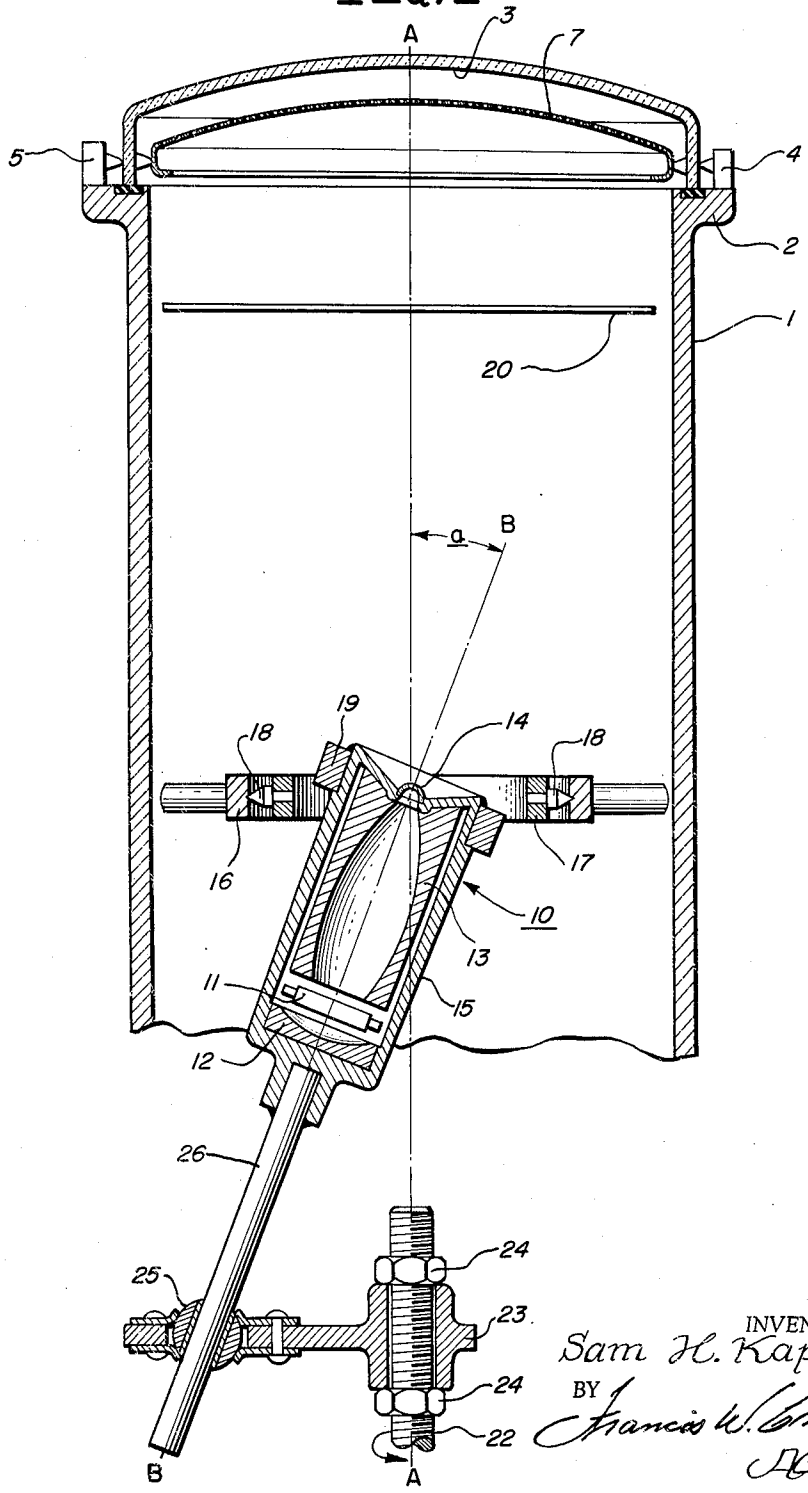
Oct. 12, 1965 S. H. KAPLAN 3,211,067

METHOD OF EXPOSING A MULTI-COLOR TARGET STRUCTURE

Filed June 15, 1962 2 Sheets-Sheet 1

FIG. 1



INVENTOR.
Sam H. Kaplan
BY
Francis W. Crotty
Atty.

Oct. 12, 1965 S. H. KAPLAN 3,211,067

METHOD OF EXPOSING A MULTI-COLOR TARGET STRUCTURE

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FIG. 2

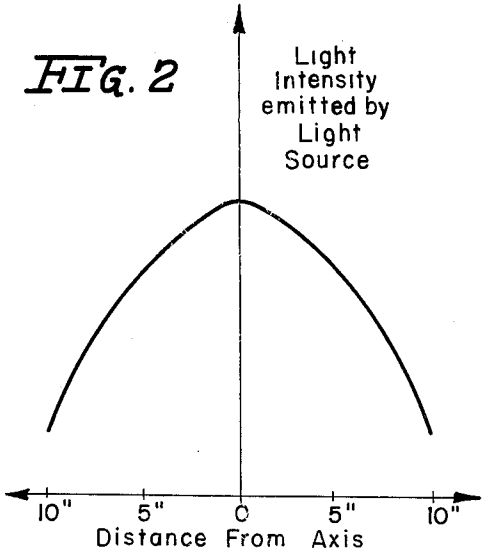


FIG. 3

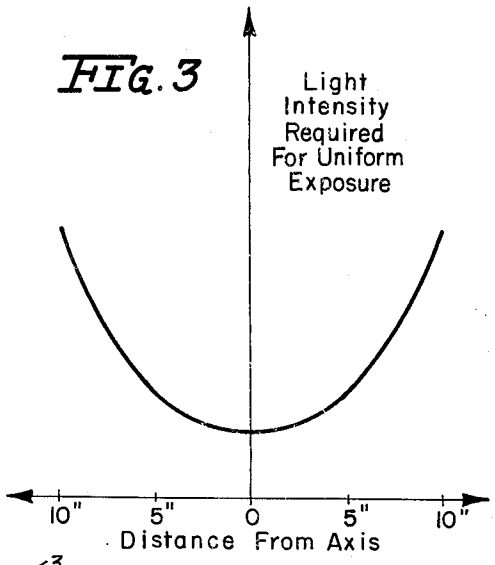
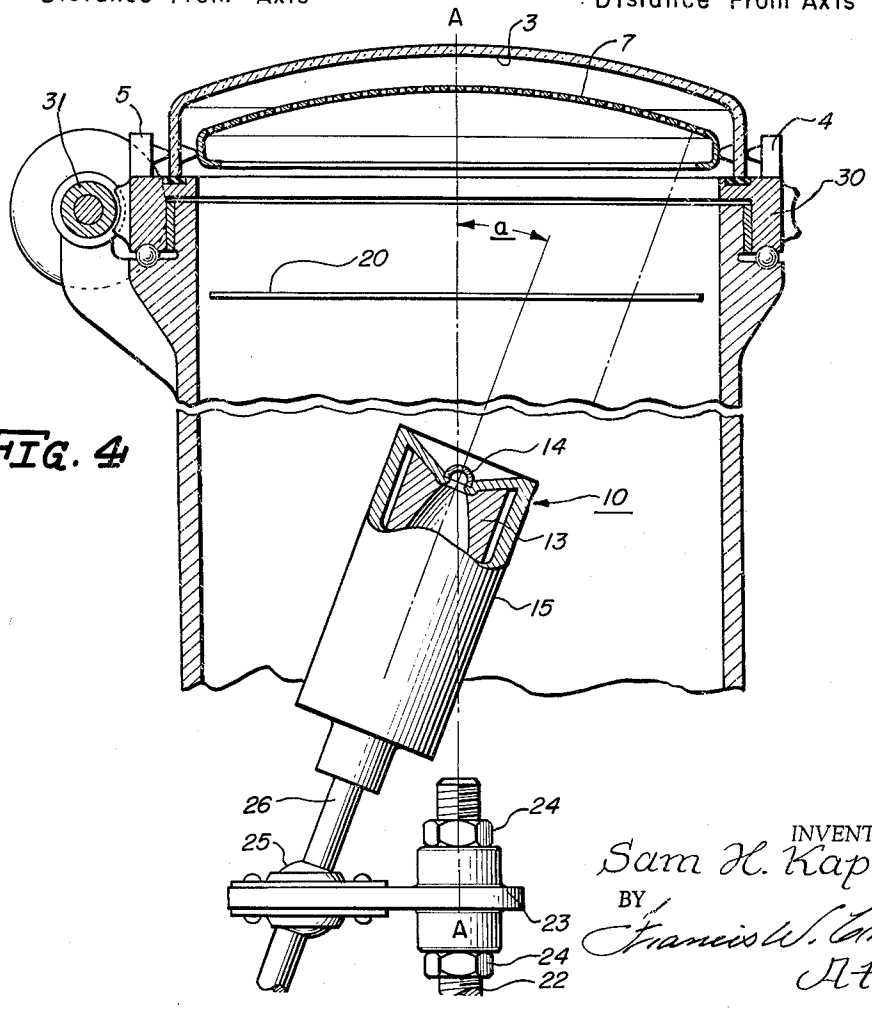


FIG. 4



INVENTOR.
Sam H. Kaplan
BY
Francis W. Crotty
Atty.

United States Patent Office

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3,211,067

METHOD OF EXPOSING A MULTI-COLOR TARGET STRUCTURE

Sam H. Kaplan, Chicago, Ill., assignor to The Rauland Corporation, Chicago, Ill., a corporation of Illinois

Filed June 15, 1962, Ser. No. 202,902
9 Claims. (Cl. 95—1)

The present invention relates to a more efficient method of exposing a multi-color luminescent target structure for a color television image reproducer.

There are several different types of cathode-ray tubes presently known in the art which are capable of reproducing images in simulated natural color. Each of these different devices utilizes a luminescent target comprising a multitude of interspersed elemental target areas forming two or more distinct groups. The different target area groups comprise phosphors which emit light having different color characteristics when subjected to electron bombardment. Typically, a luminescent target of this type includes three different groups of color target areas which emit light corresponding to the green, blue and red portions of the spectrum. The individual target areas may comprise minute dots, usually of circular configuration, or extremely narrow strips or bands extending across the target.

Color fidelity in images reproduced by devices utilizing targets of this type is dependent in large measure upon the consistency in configuration and dimensional accuracy of the individual target areas and their positions with respect to one another. The individual target areas are extremely small; for example, there may be more than 1,000,000 individual target areas in the screen of a twenty-one inch round picture tube. Consequently, the techniques and processes used to fabricate these targets must permit the maintenance of extremely precise dimensional tolerances.

Usually such multi-color targets are deposited directly on the spherical screen surface of cathode-ray tubes by means of photographic techniques. Although these techniques have been used with some success, they are not free of difficulty. For example, it is common practice to coat the entire screen area with a photo-sensitive resist in which a selected color phosphor is retained in suspension. Thereafter the color selection electrode of the tube, popularly referred to as the "shadow mask" is employed as a mask through which the resist is exposed. The shadow mask as presently constructed has a multiplicity of apertures distributed over its surface in generally the same pattern as the distribution pattern desired of the elemental target areas to be established on the screen. The aperture size, however, is non-uniform; usually the aperture size decreases with distance from the center of the mask. This variation in aperture size has been adopted to facilitate maintaining color purity but results among other factors in non-uniform exposure of the surface of the screen. The intensity of the light source presently in use is strongest in the direction of the center of the aperture mask where the apertures are largest and as a consequence the exposure in the central portion of the screen is greater than that as one approaches the edges.

Of course, optimum results require that the exposure of the screen area should be of uniform time. Prior art processes were wasteful of light and required rather long exposure times. It has been found necessary to resort to a heavy optical filter interposed in the projection path to introduce an attenuation for light which is greatest at the center and varies toward the periphery in inverse relation to the variation in exposure experienced without the filter. Due to the specification of the filter a very large part, up to 85% of the available light in the screen center is wasted

in that it is not usefully employed in the exposing of elemental target areas on the screen.

It is, therefore, a principal object of the invention to provide a method of exposing the multi-color target of a cathode-ray tube which overcomes limitations of prior methods.

It is a particular object of the invention to provide a method of exposing a multi-color target of a cathode-ray tube which is characterized by a more efficient utilization of the exposing light source.

It is a further object of the invention to provide a new and improved method of exposing the multi-color target of the cathode-ray tube which is applicable to tubes of rectangular as well as circular screen areas.

The method of the invention for exposing the multi-color target of a cathode-ray tube designed for the reproduction of an image in simulated natural color comprises the following steps. The target is supported in an exposure position which is substantially normal to a reference axis passing centrally through the target. The light source is supported at a predetermined distance from the central portion of the target in the general direction of the reference axis. The approximate point light source is supported at an acute angle relative to the reference axis to provide a directivity pattern of light intensity which increases along a selected radius of the target from a minimum at the central portion of the target to a maximum in the direction of the outer periphery thereof. An imaging structure, usually the color selection barrier to be employed in the tube, is supported across the reference axis between the target and the light source. Finally, relative rotary motion is established between the target and the light source throughout a selected exposure interval while maintaining the light source at the acute angle relative to the reference axis and in a fixed location relative to the axis and to the target to sequentially establish the specified directivity pattern of light intensity along all radii of the target and effect substantially uniform exposure of the target to a projected image of said imaging structure. Stated more generally, and especially in the environment of the present-day shadow-mask tube, the mask has has an aperture pattern characterized by the fact that the diameter of the apertures varies in one sense from the center to the edges of the mask and the directivity pattern of the light source, from center to the edges of the mask, varies in the opposite sense.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The organization and manner of operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIGURE 1 is a schematic representation of apparatus which may be used in practicing the invention;

FIGURES 2 and 3 are graphs employed in explaining the method of the invention; and

FIGURE 4 is another form of apparatus that may be employed.

Referring now more particularly to FIGURE 1, the arrangement there represented is referred to in the art as a "light house" used in the screening of a cathode-ray tube for use in the reproduction of images in simulated natural color. As presently constructed, the envelopes of such tubes have two principal sections which are separate initially but are mated and bonded together to form a unitary envelope after the multi-color screen has been formed.. These two principal components of the envelope are the faceplate or screen section which is rather like a shallow dish and the conical section which termi-

nates in the narrow diameter neck at one end and at its opposite end is dimensioned and shaped accurately to correspond with the free end of the screen section. The specific cross-sectional configuration of the screen section may be round or rectangular and either form may be processed in accordance with the method of the subject invention. In any event a multi-color target is laid down on the inner surface of the faceplate of the tube before the screen and cone sections are assembled. Since the present invention is directed solely to the formation of the multi-color target, no further consideration will be given to the other processing steps employed in the fabrication of the complete device.

The system of color television currently in commercial use is a three-color system in which images in simulated natural color are translated by processing at the transmitter and at the receiver the red, blue and green components of the image. Necessarily, therefore, the reproducer must have a corresponding number of groups of elemental target area with each group composed of phosphor dots or elements which, in response to electron excitation, emit light of one of the three colors. Further to simplify this discussion, it will be assumed that the color tube is of the shadow mask type for which the multicolor target is a multiplicity of triads uniformly distributed over the screen of the tube. "Triad" is here used in the sense of a cluster of one element from each of the three interspersed groups of elemental target areas of the tube, that is to say, each triad includes a red, a green and a blue color phosphor dot.

Each color group is laid down by the same process except that only one such group is formed in any one operating cycle. The invention in question is applied in the same way in the processing of each of the three groups and, therefore, it is sufficiently to consider only one such process without any particular regard for the color component that may be involved.

As a general proposition, the entire inner surface of the screen section is first coated with a photo-sensitive resist which carries the appropriate color phosphor in suspension. The shadow mask of the tube is used to the end that only those areas of this particular photo-resist coating are exposed which correspond to the desired location of the members of the particular color group being processed. To achieve that result, the selected areas of the photo-sensitive layer are exposed from an approximate point light source through the shadow mask. In accomplishing this exposure, the shadow mask has the same relation to the screen that it has in the final assembled version of the tube and the light source is placed at the center of deflection for the electron beam which corresponds or is assigned to the particular color being processed. The mechanism for exposing the photo-resist layer in accordance with the invention is represented in FIGURE 1.

As stated, it is known as a light house and comprises an enclosure **1** shown in fragmentary form. It is completely closed on all sides and faces except for the uppermost or top face **2** which is cut away to form a shelf for receiving and supporting the circumferential edge or the periphery of screen section **3** of the tube under construction. The shelf **2** must be deep enough to provide firm support for screen section **3** while permitting total exposure of the area of the screen desired to be covered with color triads. Hence it may be said that the shelf supports the target in an exposure position illustrated in FIGURE 1 in which the target is substantially normal to a reference axis A—A passing through the central portion of the target.

Since the target area is to be exposed through a shadow mask, such a mask **7** is indicated as attached to envelope section **3**. This may be accomplished in any of a variety of ways. In some cases, studs are provided within envelope section **3** to receive mounting springs secured to the mask structure but a preferable arrangement features holes in the envelope section to receive positioning pins which are secured to leaf springs attached to the periphery of the mask. It will be assumed that the mask has the now familiar aperture pattern in which a multiplicity of apertures are distributed in essentially the same pattern of distribution as desired for the triads to be constructed on envelope section **3**. The diameter of the screen apertures or holes varies in one sense with distance from the center to the periphery of the mask. In particular, the hole diameter decreases with distance from the center of the masks in all radial directions.

Locating and holding fixtures **4**, **5** are attached to shelf **2** to facilitate quickly, accurately and securely positioning envelope section **3** in its exposure position.

In order to expose envelope section **3** through shadow mask **7**, a light source **10** is supported within the light house at a predetermined distance from the central portion of envelope section **3** in the general direction of or along reference axis A—A but at an acute angle *a* relative to that axis. More specifically and as explained above, the light source during the processing of one group of elemental target areas is positioned at the center of deflection of that beam which the light source simulates during the photographic exposure process. Generally, the center of deflection is located near the center of the deflection yoke that is to be associated with the completed tube when the tube is to be used for image reproduction. Obviously, there are three centers of deflection, one for each of the three primary colors, and the centers are spaced approximately 120° apart. In short, the position of the light source and its spacing from screen **3** are well defined in terms of the center of deflection in the manner thoroughly understood in the art.

Light source **10** comprises a linear mercury lamp **11** to one side of which is positioned a spherical reflector **12** of aluminum. The lamp is commercially available under the designation BH–6 from General Electric Company and, for convenience, the excitation circuit of the lamp has been omitted from the drawing. On the opposite side of the lamp is a collimator employed so that, viewed at the center of deflection, the light appears to emanate from a point source.

It has been the practice in the past to utilize a formed quartz collimator terminating in a spherical type diffusion tip. Such a collimator exhibits total internal reflection for rays which strike the interface at any angle exceeding the critical angle but since there are a number of rays that impact at less than the critical angle, it has proven to be inefficient. Accordingly, light source **10** is improved particularly in its collimator.

The collimator **13** is constructed of metal, such as aluminum, which reflects ultra-violet light. More particularly, it is a metallic cylinder which is hollowed out so that the internal cavity represents the external configuration of the usual quartz collimator. The specific configuration of the cavity is dictated by the light source employed and where the source is linear, as is the case of lamp **11**, the cavity has the general configuration of a bullet being circular in any plane transverse to its longitudinal axis. Its diameter is large at the end opposite lamp **11** to accumulate light but the opposite end is of relatively small diameter and terminates in a diffusion tip **14** which may be formed of quartz. The specific shape of the tip is governed by the directivity pattern desired for the screen exposure. Tips of spherical or parabolic configuration have been used successfully. Also tips that conform to the configuration of a Gothic arch are advantageous. Lamp **11**, reflector **12** and collimator **13** are contained within a metallic housing **15** which is disposed at an acute angle *a* with respect to reference axis A—A.

The angle *a* of the light source is preferably adjustable to contribute flexibility to the light house structure but it is always established at a value that does not exceed

one-half the maximum deflection angle of the cathode-ray tube being processed. For example, if the tube has a 90° cone, angle *a* will be less than 45°.

The adjustability of the light angle is facilitated by securing the end of assembly **15** which contains diffusion tip **14** in a double gimble arrangement centered at the exposure center for the particular color in question. For this purpose the light house may have a support shelf **16** to which is secured an outer gimble comprising a ring **17** and pivots **18, 18.** The inner gimble comprises a ring **19** which is concentric with ring **17** and pivot pins (which do not appear in the drawing) in a plane at right angles to the plane of pivot pins **18.** Of course, the pivots for ring **19** pivot this ring to outer ring **17.** The diffusion tip **14** is at the center of the double gimble.

It is desirable to establish for light source **10** a directivity pattern such that the integrated intensity of light directed to the mask varies, with distance from the center in the direction of the periphery, in the opposite sense to the variation of the aperture diameter in the mask. More specifically, the light intensity needed for exposing the entire screen with an exposure of constant time is such that the intensity is a minimum at the center and increases toward the edge whereas the directivity pattern of the light is a maximum along the light axis B—B which in prior art devices was substantially aligned with the tube axis. In other words, as represented by the graphs of FIGURES 2 and 3, the variations are inversely related to one another. This relationship of light variation as needed may be accomplished in the construction of light source **10** alone or through the construction of the light source augmented by a filter **20** interposed between light source **10** and target **7.** The filter is merely a light attenuator with an attenuation that adjusts the light intensity for uniform time exposure. It is usually found that the diffusion tip causes the light to be strongest along the axis B—B of collimator **13** and to diminish gradually and symmetrically relative to that axis.

The support for filter **20** has not been shown because it would be a conventional bracket arrangement located so as to avoid casting any shadows on mask **7** or screen **3.**

The directional exposure light obviously exposes less than all of the screen surface at one time because of its angular relation to reference axis A—A and, therefore, it is necessary to establish relative rotary motion between target **3** and the light source throughout a selected exposure interval to effect the exposure of the target to a projected image of imaging structure **7.** While this may be accomplished by an oscillatory motion, it is more convenient to rotate envelope section **3** or light source **10** and as represented in FIGURE 1 the latter is rotated. Structurally, there is a driving shaft **22** which is rotated by any suitable power drive as indicated by the arrow (not shown). A portion of the shaft is threaded and extends through the bearing or bushing section of an adjusting plate **23.** The position of the plate along the shaft is determined by a pair of adjusting nuts **24, 24.** An extension of plate **23** accommodates a ball and socket joint **25** which slidably receives a pin **26** extending from housing **15** of light source **10.**

In using the light house of FIGURE 1, a target or envelope section **3** which has previously received a coating of a photo-resist carrying a particular color phosphor in suspension, is fixedly supported in its exposure position by being placed on shelf **2** at the top of the light house. By adjusting the vertical position of plate **23** on shaft **22** as well as its angular relation relative to shaft **22,** angle *a* of light source **10** relative to reference axis A—A is determined to establish the desired azimuth uniform but radially varying directivity pattern of the light source in relation to the mask and screen section. Angle *a* may be chosen so that the maximum light is directed to the edge portion of the mask and the diffused light, of progressively decreasing intensity, extends at least to axis A—A. Rotation of shaft **22** causes light source **10** to rotate about diffusion tip **14** as a stationary point. The effect is to scan mask **7** and effect an exposure of envelope section **3** in accordance with the light which is permitted to reach the screen section through mask **7.** In other words, the target is exposed to a projected image of the shadow mask. The exposure time is maintained so that continuous scanning causes uniform exposure of the whole target surface to the projected image of the shadow mask. Optical lens error correction means conventionally used in exposing the screen are well known in the art but have not been shown. Filter **20** may be applied to these optical means instead of being separately supported. After the exposure, the unexposed photo-resist is washed away, preparing envelope section **3** for a further coating of a photo-resist which carries a different color phosphor. The envelope section **3** with its companion mask are now ready for a second exposure with the light source positioned at the deflection center for the next one of the primary colors. In this fashion, all three groups of elemental target areas are established on envelope section **3** as required to create the desired triad structures in an appropriate pattern of distribution related to the aperture distribution of shadow mask **7.**

In carrying out the three exposures, a single light house structure may be employed but it will be necessary to, in effect, relocate the effective point light source at each of the three color centers in succession. This can be accomplished by having the light assembly mounted for rotation about an axis corresponding to the axis of the tube or by rotating screen section about the tube axis **3** a fixed amount and leaving the light source in a fixed position. As a production method, however, three light house structures are employed, one for each of the primary colors. Each such light house may be of the type shown.

It is of course possible to retain light source **10** stationary and rotate envelope section **3.** This is accomplished with the modification of FIGURE 4. In this case, shaft **22** is not driven, instead a rotatable section **30** of the light house may be driven through a worm or other drive arrangement **31** to rotate the tube section **3** secured thereto about an axis parallel to the tube axis and through the exposure center.

The described arrangement is more efficient than previous structures where the light filter attenuated up to as much as 85% of the light issuing from the diffusion tip. While a light filter **20** has been illustrated, it has very much less attenuation because the directivity pattern of the light source drastically reduces the requirements of the filter in arranging for uniform time exposure of the entire target area.

While particular embodiments of the invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. The method of exposing the multi-color target of a cathode-ray tube for reproducing an image in simulated natural color which comprises the steps of: supporting said target in an exposure position which is substantially normal to a reference axis passing centrally through said target; supporting at a predetermined distance from the central portion of said target in the general direction of said reference axis but at an acute angle relative to said axis, a directional approximate point light source having a directivity pattern of light intensity which increases along a selected radius of said target from a minimum at said central portion of said target to a maximum in the direction of the outer periphery thereof; supporting an imaging structure across said axis between said target and said light source; and establishing relative rotary motion between said target and said light source throughout a selected exposure interval while maintaining said light

source at said acute angle relative to said axis and in a fixed location relative to said reference axis and to said target to sequentially establish said directivity pattern of light intensity along all radii of said target and effect substantially uniform exposure of said target to a projected image of said imaging structure.

2. The method of exposing a multi-color target of a cathode-ray tube for reproducing an image in simulated natural color which comprises the steps of: supporting said target in a stationary exposure position which is substantially normal to a reference axis passing centrally through said target; rotatably supporting at a predetermined distance from the central portion of said target in the general direction of said reference axis but at an acute angle relative to said axis, a directional approximate point light source having a directivity pattern of light intensity which increases along a selected radius of said target from a minimum at said central portion of said target to a maximum in the direction of the outer periphery thereof; fixedly supporting an imaging structure across said axis between said target and said light source; and rotating said light source about said reference axis throughout a selected exposure interval while maintaining said light source at said acute angle relative to said axis and in a fixed location relative to said reference axis and to said target to sequentially establish said directivity pattern of light intensity along all radii of said target and effect substantially uniform exposure of said target to a projected image of said imaging structure.

3. The method of exposing a multi-color target of a cathode-ray tube for reproducing an image in simulated natural color which comprises the steps of: rotatably supporting said target in an exposure position which is substantially normal to a reference axis pasing centrally through said target; supporting at a predetermined distance from the central portion of said target in the general direction of said reference axis but at an acute angle relative to said axis, a stationary directional approximate point light source having a directivity pattern of light intensity which increases along a selected radius of said target from a minimum at said central portion of said target to a maximum in the direction of the outer periphery thereof; supporting an imaging structure across said axis between said target and said light source; and rotating said target about said axis throughout a selected exposure interval while maintaining said target substantially normal to said reference axis to sequentially establish said directivity pattern of light intensity along all radii of said target and effect substantially uniform exposure of said target to a projected image of said imaging structure.

4. The method of exposing the multi-color target of a cathode-ray tube having a predetermined maximum deflection angle and useful for reproducing an image in simulated natural color which comprises the steps of: supporting said target in an exposure position which is substantially normal to a reference axis passing centrally through said target; supporting at a predetermined distance from the central portion of said target in the general direction of said reference axis but at an acute angle relative to said axis less than half said deflection angle, a directional approximate point light source having a directivity pattern of light intensity which increases along a selected radius of said target from a minimum at said central portion of said target to a maximum in the direction of the outer periphery thereof; supporting an imaging structure across said axis between said target and said light source; and establishing relative rotary motion between said target and said light source throughout a selected exposure interval while maintaining said light source at said acute angle relative to said axis and in a fixed location relative to said reference axis and to said target to sequentially establish said directivity pattern of light intensity along all radii of said target and effect substantially uniform exposure of said target to a projected image of said imaging structure.

5. The method of exposing the multi-color target of an aperture-mask type of cathode-ray tube for reproducing an image in simulated natural color which comprises the steps of: supporting said target in an exposure position which is substantially normal to a reference axis passing centrally through said target; supporting at a predetermined distance from the central portion of said target in the general direction of said reference axis but at an acute angle relative to said axis, a directional approximate point light source having a directivity pattern of light intensity which increases along a selected radius of said target from a minimum at said central portion of said target to a maximum in the direction of the outer periphery thereof; supporting across said axis between said target and said light source a mask having a multiplicity of apertures for which the effective diameter of apertures spaced outwardly from the center of the mask varies essentially inversely to the directivity pattern of light intensity of said light source; and establishing relative rotary motion between said target and said light source throughout a selected exposure interval to sequentially establish said directivity pattern of light intensity along all radii of said target and effect substantially uniform exposure of said target to a projected image of said mask.

6. The method of exposing the multi-color target of an aperture-mask type of cathode-ray tube for reproducing an image in simulated natural color which comprises the steps of: supporting said target in an exposure position which is substantially normal to a reference axis passing centrally through said target; supporting at a predetermined distance from the central portion of said target in the general direction of said reference axis but at an acute angle relative to said axis, a light source; supporting across said axis between said target and said light source a mask having a multiplicity of apertures for which the effective diameter decreases from a maximum at the center with distance toward the periphery of said mask; interposing a filter between said light source and said target to establish for said light source a directivity pattern such that the intensity of light increases from the center toward the periphery of said mask; and establishing relative rotary motion between said target and said light source throughout a selected exposure interval to effect the exposure of said target to a projected image of said mask.

7. The method of exposing the multi-color target of an aperture-mask type of cathode-ray tube for reproducing an image in simulated natural color which comprises the steps of: supporting said target in an exposure position which is substantially normal to a reference axis passing centrally through said target; supporting at a predetermined distance from the central portion of said target in the general direction of said reference axis but at an acute angle relative to said axis, a light source; supporting across said axis between said target and said light source a mask having a multiplicity of apertures for which the effective diameter varies in one sense with distance from the center to the periphery of said mask; interposing a filter between said light source and said target to establish for said light source a directivity pattern such that the intensity of light directed to said mask varies in the opposite sense with distance from the center to the periphery of said mask at least over part of the target; and establishing relative rotary motion between said target and said light source throughout a selected exposure interval to effect the exposure of said target to a projected image of said mask.

8. The method of exposing the multi-color target of an aperture-mask type of cathode-ray tube for reproducing an image in simulated natural color which comprises the steps of: supporting said target in an exposure position which is substantially normal to a reference axis passing centrally through said target; supporting at a predetermined distance from the central portion of said target in the general direction of said reference axis but at an acute angle relative to said axis, a light source; supporting

across said axis between said target and said light source a mask having a multiplicity of apertures for which the effective diameter varies in one sense with distance from the center to the periphery of said mask; establishing for said light source a directivity pattern at least over part of the target such that the intensity of light directed to said mask varies in the opposite sense with distance from the center to the periphery of said mask; and establishing relative rotary motion between said target and said light source throughout a selected time exposure interval uniformly to expose the surface of said target to an image of said mask.

9. The method of exposing the multi-color target of an aperture-mask type of cathode-ray tube for reproducing an image in simulated natural color which comprises the steps of: supporting said target in an exposure position which is substantially normal to a reference axis passing centrally through said target; supporting at a predetermined distance from the central portion of said target in the general direction of said reference axis but at an acute angle relative to said axis, a light source; supporting across said axis between said target and said light source

a mask having a multiplicity of apertures for which the effective diameter varies in one sense with distance from the center to the periphery of said mask; establishing for said light source a directivity pattern which projects on to only a fractional portion of said target such that the intensity of light directed to said mask varies in the opposite sense with distance from the center to the periphery of said mask; and establishing relative rotary motion between said target and said light source throughout a selected exposure interval to scan said directivity pattern over said target uniformly to expose the surface of said target to an image of said mask.

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NORTON ANSHER, *Primary Examiner.*

JOHN M. HORAN, *Examiner.*