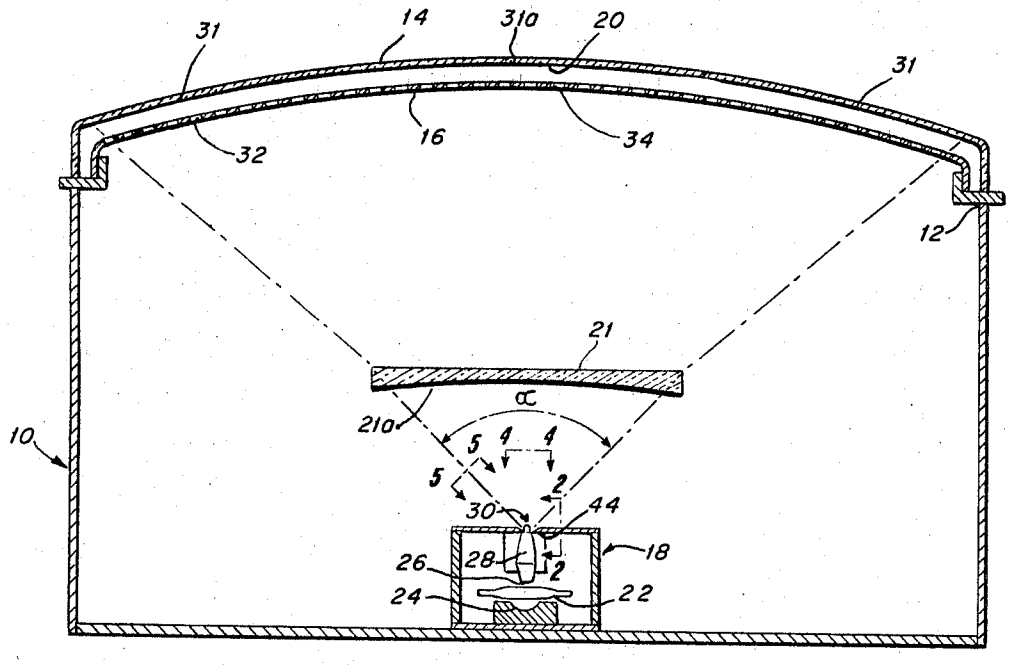
July 1, 1969 N. D. LEVIN ET AL 3,452,655

LIGHTHOUSE COLLIMATOR

Filed April 20, 1966

Fig. 1.



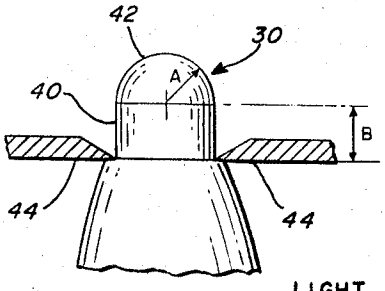


Fig. 2.



Fig. 4.

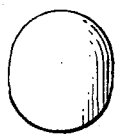


Fig. 5.

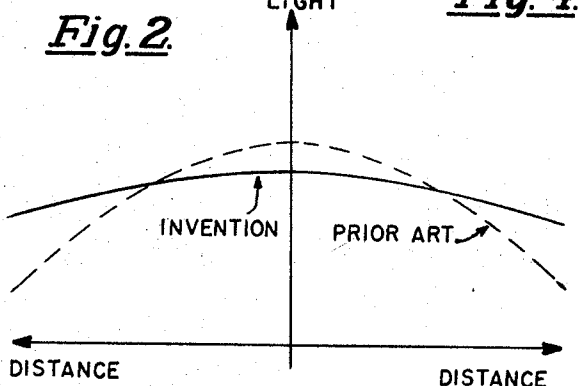


Fig. 3.

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LIGHTHOUSE COLLIMATOR

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4 Claims

ABSTRACT OF THE DISCLOSURE

A lighthouse collimator has an emitting tip comprising a hemispherical front portion and a cylindrical side portion for increasing the off-axis light flux emitted. Substantial circularity of the projected emitting surface is retained by making the radius of the hemisphere equal the height of the cylinder.

This invention relates in general to the manufacture of color cathode ray tubes and in particular to light collimators used to simulate a point light source for exposing light sensitive phosphor emulsions deposited on the face plates thereof. More particularly, this invention is concerned with a collimator having an improved light emitting tip which provides an extremely desirable light intensity distribution for more rapidly exposing a triad mosaic of substantially circular phosphor dots having an optimum ratio of corner to center size.

One step in the manufacture of color television picture tubes consists of producing a triad of phosphor dots by successively exposing several applications of photosensitive phosphor emulsions deposited on a picture tube face plate. A lighthouse is typically used in this step of the manufacture. The face plate is secured to the lighthouse in the path of light rays from a point source, which represents the location of an emerging beam of electrons from an electron gun. The point source conventionally comprises the non-polished tip of a light conducting collimator fabricated of optical quartz or Pyrex. A powerful ultraviolet light bulb, in combination with a light concentrating reflector placed adjacent the end of the collimator opposite the non-polished tip, supplies high intensity ultraviolet light to the collimator.

The light sensitive phosphor emulsion is exposed by projecting light through an apertured mask maintained adjacent the face plate, thus obtaining a particular phosphor dot pattern. The characteristics of the phosphor dot triads with respect to shape, size, and location on the face plate, are extremely important to the proper performance of a finished picture tube.

More specifically, each of the phosphor dots should have a substantially circular shape, so the dot triad will cover as much face plate area as practical without one dot overlapping another. The size of the dots should vary, with larger dots at the center of the face plate and slightly smaller dots toward the edges. The variation in dot size assists in controlling the light output of the picture tube, thus larger center dots provide a brighter center picture which is normally more pleasing to the viewer.

A phosphor dot having the described characteristics must be obtained in spite of the adverse physical limitations of a conventional cathode ray tube. Examples of such limitations are that the edges of the face plate are further from the light emitting tip than the center thereof, and the size of the mask apertures are non-uniform. Since it is well known that light intensity decreases as the square of the distance from its source, it was normally difficult to obtain sufficient light at the edges to develop phosphor dots of adequate size. Non-uniform

aperture size, with smaller apertures at the edges, further magnified the problem of adequate edge dot size.

An additional limitation, although not related to the picture tube per se, is the chemistry of the phosphor emulsion and the time required to expose it. A portion of the manufacturing cost is directly related to the exposure time, since as the exposure time increases, a greater number of lighthouses, and a larger plant area are required for production. Naturally, with respect to cost considerations, a minimum exposure time is desirable. On the other hand, due to the chemistry of the phosphor emulsion, the phosphor dots will not adhere to the face plate if the exposure is too short. A further factor which must be considered, is that as the exposure time is increased, the dots tend to become more circular due to a light scattering effect of the phosphor.

In the prior art manufacture of picture tubes, the collimator emitting tip directed very high intensity light toward the center of the face plate, and low intensity light toward the edges. Since the center is closest to the emitting tip, the light distribution of prior art emitting tips was opposite that desired. To compensate for this distribution, a high density graded filter was provided to restrict the amount of light reaching the face plate center. While the filter allowed the whole face plate to be exposed for a constant time, a dot pattern having edge dots of acceptable size and shape, could only be produced with a long exposure time. As explained above, this increased the cost of manufacture.

This invention obviates the necessity of a lengthy exposure time by utilizing a light collimator having a light emitting tip of novel configuraton. The emitting tip of this invention projects more light flux from its sides than was possible with tips of prior design, thereby insuring a dot pattern at the edges of the face plate of sufficient size. While the light flux emitted from the center of the emitting tip is greater than necessary, thereby requiring some filtering device, the total exposure time is substantially decreased. In addition, the shape of the novel emitting tip of this invention is such that its projection on any point of the face plate is substantially circular, thereby insuring phosphor dots of optimum circularity with a short phosphor exposure time.

Accordingly, it is the primary object of this invention to provide a light collimator having a novel emitting tip for producing a phosphor dot pattern on a picture tube face plate with optimum exposure time.

Another object of this invention is to provide a light collimator having a novel emitting tip suitable for exposing a phosphor dot pattern on a face plate in a short time, wherein the distances from the tip to the face plate are not constant, and the sizes of the apertures through which the pattern is exposed are non-uniform.

Another object of this invention is to provide a light collimator having an emitting tip suitable for exposing, through a graded aperture mask, a light sensitive phosphor emulsion deposited on a face plate, thereby obtaining a phosphor dot pattern of non-uniform size in a short exposure time.

An additional object of this invention is to provide a light collimator having a light emitting tip which distributes a large amount of light from the sides thereof, to facilitate control of the phosphor dot size at the edges of a face plate.

A further object of this invention is to provide a light collimator having an emitting tip for exposing a pattern of substantially circular phosphor dots on the face plate of a picture tube, in a short exposure time.

It is also an object of this invention to provide a light collimator having an emitting tip suitable for obtaining a substantially circular phosphor dot pattern of graded size on the face plate of a picture tube, in a short time.

A feature of this invention resides in the use of a collimator tip having a large side emitting area for projecting a large quantity of light flux toward the edges of a picture tube face plate.

Another feature of this invention resides in the use of a light collimator having a tip configuration such that its projection is substantially circular when observed from any point on the face plate.

Other objects and advantages of this invention will become apparent upon an examination of the following description taken in conjunction with the accompany drawings wherein:

FIG. 1 is an elevation view of a simiplified lighthouse including a light collimator constructed in accordance with the invention, wherein the distance between the collimator tip and the face plate has been shortened for convenience of illustration.

FIG. 2 is an enlarged elevation view taken line **2**—**2** of FIG. 1, illustrating the light emitting tip in detail.

FIG. 3 is a representative illustration of the light distribution of a typical emitting tip of prior art design (shown in dashed lines) as compared to an emitting tip of the invention, both as a function of horizontal distance at approximately the elevation of the lens.

FIG. 4 is a view of the emitting tip taken along line **4**—**4** of FIG. 1, drawn in the same scale as FIG. 2.

FIG. 5 is an additional view of the emitting tip taken along line **5**—**5** of FIG. 1, drawn in the same scale.

Turning to consideration of the drawings and in particular to FIG. 1, there is shown a lighthouse generally referred to by reference numeral **10**, commonly used in the manufacture of color television picture tubes. The lighthouse essentially comprises a supporting and aligning structure **12** which aligns a picture tube face plate **14**, with an aperture mask **16**, during exposure of a light sensitive phosphor emulsion coating **20** deposited on the face plate. The phosphor emulsion is exposed by light flux from a light box **18**, subsequent to modification of the light flux path by a lens **21**, which includes a neutral density filter **21***a*, thereon. The light box includes an ultraviolet mercury vapor light bulb **22** which, with the aid of a reflector **24**, directs high intensity ultraviolet light at the collecting surface **26** of a light collimator **28**. A light emitting tip **30** is formed at one end of collimator **28**, and projects ultraviolet light toward the aperture mask and face plate. More specifically, light flux emitted from tip **30** is directed through correcting lens **21**, which bends the rays to more nearly conform to the eventual path of an electron beam emerging from an electron gun located in the neck of the picture tube, which is not shown.

Still referring to FIG. 1, it is obvious that the edges **31** of face plate **14** are further from emitting tip **30** than the center or head-on portion **31***a* thereof. Also, the mask apertures adjacent the face plate edge, such as those in the area of aperture **32**, are smaller than those adjacent the center, such as in the area of aperture **34**. As explained above, under these physical limitations it is desired to expose the phosphor emulsion and obtain dots at the face plate edges which are only slightly smaller than the dots at the center, wherein each dot is substantially circular.

The final size of an exposed phosphor dot is directly dependent on the quantity of light flux which reaches an elemental area of the phosphor emulsion, through an aperture in mask **16**. For example, two phosphor dots of equal size may be exposed by casting an intense light onto the phosphor emulsion through a small aperture, or casting a light of less intensity through a larger aperture, as long as the total light flux reaching the phosphor emulsion through each of the apertures is equal.

Referring now to FIG. 2, the novel light emitting tip is shown in greater detail. The tip generally comprises a hemispherical top **42** from which light is primarily projected at the center of the face plate, and a cylinder **40** having side walls from which light is projected toward the edges. Ideally, for reasons which will become apparent below, the radius A of the hemisphere should equal the height B of the cylinder, but it is obvious that the one-to-one ratio can be varied slightly without significantly affecting the dot pattern.

At tip support **44** is provided at the top of the lighthouse and includes a chamfered edge which restricts the shape of the emitted light to a cone having an angle α, called the light exit angle. The tip also maintains the upper terminus of the collimator in the correct position within the light box.

As is well known in the art, light collimators designed to be utilized in lighthouses incorporate tips which emit light of substantially uniform intensity. By elementary geometry, it is readily shown that the projected area of a cylinder is greater than the projected area of a hemisphere, when the diameters are equal and the height of the cylinder equals one-half the common diameter. Thus, it is easily seen that a greater quantity of light is emitted from the side or cylindrical portion of an ideal tip, than is emitted from the top or hemispherical portion thereof. This is exactly the light distribution which is required to expose the phosphor emulsion, since a greater ratio of light flux is projected toward the edge of the face plate, which is furthest from the tip, and a smaller ratio is projected toward the center, which is closest thereto.

FIG. 3 illustrates the light distribution of a typical prior art light emitting tip with a dashed line, and a light emitting tip constructed in accordance with the invention with a solid line, both at approximately the vertical location of lens **21**. It is readily seen that the emitting tip of the invention distributes a greater quantity of light toward the edges, since the side light emitting area is relatively large.

The exposure of the phosphor emulsion through an aperture in the mask, is analogous to exposing photographic film with a pin-hole camera. Consequently, for a short exposure time the shape of the exposed phosphor dot is almost entirely dependent upon the projection of the emitting tip which casts light through a particular aperture, and is essentially independent of the shape of the aperture. As the exposure time is increased, the shape of the phosphor dot becomes more circular due to light scattering properties of the phosphor. Thus, while it is possible to expose a substantially circular dot from a light source having a noncircular projection, an extremely long exposure time is required.

The emitting tip of FIG. 2 has a circular head-on projection, as shown in FIG. 4, which is merely the projection of a hemisphere. This projection shapes the phosphor dots at the center of the face plate, such as through aperture **34**. At the extremities of the exit angle α, the projection of the emitting tip becomes slightly oblong, as illustrated in FIG. 5. While this projection is not absolutely circular, for an exit angle of 90° used in production, its shape, combined with a very slight light scattering, produces a substantially circular phosphor dot with a short exposure time.

What has been described is a novel collimator light emitting tip for exposing a picture tube face plate. The configuration and proportioned dimensions of the emitting tip represent a minimum compromise for obtaining substantially circular phosphor dots having an optimum edge to center size ratio, with a short exposure time.

It is obvious that upon study by those skilled in the art, the disclosed invention may be altered or modified both in physical appearance and construction without departing from its inventive concept. Therefore, the scope of protection to be given this invention should not be limited by the embodiment described above, but should be determined by the essential descriptions thereof which appear in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A lighthouse of the type for exposing a photosensitive phosphor coating deposited on the inside of a sub-

stantially flat color picture tube panel through a mating aperture mask spaced a predetermined distance with respect to the panel, the lighthouse including a source of high intensity light positioned beneath the mask, a collimator with a light receiving surface gathering the light from the source and a light emitting tip radiating the light toward said mask; the collimator having a bullet shaped body for eliminating shadows in the light by multiple internal reflection thereof; a lens positioned between the emitting tip and the mask for dispersing light flux over the mask in a predetermined pattern; and a graded filter between the light emitting tip and the mask reducing the light intensity on the central area of said panel to compensate for the longer distances between the emitting tip and edges of the panel and allow uniform exposure time in the lighthouse, the improvement comprising: providing the collimator with an emitting tip consisting of a hemispherical forward portion blending into a cylindrical intermediate portion; the light emitting tip thereby presenting a larger total radiating surface to edge portions of the panel than to central portions thereof, allowing the graded filter to be reduced in effectiveness and shortening the overall exposure time in the lighthouse.

2. The lighthouse of claim **1** where the diameter of the forward portion equals twice the height of the cylindrical portions to optimize the circularity of light projections therefrom over the panel.

3. A light collimator of generally bullet shape having a longitudinal axis of symmetry and including a wide angle light emitting tip at one end and a light collecting surface at the other end; said collimator adapted for collecting high intensity light flux at said collecting surface, collating said flux, and emitting said flux at said emitting tip; said light emitting tip including a cylindrical intermediate portion, having a height approximately equal to one-half its diameter, blending into a hemispherical forward portion of diameter equal to the diameter of said cylindrical intermediate portion; the surface area of said emitting tip, when viewed along the longitudinal axis of said collimator, thus being smaller than the surface area of said emitting tip when viewed from points displaced from said axis whereby off-axis projections of said emitting tip are substantially circular throughout said angle.

4. A light collimator as set forth in claim **3** wherein said collimator is fabricated of quartz and wherein said light emitting tip is nonpolished and said light collecting surface is polished; said collimator minimizing shadows in the light received by said light collecting surface by multiple internal reflection for producing substantially uniform flux density over the entire surface area of said emitting tip.

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