z coincides with the axis 9 of fig. 1. A diaphragm 11 having a slot 12 (shown as a line) corresponds to the diaphragm 6 and slot 7 of fig. 1. The elongate light source, (not shown in figure 2) extends along the Y-axis. The radius of curvature of the diaphragm 11 is denoted by R. A light ray 8 starts from point 14, passes through the slot 12 at 13 and has a deflection angle φ . The centre 17 of slot 12 is tangential to the X direction and its projection on the Y axis is denoted by 15. 16 is the projection of point 13 on the Y axis. θ is the azimuthal angle around the Z axis of the projection of the light ray 8 on the X, Y plane. The angle φ thus denotes the magnitude of the deflection and the angle θ the direction in which this deflection occurs. It can be seen from the figure that a light ray with $\varphi=0$ starts from the point 15. The light ray 8 shown starts from the point 14 as a result of which a radial shift Δs in the direction of the Y axis is obtained where

$$\Delta s = \Delta s_1 - \Delta s_2$$

from fig. 2. It will furthermore be seen from this figure that

$$\tan \beta = \tan \varphi \cdot \sin \theta.$$

The actual correction Δs required is determined by the properties of the reflection means and may be approximately proportional to

$$\sin^2 \varphi / \cos \varphi.$$

Δs_1 is a function of β and thus of

$$\beta = \tan \theta \cdot \sin \varphi.$$

Δs_1 may, for example, be chosen proportional to

$$\tan^2 \varphi \cdot \sin^2 \theta / \sqrt{1 + \tan^2 \varphi \cdot \sin^2 \theta}$$

The slot 12 should then have such a shape that

$$\Delta s_1 = k \cdot \sin^2 \beta / \cos \beta,$$

where k is a constant. (The above-mentioned choice for Δs_1 can be demonstrated by calculation to be desirable when the remaining correction given by means of the correction lens 10 (fig. 1) is taken into account.)

It can be derived from the Figure that

$$\Delta s_2 = R \cos \alpha.$$

The correction lens 10 should neutralize this displacement Δs_2 and should also introduce an extra shift in the radial direction because the displacement Δs_1 for $\theta=0$ and $\theta=180^\circ$ reduces to zero due to the shape of the slot. The lens 10 should also give a displacement in the direction of the Z axis (axis 9 in fig. 1). This is found to be possible without introducing undesirable virtual azimuthal displacements and in such manner that the said conditions are satisfied for $\theta=0^\circ$, $\theta=90^\circ$, $\theta=180^\circ$ and $\theta=270^\circ$ and only small deviations from the desired correction

$$(\sin^2 \varphi / \cos \varphi)$$

are obtained for other angles. These deviations could also be compensated for but only at the expense of obtaining virtual azimuthal displacements.

The correction lens 10 has a cylindrical character and it may be made up from the combination of a rotationally symmetric lens and a cylindrical lens.

The distribution of light intensity from the elongate light source in planes at right angles to the Y axis is independent of β . In planes which contain the Y axis, the intensity distribution behaves approximately according to Lambert's cosine law. In order to obtain a light distribution which is as homogeneous as possible over the whole display screen, the width of the slot should be suitably chosen. In the embodiment described, the width of the slot measured parallel to the Y axis is, for a given angle β , equal to $\cos \beta$ times the width of the slot at the centre thereof.

Fig. 3 is a perspective view of the diaphragm 6. The slot 7 has bevelled edges 19 and 20.

As previously mentioned, the diaphragm may have other shapes. For example, the cylindrical diaphragm shown may be replaced by a flat diaphragm extending parallel to the longitudinal direction of the light source (the direction Y in Fig. 2). If the diaphragm is cylindrical it need not have the circular-cylindrical form described.

in the diaphragm coincides with a circular-cylindrical surface the axis of which coincides with the longitudinal axis of the light-emissive part of the light source, the distance of the projection of any point of the slot onto said axis from the projection of the centre of the slot onto said axis being substantially proportional to

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WHAT WE CLAIM IS:—

10 1. An exposure device, for manufacturing a colour display cathode-ray tube of the shadow mask type, comprising a light source having an elongate light-emissive part, a correction lens or lens system and a diaphragm having an aperture in the form of a slot, said diaphragm being present between the light source and the correction lens or lens system, the slot being curved so that at its centre it is directed substantially at right angles to the longitudinal direction of the light-emissive part of the light source and at both ends it is directed at an acute angle to said longitudinal direction.

25 2. A device as claimed in Claim 1, wherein the diaphragm is substantially flat and extends parallel to said longitudinal direction.

30 3. A device as claimed in Claim 1, wherein the diaphragm surface coincides with a cylindrical surface which extends parallel to said longitudinal direction.

4. A device as claimed in Claim 3, where-

where β is the angle between the two projection directions.

5. A device as claimed in Claim 4, wherein the correction lens system comprises the combination of a cylindrical lens and a rotationally symmetrical lens.

6. A device as claimed in any of Claims 1 to 5, wherein the width of the slot decreases from the centre of the slot to each of the two ends thereof.

7. An exposure device substantially as described herein with reference to the drawings.

8. A cathode-ray tube manufactured using a device as claimed in any of the Claims 1 to 7.

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