Sept. 8, 1959 A. T. KURYLA ET AL 2,903,319

IMAGE REPRODUCTION DEVICE

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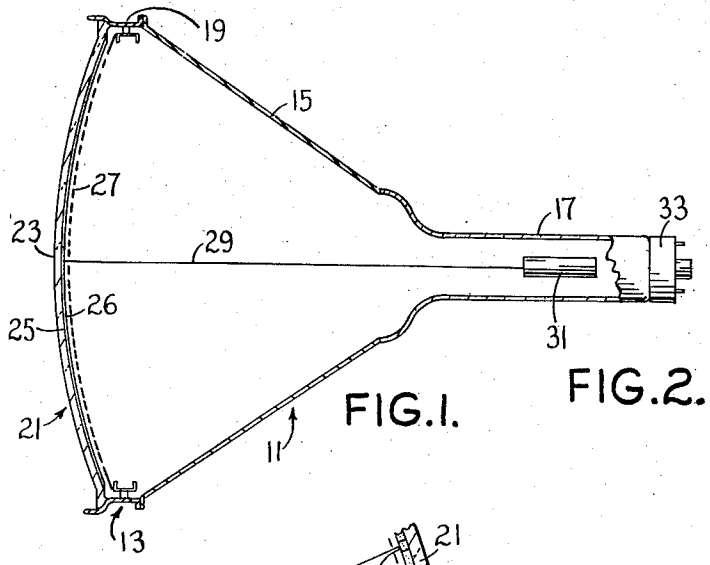


FIG. 1.

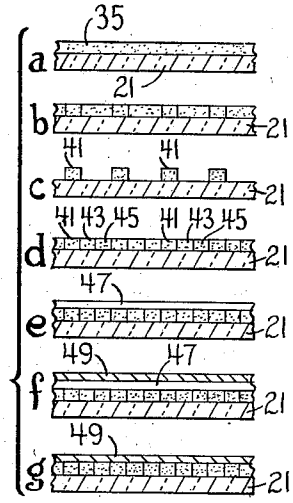


FIG. 2.

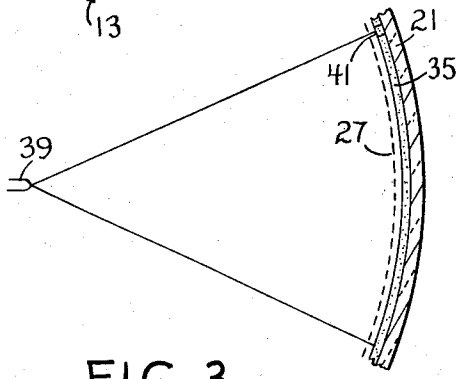


FIG. 3.

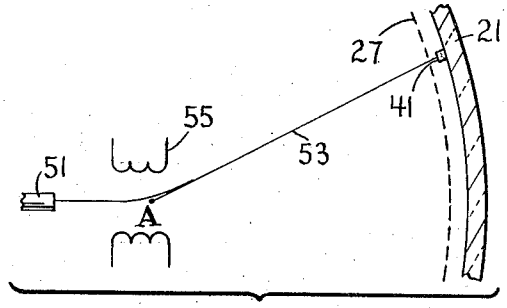


FIG. 4.

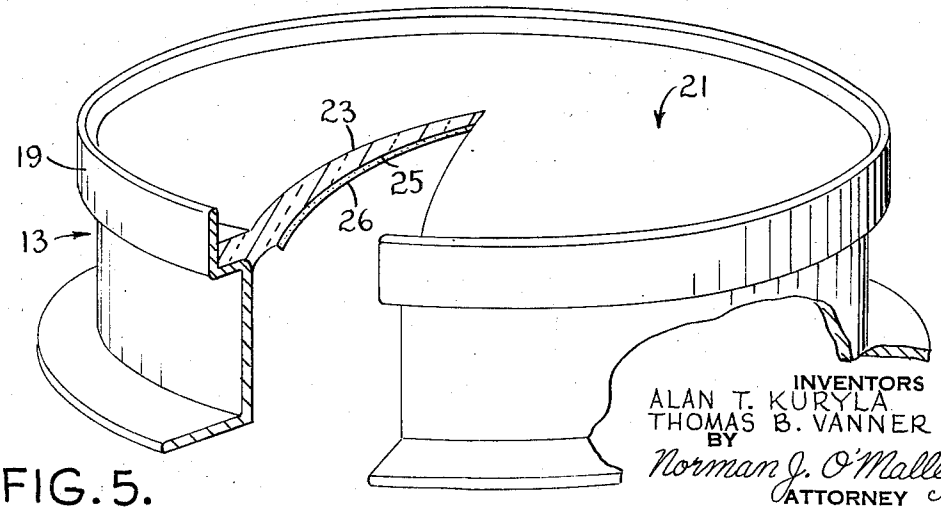


FIG. 5.

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IMAGE REPRODUCTION DEVICE

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4 Claims. (Cl. 316—18)

This invention relates to image reproduction devices such as cathode ray tubes and more particularly to a method for making such devices.

Cathode ray tubes adapted to be employed in color television apparatus have screens comprising discrete patterns of red, green and blue fluorescent materials having configurations of dots, bars or stripes. For proper reproduction of a color image, each electron beam employed in the tube must impinge the screen at those positions which are covered with the associated color fluorescent material. When an electron beam impinges one of the non-associated color fluorescent material configurations, an impure color image is produced.

Proper registry between an electron beam and the appropriate fluorescent material in the color television picture tube depends upon such factors as tube geometry, the amount of the deformation of tube elements during processing, and the magnitude of the magnetic and electrostatic forces acting on the electron beam employed in the tube. One of the more important contributors of misregistry between the fluorescent material configuration and the electron beam is the movement or deformation of the glass face plate during tube processing. This misregistry occurs when the radius of curvature or form of the face plate changes after the fluorescent material patterns have been formed thereon. The thickness, weight and area of the glass face plate in a large picture tube makes it readily susceptible to sag and deformation during those tube processing procedures which necessitate the application of heat. For instance, the screen must be baked above 400 degrees centigrade for over an hour to remove volatile impurities in one step of the process, and heated again in a later step in similar high temperatures while the tube is being exhausted. These high temperatures, when combined with the forces of gravity and atmospheric pressure, cause the glass to sag and become deformed.

Accordingly, it is an object of the invention to reduce misregistry between an electron beam and its associated fluorescent material configuration.

A further object is the provision of an improved method for making picture tubes.

The foregoing objects are achieved in one aspect of the invention by the provision of a method for making picture tubes which includes orientation of the tube face plate in a manner to cause substraction of successive deformations resulting from the use of heat in the various stages of the tube fabricating process.

For a better understanding of the invention, reference is made to the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a cross sectional view of a typical cathode ray tube;

Fig. 2 illustrates the steps utilized in the formation of a cathode ray tube screen;

Fig. 3 shows one step of the screen forming process which employs a photographic exposure operation;

Fig. 4 is a diagram illustrating the manner in which an electron beam impinges a screen configuration to cause fluorescence; and

Fig. 5 is a partially sectioned plan view of the face plate assembly for a cathode ray tube.

Fig. 1 shows a typical cathode ray tube **11** adapted to be used in a television receiver for the reproduction of color images. The envelop of the tube comprises a face plate assembly **13**, a cone **15**, and a neck portion **17**. Assembly **13** has a rim **19** and a glass face plate **21** with an exterior or viewing surface **23** and an interior or screen surface **25** upon which the fluorescent screen **26** is formed. Mounted upon assembly **13** in spaced relationship with screen **26** is a grid or mask **27**. The electron beam or beams **29** emitting from electron gun or guns **31** are caused to travel through grid **27** and impinge upon screen **26**. An electrical connector base **33** is mounted upon neck portion **17** to provide the electrical connections between the electrodes of guns **31** and their associated receiver circuitry. For purposes of explanation, the picture tube described hereafter will be of the tri-gun shadow mask type.

The method of forming the fluorescent screen for a picture tube on the internal surface **25** of face plate **21** generally utilizes a photo-printing technique. Face plate assembly **13** is not attached to cone **15** until after the screen has been formed to facilitate ease of handling and to enable the printing operation to be performed. Referring to Figs. 2 and 3, the glass face plate **21** is first covered with a coating **35** of a photosensitive substance and a fluorescent material. Generally, three types of fluorescent material patterns are formed in sequence on plate **21**, so that the first fluorescent material may comprise a phosphor such as the blue phosphor material, zinc sulfide. The photosensitive substance may consist of polyvinyl alcohol sensitized with ammonium dichromate. Coating **35** is dried and the coated face plate **21** is then aligned with a negative master or mask having the same configuration as mask **27** shown in Fig. 1. For a tri-gun shadow mask type tube, the mask **27** will comprise a formed metal sheet having over 300,000 circular apertures. One aperture in the mask is associated with each triad of color fluorescent dots in the finished tube.

Face plate **21** and mask **27** are properly positioned relative to a light source **39**, and coating **35** is subsequently exposed to light rays radiating from this source. Those portions of coating **35** which are exposed to light become hardened and adhere to face plate **21** as shown in Fig. 2*b*. After exposure, coating **35** is washed with a developing fluid such as deionized water to form the blue phosphor pattern of dots **41** shown in Fig. 2*c*. Those portions of coating **35** which were not exposed to light are removed by the developing fluid.

The above described process is repeated sequentially with the green phosphor material zinc ortho-silicate and the red phosphor material zinc phosphate. For each exposure operation, light source **39** is offset a predetermined distance so that the color phosphor dots in each triad are separate from one another and properly oriented relative to one another. Fig. 2*d* shows an oblique cross section of several of these phosphor triads, with numerals **43** and **45** designating for example, the green and red phosphor dots respectively. The composite screen is indicated in Fig. 1 by the numeral **26**.

After the fluorescent screen has been completely formed, it is covered with a pool of water, and a volatile lacquer such as nitrocellulose is floated upon the surface of the water. A decanting operation then causes the resulting lacquer film **47** to become deposited over the entire screen as shown in Fig. 2*e*. An electron permeable aluminum coating **49** is subsequently placed upon film **47** by a flashing technique to form the composite panel shown in Fig. 2*f*. In order to remove the volatile lacquer **47**, face plate assembly **13** is placed in an oven and baked above 400° C. for approximately an hour. This heating operation causes the lacquer to volatilize,

thereby leaving the completed aluminized phosphor screen shown in Fig. 2*g*.

During the baking operation, face plate **21** is positioned with viewing surface **23** in a downward direction. Since the temperature needed to completely remove the lacquer is in the plastic stage region of the glass, this plate sags downwardly as it is being baked. For a 21" spherical color picture tube, the amount of sag ranges between .004" and .008".

After the screen **26** has been completely processed, mask **27** is mounted upon frame **19** and these parts are hermetically sealed with cone **15** and neck portion **17**. Electron guns **31** were previously mounted in the neck portion so that the tube structure is complete and ready for the exhausting operation.

While tube **11** is being evacuated, all of the parts including face plate **21** are heated above 400° C. in order to drive out the gasses from these parts. After the appropriate degree of vacuum is attained, the tube is hermetically sealed. During the exhaust operation, large atmospheric pressures are exerted upon face plate **21**, which is positioned with viewing surface in an upward direction. The combination of this pressure and the high temperature causes face plate **21** to sag in the direction opposite to the sag encountered in the previously described screen baking procedure. In a 21" spherical shadow mask type face plate, a force of over two tons is exerted against surface **23**. This force, in addition to the force of gravity, causes a sag ranging from .007" to .011".

It can be seen that the movement of surface **25** upon which the phosphor dots are formed, is away from the direction of grid **27** during the screen baking procedure, and toward the grid during the exhausting operation. The result of these oppositely directed movements thereby subtracts and thereby reduces to a minimum any change in distance between surface **25** and mask **27** after the phosphor screen has been formed.

A comparison of the optical system shown in Fig. 3 and the electron system shown in Fig. 4 will point out the importance of maintaining the mask to face plate distance after the screen has been formed. The light exposure operation is intended to optically simulate the scanning electron beam motion in the operating picture tube, and to thereby form the phosphor dots on those positions of surface **25** which are impinged by the appropriate electron beam. Fig. 4 illustrates the manner in which this is accomplished. An electron gun **51** associated, for example, with the blue color signal derived from the receiver, emits an electron stream **53** which is deflected by yoke coils **55** to pass through mask **27** and strike blue phosphor dot **41**. When beam **53** impinges upon the center of dot **21**, perfect registry exists. In order to satisfy this condition, light source **39** is generally positioned relative to mask **27** in accordance with an apparent center point of deflection designated at point A to form the dot at the electron impinging position for each deflection angle. Therefore, the distance between mask **27** and the screen coating should be the same in both instances. If surface **25** of face plate **21** is closer to mask **27** in the finished tube than it was during the screen forming exposure operation, the electron beam **53** will strike below dot **41**, and an impure color image will be produced. It is to be understood that mask or grid **27** need not be the same element used in both the printing operation and the finished tube. However, if these are separate structures, they must have substantially the same configuration.

Misregistry between the electron beam and its associated phosphor dot caused by deformation of the face plate is not easily corrected because of the face plate structure, which is shown in detail in Fig. 5. Due to the slightly varying thickness of the glass, its non-uniform shape, and the inherent variations in the glass composition itself, the amount of sag is not uniform over the entire surface. However, those portions of the glass which will tend to sag in one direction will also tend to sag in the opposite direction. Therefore, provision of a method for fabricating a tube in the manner described herein fulfills the desired requirements of maintaining the mask to screen distance in the completed tube as it is during the photographic screen forming operation.

Although one embodiment of the invention has been shown and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A method of making a cathode ray tube having an envelope, a glass face plate with an image screen formed on the internal surface thereof hermetically sealed to the envelope, and an electron emitter providing an electron beam which impinges upon the screen, the method comprising the steps of forming the screen on said face plate, heating said face plate above 400 degrees centigrade with the screen in an upward direction to remove volatile impurities, hermetically sealing said face plate with the envelope to form the cathode ray tube structure, and heating said structure above 400 degrees centigrade during an exhausting operation with the screen surface of said face plate in a downward direction.

2. A process for making an image display device having a display screen positioned upon a glass support comprising heating said screen to a temperature in the plastic region of glass at one step of the process while said support member is oriented in a given direction whereat a first distortion of said glass occurs and subsequently heating said screen to a temperature in the plastic region of glass at another step in the process while said support is oriented in the opposite direction whereat a second distortion of said glass occurs which is opposite to the direction of said first distortion.

3. A method of making a cathode ray tube comprising a glass face plate having a given longitudinal axis which distorts above 400° C., said face plate having an image display screen formed on the internal surface thereof, the steps including forming the screen on said face plate, baking said face plate at a temperature above 400° C. with the screen surface mounted in a predetermined position whereat said longitudinal axis is transverse to a horizontal plane and whereat a first distortion of the face plate occurs, and heating said structure above 400° C. in a subsequent operation with said screen surface rotated from said predetermined position to the opposite axial position whereat a second distortion occurs in a compensating direction from said first distortion.

4. A method of making a cathode ray tube having an envelope, a glass face plate with an image screen formed on the internal surface thereof hermetically sealed to the envelope, and an electron emitter providing an electron beam which impinges upon the screen, the method comprising the steps of forming the screen on said face plate, heating said face plate to a temperature in the plastic region of glass with the screen positioned in an upward direction to remove volatile impurities, hermetically sealing said face plate with an envelope to form the cathode ray tube structure, and heating said structure to a temperature in the plastic region of said glass face plate during an exhausting operation with the screen surface of said face plate oriented in a downward direction.

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