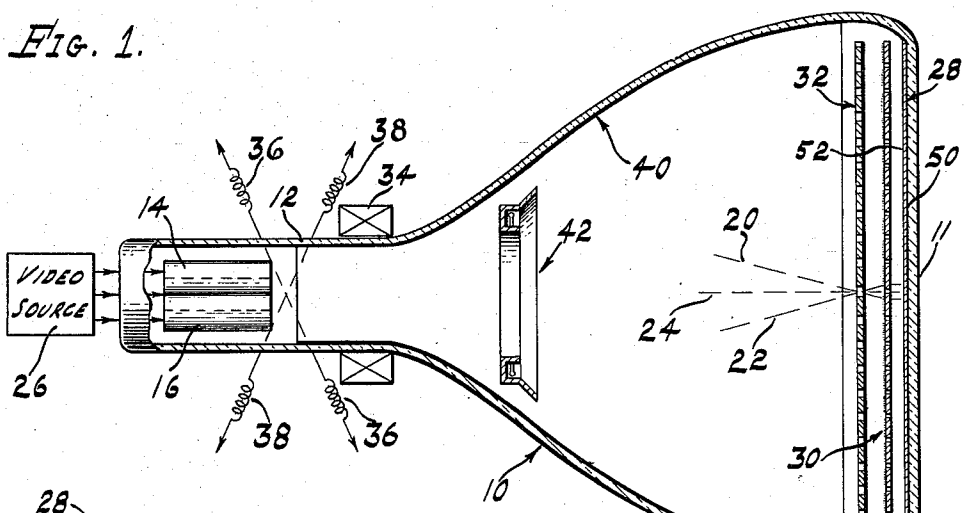
Oct. 27, 1959 S. T. SMITH 2,910,617

MULTICOLOR STORAGE TUBE

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FIG. 1.



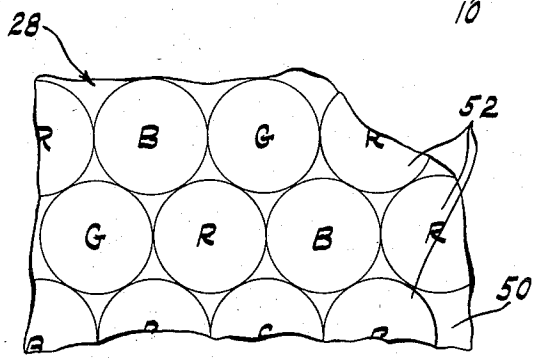
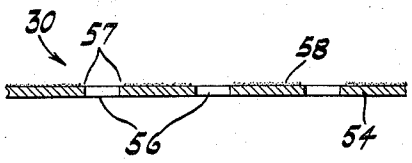


FIG. 2.

FIG. 4



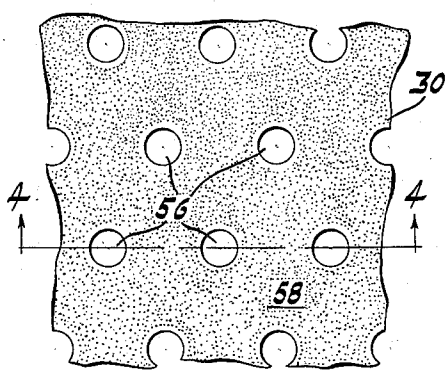


FIG. 3

INVENTOR
SIDNEY T. SMITH

Henry Heyman
ATTORNEY

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FIG. 8.

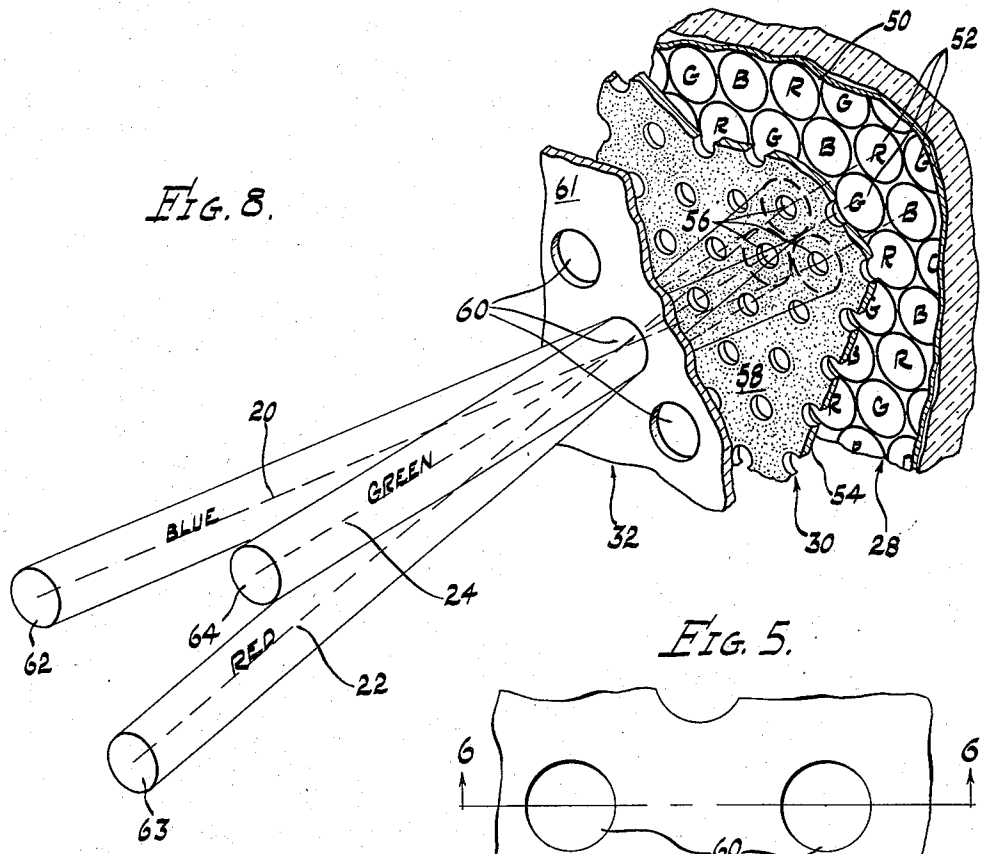


FIG. 5.

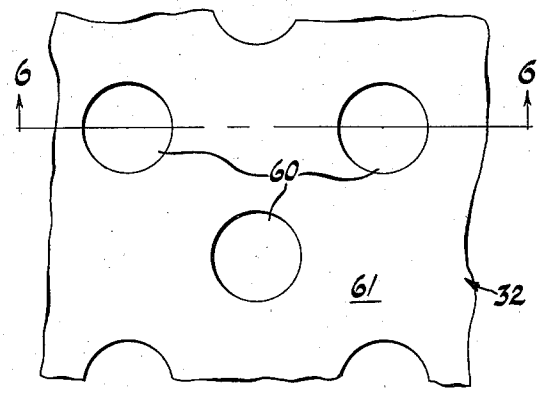


FIG. 7.

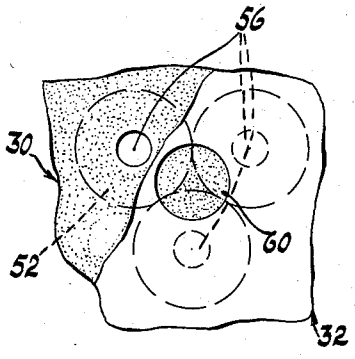


FIG. 6.



INVENTOR

SIDNEY T. SMITH

Henry Heyman

ATTORNEY

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2,910,617

MULTICOLOR STORAGE TUBE

Sidney T. Smith, Pacific Palisades, Calif., assignor to Hughes Aircraft Company, Culver City, Calif., a corporation of Delaware

Application September 27, 1955, Serial No. 536,875

2 Claims. (Cl. 315—12)

This invention relates to direct-viewing storage tubes, and more particularly to a long-persistence three-color indicator tube of the cathode-ray type capable of producing a visual half-tone presentation of good color purity.

The direct-viewing storage tube of the present invention comprises three electron guns for producing, respectively, three electron beams which are scanned over a storage screen disposed adjacent to and coextensive with a three-color phosphor dot viewing screen. The storage screen is characterized by the fact that it has a single aperture disposed in alignment with each phosphor dot of the viewing screen. A shadow mask is interposed between the electron guns and the storage screen. This shadow mask is disposed adjacent to and coextensive with the storage screen and has one opening for each set of three apertures of the storage screen which are in alignment with three adjacent different colored phosphor dots on the viewing screen. The placement of the apertures in the storage screen relative to the openings in the shadow mask is such that each electron beam, upon penetrating through an opening in the shadow mask, is incident on the storage surface surrounding only the aperture in the storage screen in alignment with its associated color of phosphor dot on the viewing screen. A color presentation is then produced by directing flood electrons through the shadow mask and thence through the apertures in the storage screen in proportion to the charge on the surrounding storage surface to the corresponding phosphor dots on the viewing screen.

One of the problems encountered in present day multicolor direct-viewing storage tubes of this type is that of maintaining "color purity." In order to achieve color purity in prior art devices, it was found necessary to employ a storage screen having at least 5 to 10 interstices per color dot on the viewing screen. For a picture having normal resolution, this necessitated the use of a storage screen having, for example, 500 meshes per inch. A storage screen having interstices this small, however, reduced the electric field penetration from the viewing screen to the extent that no half-tones could be reproduced. Thus, it is apparent that color purity considerations dictated the use of a fine mesh storage screen, while reproduction of half-tones dictated the use of a coarse storage screen.

In accordance with the present invention, the above conflicting considerations are eliminated by employing a storage screen having a single circular aperture in alignment with each phosphor dot on the viewing screen. Further, in order to maintain color purity, the storage surface is symmetrically disposed about each aperture of the storage screen so as not to impart any transverse velocity to the flood electrons when passing through the storage screen. It has been found that such a structure provides a wide range of half-tones, better color purity in that each color dot has its individually aligned beam and, lastly, greater strength and rigidity which is especially important in large-diameter curved-screen construction.

It is therefore an object of the invention to provide an improved multicolor direct-viewing storage tube.

Another object of the invention is to provide a direct-viewing storage tube adapted to produce a color presentation having both color purity and half-tones.

A further object of the invention is to provide a three electron gun, three-color, direct-viewing storage tube adapted for use with conventional systems to produce a television picture in color.

The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages thereof, will be better understood from the following description considered in connection with the accompanying drawings in which an embodiment of the invention is illustrated by way of example. It is to be expressly understood, however, that the drawings are for the purpose of illustration and description only, and are not intended as a definition of the limits of the invention.

Fig. 1 is a longitudinal sectional view of a direct-viewing storage tube embodying the present invention;

Fig. 2 is a greatly enlarged view of a portion of the viewing screen in the device of Fig. 1;

Figs. 3 and 4 are greatly enlarged plan and cross-sectional views, respectively, of the storage screen in the device of Fig. 1;

Figs. 5 and 6 are greatly enlarged plan and cross-sectional views, respectively, of the shadow mask in the device of Fig. 1;

Fig. 7 is a greatly enlarged plan view showing the manner in which the phosphor dots of the viewing screen, the apertures in the storage screen, and the openings in the shadow mask are aligned at a central portion of the screens in the device of Fig. 1; and

Fig. 8 is a schematic view in perspective illustrating the manner in which the three electron beams of the electron guns in the device of Fig. 1 pass through a given opening in the shadow mask and impinge on the storage surface surrounding selected apertures in the storage surface.

Reference will be made first to Fig. 1 for a general description of an illustrative embodiment of the multicolor direct-viewing storage device of the present invention. The device comprises an evacuated bulbous envelope **10** having a substantially flat portion **11** and a neck portion **12** at opposite extremities thereof. For the purpose of explanation, it will be assumed that a presentation having three primary colors is to be produced. Accordingly, the neck portion **12** of the envelope **10** is adapted to house electron guns **14, 16** and **18**. These electron guns are symmetrically disposed about the longitudinal axis through the neck portion **12** and are equal in number to the aforementioned number of primary colors. The three electron guns **14 16** and **18** are conventional and produce three electron beams which are represented schematically in the right half of the envelope **10**, as viewed in the drawing, with their angular relationships greatly exaggerated for purposes of illustration, by the dashed lines **20, 22** and **24**, respectively. Each of the electron guns **14, 16, 18** has impressed thereon a video "color" signal provided by a video source **26** in a manner to intensity modulate the electron beams **20, 22** and **24**, respectively.

Adjacent the flat portion **11** of the envelope **10** there is disposed, in the order named, a viewing screen **28**, a storage screen **30**, and a shadow mask **32**. In addition, a magnetic convergence coil **34** and magnetic electron beam deflecting yokes **36, 38** are disposed about the out-

side of the neck portion **11** of envelope **10** for converging the electron beams together in the plane of the shadow mask **32** and for simultaneously directing the electron beams towards selected elemental areas of the storage screen **30**, respectively. It is realized, of course, that the angles between the beams **20**, **22**, **24** and the spacing between the shadow mask **32** and the storage screen **30** as compared with the length of the tube are exaggerated for better illustration of the operation of the tube. Also, an equipotential region is provided between the electron guns **14**, **16**, **18** and the shadow mask **32** by means of a conductive coating **40** disposed about the inner surface of the envelope **10** therebetween. Lastly, an annular flood gun **42** for providing a source of flood electrons is disposed about the paths of the electron beams at the extremity of envelope **10** adjacent the junction with the neck portion **12**.

More particularly, as indicated in Fig. 1, the viewing screen **28** is disposed directly on the inner surface of the flat portion **11** of evacuated envelope **10**. The viewing screen **28** comprises a transparent conductive coating **50** on top of which is disposed a phosphor dot viewing screen **52**, as shown in Fig. 2. An aluminized layer over the phosphor dots could be used in lieu of the conductive coating. In the event that it is desired to reproduce the true colors of a picture, the phosphor dots of the viewing screen **28** are composed of three primary colors such as, for example, red, blue and green. These phosphor dots may have a diameter of the order of 0.0136 inch and are arranged so that the perimeter of a dot of any one color is in contact with the perimeter of dots of the remaining two color dots disposed alternately as illustrated in the figure. Thus, as can be seen in this figure, any group of three dots in mutual contact with each other includes one each of the primary color dots.

Referring to Figs. 1, 3 and 4, the storage screen **30** is disposed adjacent to and coextensive with the viewing screen **28** and may comprise, for example, a thin sheet **54** of metal of the order of 0.004" thick which has apertures **56** of a diameter of the order of 0.004" in alignment with each phosphor dot of the viewing screen **28**. It has been found that an alloy of 70% copper and 30% nickel is a suitable metal out of which to fabricate the sheet **54** of the storage screen. A thin layer **58** of dielectric material having secondary electron emission characteristics such as, for example, magnesium fluoride is evaporated on the side of the metallic sheet **54** facing the electron guns **14**, **16** and **18**. This layer **58** is of a uniform thickness of the order of two microns.

When evaporating the layer **58** of dielectric material on the one side of the metallic sheet **54**, it is essential that no particles of dielectric material be deposited within the apertures **56** in an unsymmetrical way. The reason for this is that, in order to maintain color purity, it is necessary that no transverse velocity be imparted to the flood electrons in traversing through the apertures **56** to the phosphor dots on the viewing screen **28**. In operation, any particles of dielectric deposited within the apertures **56** may accumulate erroneous charges from the viewing screen **28** or from the electron beams **20**, **22**, **24** and thus impart sufficient transverse components of velocity to the flood electrons to cause them to impinge on an adjacent phosphor dot. In addition it may be desirable to leave a small symmetrical portion of the metallic plate **54** about each of the apertures **56** exposed so as to increase the range potentials over which halftone signals may be stored. The manner in which a screen of this type may be fabricated is taught in a copending application for patent, Serial No. 519,384, filed June 30, 1955, now Patent No. 2,858,463, entitled Storage Screen for Direct-Viewing Storage Tube, by Sidney T. Smith and Nobuo J. Koda and assigned to the same assignee as is the present application. As taught in the above application for patent, the metallic plate **54** is coated with a layer of photoresist, one side of the coated plate **54** exposed to light to harden the photoresist, and the unexposed portions of the layer of photoresist dissolved away. A layer of magnesium fluoride may then be evaporated on the exposed portions of the metallic plate **54**. In accomplishing this operation it is desirable to maintain the plate at a temperature of the order of 200° C. so as to prevent "crazing" of the layer **58**. The hardened portions of the layer of photoresist may then be "burned off" leaving a layer of magnesium fluoride on only one side of the metallic sheet **54**. In the event that it is desired to have a narrow border **57** of exposed metal about the outer periphery of each aperture **56**, additional metal may be electroplated within each of the apertures until borders of the desired width are produced. When metal is electroplated within apertures **56** in this manner, their initial diameter should make an allowance for the amount by which it will decrease due to the electroplating operation.

The shadow mask **32** is disposed adjacent to and coextensive with the storage screen **30** on the side thereof facing the electron guns **14**, **16**, **18**. As shown in Figs. 5 and 6, the shadow mask **32** has one opening **60** for each set of three of the apertures **56** in the storage screen **30**. A metal sheet **61** of the order of 0.004" thick composed of an alloy of 70% copper and 30% nickel is a suitable material out of which to fabricate the shadow mask **32**. In the center portion of the mask **32** and the screens **28**, **30**, the openings **60** of the shadow mask **32**, the apertures **56** of the storage screen **30**, and the phosphor dots **52** of the viewing screen **28** are aligned in the manner shown in Fig. 7. In this figure the phosphor dots **52**, apertures **56**, and the openings **60** are all projected into a single plane and an opening **60** is represented by a shaded circle. Each of the apertures **56** is centrally located over a different color phosphor dot. The opening **60**, on the other hand, is disposed so that its outer periphery is equidistant from the center of each of the apertures **56**. In the regions nearer the outer periphery of the mask **32**, on the other hand, allowance must, of course, be made for parallax of the electron beams. Thus, it is necessary to align the openings **60** of the shadow mask **32** with both the phosphor dots **52** of the viewing screen **28** and the apertures **56** of the storage screen **30**. The spacing between the shadow mask **32** and the storage screen **30** is determined by the spacing between the apertures **56**, the distance from the shadow mask **32** to the centers of deflection of the electron beams **20**, **22**, **24** and the distance separating the centers of deflection of the electron beams.

During the operation of the device, the cathodes of the electron guns **14**, **16**, **18** are maintained at a potential of the order of −6000 volts with respect to the potential of the cathode of the flood gun **42**, which may, for example, be maintained at ground. In this case, the shadow mask **32** is maintained at +1000 volts, the metal sheet **54** of the storage screen **32** at +8 volts, and the transparent conductive coating **50** of the viewing screen **28** at 5000 volts positive with respect to ground. The electron beams **20**, **22** and **24** are first directed along the neck portion **12** parallel with each other until they arrive at the centers of deflection **62**, **63**, **64**, respectively, of the yokes **36**, **38**, as indicated in Fig. 8. Simultaneously with being scanned over the shadow mask shown in Fig. 8, the electron beams **20**, **22**, **24** are converged towards a common point in the plane of the mask **32** in the usual manner. The electron beams pass through the openings **60** of the shadow mask **32** and impinge on the storage surface surrounding the apertures **56** directly opposite phosphor dots of the viewing screen **28** of a color corresponding with the signal employed to modulate the electron guns **14**, **16**, **18**. In that the electron beams **20**, **22**, **24** would have to traverse both the shadow mask **32** and the storage screen **30** to impinge on the viewing screen **28**, their efficiency

to produce light upon reaching screen **28** is less than 5% of what it would be if the beams **20, 22, 24** were unintercepted. Simultaneously with the beams **20, 22, 24** charging the storage surface surrounding the apertures **56** of storage screen **30**, flood electrons provided by the flood gun **42** are directed towards the shadow mask **32**. Each opening **60** in the shadow mask **32** acts as a diverging lens to the flood electrons due to the negative potential gradient from the mask **32** to the storage screen **30**. This lens calculates to be weak and tends to be beneficial in that it improves the uniformity of the flood electrons and avoids "shadowing" of flood electrons by the shadow mask **32**. This lens effect is, of course, negligible for the high-velocity beams **20, 22** and **24**. The flood electrons which approach the storage surface may be reflected or captured by one of the converging lenses produced in the vicinity of the apertures **56** of the storage screen **30**. Flood electrons are thus captured in proportion to the charge on the surrounding storage surface and are then accelerated through the aperture to the corresponding phosphor dot in alignment therewith to produce a color presentation. If it is desired to produce a half-tone presentation, the three-color direct-viewing storage tube of the present invention may be operated in the mode described in the copending application for patent, Serial No. 459,403, filed September 30, 1954, entitled Direct-Viewing Half-Tone Storage Device, by George F. Smith and Elvin E. Herman and assigned to the assignee of this application, now Patent No. 2,790,929.

What is claimed is:

1. A multicolor direct-viewing storage tube comprising an evacuated envelope; first, second and third electron guns, disposed within one extremity of said envelope in a predetermined relationship to the longitudinal axis thereof for producing first, second and third electron beams, respectively; means coupled to each of said electron guns for modulating said electron beams in accordance with signals representative of first, second and third colors; a viewing screen disposed at an opposite extremity of said envelope, said viewing screen being composed of numerous clusters, each consisting of first, second and third colored phosphor dots, the orientation of the first, second and third colored phosphor dots in each of said clusters being dependent on said predetermined relationship; a storage screen disposed adjacent to and coextensive with said viewing screen on the side thereof nearest said electron guns, said storage screen having a single aperture in alignment with each of said first, second and third colored phosphor dots of said viewing screen; a shadow mask disposed adjacent to and coextensive with said storage screen on the side thereof nearest said electron guns, said mask having a single opening for each of said clusters of said viewing screen to allow each of said first, second and third electron beams to be incident only on the storage surface surrounding the respective apertures in alignment with phosphor dots of one of said first, second and third colors; means for producing a negative potential gradient from said shadow mask to said storage screen; means for scanning each of said first, second and third electron beams over said mask whereby portions of each of said electron beams penetrate therethrough to said storage screen to produce a composite charge pattern thereon; and means for directing flood electrons uniformly over the entire area of said shadow mask whereby a portion of said flood electrons penetrate therethrough and are diffused over said storage screen by said negative potential gradient and proceed through respective apertures in said storage screen in proportion to the charge therearound to the phosphor dots of said viewing screen in alignment therewith thereby to produce a color presentation representative of said signals.

2. The multicolor direct-viewing storage tube as defined in claim 1 wherein said dots are of red, blue and green phosphors thereby enabling a true colored replica of a picture to be produced.

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