United States Patent

[11] 3,614,504

[72] Inventor **Sam H. Kaplan**
Chicago, Ill.

[21] Appl. No. **27,052**
[22] Filed **Apr. 9, 1970**
[45] Patented **Oct. 19, 1971**

[73] Assignee **Zenith Radio Corporation**
Chicago, Ill.

[54] **COLOR PICTURE TUBE SCREEN WITH PHOSPHORS DOTS OVERLAPPING PORTIONS OF A PARTIAL-DIGIT-TRANSMISSIVE BLACK-SURROUND MATERIAL**
4 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** ..... **313/92 CS,** 96/36.1
[51] **Int. Cl.** **G03c 5/00,** H01j 29/32
[50] **Field of Search** ..... 313/92, 92 CS, 92 PH

[56] **References Cited**
UNITED STATES PATENTS

3,146,368	8/1964	Fiore et al.	313/92 B
3,344,301	9/1967	Kaplan	313/92 B
3,365,292	1/1968	Fiore et al.	313/92 B

Primary Examiner—Roy Lake
Assistant Examiner—V. La Franchi
Attorney—Francis W. Crotty

ABSTRACT: The screen area of a color cathode-ray tube is covered with a graphite layer which is discontinuous in the sense that it has holes into which various phosphor materials are deposited to form the usual dot triad arrangement. The phosphor dots overlap the graphite and the graphite has a transmissivity to visible light of at least 5 to 20 percent so that the overlapping parts of the phosphor dots make a contribution to useful light output.

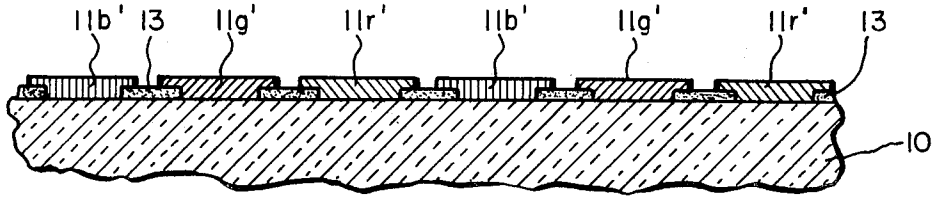


FIG. 1

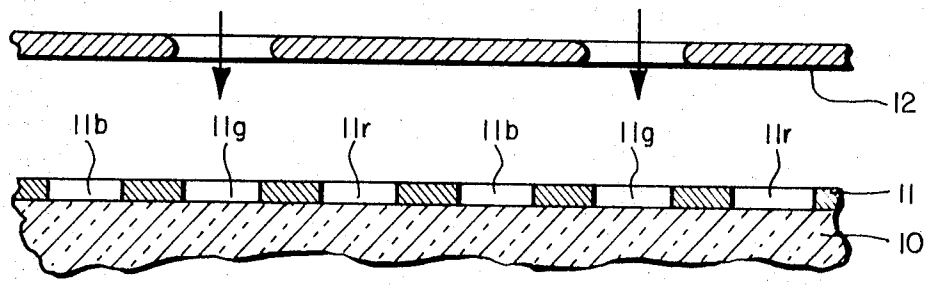


FIG. 2

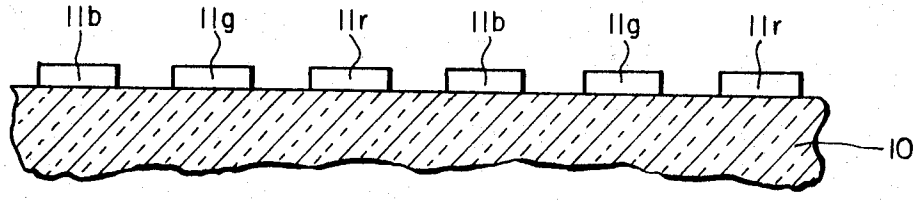


FIG. 3

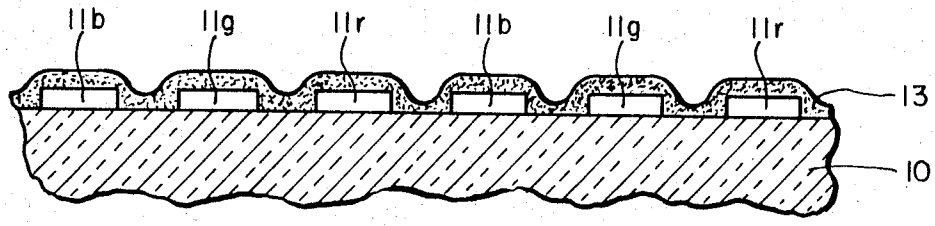


FIG. 4

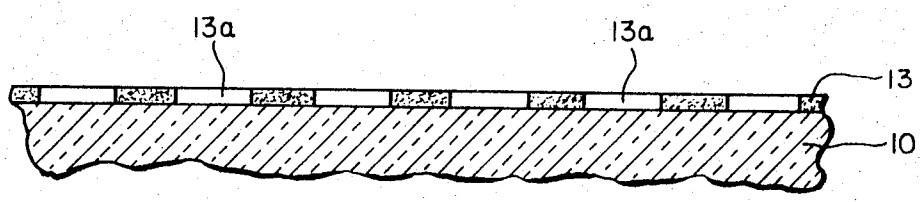
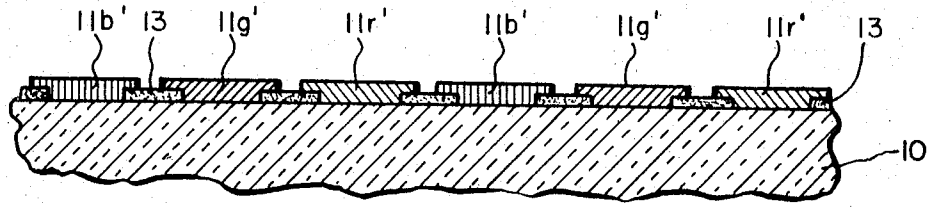


FIG. 5



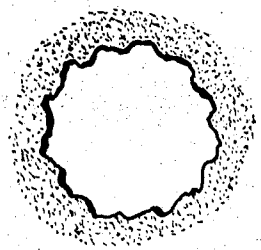


FIG. 6

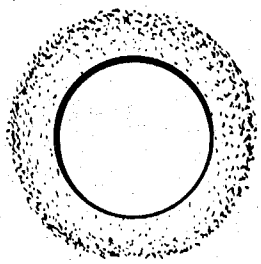


FIG. 7

Inventor
Sam H. Kaplan
By Francis W. Crotty
Attorney

COLOR PICTURE TUBE SCREEN WITH PHOSPHORS DOTS OVERLAPPING PORTIONS OF A PARTIAL-DIGIT-TRANSMISSIVE BLACK-SURROUND MATERIAL

BACKGROUND OF THE INVENTION

The invention is particularly concerned with improving the light output of a black-surround color picture tube. Such a tube has interleaved deposits of different phosphor materials and the spaces between those deposits are filled with a light-absorbing material which is usually graphite or some other black material from whence the structure derives its name.

The phosphor may be applied in the form of strips or dots but for the purpose of a specific disclosure particular attention will be directed to the mosaic type of screen characterized by a multiplicity of dot triads distributed over the screen area with each such triad comprising a dot of green, a dot of blue and a dot of red phosphor.

In addition to a choice as to the configuration of the phosphor dot, tubes of the type under consideration also give a choice with respect to the relative dimensions of the phosphor dots and the electron beams. If desired, the diameter of the electron beams may be smaller than the diameter of the phosphor dots but preferably the converse relation is employed and the electron beams are larger than the phosphor dots. Such a structure is described and claimed in U.S. Pat. No. 3,146,368, issued on Aug. 25, 1964 to Joseph P. Fiore et al. This structure has distinct advantages over other forms of shadow mask color tubes in respect of brightness and contrast.

For the purpose of optimum contrast and reflectance, the light-absorbing layer employed in a structure of the type to which the Fiore et al. patent is directed is opaque or has zero transmissivity for visible light. This is the optimum arrangement in that it permits of the best conditions for contrast and maximum relief from adverse effects attributable to ambient light. The present invention teaches that such a structure may be arranged to provide a substantial increase in brightness or light output with a relatively minor sacrifice in contrast and reflectance.

Accordingly, it is an object of the invention to provide a black-surround type of color cathode-ray tube which has an enhanced light output.

It is a particular object of the invention to improve the brightness of a black-surround tube without substantially impairing its other fine qualities including high contrast.

SUMMARY OF THE INVENTION

The invention is an improvement in a color cathode-ray tube having a screen comprised of an interlaced pattern of dots of different phosphor materials and further comprised of a layer of light-absorbing material in the spaces between and at least partially overlapped by the phosphor deposits. The improvement is characterized by the fact that the light-absorbing material, instead of being opaque, has a transmissivity to visible light of at least 5 to 20 percent.

BRIEF DESCRIPTION OF THE DRAWING

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. 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 drawing, in the several figures of which like reference numerals identify like elements, and in which:

FIGS. 1 to 5 are fragmentary views pertaining to one embodiment of the invention; while

FIGS. 6 and 7 are enlarged fragmentary views of other forms of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The envelope of the shadow mask color tube has a faceplate section that is initially separated from a conically shaped envelope portion. A fragmentary portion **10** of such a faceplate

section or screen of a color cathode-ray tube is represented in FIG. 1 and may be considered as a substrate to which are applied deposits of the various materials which collectively define the screen. Neither the size nor configuration of the substrate is of any particular consequence, nor is it of any special moment whether the phosphor be applied as strips or in the form of dots. For the purpose of a specific disclosure, however, it will be assumed that faceplate **10** is part of the screen section of a 25-inch rectangular color tube having a mosaic type of screen with dot triads distributed uniformly over the internal screen surface and with each such triad comprised of a dot of green, a dot of blue and a dot of red phosphor. Since the invention concerns color tubes of the black-surround variety, the dots of all of the triads are circumscribed by light-absorbing material such as graphite, that is to say, all of the screen surface between the phosphor deposits is covered with such material. The present invention has to do with the screen structure resulting from a procedure by which the light-absorbing material is first applied to the screen and provided with discontinuities or holes into which the phosphor is subsequently deposited. This procedure will be described in relation to FIGS. 1 through 5.

After the screen has been made chemically clean, it is coated with a removable layer **11** of clear polyvinyl alcohol sensitized with ammonium dichromate. After layer **11** has been dried, selected portions thereof are exposed to ultraviolet light to establish in the layer interleaved sets of images of those elemental areas of the screen that are to receive assigned ones of the phosphor materials. This is accomplished in a step analogous to that conventionally taken in photoresist screen printing to define the elemental areas of the screen which are to receive a particular phosphor and to distinguish them from the other portions of the screen. Such discrimination is easily attained by exposure to ultraviolet light through the holes or apertures of the shadow mask **12** of the tube in process. For that purpose shadow mask **12** is installed within the faceplate section of the tube envelope in juxtaposition with respect to the internal surface of the screen and this subassembly, with the screen bearing *PVA* layer **11**, is placed in an exposure chamber so that ultraviolet light is directed to selected elemental areas of the screen through the holes of mask **12**. If the light source of the exposure chamber has been positioned to simulate the electron gun of the tube in process which is intended to excite the green phosphor material, the ultraviolet light will be confined to expose only those portions **11***g* of layer **11** which overlie elemental areas of screen **10** assigned to receive deposits of green phosphor. After this exposure, a similar series of portions **11***b* of layer **11** are exposed, these constituting the portions of layer **11** that overlie elemental areas of the screen to receive deposits of blue phosphor. To achieve their exposure, it is only necessary to modify the position of the light source in the exposure chamber, or to place the subassembly of the faceplate and shadow mask in another exposure chamber in which the light source simulates the electron gun of the tube intended to energize the blue phosphor dots. In a like but third exposure step, with the light source simulating the electron gun of the tube that is to excite the red phosphor dots, a third set of portions **11***r* of layer **11** are exposed and these portions overlie elemental areas of the screen assigned to receive red phosphor. As a consequence of the multiple exposure, there are established in layer **11** interleaved sets of images of circular, elemental areas of the screen separated from one another and intended to receive assigned ones of the phosphor materials. Between these sets of images there are portions of layer **11** that have not been exposed and these portions are represented by crosshatching in FIG. 1.

It is distinctly preferred that the exposed elemental areas of layer **11** be smaller in size than the apertures of shadow mask **12** as that mask is finally and permanently installed within the completed tube. The correct relative size may be realized in a variety of ways. The mask may be formed initially with holes of a desired final size but a coating or other filler may be

added to temporarily close down or reduce the mask holes to a size required for screening to develop phosphor dots, determined by exposure through the mask, and of the proper desired dimension. If closing down of the mask apertures in resorted to, the temporary coating or filler is removed after screening has taken place to the end that the final hole size of the mask is properly related in diameter to the phosphor dots. Another and more attractive process currently in commercial use is one in which the apertures originally formed in mask **12** have the precise size required for screening. In this case after screening has been completed, the mask is re-etched to open up or enlarge its apertures to the desired final size. This has an advantage in precisely controlling the dimensions of the phosphor dots and also in attaining uniformity of size and configuration of those dots.

By whichever approach the selected portions **11***g*, **11***b* and **11***r* of *PVA* layer **11** are exposed, the interleaved sets of images resulting from such exposures are next developed by removing all unexposed portions of photosensitive layer **11** producing the screen condition of FIG. **2**. Inasmuch as the photosensitive material of layer **11** as applied to screen **10** is soluble in water, whereas all exposed portions thereof have been rendered insoluble, washing the screen with water after the third exposure step removes all of the unexposed portions of layer **11**. The screen of FIG. **2** may be described as having clear deposits or dots of *PVA* separated from one another by screen portions which are bare and are to receive a pigment or material having light-absorbing capabilities.

The next step of the screening process constitutes depositing in the spaces between the elemental screen areas covered by the dots of clear *PVA* a coating **13** of an inorganic pigment having light-absorbing capabilities and having the property that its adherence to screen **10** is substantially immune to attack by an active agent which may be employed to destroy the adherence of *PVA* dots **11***g*, **11***b* and **11***r* to the screen. While this light-absorbing material may be applied only to the areas surrounding the clear *PVA* dots, it is more convenient to apply coating **13** over the entirety of the screen, as indicated in FIG. **3**, in which case the coating of light-absorbing material is also applied over the clear *PVA* dots as an overcoat. Preferably, layer **13** is applied as a slurry and also preferably it is a colloid having in suspension a fine pulverulent material such as black iron oxide, powered mica, molybdenum disulfide, manganese carbonate, ceramic black or graphite. A water dispersion of particulate graphite plus a resinous binder, commercially available under the trade name "Aquadag," is acceptable for use in layer **13**. While the application of a graphite layer is a practice known prior to the present invention, the transmissive properties of that layer with respect to visible light is distinctly different, in accordance with the invention, than with the prior art. The particulars of this property and the reasons for change over prior practices will be considered presently.

It is now desirably to remove the clear *PVA* dots **11***g* **11***b* and **11***r* to establish the screen condition of FIG. **4**. This is accomplished by the use of a chemical stripper which destroys the adherence of the clear *PVA* dots to screen **10** but does not impair the adherence of layer **13** to the screen. A suitable stripper is 30 percent hydrogen peroxide and 70 percent water which may be slurried over the screen and the excess poured off. The screen is then washed with a spray of deionized water, removing clear *PVA* dots **11***g*, **11***b* and **11***r* and along with them the overcoat of graphite **13**. As a consequence, the screen as represented in FIG. **4** has a mat or grille **13** of graphite which is discontinuous in that it has holes **13***a* into which the various phosphor materials are to be deposited.

The various phosphor materials are now applied through these openings of layer **13**. A number of techniques are known through which the phosphor may be laid down but it is convenient to use a photosensitive *PVA* slurry which carries particles of a particular phosphor in suspension. In applying the green phosphor, for example, the entire surface of screen **10** is covered with a suitable layer of a green slurry and those portions which overlie the elemental areas **11***g* of the screen intended to receive green phosphor are exposed through mask **12** and, after exposure, are developed by washing with water. In this manner, deposits **11***g'* are applied to the appropriate elemental areas of screen **10**. As indicated in FIG. **5**, the phosphor deposited overlaps the graphite or black-surround material **13**. The size of the green phosphor dot and the extent to which it overlaps the black-surround material are easily determined by controlling the intensity of the ultraviolet light used during exposure and the duration of the exposure interval through which the images of the green phosphor elements **11** *g'* are developed. In like fashion, blue phosphor deposits **11***b* ' are made in the appropriate elemental areas **11***b* of screen **10** and red phosphor deposits **11***r'* are made in the screen areas **11***r* intended to receive red phosphor. The procedure for applying the dots, arrayed to form phosphor triads, is sufficiently well known in the art to require no further explanation. After the phosphor has been applied, the screen is filmed and aluminized in the usual way.

Aside from the properties of graphite layer **13**, the structure as thus far described is well known. It has phosphor dots that are physically larger than the holes provided in graphite layer **13** but heretofore their effective size has been confined to the dimensions of the holes in the graphite layer since, in accordance with prior practices, the graphite layer is opaque, that is to say, it is nontransmissive to visible light. The electron beams of the tube which scan screen **10** in picture reproduction are larger in diameter than the holes of graphite layer **13** and, therefore, larger than the effective size of the phosphor dots. As a consequence, parts of the phosphor dots which overlap the graphite layer are excited but the light they generate is, for all practical purposes, attenuated and lost in graphite layer **13** which is interposed between these marginal portions of the phosphor dots and screen **10**. The present invention makes it possible to recover part of this light which is otherwise lost and, therefore, to enhance the light output and brightness of the tube. This is accomplished, in accordance with the teaching of the subject invention, by arranging light-absorbing or graphite layer **13** to have a transmissivity to visible light of at least 5 to 20 percent. Where graphite is the material of layer **13** it may be rendered permeable to light, at least to the extent desired, by suitably reducing the concentration of solids in the coating material employed in laying down layer **13**. To achieve transmissivity in the range of 5 to 20 percent, the graphite composition is one which has 1 percent solids which contrasts with a material of 3 percent solids used heretofore in achieving a light-absorbing layer that is substantially opaque, having no perceptible transmissivity to visible light. FIG. **5** indicates that while the phosphor dots do, in fact, overlap layer **13** as require to take advantage of the teachings of this invention, they are nevertheless of such dimension that there is a spacing between them. One may, however, have the dots tangential and for that case layer **13** would be homogenous whereas if the phosphor dots are separated from one another one could, at least in theory, have the graphite layer which is overlapped by the phosphor transmissive to light in the manner described but the graphite layer which is interposed between the edges of the phosphor could be black and opaque. As a practical matter, it is easier in any case to use a relatively homogenous layer **13**.

In one structure of the screen that has been built and satisfactorily tested, the following parameters were employed:

Ps

mask aperture	16.2 mils
holes in layer 13	12.7 mils
phosphor dots, maximum diameter	16.7 mils
spacing of holes in the mask	28 mils
permeability of layer 13	5 to 20 percent

This structure has a brightness gain of about 10 percent if the permeability of layer **13** is about 10 percent.

An alternative approach to achieving a desired amount of transmissivity in grille **13** contemplates the use of light diffusing material, such as sand, in the slurry utilized in forming the clear *PVA* dots **11***g*, **11***b* and **11***r*. The effect of diffuse material in the *PVA* is to provide these dots with a ragged or serrated edge as shown in FIG. **6**. When the *PVA* dots are removed through the use of a chemical stripper, the holes that they leave in the grille or light-absorbing layer **13** will have the same configuration. If the dotted line construction of FIG. **6** shows the usual dot, it will be clear that the ragged periphery increases effective size of the phosphor dot contributing to light output. Through this technique a brightness gain of 10 to 20 percent may be realized.

Still another approach is represented in FIG. **7** where the graphite, instead of being homogenous, is graded. It has essentially 100 percent transmissivity at the juncture with each phosphor dot and is less transmissive with distance measured radially outwardly of any particular dot. Preferably, the grille is opaque at distances that are equal to or slightly greater than the periphery of the part of the dot which overlaps layer **13**. In preparing such a variable permeable grille, one first prepares a grille like that of FIG. **4** but with larger holes, obtained through the processing described above but with longer exposure intervals. Next, the grille is coated with ammonium dichromated *PVA* and is then re-exposed. Thereafter, a slurry of *PVA* plus ion-oxide and alcohol is applied and the panel is then washed. The black ion-oxide will adhere only in peripheral edges of the *PVA* dots because the edge portions are least exposed and tend to be soft compared with the central area of the dot. Maximum adhesion recurs at the extreme edge of each dot and consequently the desired condition of variable permeability is attained.

The overall improvement realized in practicing the subject invention may be demonstrated by assuming representative parameters for a particular case. For example, assume that the area of the grille equals T_1 and the phosphor dot area equals $2T_1$ while the transmissivity of the grille is 10 percent. If the entire dot is energized, which would be the case for complete registration of a beam with the dot, assuming the beam to have the same maximum dimension as the dot, the brightness would be equal to 100 units derived directly through the hole in the grille plus 10 units which is the proportion of the light generated by the segment of the phosphor dot which overlaps the grille and delivered through the screen for a grille transmissivity of 10 percent. In other words, the entire output will be 110 light units. For conditions of misregistration in which, for example, 10 percent of the total phosphor dot area is energized by the wrong electron beam, the output for the particular dot would again be 100 units through the hole in the grille plus 9 units which is contributed by so much of the overlapping part of the dot that is energized by its assigned electron beam. At the same time, undesired light in excess of 10 units is developed because of energization by the wrong beam. This reduces to 1 light unit at the face of the screen so that while there is an undesirably contribution to total light output due to energization by the wrong beam it is trivial in amount compared to the useful light attributable to excitation of the peripheral portion of the phosphor dot by the proper electron beam . Accordingly, in terms of useful light there has indeed been a brightness gain.

From the standpoint of ambient light, let it be assumed that in intensity it amounts to 100 light units. After its first traverse through grille **13**, this is reduced to 10 light units and, assuming perfect reflection at the inner surface of the grille, it is reduced to an insignificant 1 light unit as it emerges from the output of screen **10**. Accordingly, making the grille 10 percent transmissive to visible light contributes approximately a 10 percent increase in the output of the light generated by the phosphors with an inconsequential increase in response to ambient light.

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. In a color cathode-ray tube having a screen comprised of an interlaced pattern of deposits of different phosphor materials and further comprised of a layer of light-absorbing material in the spaces between and at least partially overlapped by said phosphor deposits, the improvement which is characterized by the fact that said light-absorbing material has a transmissivity to visible light of a t least 5 to 20 percent.

2. The improvement in accordance with claim **1** in which said light-absorbing layer has uniform transmissivity over said screen.

3. The improvement in accordance with claim **1**, for a color cathode-ray tube in which said phosphor deposits define phosphor dot triads, and in which the boundary of said phosphor dots with said light-absorbing layer is serrated.

4. The improvement in accordance with claim **1**, in which the transmissivity of said light-absorbing layer is graded, having a maximum value at the boundary of said layer with said phosphor deposits and decreasing with distance from that boundary.