Oct. 10, 1961 V. K. ZWORYKIN 3,003,873

COLOR KINESCOPES AND METHODS OF MAKING THE SAME

Filed Dec. 23, 1953 2 Sheets-Sheet 1

Fig. 1.

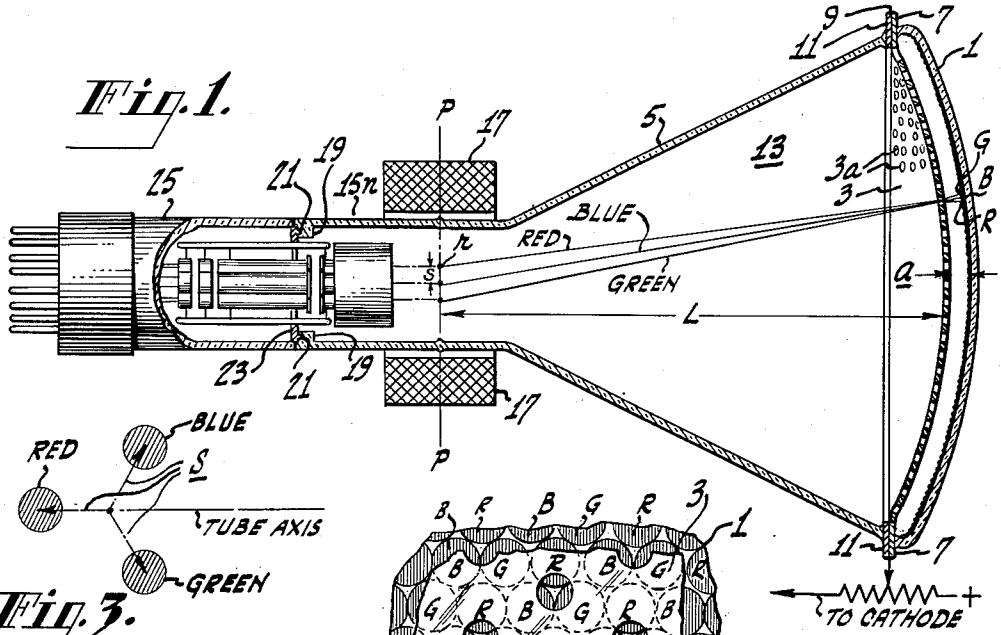


Fig. 3.

Fig. 2.

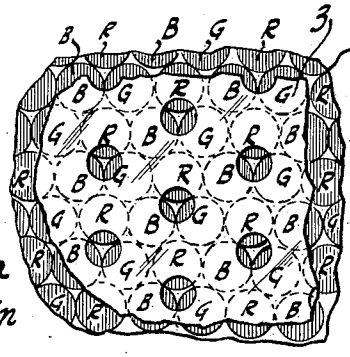


Fig. 6.

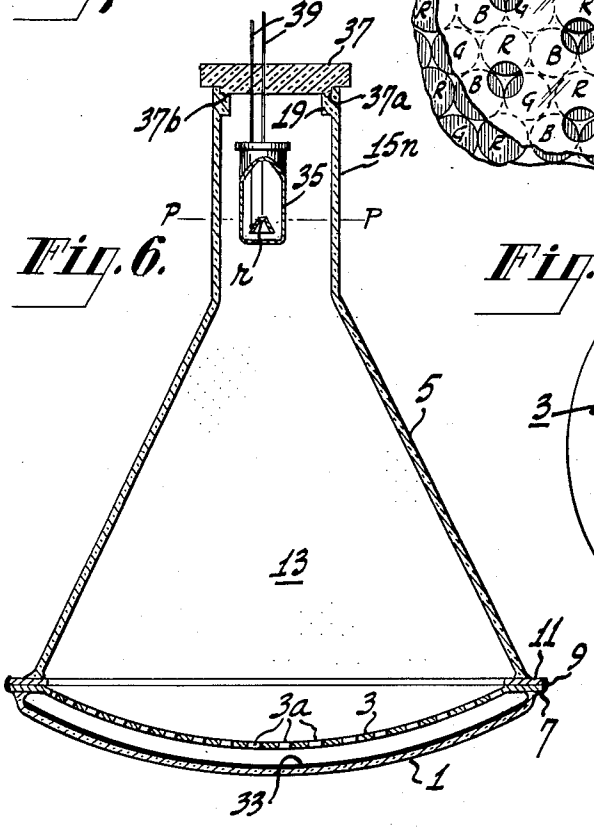
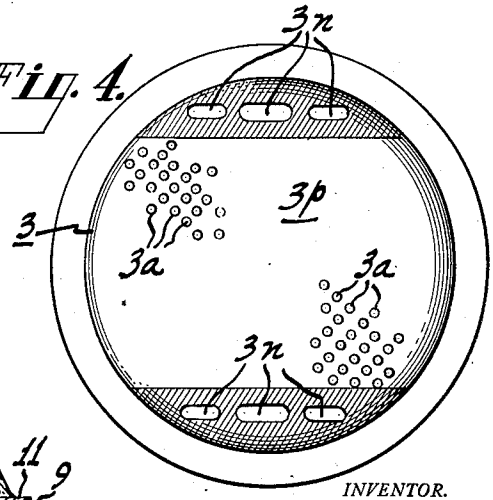


Fig. 4.



INVENTOR.
VLADIMIR K. ZWORYKIN

BY Roderick Malcolm.
ATTORNEY

Oct. 10, 1961 V. K. ZWORYKIN 3,003,873

COLOR KINESCOPES AND METHODS OF MAKING THE SAME

Filed Dec. 23, 1953 2 Sheets-Sheet 2

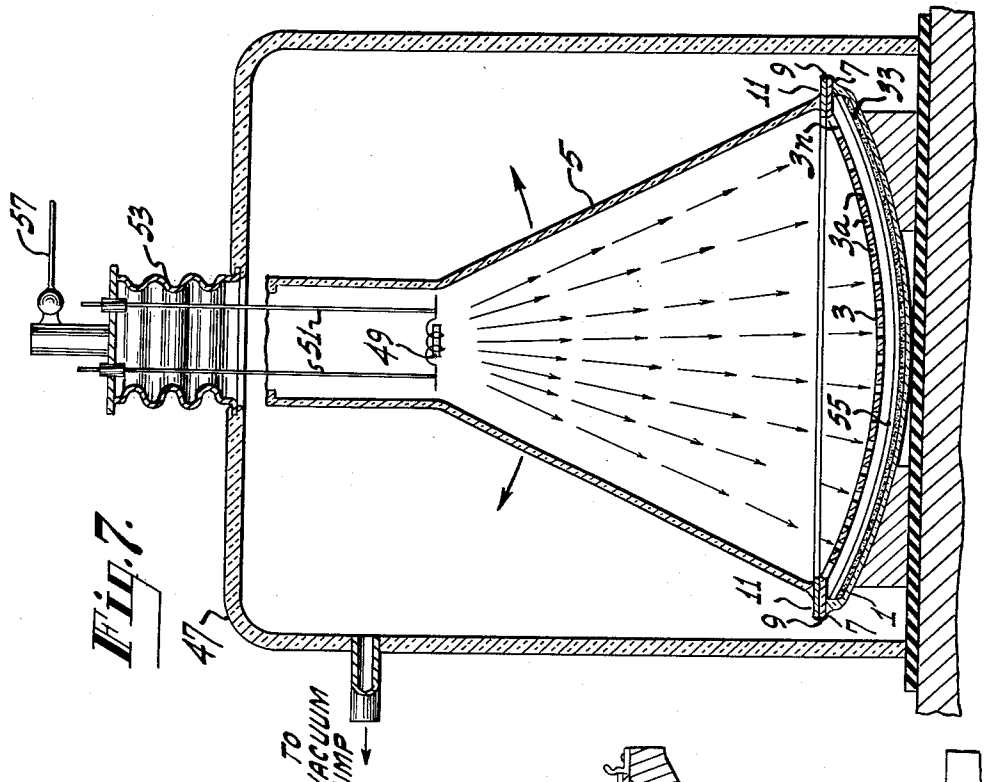


Fig. 7.

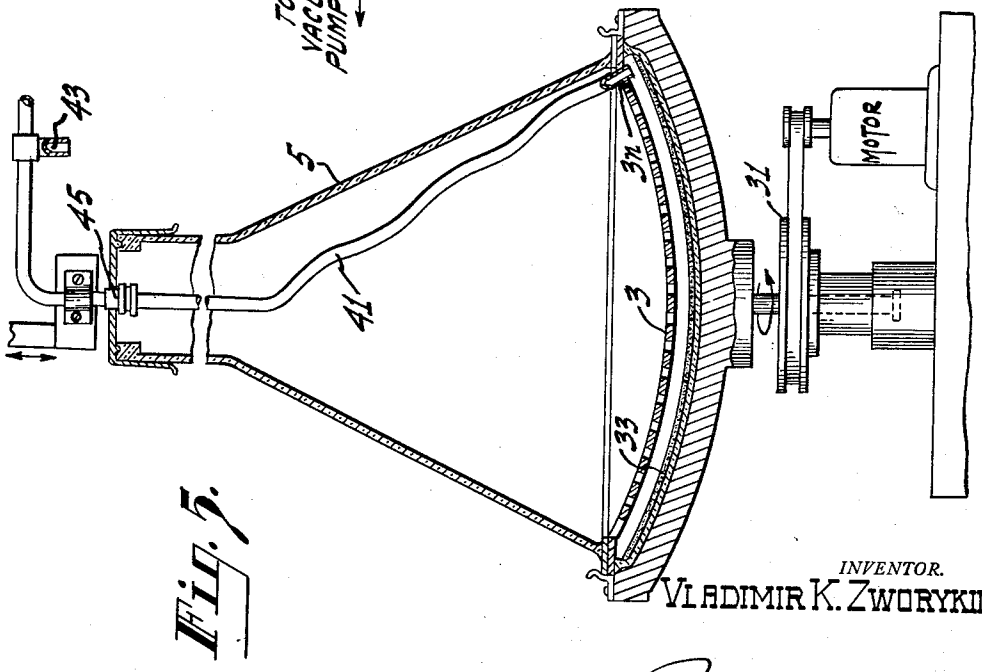


Fig. 5.

INVENTOR.
VLADIMIR K. ZWORYKIN

BY Roderick Malcolm
ATTORNEY

United States Patent Office 3,003,873 Patented Oct. 10, 1961

3,003,873

COLOR KINESCOPES AND METHODS OF MAKING THE SAME

Vladimir K. Zworykin, Princeton, N.J., assignor to Radio Corporation of America, a corporation of Delaware

Filed Dec. 23, 1953, Ser. No. 400,040
4 Claims. (Cl. 96—34)

This invention relates to improvements in the art of manufacturing color-kinescopes and other cathode-ray (CR) tubes of the kind having a plane-of-deflection (or "center-of-scan") and containing a screen-unit comprising (*i*) a "mask" containing a multiplicity of systematically arranged apertures through which beam-electrons pass along different angularly related paths in their transit from said plane-of-deflection to (*ii*) selected ones of the metallized dot-like or line-like elemental areas on the target-surface of a nearby screen-plate.

The problem of making a satisfactory mosaic-screen for use in color-kinescopes and analogous (e.g., "camera" and "stereoscopic") CR tubes has long been recognized and has engaged the attention of many scientists and experts in the television and photoengraving arts.

Thus, Dr. Zworykin, in his U.S. Patent 1,691,324 (filed July 13, 1925), proposed ". . . a three-color screen of the Paget type" placed in front of a conventional ("black-and-white") fluorescent screen. (The idea of using an optical color filter in conjunction with a black-and-white screen is a recurrent one, but one not likely to be adopted, commercially, because the thickness dimension of the tube's window introduces problems of parallax.)

Dr. Goldsmith in his U.S. Patent 2,630,542 (which is based on an application filed August 5, 1944), proposed (column 11) to use the mask of his screen-unit as a stencil through which the different color-phosphors are laid down in different positions by shifting said stencil. Dr. Goldsmith also proposed (column 10) to form his screen by ". . . weaving extremely thin wires carrying fluorescent material as an adherent coating."

The above mentioned Zworykin and Goldsmith methods of making mosaic screens were followed (*a*) by the printing-plate method of Hansen, 2,568,448; (*b*) the silk-screen printing method of Law, 2,625,734, and (*c*) the "direct" photographic method of Law, described and claimed in copending application Serial No. 239,358, filed July 30, 1951.

The Hansen method and the Law silk-screen method, like the method described in column 11 of the Goldsmith patent, have a disadvantage common to all three. That is to say, they each use a single printing plate (or stencil) for laying down two or more colors. Hence, the printing element must be shifted (with respect to the screen-plate) between the separate printing operations; thus introducing problems of color-registration. An analogous problem is encountered in the Law "direct photographic" method (Serial No. 239,358) wherein the screen-unit must be disassembled several times (for the purpose of sensitizing the separately photographed red, blue and green phosphor patterns on the screen-plate) and subsequently re-assembled prior to aligning said unit with the battery of electron-guns in the tube in which said screen-unit or "target assembly" is to be used.

Accordingly, the principal object of the present invention is to provide an improved CR tube of the masked-target variety and one characterized by its freedom from alignment and re-alignment problems encountered in the manufacture of present-day tubes wherein the mask-to-screen spacing is not permanently established until after the entire mosaic pattern has been laid-down on the screen-plate.

Another and related object of the invention is to provide improvements in the Law "direct photographic" method

of plotting and laying down electron-sensitive materials of different color-response characteristics upon a curved (or flat) target-surface of a screen-plate, and which dispense with the auxiliary "light-house," jigs, etc. required in the practice of earlier analogous methods.

Another object of the present invention is to provide a method of and means for applying an electron-permeable metal coating of substantially uniform thickness to a permanently masked screen-plate.

Stated generally, the foregoing and related objects are achieved in accordance with the method of the present invention by (*a*) first permanently securing the mask and the curved, or flat, foundation plate for the color-screen in the required spaced-apart relationship and (*b*) thereafter recording the mask's pattern of apertures on said screen-plate. When the "direct photographic" method of Law is employed the mask is of a special open-work construction which permits the photosensitive materials to be applied to the screen-plate without clogging the electron-transparent openings in the mask. The method is preferably carried out within the main chamber of a tube envelope of a novel "indexed" construction which ensures accurate location not only of the photographic light-source, but of the electron-gun assembly as well.

When, as is usually the case, the electron-sensitive mosaic pattern on the screen-plate is to be provided with an electron-transparent metal (e.g., aluminum) layer, the entire screen-unit is immersed in a vacuum and subjected to movement with respect to the source of metal, whereby particles of the metal are deposited substantially uniformly upon said mosaic surface irrespective of the presence of the mask in the path of the vaporized metal.

The invention is described in greater detail in connection with the accompanying two sheets of drawings wherein:

FIG. 1 is a partly diagrammatic longitudinal sectional view of a 3-gun tri-color kinescope of the "shadow-mask dot-screen" variety, the bulb or envelope of the kinescope and the screen-unit or "target-assembly" therein being constructed in accordance with the principle of the invention;

FIG. 2 is a fragmentary rear elevational view of the screen-unit of the color-kinescope of FIG. 1, showing a conventional (hexagonal) pattern of mask-apertures and color-dots;

FIG. 3 is a diagram showing the relative location of the three beams, with respect to the tube axis, in the plane of deflection;

FIG. 4 is an elevational view of the mask of the screen-unit; said mask being provided with openings adjacent to its periphery to permit access to the screen-plate which is therebeneath;

FIG. 5 is partly diagrammatic sectional view of a tube-envelope containing a screen-unit at a stage of its manufacture whereat it is subjected to centrifugal force in order to spread a photosensitive material evenly over the target-surface of its screen-pate;

FIG. 6 is a partly diagrammatic sectional view of a tube-envelope containing a source of light-rays for projecting the pattern of mask apertures on the photosensitized screen-plate;

FIG. 7 is an elevational view, partly in section, of a vacuum apparatus employed in metalizing the mosaic target-surface of the screen-plate of the unit.

In the drawings the invention is shown as applied to the manufacture of a 3-gun tri-color kinescope of the so-called "masked-target dot-screen" variety (see Schroeder, 2,595,548) wherein the red (R), blue (B) and green (G) phosphor dots (see FIG. 2) are arranged in a hexagonal mosaic-pattern on the rear or "target surface" of a glass screen plate **1**. The glass-plate **1** may be of any desired shape (e.g. circular or rectangular) and curva-

ture (e.g. flat or spherical). In the instant case it is in the form of a circular section of a spherical shell. Alternatively, as shown, for example, in the Schroeder patent, the color-screen may comprise a flat glass plate independently mounted behind the window. The mask 3 for the screen-plate 1 may be made of perforated glass which has been metallized to render its surface conducting, or it may be formed of thin-metal or of any other conducting material which is immune to the materials employed in laying down the pattern of phosphor dots on the screen-plate 1.

When, as in the instant case, the mosaic screen pattern is to be laid down directly on the curved face plate 1 of the tube envelope 5, the mask 3 is appropriately curved so as to be approximately concentric with the curved inner or target-surface of said plate. In the finished tube of FIG. 1, the reference character *a* designates the spacing between the mask 3 and screen 1. The spacing *a* between these elements 3 and 1 of the screen-unit is approximately uniform throughout the "picture area" of the unit. The apertures 3*a* in the "picture area" 3*p* (see FIG. 4) of the mask 3 are arranged in the same (hexagonal) pattern as the phosphor "triads" R, B and G which are to be laid down on the screen-plate 1. In the instant case the apertures 3*a* which make up the "picture area" 3*p* of the mask 3 are of circular contour with a constant separation *d* between their centers. With such an hexagonal arrangement of apertures the "red," "blue" and "green" scanning beams (see FIG. 1) pass through the tube's plane-of-deflection P—P with the beam-centers equally spaced from each other and at a common distance *s* from the tube axis, as indicated in FIG. 3. The relation between the spacing *a*, the distance *s*, the aperture spacing *d* on the mask, and the separation L between the plane-of-deflection P—P and the mask 3 then becomes, for uniform coverage of the screen by phosphor dots,

$$a=Ld/(3s-d) \qquad (1)$$

Thus, if $L=14''$, $d=0.023''$, $s=0.225''$, $a=0.495''$. A comparable relation may be derived if, for example, a line-screen pattern is desired and slits, stablized by thin cross-bars, are provided on the mask, as in Flechsig's French Patent 866,065.

While the invention is applicable to masked-target tubes of both the "line-screen" and "dot-screen" varieties the rest of this description will be limited, in the interest of brevity, to tubes of the latter variety. In such tubes the dot-like apertures 3*a* in the "picture area" 3*p* of the mask 3 can ordinarily be no larger than:

$$\frac{d}{\sqrt{3}} \qquad (2)$$

in diameter although they may be made larger if a voltage is to be applied between the mask and the screen ("post-acceleration focusing"). In that event the herein described light-ray method of plotting the location of the color-dots can be modified by the substitution of electron-exposure (as taught by Law in copending application Serial No. 277,133, now U.S.P. 2,727,828), in place of light-exposure. In the rest of this description it will be assumed that the mask 3 and screen 1 are to be operated at the same voltage (as claimed by Law in U.S. Patent No. 2,663,821, issued December 22, 1953).

As previously mentioned, the present invention contemplates, and its practice provides, a screen-unit of the "masked-target" variety wherein the screen-plate 1 and its mask 3 are permanently joined, in the required spaced-apart relationship, prior to laying down the electron-sensitive mosaic pattern on the target surface of the screen. When the screen plate 1 and mask 3 are permanently united they may be handled as a single unit throughout all of the chemical and mechanical operations incident to the manufacture of a finished tube. As a consequence, image-defects, heretofore occasioned by the necessity of registering the mask apertures with the elemental or sub-elemental screen-areas, are obviated.

In practicing the invention it is preferable to weld, or otherwise affix the screen-unit 1—3 to the large end of the "shell" or body-portion of the tube envelope 5 prior to laying down the dot-like pattern R, B, G on the target surface of the screen 1. One very real advantage of securing the screen-unit to the tube-shell prior to laying down the mosaic pattern on the screen-plate is that the heat employed in making the required hermetic seal cannot adversely affect the phosphors or other electron-sensitive or photosensitive materials of which said pattern is formed. Furthermore, the tube when thus assembled may be used as the "light-house" during the plotting operation (cf., Law 2,532,511).

Accordingly, in carrying the method of the invention into effect the first step is to weld, or otherwise permanently secure, the marginal edge of the mask 3 to a metal sealing ring 7 or to mount it firmly in any other manner, at the desired distance from the target surface of the face-plate 1 or other "foundation member" upon which the mosaic screen-pattern is to be formed. Thereafter, the sealing ring 7 on the unfinished screen-unit 1, 3 is preferably sealed, as by a weld 9 about its periphery, to a complementary ring 11 on the large open end of the glass (or metal) shell 5 comprising the main chamber 13 of the kinescope.

The main body or shell of the envelope 5 includes the portion 15*n* of the neck 15 upon which the beam-deflection yoke 17 (FIG. 1) of the kinescope is mounted. This portion 15*n* of the neck extends beyond the plane-of-deflection P—P of the tube and is provided adjacent to its end with an indexed seat, which here takes the form of a number (say, three) of inwardly extending glass or metal studs 19 spaced (say 120°) apart for engagement with a similar number of complementary lands (or grooves) 21 in a flange 23 on the gun-assembly of the tube. Alternatively, the lands and grooves may be impressed on a pair of metal flanges similar to the ones (7 and 11) at the front end of the tube, in which case the horizontal and vertical deflecting coils in the yoke 17 can be assembled in situ on the neck of the tube. After the color-areas R, B and G have been laid down on the screen, and the gun-assembly properly oriented on its indexed seat, the gun-supporting glass end-portion 25 of the neck is hermetically sealed to the adjacent free end 15*n* of the neck as by means of a low-temperature glass-frit material, not shown. As will hereinafter more fully appear, prior to mounting the gun-assembly in the tube, the indexed seat 19, 21 also serves as support for certain auxiliary apparatus employed in laying down the mosaic pattern on the screen-unit.

The mosaic of red (R), blue (B) and green (G) phosphor dots may be laid down on the masked screen-plate 1 in any of various ways. For example, any of the four "direct" photographic methods described and claimed by Law (in application Serial No. 239,358) may be employed.

In order that the various photosensitive and electron-sensitive materials used in the Law photographic methods may be deposited on the masked screen-plate without clogging the apertures 3*a* in the mask 3 (see FIG. 3), the mask is provided with one or more openings 3*n* large enough to accommodate to spout, pipe, siphon or the like for said materials. As shown in FIG. 4 duplicate groups of openings 3*n* may be disposed on opposite sides of the apertured "target area" 3*p* of the mask.

In forming a tri-color mosaic in accordance with the Law photographic method the different color-phosphors are laid down one at a time on the screen-plate. Assuming that the "red" pattern is the first to be laid down, a red-phosphor powder in a liquid gelatine potassium bichromate emulsion is introduced through the large openings 3*n* in the mask. As indicated by the arrow ad-

jacent to the pulley **31** in FIG. 5 the tube envelope **5** is then spun about its vertical axis, to cause an even distribution of the emulsion **33** over the curved face-plate **1**, until the emulsion has solidified. If R is the radius of curvature of the face-plate, the appropriate number of revolutions per second is:

$$\frac{\sqrt{\frac{g}{R}}}{2\pi} \quad (3)$$

where g is the acceleration of gravity. Thus, for a radius of curvature of 24 inches, a speed of 38 revolutions per minute is appropriate.

Referring now to FIG. 6: As in the Law "direct" photographic methods, the photosensitive layer **33** is next exposed to a point-source of light **35** (such as a zirconium arc) positioned a point (r) corresponding to the point at the center-of-scan P—P which is allotted to the first color (in this case "red") to be laid down on the screen-plate. When, as in the instant cast, the neck-portion **15***n* of the tube is provided with an indexed seat **19** the lamp **35** is provided with an indexed baseplate **37** through which a pair of rod-like current leads **39** extend, off-center, the exact distance required to locate the point source of light in the plane of deflection. The base-plate **37**, like the gun mounting-flange **23**, is triply indexed, that is to say it is marked with three radial lands or grooves **37***a*, **37***b*, etc. permitting it to be shifted from a position corresponding to that of the red beam to that of the green and blue beams. As an alternative, a lamp with three point sources (not shown) which can be switched on in succession, mounted on a singly indexed base-plate may be employed as the removable insert.

When light-rays, from the point r, pass through the mask apertures **3***a* the photosensitive layer **33** on the screen-plate **1** is rendered insoluble at the positions of all of the red phosphor dots R in the mosaic.

The remaining soluble emulsion is then dissolved and drawn off (see FIG. 5) through a piece of tubing **41** presented to the screen-plate **1** through one of the large mask-openings **3***n* and which is connected to an aspirator **43** through a universal joint **45**. When the soluble emulsion has been drawn off, and the screen-plate properly cleansed, a photosensive emulsion containing the "blue" phosphor is introduced, then dried and the exposure repeated with the light source **35** (FIG. 6) at the point at the center-of-scan P—P which is allotted to the "blue" electron-beam (FIG. 1). Again the process is repeated, this time with a green-phosphor emulsion, leaving red, blue and green phosphor-dots in the proper position to be scanned by the red, blue and green electron-beams (FIG. 1).

In order to provide the tri-color mosaic with an electron-pervious light-reflecting conductive coating, the screen-plate **1** is covered with water in an amount sufficient to produce a layer less than the mask-screen separation in thickness. The tube is then spun (as in FIG. 5), with the velocity mentioned above, to make the water layer of uniform thickness and a few drops of collodion-solution are introduced through the large mask-openings **3***n* and spread over the surface of the spinning layer of water forming a solid film. The water is then siphoned off; the velocity of rotation being increased gradually to bring the water to the edge of the screen-plate. After drying, the unit is placed in an evacuable chamber or bell jar **47** (FIG. 7) and a piece of aluminum **49** is evaporated by a means of a heating current supplied through rod-like leads **51** which extend through a flexible seal, such as a Sylphon bellows **53** at the top of the chamber. Some of the evaporated aluminum settles on the mask **3** and some of it passes through the dot-like mask apertures **3***a* and settles upon the collodion blanket **55** covering the screen plate. A rotating movement is applied to the rod-like leads **51** through the flexible bellows **53** by a drive shaft **57**, during evaporation of the metal. The area scanned by the source of aluminum (**49**) in the plane-of-deflection should be, approximately, a circle with a diameter **3***s* (FIG. 3) about the tube axis to ensure a complete and even coating of aluminum on the target area of the mosaic screen; irrespective of the shadowing effect of the mask **3**. After evaporating the collodion layer or blanket **55**, the base portion **25** of the neck of the tube, with the three-electron-guns already mounted therein, is sealed to the small end **15***n* of the tube envelope **5** and the entire envelope subjected to evacuation in the usual way.

It should now be apparent that the present invention provides an improved screen-unit of the "masked-target" variety and one characterized by its freedom from alignment and re-alignment problems encountered in present-day screen-units wherein the mask-to-screen spacing is not permanently established until after the entire mosaic pattern has been laid down on the screen-plate.

What is claimed is:

1. Method of making a color-kinescope of the kind that includes a target-assembly comprising a mask containing a systematic pattern of apertures and a transparent envelope portion having a color-phosphor mosaic on its inner surface and a mask-supporting rim portion surrounding said mosaic, said method comprising: permanently securing said mask to said rim portion and thereafter coating said inner surface with a photosensitized organic gel containing phosphor particles of one color, exposing said coating to light rays through the apertures in said mask whereby photographically to record the pattern of said mask apertures on said surface, washing said surface to develop the photograph thereon, repeating said coating, exposing and developing steps for each of the other colors of said mosaic and then heating said surface to volatalize and remove said organic gel therefrom.

2. The invention as set forth in claim 1 and including the additional step of depositing metal in a finely divided state upon said color-phosphor mosaic through the apertures in said permanently secured mask.

3. The invention as set forth in claim 2 and wherein said permanently secured mask and envelope portion are rotated with respect to the source of said finely divided metal during the deposition of said metal, whereby said metal is deposited substantially uniformly upon said mosaic irrespective of the shadowing effect resulting from the presence of said mask in the path of said finely divided metal.

4. Method of making a tri-color kinescope of the kind having a plane-of-deflection and containing a target assembly comprising (*a*) a mask having a multiplicity of systematically arranged apertures therein through which beam-electrons pass in their transit from said plane-of-deflection to (*b*) selected ones of the elemental areas on the mosaic target surface of a nearby tri-color phosphor screen; said method comprising the following steps in the order indicated, (1) permanently securing said mask and the foundation plate of said screen in the required spaced-apart relationship, (2) coating said target surface with a film comprising phosphor of a first color contained in a photosensitive material, (3) directing light rays upon said permanently secured apertured mask from a first point in a plane corresponding to said plane-of-deflection whereby to provide a phosphor-containing photograph upon said target surface of the mosaic pattern resulting from the passage of said light rays through the apertures in said mask, (4) developing said photograph, (5) coating said target surface and the photograph thereon with a film comprising phosphor particles of a second color contained in a photosensitive material, (6) directing light rays upon said permanently secured apertured mask from a second point offset from said first point in said plane whereby to provide a second phosphor-containing photograph upon said target surface, (7) developing said second photograph, (8) coating said target surface, and the

photographs thereon, with a film comprising phosphor particles of a third color contained in a photosensitive material, (9) directing light rays upon said permanently secured apertured mask from a third point offset from said first and second points in said plane to provide a third phosphor-containing photograph upon said target surface, and then (10) developing said third photograph to provide a tri-color phosphor mosaic upon said target surface.

References Cited in the file of this patent

UNITED STATES PATENTS

1,099,934 Rafn et al. ---------- June 16, 1914

2,160,981 O'Brien ---------- June 6, 1939
2,435,889 Kerridge ---------- Feb. 10, 1948
2,446,915 Filmer ---------- Aug. 10, 1948
2,669,672 Kaplan ---------- Feb. 16, 1954
2,682,620 Sanford ---------- June 29, 1954
2,687,958 Neugebauer ---------- Aug. 31, 1954
2,755,402 Morrell ---------- July 17, 1956
2,767,457 Epstein ---------- Oct. 23, 1956

OTHER REFERENCES

Electronics, pp. 86–88, May 1951.

UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 3,003,873 October 10, 1961

Vladimir K. Zworykin

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, list of references cited, under UNITED STATES PATENTS, add the following:

2,540,635	Steir	Feb. 6, 1951
2,625,734	Law	Jan. 20, 1953

Signed and sealed this 10th day of April 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents