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Barten et al.

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[54] EXPOSURE DEVICE FOR MANUFACTURING A DISPLAY SCREEN OF A COLOUR TELEVISION DISPLAY TUBE

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[30] Foreign Application Priority Data

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[52] U.S. Cl. .... 95/1 R
[51] Int. Cl. G03b
[58] Field of Search .... 95/1 R

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Assistant Examiner—Kenneth C. Hutchison
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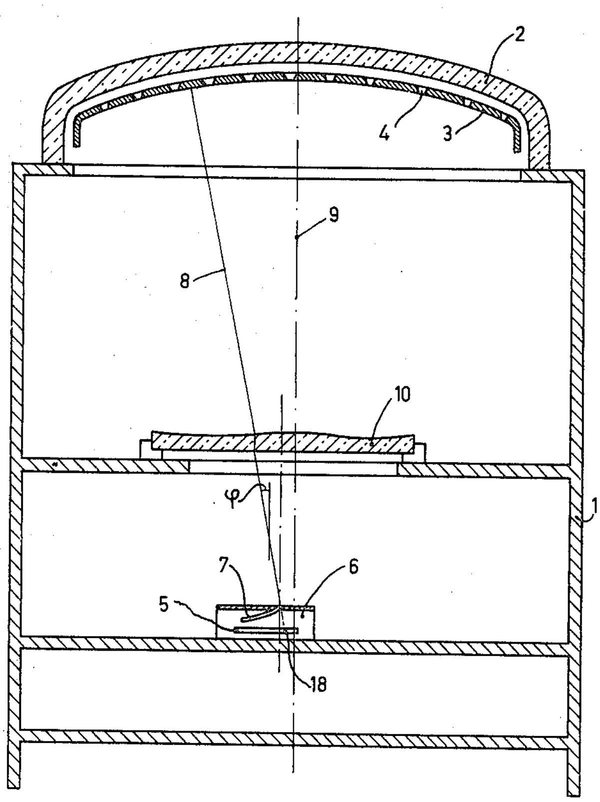
[57] ABSTRACT

An exposure device for manufacturing a display screen of a colour television display tube. The device comprises a quasi-line-shaped light source and a diaphragm having a narrow slot. As a result of this combination a quasi-punctiform part of the light source is visible from the display screen. The shape of the slot is such that the quasi-puntiform part varies its position as a function of the deflection. This position variation is accomplished partly by varying the position of the virtual light source, which is necessary because of the actual shift of the deflection point in the operating tube. The rest of the position variation of the virtual light source is obtained by means of a correction lens system. A special shape of the slot is indicated.

6 Claims, 5 Drawing Figures



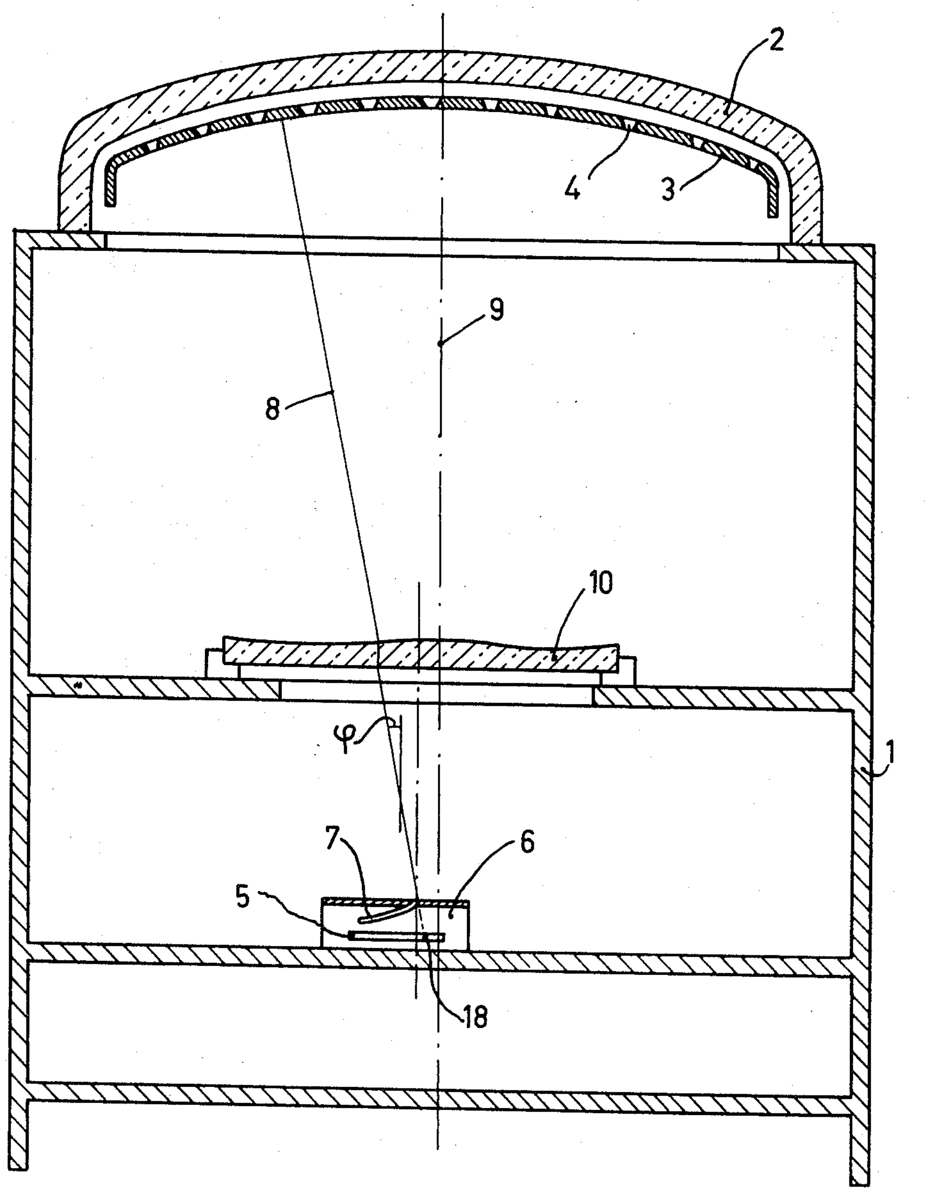


Fig.1

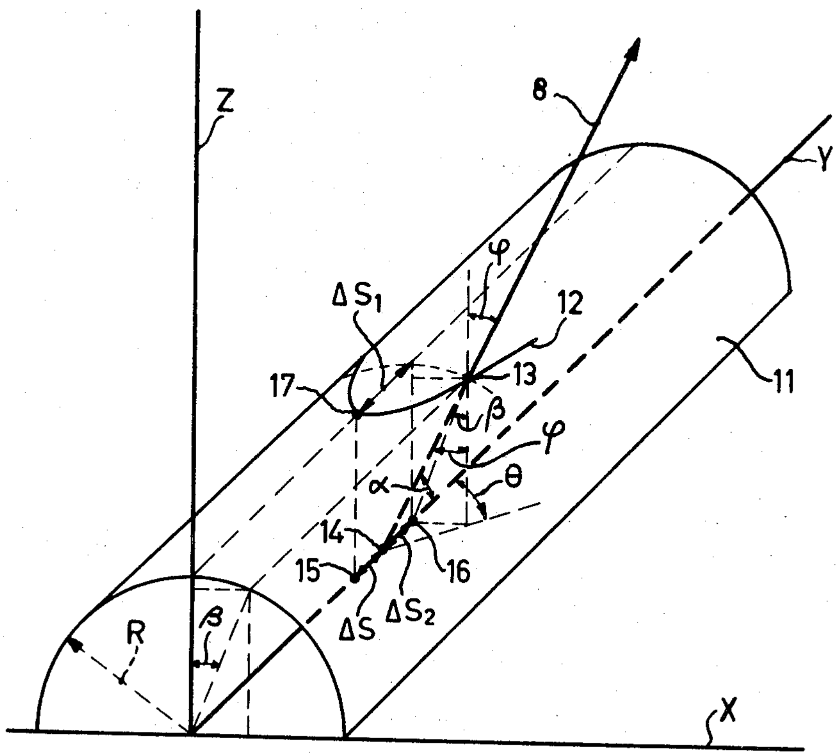


Fig. 2

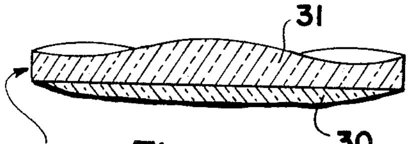


Fig. 5

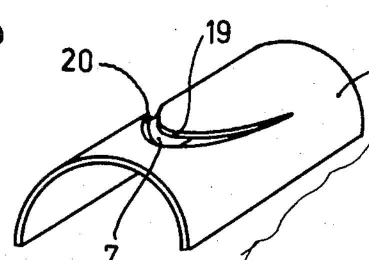


Fig. 3

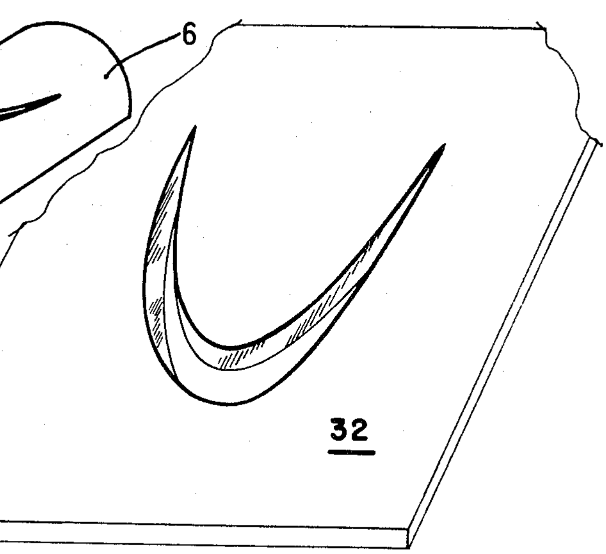


Fig. 4

EXPOSURE DEVICE FOR MANUFACTURING A DISPLAY SCREEN OF A COLOUR TELEVISION DISPLAY TUBE

The invention relates to an exposure device for manufacturing a colour television display tube of the shadow mask type comprising a light source having an elongate light-emissive part, a correction 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 system.

Such a device is known from the U.S. Pat. No. 3,587,417.

A colour television display tube manufactured with such a device comprises a general means for producing three electron beams, a display screen which is provided with 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 comprises a large number of apertures, each corresponding to a triplet. Each triplet comprises in general phosphor dots which luminesce in red, green and blue, respectively, when an electron beam impinges upon them. Under the influence of deflection means, the three electron beams collectively scan the shadow mask, intersecting each other under the influence of convergence means in the proximity of the shadow mask. As a result of the angle which the electron beams enclose with each other, the electrons which pass the shadow mask through the apertures each impinge upon separate phosphor dots. As a result of this it is possible to divide the colour information of the picture to be displayed into the three above-mentioned colours and to have each controlled by a separate electron beam.

Since the pattern of the phosphor dots on the screen must accurately correspond to the pattern of the holes in the shadow mask, the same shadow mask which is afterwards present in the finished tube is in general used in the manufacture of the display screen. The patterns of the red, the green and the blue phosphor dots are each individually provided by means of a photosensitive layer which is exposed through the shadow mask. Such a photochemical method is generally known. In this method the shadow mask 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 should be placed in a different location for each exposure in accordance with the three different deflection points of the electron beams in the deflection field produced by the deflection means. A deflection point is to be understood to mean the crossing of the extension of the axis of an electron beam which is not yet deflected with the extension of the axis of the deflected electron beam.

It is generally known that the deflection point undergoes a displacement upon increasing deflection as a function of the deflection angle. This displacement consists of an axial displacement as a result of the action of the deflection means and a radial displacement mainly as a result of the action of the convergence means. Axial is to be understood to mean the direction parallel to the axis of the tube. Radial is to be understood to mean a direction at right angles to the axis of the tube in a place through the axis of the tube. The radial displacement is directed for each beam according to the radial direction of its eccentricity relative to the axis of the tube. The said displacement of the deflection point of the electron beams should be imitated with a virtual displacement of the light source which depends upon the deflection angle so that in the operating tube the pattern of the phosphor dots corresponds accurately to the places of impact of the electron beams on the screen. For that purpose U.S. Pat. No. 3,504,599 provides a correction lens which produces both the axial and the radial virtual displacement of the light source. It can generally be proved that such a correction lens which produces an axial and a radial virtual displacement of the light source as a function of the deflection angle also produces a virtual azimuthal displacement of the light source. Azimuthal is to be understood to mean a direction at right angles to the axial and a radial direction. As a result of the azimuthal displacement, the virtual light source thus rotates about the axis of the tube. Said virtual azimuthal displacement which in addition depends upon the direction in which the electron beams are deflected, that is to say on the place 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 causes an elongation of the triplets of phosphor dots on the display screen along a line through the centre of the display screen. As a result of this a poor screen filling is generally obtained. It is to be noted that as a result of the curvature of the display screen a compression of the triplets of phosphor dots also occurs so that it is possible in principle to compensate herewith for a part of the elongation. However, this is possible only to a restricted extent.

It is the object of the invention to provide an exposure device of the type mentioned in the first paragraph in which substantially no virtual azimuthal displacement of the light source is caused or only such a large virtual azimuthal displacement as is necessary to obtain an optimum screen filling or to compensate for other detrimental effects.

According to the invention, an exposure device of the type mentioned in the first paragraph is characterized in that the slot is curved so that the centre of the slot crosses the longitudinal direction of the light-emissive part of the light source at right angles and both ends of the slot cross the longitudinal direction of the light-emissive part of the light source at an acute angle.

The invention is based on the recognition of the fact that the required virtual displacement can be achieved partly with a real displacement of the effectively used, quasi-punctiform part of an elongate light source. It has been found that this part of the displacement can be chosen to be so that the part of the displacement which is still to be obtained with the correction lens system does not result in any undesirable virtual azimuthal displacement. The used part of the light source is determined according to the invention by the slot-like aperture of the diaphragm which, viewed from a given place on the display screen, passes light from only a quasi-punctiform part of the elongate light source. The location of this quasi-punctiform part depends upon the shape of the slot and the viewing position on the display screen.

According to the invention, 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, a favourable embodiment of an exposure device according to the invention is found to be one in which the diaphragm coincides with a circular cylindrical surface, the axis of which coincides with the longitudinal direction of the light emissive part of the light source, and in which the distance of the projection of an arbitrary point of the slot on the axis to the projection of the centre of the slot on the axis is substantially proportional to $\sin^2\beta/\cos\beta$, where β is the angle between the two projecting lines. The correction lens system then consists preferably of 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 throughout the display screen which is as homogeneous as possible, the width of the slot furthermore preferably decreases from the centre of the slot to each of the two ends.

The invention will be described in greater detail with reference to the accompanying drawing of an embodiment, of which

FIG. 1 shows an exposure device according to the invention,

FIG. 2 shows diagrammatically a diaphragm for a device according to the invention drawn in a rectangular system of coordinates, and

FIG. 3 is a perspective view of said diaphragm.

FIG. 4 is a perspective view of an embodiment of a diaphragm that can be employed in the present invention.

FIG. 5 is a sectional elevation view of a correction lens system employable in the present invention.

Reference numeral **1** of FIG. **1** denotes an exposure device on which a window **2** is secured having a shadow mask **3**. The shadow mask **3** comprises a very large number of apertures of which a few are drawn, not to scale, and one of which is denoted by **4**. The connection means of shadow mask **3** to window **2** and of window **2** to exposure device **1** are not shown.

On window **2** on the side facing shadow mask **3** a photosensitive layer, not shown, is provided for manufacturing a display screen on window **2**. In this case a generally known photochemical method is used. The photosensitive layer is exposed through holes **4** of shadow mask **3** by light source **5**, which is shown diagrammatically. The light source **5** is a quasi-line-shaped light source of a tubular gas discharge lamp and is arranged inside of a semicircular diaphragm **6** having a slot **7**. The axis of diaphragm **6** and of light source **5** lies in the plane of the drawing. From an arbitrary point of shadow mask **3**, a quasi-punctiform part **18** of light source **5** is seen. A light ray is denoted by **8** and encloses a deflection angle ϕ with the axis **9** of the display screen to be manufactured. The light ray **8** passes correction lens system **10**. It is already seen from FIG. **1** that the place of the quasi-punctiform part **18** of light source **5** depends upon ϕ and the direction of the deflection as will be explained hereinafter in detail with reference to FIG. **2**. The correction lens system **10** serves to obtain a part of the required virtual displacement of the light source, which part is such that no or hardly any azimuthal displacement occurs. Although correction lens system **10** is shown as one lens it may alternatively consist of several lenses and consist in particular of one cylinder lens and one rotationally symmetrical lens. Diaphragm **6** and correction lens system **10** are slightly eccentric relative to axis **9** in connection with the eccentric arrangement of the electron guns in the colour television display tube to be manufactured.

FIG. **2** shows a rectangular co-ordinate system with axes X, Y and Z. The Z axis coincides with axis **9** of FIG. **1**. Diaphragm **11** is shown diagrammatically with slot **12** shown as a line, corresponding to reference numbers **6** and **7** of FIG. **1**. The elongate light source, which is not shown in this FIGURE, extends along the Y-axis. The radius of diaphragm **11** is denoted by R. A light ray is denoted by **8**, starts from point **14**, passes slot **12** at point **13** and has deflection angle ϕ. The centre **17** of slot **12** is parallel to the X axis and has a projection **15** on the Y axis. The FIGURE furthermore shows the anglesα, β and θ with respect to the direction of light ray **8**, of which θ is the azimuthal angle around the Z axis of the projection of light ray **8** on the X, Y plane. Angle ϕ thus determines the magnitude of the deflection, and angle θ the direction of the deflection. It is seen from the FIGURE that a light ray with $\phi = O$ starts from the point **15**. Light ray **8** starts from the point **14** as a result of which a radial shift Δs in the direction of the Y axis is obtained. $\Delta s = \Delta s_1 - \Delta s_2$, see FIG. **2**. It is furthermore seen from this FIGURE that $\tan\beta = \tan\phi \,.\, \sin\theta\gamma\theta$. The desirable Δ s correction which is determined by the properties of the deflection means is approximately proportional to $\sin^2\phi/\cos\phi$.Δs_1 is a function of β and thus of $\tan\beta = \tan\theta \sin\theta$. A favourable choice for Δs_1 is, for example, proportional to $\tan^2 \phi \sin^2 \theta / \sqrt{1 + \tan^2 \phi \sin^2 \theta}$. The slot **12** should then have such a shape that $\Delta s_1 = k \sin^2\beta / \cos\beta$, wherein k is a constant. The above-mentioned choice for Δs_1 is favourable as can be demonstrated by calculation, in connection with the remaining correction which takes place by means of correction lens **10** (FIG. **1**). It can be derived from the FIGURE that $\Delta s_2 = R \cos\alpha$. The correction lens **10** should neutralize said displacement Δs_2, furthermore introduce an extra shift in the radial direction because the displacement Δs_1 for $\theta = O$ and $\theta = 180°$ reduces to zero due to the shape of the slot, and also give an axial 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 for $\theta = 0°$, $\theta = 90°$, $\theta = 180°$ and $\theta = 270°$ that the conditions are satisfied and only small deviations of the desired correction ($\sin^2\phi/\cos\phi$) are obtained for other angles. These deviations can also be compensated for but then at the expense of virtual azimuthal displacements. The correction lens **10** has a cylindrical character from which it follows that it can be composed of the combination of a rotationally symmetric lens and a cylindrical lens. The distribution of light intensity of 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 distribution of the light intensity behaves approximately according to Lambert's cosine law. In order to obtain a light distribution throughout the display screen which is as homogeneous as possible, the width of the slot should be adapted. In the present embodiment, the width of the slot for a given angle β, measured parallel to the Y axis is equal to $\cos\beta$ times the width of the slot in the centre **17** of the slot.

For further illustration, FIG. **3** is perspective view of the diaphragm **6**. The slot **7** has bevelled edges **19** and **20**. A diaphragm **32** (FIG. **4**) having a substantially flat surface, also can be satisfactory used in the present invention, instead of a diaphragm (e.g., 6 in FIG. 1) having a cylindrical surface. Where it is desired, the correction lens 10 (FIG. 1) can be replaced by another such lens 10' (FIG. 5) comprising a cylindrical lens 30 combined with a rotational symmetric lens 31.

It is to be noted that the shape of the diaphragm described with reference to the embodiment constitutes by no means a restriction of the possibilities of application of the invention. The main aspect of the invention is that an extra degree of freedom is created by means of a diaphragm having a curved, slot-like aperture in combination with an elongate light source, as a result of which restriction in the correction possibilities of a correction lens can be avoided.

What is claimed is:

1. An exposure device for manufacturing a colour television display tube of the shadow mask type comprising a light source having an elongate light-emissive part, a correction 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 system, characterized in that the slot is curved so that the centre of the slot crosses the longitudinal direction of the light-emissive part of the light source substantially at right angles and both ends of the slot cross the longitudinal direction of the light-emissive part of the light source at an acute angle.

2. An exposure device as claimed in claim 1, characterized in that the diaphragm coincides with a flat surface which extends parallel to the longitudinal direction of the light-emissive part of the light source.

3. An exposure device as claimed in claim 1, characterized in that the diaphragm coincides with a cylindrical surface which extends parallel to the longitudinal direction of the light-emissive part of the light source.

4. An exposure device as claimed in claim 3, characterized in that the diaphragm coincides with a circular-cylindrical surface the axis of which coincides with the longitudinal direction of the light-emissive part of the light source and that the distance of the projection of an arbitrary point of the slot on the said axis to the projection of the centre of the slot on the said axis is substantially proportional to $\sin^2\beta/\cos\beta$, where β is the angle between the two projecting lines.

5. An exposure device as claimed in claim 4, characterized in that the correction lens system consists of the combination of a cylindrical lens and a rotationally symmetrical lens.

6. An exposure device as claimed in claim 1, characterized in that the width of the slot decreases from the centre of the slot to each of the two ends.

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