Aug. 6, 1957 R. D. EATON 2,801,566

APPARATUS FOR MAKING PHOTOGRAPHIC NEGATIVES

Filed April 7, 1954 2 Sheets-Sheet 1

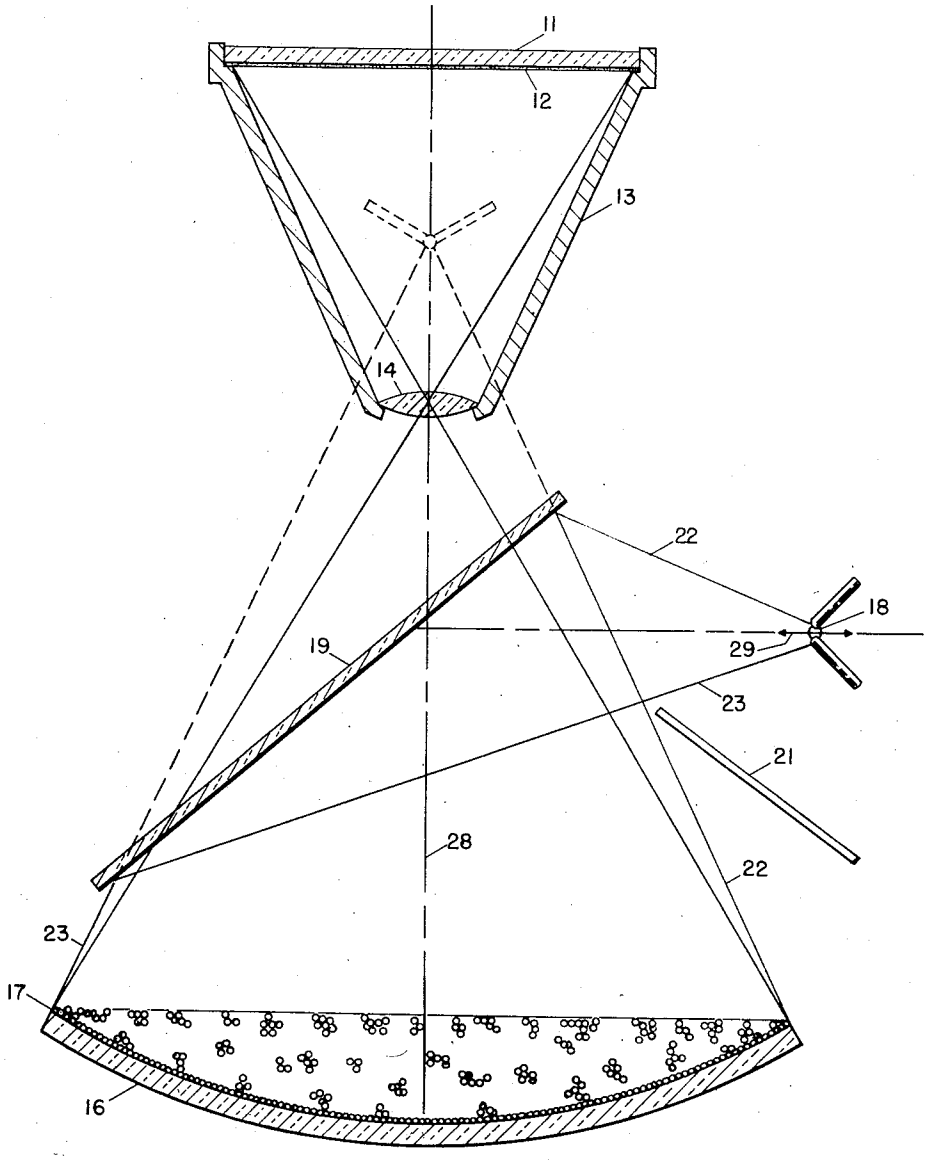

Fig. 1

INVENTOR.
ROLAND D. EATON
BY Darby & Darby
ATTORNEYS

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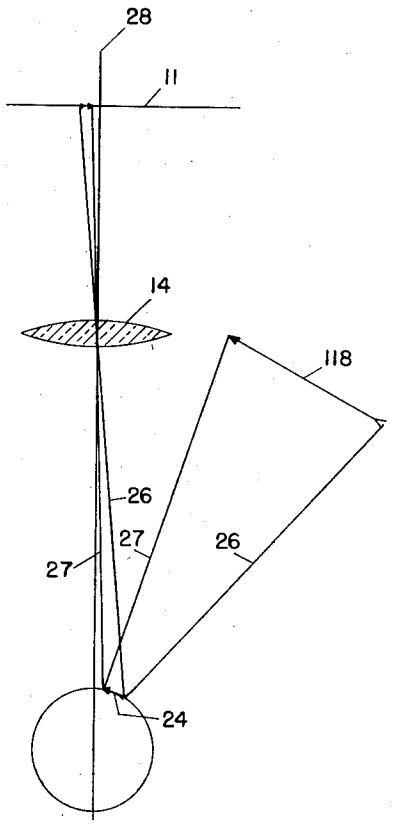

Fig. 2

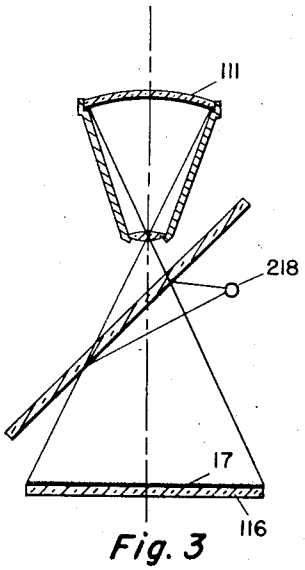

Fig. 3

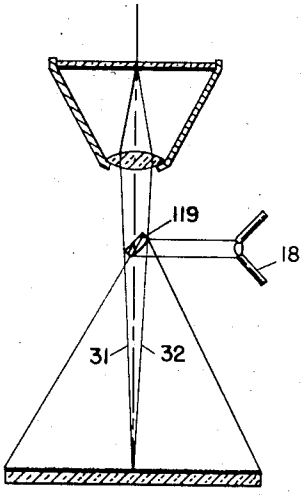

Fig. 4

INVENTOR.
ROLAND D. EATON
BY Darby & Darby
ATTORNEYS

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APPARATUS FOR MAKING PHOTOGRAPHIC NEGATIVES

Roland D. Eaton, Radburn, N. J., assignor to Allen B. Du Mont Laboratories, Inc., Clifton, N. J., a corporation of Delaware

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6 Claims. (Cl. 88—24)

This invention relates to an apparatus for making a photographic image consisting of a large number of dots or lines arranged in a precise and predetermined pattern. The invention relates in particular to the making of such images as part of the process of forming masks for color television tubes.

This application is a continuation-in-part of co-pending application Serial No. 343,987.

One form of cathode ray tube for color television is a so-called dot tube in which the faceplate of the tube, or an internal faceplate, is covered with phosphor dots arranged in groups of three. These groups, which are called triads, each contain a dot of phosphor capable of emitting light having a red hue, a second dot emitting light having a green hue, and a third dot emitting light having a blue hue. The faceplate on which these dots are arrayed is located within the tube in position to be scanned by an electron beam or beams from one or more electron guns, and a perforated mask is placed between the guns and the plate. The mask allows the electron beam from one gun, or from one direction, to strike only those elemental phosphor dots emitting light having a red hue. Correspondingly, electron beams from other guns or directions are restricted to strike phosphor dots emitting light having green or blue hues.

It is customary to deposit several hundred thousand phosphor dots on a single faceplate and it is necessary to obtain a maximum coverage of the screen area. The usual arrangement is to disperse the dots in each triad to the three corners of an equilateral triangle and to disperse the triads in a generally hexagonal pattern to make each triad uniformly contiguous with its neighbors, or substantially so. Since there must be one opening in the mask for each triad, the openings are required to be dispersed in the same hexagonal pattern and to be spaced precisely from one another.

Another type of tube for color television has the elemental phosphor areas arranged in lines instead of dots. The accuracy of placement of these lines must be as great as the accuracy of placement of dots in the tubes mentioned hereinabove in order to make maximum use of the faceplate area.

It is one object of the present invention to produce a mask having the required uniform dispersion of openings therein to be used in color television cathode ray tubes.

It is another object of this invention to make such masks in part by means of a photographic process and to utilize the known accuracy of ball bearings or rods in forming a photographic image from which the masks may be made. A further object is to produce a photographic image having properly dispersed elemental exposed areas thereon in which a comparatively large source of illumination is used to expose the photographic plate.

Other objects will be aparent from a study of the specification in connection with the drawings, in which,

Fig. 1 is a side view of one arrangement for making a photographic image of the type required in producing masks for color television tubes;

Fig. 2 shows diagrammatically the principles of the optical system of Fig. 1;

Fig. 3 shows a modification or rearrangement of the elements of Fig. 1;

Fig. 4 shows a modification of the mirror in Fig. 1.

The apparatus and method by which the desired photographic images are accomplished is briefly as follows: A support member having a large number of precisely spaced curved protuberances on one surface thereof is illuminated and the light reflected by the protuberances is focused by a lens onto a photosensitive image plate. One simple way of attaining precision in the spacing is to use, for the protuberances, closely packed ball bearings resting on the upper surface of a support member. Alternatively rod-like bearing may be used; or protuberances may be formed, based on ball or rod bearing spacings, on a surface, such as metal or glass. Either the surface or the image plate may be planar, spherical, or cylindrical and advantages of each form will be set forth more fully hereinafter.

In order to direct the light to proper portions of the surfaces of the protuberances, a mirror may be placed above the support member and oriented at an angle so as to reflect light from the source down onto the protuberances at the same angle as if the source were located on the optical axis with the image plate and lens. Preferably this mirror is of the semi-transparent, or interference, type so that light reflected by the protuberances passes through the mirror in reaching the image plate, which, together with an objective lens, is suspended over the support member. Alternatively, the mirror may be opaque, but in that event, it must be made small enough to allow light to pass beside it and still enter the lens to be focused on the image plate. Since it is necessary that all of the protuberances be illuminated, the mirror must reflect a widely dispersed cone of light. This is no problem if an interference mirror is used because such a mirror can and should be made large enough to intercept a large cone of light from the source, but a small mirror can intercept only a small cone and hence must have a convex surface to disperse the reflection thereof over a suitably large angle.

Fig. 1 shows one form of apparatus for making photographic images consisting of a large number of spots of light precisely spaced in a black field. The image is formed on an image plate **11** which has been treated with a layer **12** of photosensitive material on one surface. The plate **11** is secured in a holder **13** which includes an objective lens **14**. Although the lens **14** is depicted as a simple magnifying lens of fixed focus in Fig. 1, it is well known to use different objective lenses in similar optical arrangements when special characteristics are required. The object field or the lens **14** comprises a member **16**, preferably concave in shape, having on the inner surface thereof the plurality of curved protuberances. Individual points of light may be reflected from the curved protuberances through the lens **14** onto the photosensitive layer **12** of image plate **11**. The protuberances may be in any preferred form. They may, for instance, comprise a plurality of dimple-like or convex points formed in the member **16**. Alternatively, they may comprise a large number of rounded light-reflecting surfaces such as ball bearings mounted or set fixedly in position to cover the area or surface of the support member **16**.

The bearings are illuminated by light from a bright source, such as the electric arc **18**, the light from which reaches the bearings only after being reflected from a semi-transparent or interference mirror **19**. The light is positioned preferably adjacent one side of the apparatus to reflect light from the mirror into the bearings. A baffle **21** shades the ball bearings **17** from direct rays of the arc **18** so that only that portion of the light included

within the marginal rays 22, 23 reaches the ball bearings 17.

Referring to Fig. 2, it will be seen that, although light from the source, here represented by an arrow 118, illuminates an entire hemisphere of each ball, only a small portion, as indicated by the arrow 24 is reflected in such a direction as to pass through the lens 14. Thus, a greatly reduced image of the source 118 is reflected by each ball bearing 17. As a matter of fact, the image will not only be reduced in size but will be distorted in outline so as to appear even more circular than it normally is. A further refinement which may be noted in passing is that the size of the image of the arrow actually focused on the plate 11 is not limited to the minute length determined by the rays 26 and 27 but, because of rays which pass through lens 14 in regions other than the center thereof, is somewhat larger. However, to a first approximation, the length of the image of arrow 118, focused on plate 11, is very nearly determined by the small distance between ray 26 and ray 27.

For simplicity, Fig. 2 was drawn without the interference mirror 19 of Fig. 1. The apparatus of Fig. 1 may actually be set up without the mirror 19 and the baffle 21, but if that is done, the image of arc 18 reflected by the ball bearings 17 will be located in a slightly different position on each of the balls. If the resultant assymmetry in the image on plate 11 is objectionable, the arc 18 should be moved as close to the optical axis as possible without allowing light from the arc to enter lens 14 directly.

Referring again to Fig. 1, the lens 14 has an optical axis 28 on which the plate 11 and support member 16 are aligned. Interference mirror 19 is oriented at approximately a 45° angle to the axis 28 so that light from the arc 18 strikes the balls 17 from the same angle as if the arc were located in the position indicated in dotted outline. By moving the arc 18 back and forth in the direction indicated by the double-ended arrow 29, the apparent position of the arc moves up and down on axis 28. The arc 18 may be moved to such a position that it appears to be at the center of curvature of support member 16, in which case all of the balls 17 will be equidistant from the arc and will receive equal illumination. Furthermore, the lens 14 may be placed at the same center of curvature. As is well known, a simple lens really focuses a spherical object on a planar image plate, so that by moving the lens 14 to the center of curvature of support member 16, light spots reflected from each of the balls 17 will be equally in focus on the image plate 11.

Fig. 3 shows an alternative arrangement wherein light from balls 17 on a planar support member 116 is focused on a spherical image plate 111. The balls 17 may be retained on the flat support member 116 in any suitable manner such as cementing.

Fig. 3 also illustrates a different type of light source 218. Because of the reducing effect of the balls 17 on the image of the light source, a comparatively large source may be used instead of point sources which have been considered necessary heretofore.

Fig. 3 may be considered illustrative of yet another arrangement if the curved protuberances are considered to be the ends of smoothly polished rods. In that case, the light source 218 preferably should be an elongated source, such as a fluorescent tube or the like extending parallel to the rods on support member 116. Also, for such a modification, the concave image plate 111 may be a section of a cylinder rather than a section of a sphere.

Elements of Figs. 1 and 3 may be combined so that there is a concave support member 16 as shown in Fig. 1 and a concave image plate 111 as shown in Fig. 3. The advantage of such an arrangement is that the ball bearings or rods would remain in position without being cemented on the concave surface of support member 16, while, by making the radius of curvature of this surface greater than the distance along axis 28 from lens 14 to the support member 16, optimum focus would most easily be obtained by curving the image plate slightly, as shown by the image plate 111 of Fig. 3.

This arrangement would be particularly advantageous if it were desired to use curved masks where the curvature is determined by the configuration of the tubes. It is a simple matter to so construct the support member 16 that the image plate 111 would have the required curvature. Known methods could then be used to etch holes in the exposed image plate and the treated plate used directly as the mask of a color television tube.

Fig. 4 shows yet another embodiment of the invention, this time with a small mirror 119 in place of the large, plane, interference mirror 19 of Figs. 1 and 3. The mirror 119 is opaque and, since light reflected by the balls 17 cannot pass through it, the mirror 119 must be small enough so as not to obscure the lens 14. Then light reflected by any of the balls 17 can reach lens 14 by passing around the mirror 119. The light most likely to be cut off by making the mirror 119 too large is that reflected by the balls closest to the axis 28. If, as is indicated by the light rays 31 and 32, light from the ball directly on the axis 28 may pass around the mirror 119 and still fall within the periphery of lens 14, light from all of the balls 17 will reach the image plate 11.

However, the use of a small mirror 119 means that the cone of light from source 18 intercepted thereby will have a small angle. In order to reflect light from mirror 119 over a large angle, it will be necessary to make the reflecting surface thereof either convex or concave with a radius of curvature such as to spread a narrow cone of impinging light from source 18 over a wide angle.

What is claimed is:

1. Apparatus for producing a photographic negative, comprising a plurality of discrete light-reflective surfaces lying in a segment of a sphere, said discrete light-reflective surfaces comprising a plurality of polished light-reflective ball-like elements, a mirror positioned near the center of radius of said sphere on the axis thereof, a light source positioned to project light onto said mirror, said mirror and said source being positioned so that said light is reflected onto said plurality of discrete reflective surfaces, a flat photographic plate, and light focusing means positioned axially with respect to said segment and between said mirror and said plate, for focusing the light reflected from said discrete surfaces onto said plate.

2. Apparatus for making a photographic image consisting of a plurality of elemental areas having a predetermined spaced relation to each other, said apparatus comprising an image plate on which said image is formed; an object surface having a plurality of identical convex protuberances thereon; a source of illumination; a mirror to direct light from said source to all of said protuberances; and a lens to focus a portion of the light reflected by said protuberances onto said image plate; said mirror intercepting a sufficiently large cone of light from said source to reflect light to all of said protuberances and being located on an optical axis through the center of said lens and through said surface, the portion of said mirror through which said optical axis passes being oriented at substantially a 45° angle to said axis; said mirror being convex and opaque and smaller in projected area than the area of said lens.

3. Apparatus for making a photographic image consisting of a plurality of dots arranged according to a predetermined pattern, said apparatus comprising: an image plate on which an image is to be formed; a concave object surface; a plurality of identical ballbearings resting on said surface and packed together in continuous equilateral triangular relation; a light source to illuminate all of said bearings, said light source being positioned off said axis and projecting light at substantially a right angle to said axis; a lens to focus a portion of light reflected by said bearings onto said image plate, said lens having an optical axis passing perpendicularly through said image plate and said object surface; a mirror positioned on said

axis and oriented at substantially a 45° angle thereto to reflect light from said source onto said ballbearings, said mirror being semi-transparent to allow light reflected from said ballbearings to pass therethrough.

4. Apparatus for making a photographic image consisting of a plurality of elemental areas spaced in a predetermined and precise pattern, said apparatus comprising an image plate; an object surface having a plurality of identical light-reflecting protuberances thereon, said protuberances comprising a plurality of identical bearing balls dispersed on said surface in said predetermined pattern; a source of illumination to illuminate said protuberances; and a lens to focus a portion of the light reflected by each of said protuberances onto said image plate.

5. Apparatus according to claim 4 in which said surface is concave.

6. Apparatus for making a photographic negative consisting of uniformly spaced exposed portions, comprising: a camera-like arrangement including a lens and an image plate; a concave supporting member, said supporting member positioned on the optical axis of said camera-

like arrangement; means to provide discrete, specular-reflective areas uniformly spaced on said support member, said means including opaque rotund protuberances consisting of highly-reflective spheres in a closely packed relationship; means to illuminate said proturbances from a point effectively on said optical axis and near said lens; means to focus specular-reflections from said reflective areas onto said image-plate of said camera-like arrangement.

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