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Suzuki et al.

[11] **3,890,151**

[45] **June 17, 1975**

[54] **METHOD FOR MAKING ELECTROLUMINESCENT SCREENS FOR COLOR CATHODE-RAY TUBES OF CONTINUOUS PHOSPHOR STRIPES**

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[73] Assignee: **Tokyo Shibaura Electric Co., Ltd.,** Kawasaki, Japan

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[21] Appl. No.: **386,317**

[30] **Foreign Application Priority Data**

Aug. 7, 1972 Japan 47-78420

[52] **U.S. Cl.** **96/36.1;** 354/1

[51] **Int. Cl.** **G03c 5/00**

[58] **Field of Search** .... 96/36.1; 313/92 B; 117/33.5 CM, 33.5 C, 33.5 CP; 354/1

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Primary Examiner—Norman G. Torchin
Assistant Examiner—Edward C. Kimlin
Attorney, Agent, or Firm—Schuyler, Birch, Swindler, McKie & Beckett

[57] **ABSTRACT**

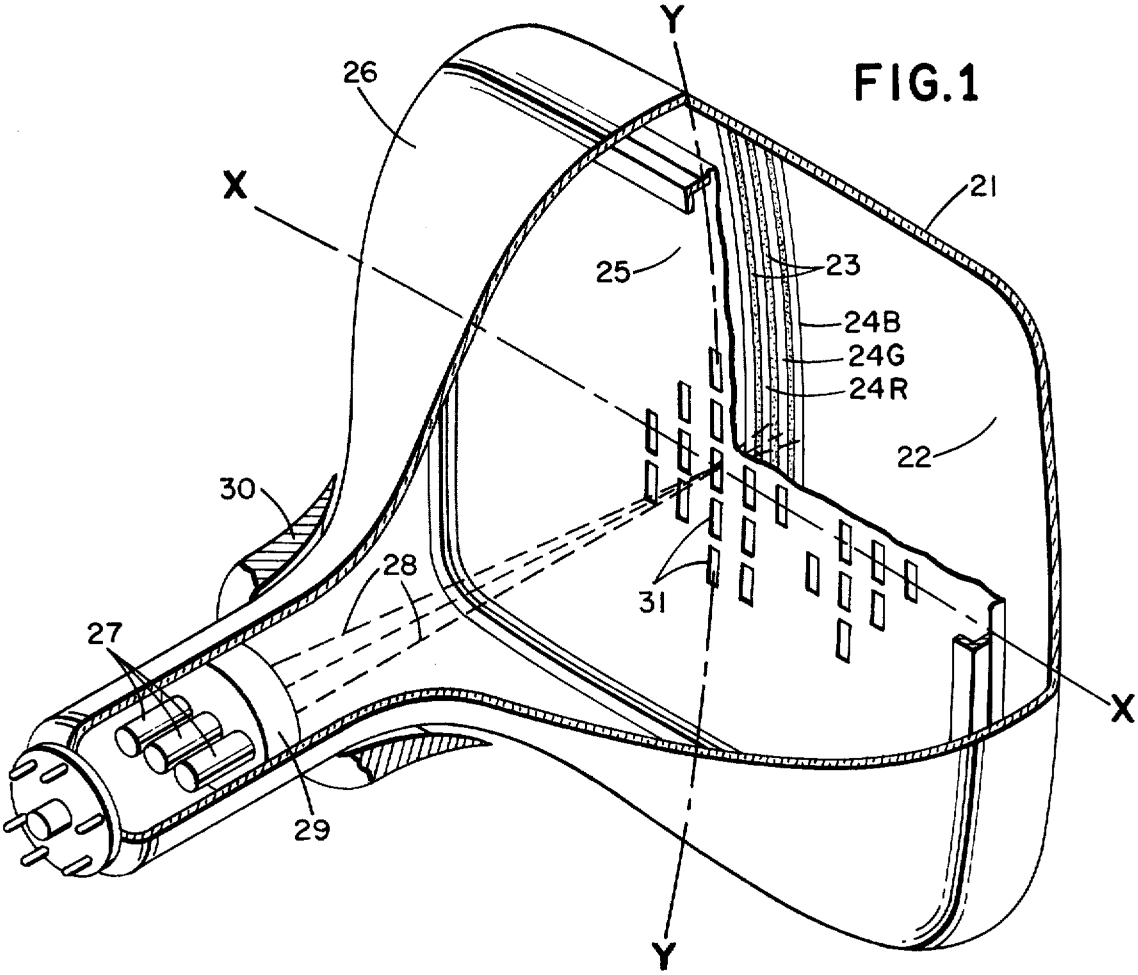
An electroluminescent screen comprising a plurality of continuous phosphor stripes running the length of the screen formed on a panel for a color cathode-ray tube by applying film containing photosensitive material onto the panel. A shadow mask is attached to the panel, and the mask and film are irradiated by light from a light source.

The shadow mask has on its concave face which faces the light source apertures arranged in substantially parallel rows, the apertures along the length of each of the rows being separated from each other by thin beam-intercepting bridge portions. The area on the shadow mask irradiated by the light is limited to cover only a part of the length of the rows of apertures by a shield plate having an opening for limiting the path of the light.

The shield plate is moved so as to move the irradiated area on the shadow mask along the length of the rows of the apertures. The light source has sufficient length in the lengthwise direction of the rows of apertures to produce on the film the bright image of the apertures, each image being expanded to be connected with the adjacent bright images of the apertures on either side along the length of the row. The light source is gradually inclined synchronously with the moving of the irradiated area on the shadow mask, to always be kept substantially parallel to the rows of apertures in the irradiated area.

6 Claims, 10 Drawing Figures

FIG.1


Y
26
X
21
25
23
24B
24G
24R
22
30
28
31
27
X
29
Y

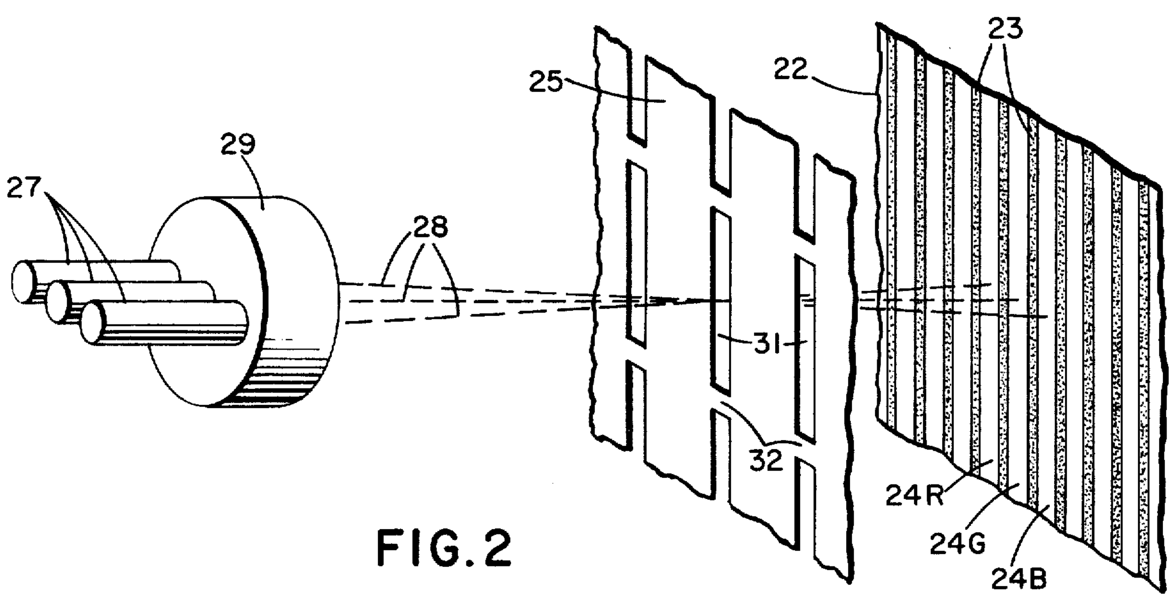

23
25
22
29
27
28
31
32
24R
24G
24B

FIG.2

PATENTED JUN 17 1975 3,890,151

SHEET 2

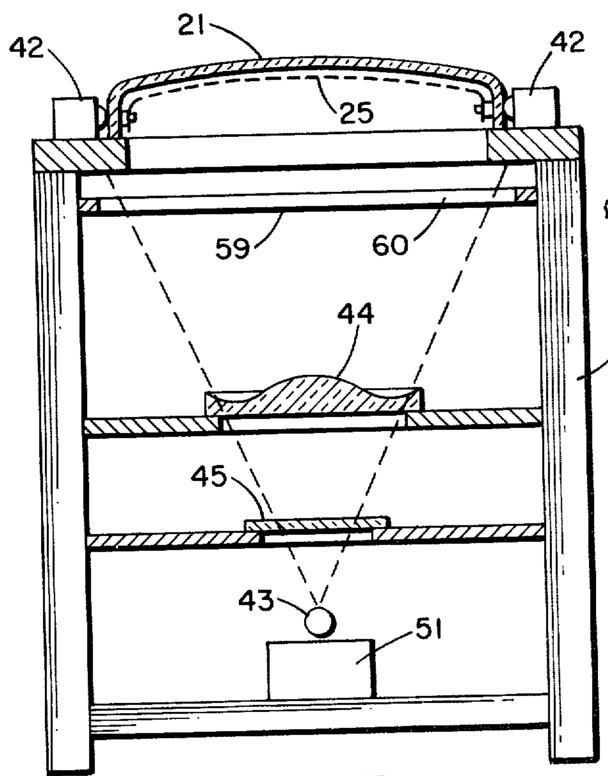


FIG. 3

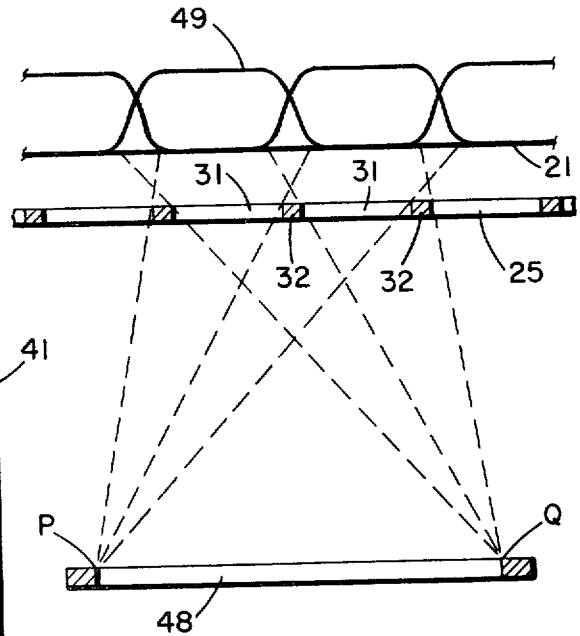


FIG. 5

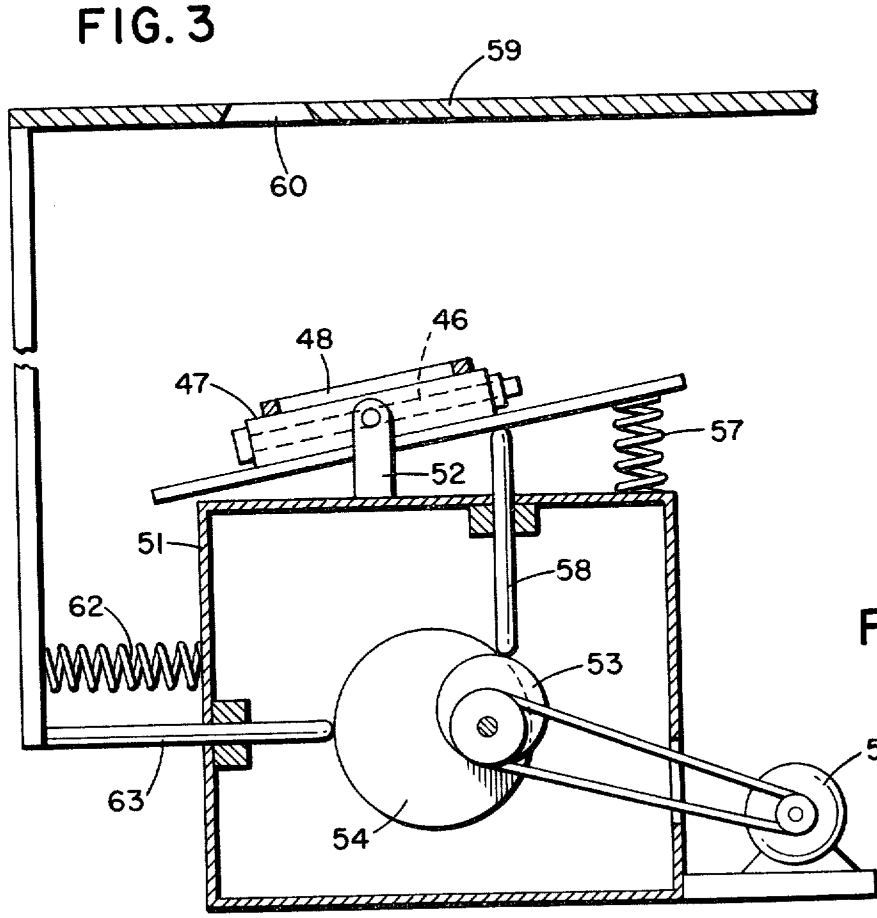


FIG. 4

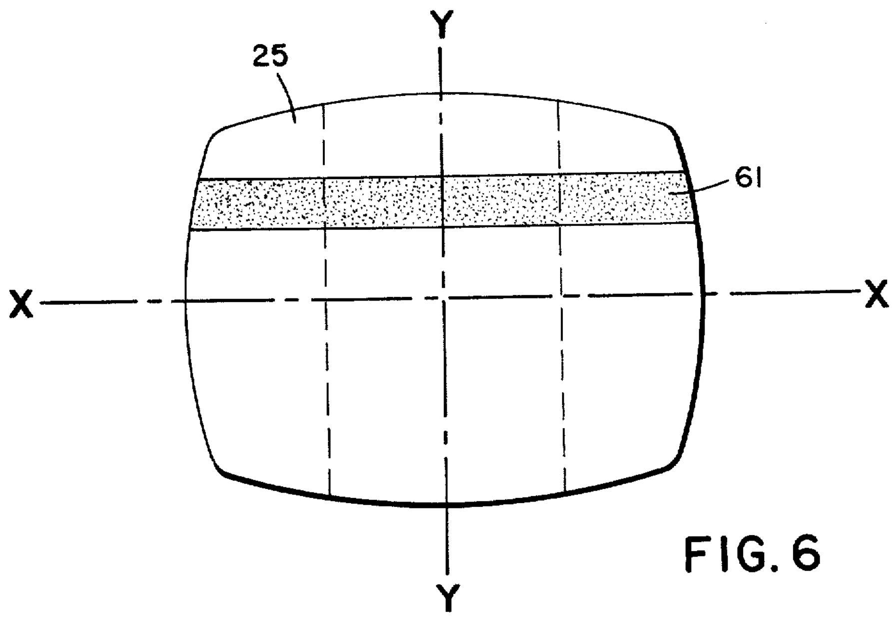
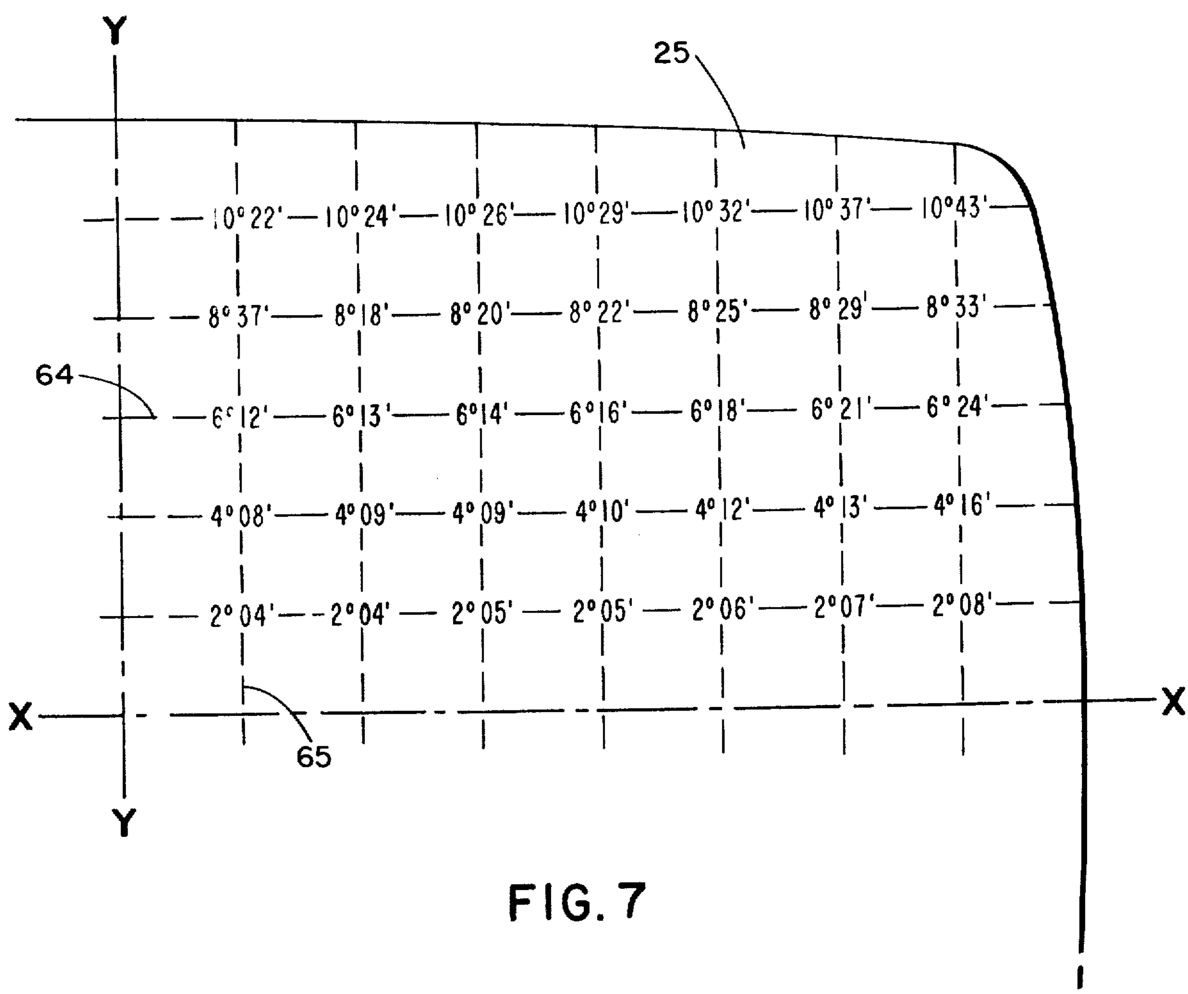

Y
25
61
X
X
Y

FIG. 6


Y
25
10°22'
10°24'
10°26'
10°29'
10°32'
10°37'
10°43'
8°37'
8°18'
8°20'
8°22'
8°25'
8°29'
8°33'
64
6°12'
6°13'
6°14'
6°16'
6°18'
6°21'
6°24'
4°08'
4°09'
4°09'
4°10'
4°12'
4°13'
4°16'
2°04'
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2°06'
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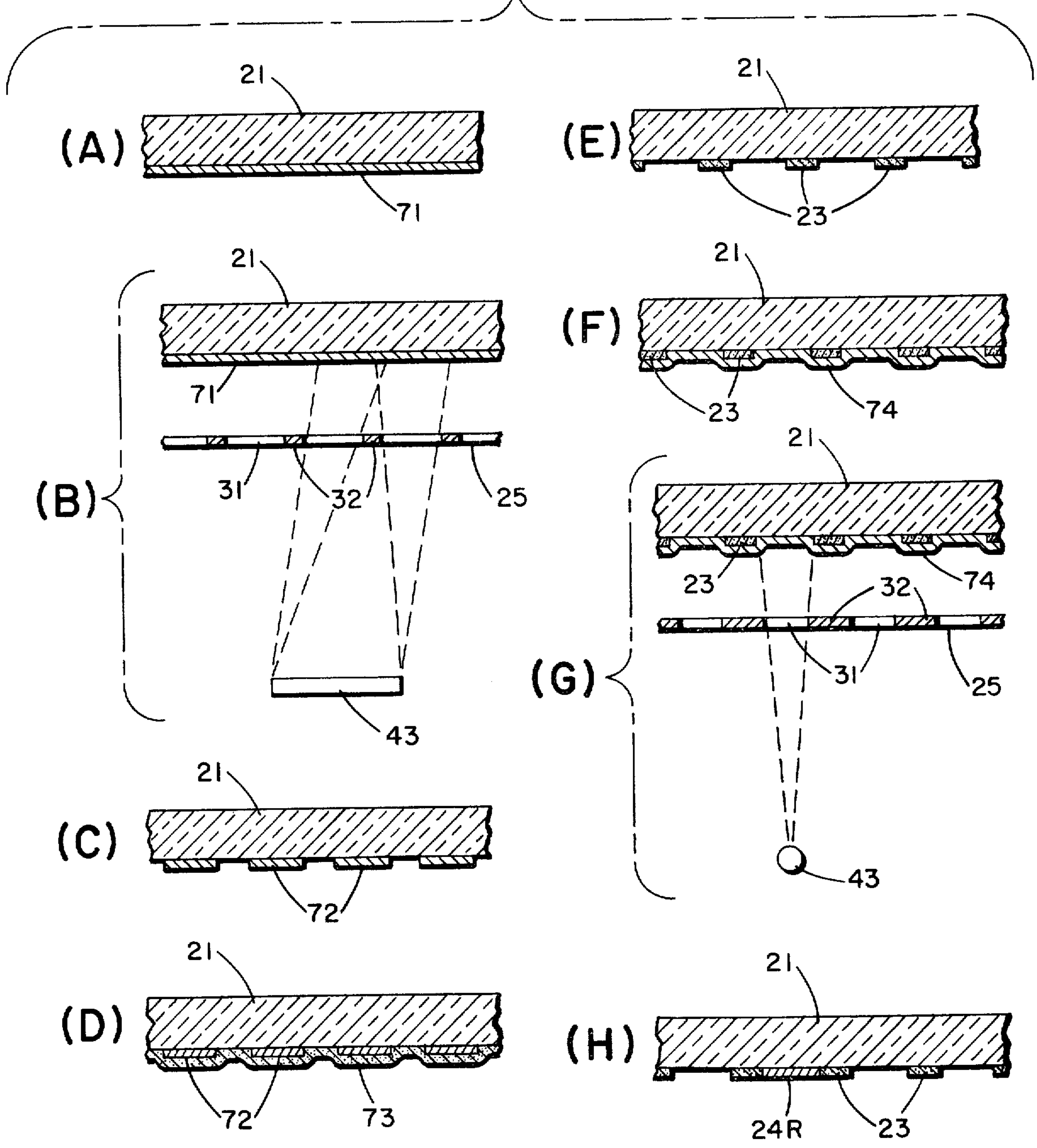
X
X
65
Y

FIG. 7

FIG. 8


(A)
21
71
(B)
21
71
31
32
25
43
(C)
21
72
(D)
21
72
73
(E)
21
23
(F)
21
23
74
(G)
21
23
32
74
31
25
43
(H)
21
24R
23

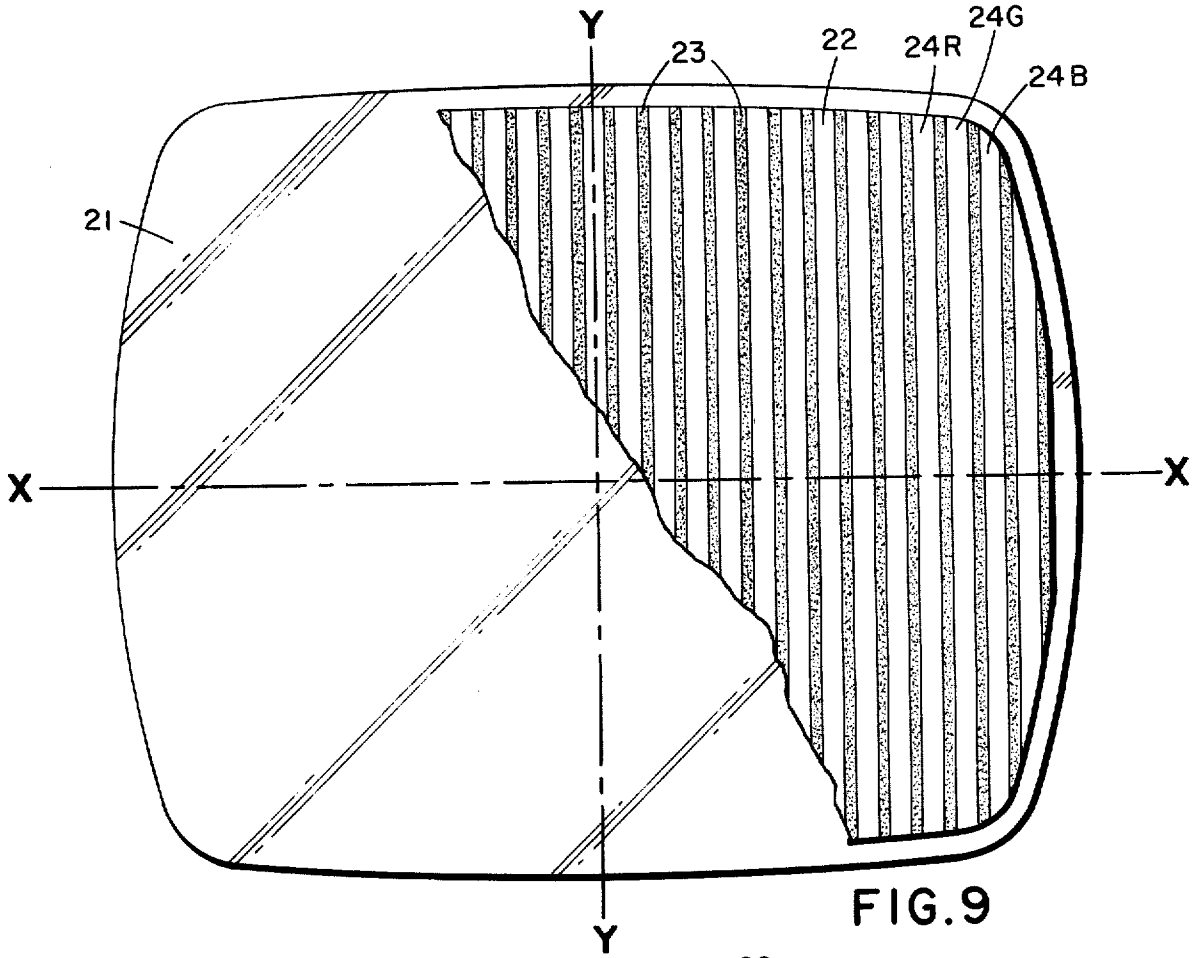


FIG. 9

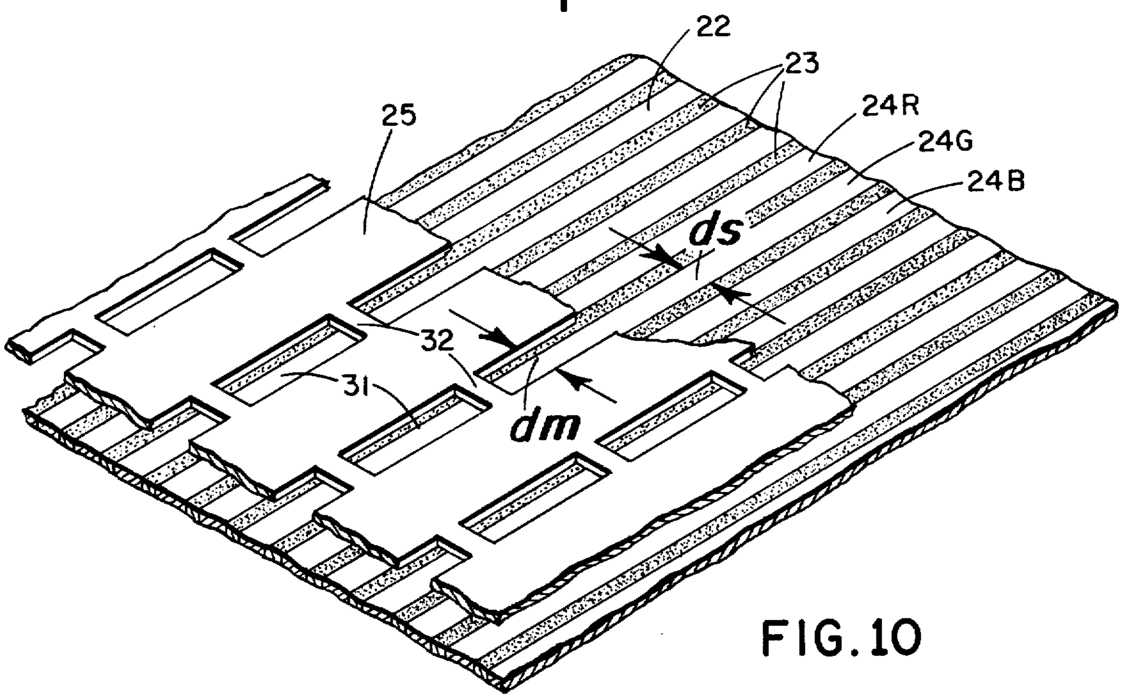


FIG. 10

METHOD FOR MAKING ELECTROLUMINESCENT SCREENS FOR COLOR CATHODE-RAY TUBES OF CONTINUOUS PHOSPHOR STRIPES

BACKGROUND OF THE INVENTION

This invention relates to the manufacture of electroluminescent screens for color cathode-ray tubes, in particular to the exposure of panels for the color cathode-ray tubes, for making electroluminescent screens thereon.

DESCRIPTION OF PRIOR ART

Conventional color cathode-ray tubes employ an electroluminescent screen consisting of circular phosphors dots surrounded by light-absorbing material, and a shadow mask having a circular aperture corresponding to each triad of the phosphor dots. These conventional color cathode-ray tubes have some difficulties such as complexity in structure and manufacture of the tubes, necessity of many attachments to tubes, and necessity of particular consideration being given to electron beam landing tolerance.

A color cathode-ray tube of a new type, called "in-line" gun type, has been developed to eliminate such difficulties. It employs an electroluminescent screen, a shadow mask and three electron guns of the following configurations. The electroluminescent screen of this new tube consists of vertical stripes of blue, green and red-emitting phosphors arranged in parallel with each other, and stripes of light-absorbing material placed between and adjoining the phosphor stripes. Each of the stripes of phosphor and light-absorbing material runs the vertical length of the screen. The shadow mask of this new tube has long, small-width apertures, for limiting the path of electron beams, arranged in rows corresponding to the phosphor stripes of the screen. The apertures on each of the rows are separated from each other by a bridge portion to maintain the mechanical strength of the mask. The three electron guns of this new tube are placed horizontally adjacent in a so-called "in-line" configuration.

This newly developed color cathode-ray tube, however, has some disadvantages. The electroluminescent screen of this new tube is made by a well-known photographic method, using photosensitive resin on the surface of the panel for the tube, the above mentioned shadow mask having long apertures, and a light source for projecting bright images of the apertures of the shadow mask onto the surface of the panel. Though there are bridge portions at which the light beam is intercepted in the row of apertures, the phosphor stripe which is to be formed on the panel surface by the bright image of the apertures must be continuous throughout the vertical length of the screen. By using a long light source elongated parallel to the aperture row, a continuous stripelike bright image corresponding to the whole length of the row is acquired: the dark image of the bridge portion which is projected on the panel by the light beam from an end of the light source is overlapped by a bridge image of the light beam coming through the aperture made from another end of the light source. In rectangular color cathode-ray tubes, the stripes of bright images of apertures produced on the panel as above are sufficiently straight and uniform in width on and near the vertical and horizontal axes of the panel face. But, in the corner regions of the panel face, the stripes of bright image become considerably zigzagged and ununiform in width. Consequently, phosphor stripes in the corner regions are zigzagged and ununiform in width, resulting in a decrease in quality of picture produced by the screen.

We have found that the zigzag form of the stripe images produced on the corner regions of the panel is due to the angular difference between the face of the shadow mask in the lengthwise direction of the aperture rows and the light source. As a result, we have improved the method of manufacture of electroluminescent screens for the tubes, using an improved manufacturing apparatus to obtain cathode-ray tubes of better quality.

SUMMARY OF THE INVENTION

According to this invention, in-line type tri-color cathode-ray tubes of highly improved characteristics can be obtained, the electroluminescent screen having very straight phosphor stripes, electron beam landing tolerance being very small over the whole area of the screen, adjustment of the tube being simple and easy, and the picture produced by the screen being clear and of high quality both in colors and whiteness.

Accordingly, an object of this invention is to provide an improved method of making electroluminescent screens for color cathode-ray tubes of the in-line type in which there is substantially no zigzag form of phosphor stripes.

Another object of this invention is to provide apparatus for making such electroluminescent screens.

These and other objects are accomplished by providing an electroluminescent screen comprising a plurality of continuous phosphor stripes running the length of the screen formed on a panel for a color cathode-ray tube by applying film containing photosensitive material onto the panel. A shadow mask is attached to the panel and the mask and film are irradiated by light from a light source.

The shadow mask has on its concave face which faces the light source apertures arranged in substantially parallel rows, the apertures along the length of each of the rows being separated from each other by thin-beam-intercepting bridge portions. The area on the shadow mask irradiated by the light is limited to cover only a part of the length of the rows of apertures by a shield plate having an opening for limiting the path of the light.

The shield plate is moved so as to move the irradiated area on the shadow mask along the length of the rows of the apertures. The light source has sufficient length in the lengthwise direction of the rows of apertures to produce on the film the bright image of the apertures, each image being expanded to be connected with the adjacent bright images of the apertures on either side along the length of the row. The light source is gradually inclined synchronously with the moving of the irradiated area on the shadow mask, to always be kept substantially parallel to the rows of apertures in the irradiated area.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects, features and advantages of this invention will be apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. **1** is a perspective view of a color cathode-ray tube employing an electroluminescent screen made according to the invention;

FIG. **2** is a fragmentary perspective view of the electroluminescent screen, the shadow mask and the electron guns of the tube of FIG. **1**;

FIG. **3** is a schematic elevational view, partially in section, of an exposing apparatus according to the invention, and a panel of a color cathode-ray tube set up thereon;

FIG. **4** is an elevational view of a light source and the attached mechanism of the apparatus of FIG. **3**;

FIG. **5** is a schematic elevational view of part of the apparatus of FIG. **3**, showing a shadow mask, a long light source, and a graph showing the distribution of the energy of the light;

FIG. **6** is a plan diagram illustrating the irradiated area on the shadow mask according to the invention;

FIG. **7** is a diagram illustrating the curvature of a shadow mask;

FIG. **8** comprises fragmentary views explaining the process of manufacturing the electroluminescent screen according to the invention;

FIG. **9** is a plan view of the electroluminescent screen manufactured according to the invention;

FIG. **10** is a fragmentary view of the electroluminescent screen and the shadow mask according to an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** and FIG. **2** show a tri-color cathode-ray tube of in-line gun type. A rectangular-shaped glass panel **21** has, on the inner concave surface of its face plate, an electroluminescent screen **22** consisting of alternating light-absorbing stripes **23** and elemental phosphor stripes **24R**, **24G**, **24B**, as will be described in particular hereinafter, arranged in parallel to the vertical or Y axis of the face plate. A shadow mask **25** of a shape substantially corresponding to the panel is fixed face to face with the concave surface thereof inside the panel **21**. The panel **21** is fixed to a glass funnel **26** to construct an evacuated envelope for the tube. The funnel **26** has, in its neck portion, three electron guns **27** for emitting three electron beams **28** toward the screen **22**, aligned side by side in a plane containing the X axis of the panel. A means **29** for converging the electron beams is placed ahead of the guns **27**. A means **30** for deflecting the electron beams is attached around a portion of the funnel **26**.

The shadow mask **25** has, looking at its concave face from the guns **27**, a number of long, small-width apertures **31** for limiting the path of electron beams. These apertures **31** are arranged in rows parallel to the vertical or Y axis of the face. The apertures **31** in each of the rows are aligned lengthwise, as if a very long opening of the same width as that of the aperture is divided into many apertures by narrow bridge portions **32** of about 1 mm in width, for example.

To make an electroluminescent screen, the panel **21** with the shadow mask **25** attached thereon is placed with its inner surface downward on the top of an exposing box **41** in a position determined by stoppers **42**, as shown in FIG. **3**. On the bottom of the box **41**, there is provided a light source assembly **43** for projecting light onto the inner surface of the panel **21** through the shadow mask **25**. Between the light source assembly **43** and the panel **21** there is provided a lens **44** for correcting the path of the light beam from the light source assembly **43**. A filter **45** for correcting distribution of the light in co-operation with the lens **44** may be provided, if desired.

The light source assembly **43** has, as shown in FIG. **4**, a lamp such as a mercury lamp **46** enclosed in a lamp house **47** which has a long, narrow window **48** in its top for the adjustment of the path of light projected from the lamp **46** toward the top of the box **41**. The window **48** has a sufficient length parallel to the row of apertures **31** of the shadow mask **25**, so that the dark images of the bridge portions **32** appaering on the panel **21** due to the light projected through an end of the window **48** are overlapped by the neighbouring bright images of the apertures **31** made by a light projected through another end of the window, a continuous stripe-like bright image of uniform light intensity being obtained, as shown in FIG. **5**.

Lines **49** show the distribution of intensity of light on the panel **21** produced by the light from lamp **48**. Thus a straight and continuous stripe-like bright image of a length corresponding to the length of the row of apertures of the shadow mask and of substantially uniform intensity of light is obtained on the panel. The window **48** of the lamp house is preferably of a long slit-shape, but may be of any other shape which can produce such a continuous stripe-like bright image as described above.

The lamp house **47** is rotatably supported on a housing **51** by a pair of supports **52**. In the housing **51**, there are provided cams **53**, **54** rotated by a motor **55**. The lamp house **47** is swingingly rotated around a supporting axis **56**, in a plane containing the longitudinal axis of the window **48** and substantially perpendicular to the shadow mask, by a spring **57** and connection rod **58** which is driven by the cam **53**.

Above the lamp house **47**, there is provided a shield plate **59** which has a long and narrow slit-like opening **60**, the longitudinal axis of which is perpendicular to the longitudinal axis of the window **48**, that is, parallel to the X axis of the shadow mask **25**. The shield plate **59** serves to limit the path of the light from the lamp **46** so that an area **61** on the shadow mask **25** irradiated by the light which comes from the window **48** through the opening **60** may have a predetermined limited length in the Y axis direction of the shadow mask **25** so as to cover only a portion of the length of the mask **25**, as shown in FIG. **6**. The irradiated area **61** of the mask **25** has a sufficient width in the direction of the X axis to cover the horizontal length (i.e., the width) of the mask. The shield plate **59** is preferably placed close to the shadow mask **25**. The shield plate **59** is driven back and forth in the lengthwise direction of the window **48**, that is, parallel to the Y axis of the shadow mask **25**, by a spring **62** and a connection rod **63** which is driven by the cam **54**.

The two cams **53**, **54** rotate with a definite mutual relation, and the lamp house **47** slantingly rotates in a definite relation with the movement of the shield plate **59**. A suitable speed adjusting means may be applied, between the motor **55** and the cams **53**, **54**, for instance, to vary the rotating speed of the lamp house **47** and the moving speed of the shield plate **59**.

With the movement of the shield plate **59**, the irradiated area **61** on the shadow mask **25** moves in the Y axis direction, and, at the same time, the lamp house **47** rotates to vary gradually its slant angle so that the window **48** can be always kept substantially parallel to the Y axis direction slant of the shadow mask in the light irradiated area **61**.

FIG. **7** shows a quarter of the concave surface, limited by the X and Y axes, of a shadow mask widely used for color cathode-ray tubes. Figures at cross points of equal-interval horizontal lines **64** and vertical lines **65** show slant angles in the Y axis direction of the mask surface with the X–Y plane at the cross points respectively. Shadow masks are formed symmetrically with respect to the X and Y axes. As taught by FIG. **7**, the slant angle on each horizontal line of the mask is substantially uniform. Accordingly, the lamp house **47** which is inclined at the slant angle at one of the cross points will be substantially parallel to the mask surface all along the horizontal line which contains said cross point.

The exposure of the panel is obtained by moving the shield plate **59** along as the lamp house **47** rotates, the irradiated area **61** on the shadow mask **25** moving over the full length of the mask in its Y axis direction. When the shadow mask is very large, or when the shadow mask has a substantial curvature in the X axis direction, the exposure may be done with good effect by dividing the whole area of the mask **25** into several sections as shown by broken lines parallel to the Y axis in FIG. **6**, and irradiating the respective sections in succession.

An electroluminescent screen on the panel is made by the following process using the above described apparatus.

A photosensitive resin film **71** consisting, for example, of polyvinyl alchohol activated with dichromate (hereinafter called PVA) is applied to the inner surface of a panel **21** as shown by FIG. **8**(A).

Then, a shadow mask **25** is attached to the panel **21**, and this panel-mask assembly is set on the exposing box to expose the panel surface to the light through the shadow mask **25**, as shown by FIG. **8** (B). The exposure is done three times: first with the light source located at a first position corresponding to blue-emitting phosphor stripes; secondly, with the light source at a second position corresponding to green-emitting stripes; and thirdly with the light source at a third position corresponding to red-emitting stripes.

Then, the panel **21** is removed from the shadow mask and is treated with developing solution to form PVA stripes **72** as shown by FIG. **8** (C). All of these stripes **72** are continuous, straight and uniform in width throughout the whole predetermined length of the panel in the Y axis direction.

Then, a film of light-absorbing material such as carbon **73** is applied to the surface of the panel **21** as shown by FIG. **8** (D).

Then, after dissolving the PVA stripes **72** underlying the film **73** with a solution such as peroxide water, the light-absorbing material which overlies the PVA stripes **72** is removed together with the PVA stripes by hot water spraying, so that only light-absoring stripes **23** remain on the panel **21** as shown by FIG. **8** (E). All of these stripes **23** are continuous, straight and uniform in width throughout the whole predetermined length of the panel in the Y axis direction.

The light-absorbing stripes having been made as above, then the phosphor stripes are made according to the following steps.

A film of phosphor slurry consisting of dichromate-activated PVA solution and red-emitting phosphor

powder **74** is applied to the inner surface of panel **21** as shown by FIG. **8** (F).

Then, after attaching the shadow mask **25** to the panel, the panel **21** is exposed to the light by the use of the described exposing apparatus with the light source so located as to irradiate the gap portions between the light-absorbing stripes **23** at every third interval as shown by FIG. **8** (G) The projected light must cover the full width of each gap.

Then, after removed from the shadow mask, the panel **21** is treated with developing solution to form red-emitting phosphor stripes **24R** which fill the gaps between the adjacent light-absorbing stripes **23** as shown by FIG. **8** (H).

This exposure for making phosphor stripes may also be accomplished by using conventional exposing apparatus in place of the above mentioned apparatus, because effective phosphor stripes formed in the gaps are limited in their width by the adjoining light-absorbing stripes **23**, even if the phosphor overlaps the light-absorbing stripes.

Blue-emitting phosphor stripes and green-emitting phosphor stripes are formed in the same manner as above, except that the blue-emitting stripes are made in the gaps adjacent to the gaps having the red-emitting stripes, and the green-emitting stripes are located in the gaps adjacent to the blue-emitting stripe gaps, by locating the light source at the positions corresponding to the blue and green-emitting stripes respectively.

An electroluminescent screen **22** made on the inner surface of the panel in the above described manner consists of the light-absorbing stripes **23** and the red, green and blue-emitting phosphor stripes **24R**, **24G**, **24B** arranged in succession and filling the gaps between the light-absorbing stripes, as shown in FIG. **2**. All of these stripes are straight, uniform in width and parallel over the whole area of the screen **22** as shown in FIG. **9**. With the method or apparatus of the prior art, the stripes were zigzagged in the corner portions which are far from both X and Y axes.

In the above described embodiment, the light-absorbing stripes **23** are so made that the width of gap between them (ds) is smaller than the width of the aperture **31** of the shadow mask (dm), as shown in FIG. **10**.

With the use of this exposing apparatus, an electroluminescent screen which consists only of phosphor stripes can also be made, the phosphor stripes of which are straight, uniform in width and continuous throughout the vertical length of the screen, by employing the above described steps for making phosphor stripes.

What is claimed is:

1. In a method of making an electro-luminescent screen for a color cathode ray tube comprising a plurality of separate color fields of continuous vertical stripes disposed on the viewing panel of said electroluminescent screen, each of said color fields being defined by exposure of said panel to a light source through a shadow mask, the light projected through said mask onto said panel producing a developable image of each said color fields on said panel, the steps comprising:

a. applying a film containing photosensitive material having a predetermined solvency in response to incident light onto the panel for the cathode-tay tube;

b. attaching to said panel a shadow mask with a concave face having a number of beam-passable apertures arranged in rows substantially parallel with each other, said apertures along the length of each of said rows being separated from each other by beam-intercepting bridge portions;

c. locating a light source to irradiate an area of said shadow mask on the opposite side of said shadow mask at a position representing the location of the electron gun in said cathode ray tube used to illuminate each said color field, projecting the light from said source through said mask on said film on said panel in a pattern comprising images defined by said apertures of said shadow mask, controlling the light projected by said light source to limit said lighted area in length in the direction of said rows of apertures, the apertures within said lighted area having a nearly equal angle of inclination with respect to the vertical axis of said screen, said light source having a sufficient effective length to produce on said film an image of each aperture so expanded in the lengthwise direction of the rows of the apertures as to overlap the image of each adjacent aperture in the lengthwise direction of each of the rows thereby obtaining images of the continuous vertical stripes of each said color field along the length of each of said rows on said panel film, and

d. controlling said light source to move said irradiated area on the shadow mask along the length of the rows of the apertures while inclining said light source to keep the longitudinal axis thereof substantially parallel to a line drawn tangent to the apertures in the irradiated area of said shadow mask.

2. A method according to claim **1** wherein said irradiated area on the shadow mask has a sufficient width to cover all of the rows of apertures.

3. A method according to claim **1** wherein said irradiated area on the shadow mask is limited to a short width to cover a portion of the rows of apertures, and the irradiation of all the rows of apertures is obtained by repeatedly performing the moving of the irradiated area and the inclining of the light source for every portion of the rows on the shadow mask.

4. A method according to claim **1** wherein said irradiated area is moved on said shadow mask synchronously with the charging inclination of said light source.

5. A method as claimed in claim **1** wherein said photosensitive material comprises a photosensitive resin.

6. A method as claimed in claim **5** wherein said photosensitive material comprises a dichromate activated PVA solution.

* * * * *