

United States Patent

[11] 3,615,461

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

3,365,292 1/1967 Fiore 96/36
3,387,975 6/1968 Tamura 117/33.5

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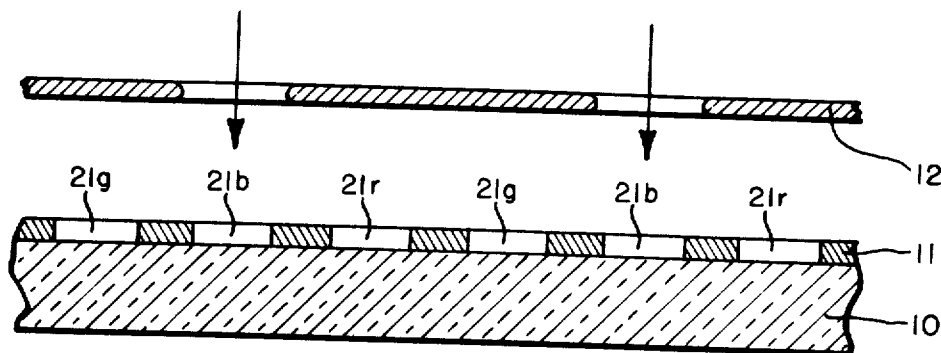
[54] METHOD OF PROCESSING A BLACK SURROUND SCREEN 4 Claims, 10 Drawing Figs.

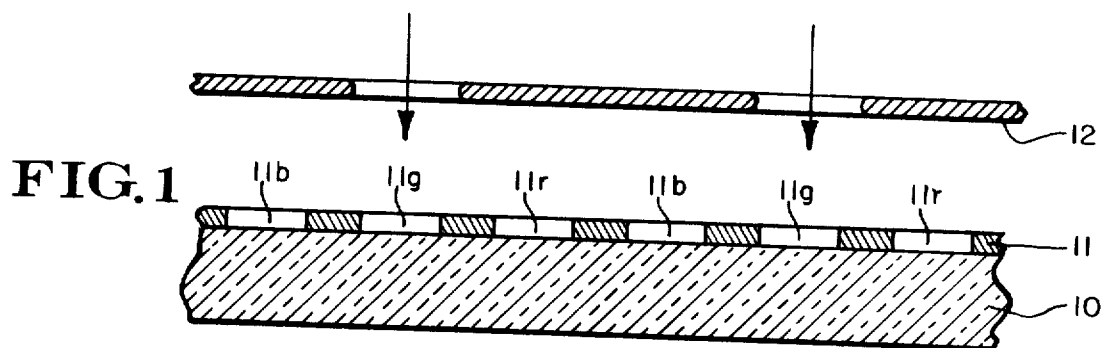
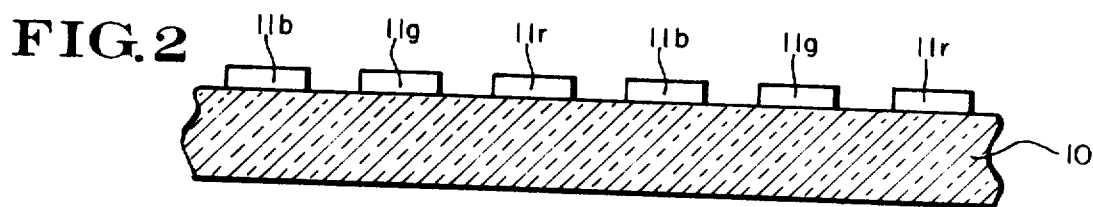
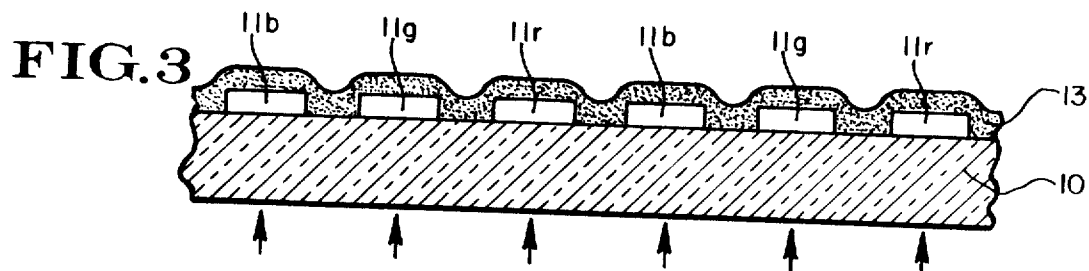
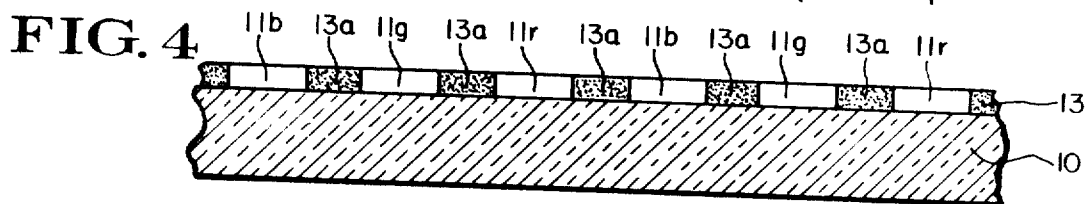
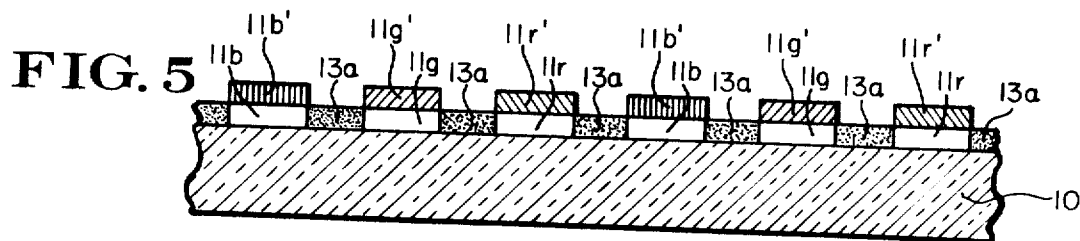
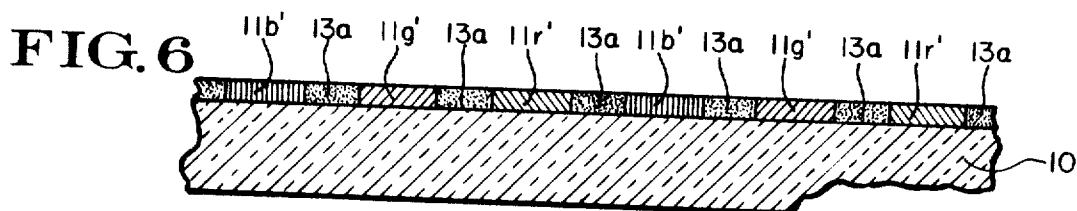
[52] U.S. Cl. 96/36.1,
96/1, 96/29, 96/36, 96/45.1, 117/33.5, 313/109
[51] Int. Cl. H01j 1/54,
H01j 9/22
[50] Field of Search 96/36, 36.1,
36.2, 29, 1; 117/33.5; 313/109

[56] References Cited UNITED STATES PATENTS

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3,146,368	8/1964	Fiore et al.....	96/36.1
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ABSTRACT: The faceplate of a color cathode-ray tube is covered with a layer of sensitized polyvinyl alcohol and is exposed through the shadow mask of the tube to establish images of the elemental areas of the screen that are to receive deposits of phosphor. These images are developed by treating the screen with water which removes the unexposed portions of the layer and then the screen is baked to render the images opaque to actinic radiation. The screen next receives a second coating of a similar photosensitive material including a pigment having light-absorbing capabilities. Exposing the screen from the surface opposite that which has been coated and treating with the solvent of the second layer washes away the portions of that layer which overlie the opaque dot images. Thereafter, phosphor is deposited on assigned series of the dot images and a final baking step removes the polyvinyl alcohol, leaving on the screen phosphor dot deposits individually surrounded by light-absorbing pigment.





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FIG. 7

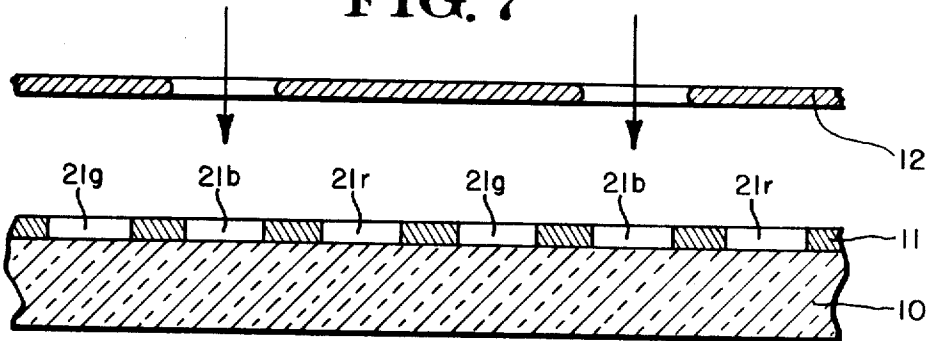


FIG. 8

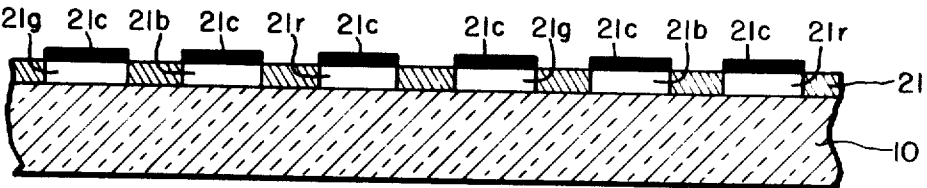


FIG. 9

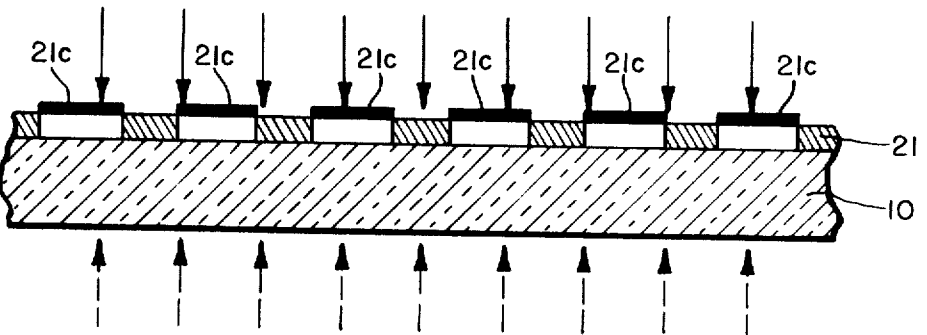
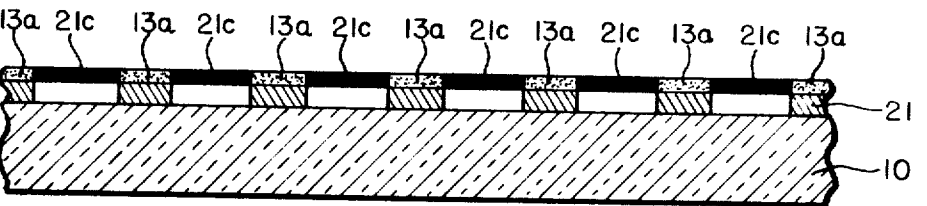


FIG. 10



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METHOD OF PROCESSING A BLACK SURROUND SCREEN

An alternative process is described which is basically the same but features the use of electrophotography.

BACKGROUND OF THE INVENTION

The present invention concerns the processing of a "black surround" screen for a color picture cathode-ray tube. Such a screen has interleaved sets of deposits of different phosphor materials separated from one another by a light-absorbing pigment.

A screen of this type has distinct advantages both with respect to contrast and brightness and is the subject of U.S. Pat. No. 3,146,368, issued on Aug. 25, 1964, to Joseph P. Fiore et al. That patent not only describes the structure of the screen but also methods of its manufacture. Another attractive manufacturing method is described and claimed in U.S. Pat. No. 3,365,292, issued Jan. 23, 1968 to the same inventors. Both patents are assigned to the assignee of the present invention.

The improvement represented by the black surround technique may be employed advantageously whether the phosphor deposits on the screen have the form of stripes or dots. The latter is more frequently used commercially and the discussion will continue on the assumption that the screen under process has dot triads with each triad comprising a dot of green, a dot of red, and a dot of blue phosphor as is now well understood in the art.

In fabricating such a screen, one has a choice of forming the phosphor dots and then filling the spaces between such dots with light-absorbing pigment or the pigment may be applied to the screen first, followed by the formation of the dot triads. The latter is the more attractive because it provides some latitude in forming the phosphor dots that is not available where those dots are formed before the application of the light-absorbing material. It has been found that extreme care must be exercised to prevent cross contamination of the light-absorbing pigment with the phosphor materials and this problem is especially pronounced where the pigment is applied to the screen before the dot triads are formed. The present invention addresses itself to that problem.

Accordingly, it is an object of the invention to provide a novel method of forming a black surround screen for a color image reproducing device, such as a color cathode-ray tube.

It is a particularly object of the invention to provide a method of forming such a screen which minimizes the possibility of contaminating the phosphor deposits with the light-absorbing pigment.

SUMMARY OF THE INVENTION

The method of the invention facilitates forming on the screen of a color image reproducing device a multiplicity of interleaved sets of deposits of different phosphor materials separated from one another by light-absorbing material. In accordance with one aspect of the invention, the screen is coated with a removable layer of a photosensitive material having only volatilizable ingredients to establish a surface condition that may be altered by exposure to actinic energy. Selected portions of the screen are exposed to such energy to establish in the photosensitive layer images of elemental areas of the screen that are separated from one another and are to receive the phosphor materials. Next, the images of these elemental areas are developed and then an inorganic pigment material having light-absorbing capabilities is deposited in the space between the images of such elemental areas. Thereafter, phosphor materials are deposited over respectively assigned ones of the images of the elemental areas and, finally, the residuum of the photosensitive layer is removed.

The invention may be practiced by the use of photosensitive resists which, as is well understood in the art, have a solubility that is readily altered by exposure to actinic energy. In the most common form, the photosensitive resist is rendered insoluble in a particular solvent, preferably water, by exposure to ultraviolet light.

Alternatively, the invention may be practiced by the techniques of electrophotography in which a photoconductive layer which is uniformly charged experiences selective discharging to create latent charge images of elemental areas of the screen that are to be developed.

Both aspects of the invention will be described.

BRIEF DESCRIPTION OF THE DRAWINGS

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 drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIGS. 1-6 are similar fragmentary cross-sectional views of the faceplate of a color cathode-ray tube showing sequential process steps involved in practicing the invention with photosensitive resists, while FIGS. 7-10 are similar views showing sequential process steps featuring electrophotographic or electrostatic screening.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The color television tube currently in extensive commercial use is the shadow mask type having deposits of red, green and blue phosphor materials interleaved to define a multiplicity of dot triads. In describing the present invention, it will be assumed that the screening of such a tube is taking place but the detailed description will not include a discussion of the steps necessary for depositing the phosphor materials, as such, since these steps are well known for the application of phosphor by means of a photosensitive resist and are described in a copending application of Howard G. Lange, Ser. No. 481,316, filed Aug. 20, 1965, now U.S. Pat. No. 3,475,169, for screening with phosphor materials electrophotographically. Principal attention will be focused on so much of the screening process as is involved in applying the black surround material while leaving elemental areas of the screen in a condition to receive subsequent applications of phosphor materials in accordance with previously developed screening practices.

The envelope of a shadow mask color tube has a faceplate section that is initially separated from the conically shaped envelope portion which is a convenience in screening. A small or fragmentary portion 10 of such a faceplate is represented in FIG. 1 and, after it has been made chemically clean, it is coated with a removable layer 11 of a photosensitive material having only volatilizable ingredients and provided in order to establish on the screen area a surface condition that may be altered by exposure to actinic radiation or energy. Specifically, for the example under consideration layer 11 is a photosensitive resist such as polyvinyl alcohol PVA sensitized by ammonium dichromate and having no ingredients that are not readily removable through volatilization which is here used in the broad sense to encompass removal by conversion to a vapor state or by decomposition through heat treatment. In particular, layer 11 contains no phosphor particles and no inorganic pigment particles. The PVA resist is soluble in water and faceplate 10, after having been coated with a suitable emulsion of the resist, is dried.

In the next process step selected portions of the screen are exposed to actinic energy, such as ultraviolet light, to establish in layer 11 images of elemental areas of the screen that are separated from one another and are intended to receive deposits of phosphor materials. This is most conveniently accomplished in a step very analogous to that which is conventionally undertaken in photoresist screening 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. The discrimination is easily obtained by exposing layer 11 through the shadow mask 12 of the tube in process. For that purpose, such a mask having a multiplicity of electron permeable portions or apertures is installed in the usual way within the faceplate portion of the tube envelope and this sub-

assembly is supported in an exposure position in a known form of exposure chamber or lighthouse having an energy source which directs ultraviolet light to elemental areas of the screen through the transparent portions of the shadow mask. If the light source is positioned to simulate, for example, the electron gun of the tube in process which is to excite the green phosphor material, the ultraviolet light will expose only those portions 11g of layer 11 which overlie elemental areas of screen 10 assigned to receive deposits of green phosphor. After this exposure step, portions 11b of layer 11 are similarly exposed, these being the portions that overlie elemental areas of screen 10 that are to receive deposits of blue phosphor. To achieve their exposure, it is only necessary to change the position of the light source so that it now simulates the electron gun of the tube intended to energize the blue phosphor dots. In a third position of the light source, where it simulates the red electron gun of the tube, a third set of small portions 11r or layer 11 are exposed and these portions overlie elemental areas of the screen intended to receive red phosphor. In short, by the multiple exposures there are established in layer 11 images of all those elemental areas of screen 10 that are to receive deposits of the three phosphor materials.

It should be noted in passing that this exposure step differs in one aspect from that which is typical of photoresist color screening, namely, the exposed elemental areas of layer 11 having a size that is smaller than the transparent portions or apertures of the shadow mask as used in the completed tube. This may be accomplished in a variety of ways and one that suggests itself directly is coating the shadow mask initially and temporarily to close down the size of its apertures so that the dimensions of the phosphor dots, determined by exposing through the shadow mask, are properly related to the final size of the mask apertures. After the mask has been used in screening, the coating is removed from the mask and the desired relation of dot size to the size of the apertures of the mask shall have been attained.

In the next processing step, the images of the aforedescribed elemental areas of screen 10 are developed, producing the screen condition of FIG. 1 in which screen 10 now bears only the exposed portions of photosensitive layer 11. The development process is well known. The photosensitive material as applied to screen 10 is soluble in water and all portions thereof that have been exposed become insoluble so that washing the screen after the three exposure steps have been taken removes the unexposed portions of layer 11. The screen as represented in FIG. 2 may be described as having clear deposits of polyvinyl alcohol separated from one another by screen areas which are bare and which are to receive a pigment or a material having light-absorbing capabilities. Accordingly, the processing is continued by depositing such material in the spaces between the elemental areas of the screen that are covered by dots of clear polyvinyl alcohol. In this continued processing, it is convenient to use a second photosensitive layer with appropriate procedural steps to assure that the light-absorbing material is deposited only where it is desired and here again if a surface condition is established on screen 10 that may be altered by actinic energy, the vehicle for effective discrimination will have been provided. This condition is easily established by using a second photosensitive coating over the screen but it is desirable that the deposits of clear polyvinyl alcohol previously established on the screen be rendered opaque to actinic energy prior to the application of this second layer. While the PVA dots may be made opaque by the application of a suitable dye, such as tartrazine yellow or congo red, it has been found that baking the screen in the condition represented in FIG. 2 to a temperature of about 175° C. or higher, but of course less than its decomposing temperature which is about 380° C., turns the deposits brown so that they no longer transmit ultraviolet light and additionally imposes a surface hardness which minimizes cross contamination as will be made clear presently.

After the faceplate has been baked at a temperature of 175° C. for a period of 30 minutes, a second photosensitive layer 13

is applied to it as indicated in FIG. 3. This may be a photosensitive resist of the same type as described above, namely, one which becomes insoluble in a given solvent upon exposure to actinic energy but has as an ingredient a pigment having light-absorbing capabilities such as a black material. The faceplate is now exposed by diffuse radiation through the face opposite that which has been coated, as indicated by the arrows in FIG. 3. Since the dots 11b, 11g, 11r of clear PVA that were previously formed have been rendered opaque to the radiation by heat treatment, the exposure establishes in layer 13 an image of simply those spaces which intervene the clear PVA dots, and these images are developed by washing the screen in the solvent of layer 13.

It is most desirable that the described first and second photosensitive layers not adversely affect one another; in particular, it is necessary to avoid interaction between the layers that may cause particles of the light-absorbing material to be retained in the clear PVA dots, giving rise to cross contamination. This result may be obtained by forming the layers of different but chemically compatible compositions but is achieved in the example under consideration by the baking step which creates a surface hardness to the clear PVA dots so that the second photosensitive layer may likewise be a water soluble photoresist. When the dots 11b, 11g, 11r are so hardened, they do not become tacky upon the application of layer 13 even though the resist of layer 13 is normally soluble in water. Accordingly, the pigment ingredient of layer 13 does not adhere to the clear PVA dots and, therefore, washing the screen with water after the exposure of FIG. 3 provides the screen condition of FIG. 4, having light-absorbing pigment or black-surround material 13a in the spaces that intervene the clear PVA dots 11g, 11r, 11b while those dots themselves are free of such material. This is the necessary condition to avoid cross contamination.

It has been convenient in describing the process up to this point to consider that the second photosensitive layer 13 includes a pigment material that is light absorbing. As described in U.S. Pat. No. 3,365,292 mentioned above, this layer may contain manganous carbonate which, at the time the screen is finally baked, is converted to manganese dioxide. While the carbonate is not as absorptive of light as desired, manganese dioxide is very effective for use as black-surround material.

It is also apparent that the pigment material need not be applied as an ingredient of layer 13. If desired, after the development step, following the exposure of layer 13 and while that layer remains tacky, the pigment may be applied through a dusting or spraying process.

In any event, the screen represented in FIG. 4 features light-absorbing material surrounding a multiplicity of dots of clear PVA which have protected the elemental areas of the screen intended to receive phosphor from the possibility of contamination that would ensue were the light-absorbing material able to deposit in such areas. This screen may now receive deposits of red, blue and green phosphor in accordance with any known coating process. For example, the phosphors may readily be applied through slurry screening or dusting in which the green phosphor is applied exclusively over PVA dots 11g, while the blue phosphor is applied exclusively over PVA dots 11b and the red phosphor is applied exclusively to the third set of PVA dots 11r. In FIG. 5, the green phosphor deposits are designated 11g', the blue phosphor deposits are designated 11b', and the red phosphor dots are 11r'. Each is shown as deposited over one of the previously formed dots of clear PVA. In the final baking process of the screen all of the volatilizable materials, including in particular the residuum of the initial photosensitive layer 11, is removed leaving the screen with dots of phosphor materials surrounded by deposits of a light-absorbing pigment 13a as represented in FIG. 6.

As indicated above, the inventive process is not confined to the described use of photosensitive resists but lends itself as well as electrophotographic or electrostatic screening as indicated in FIGS. 7-10.

In this case, a coating 21 which is applied over faceplate 10 comprises first a layer of suitable conductor and a superposed layer of a photoconductor. The materials of both layers are volatilizable so that they are readily removed in the final baking steps of the tube processing. Suitable materials for these layers are described in the above-identified copending application of Howard G. Lange which is assigned to the assignee of the present invention. Where coating 21 comprises a photoconductive layer, the desired surface condition required to delineate the elemental areas of the screen intended to receive phosphor materials from those that are to be covered with a light-absorbing material is established by charging that layer to some uniform level by a corona discharge device. Exposure of the charged layer to ultraviolet light through shadow mask 12 discharges selected portions of coating 21 to establish images of the elemental areas of the screen that are to receive phosphor materials. Such an exposure step is taken for each of the three phosphor materials to be applied to the screen and the resulting exposed portions of coating 21 have been designated 21g, 21b and 21r. They, of course, require that the exposing light source be positioned to simulate the appropriate electron gun of the tube during the exposure steps in order that exposed portions 21g, 21b and 21r may be properly located within layer 21. These images of the elemental screen areas that are intended to receive phosphor material are then developed by the application of a toner which may include a surfactant, as described in the Lange application, so that the toner deposits exclusively in the exposed portions 21g, 21b and 21r but not elsewhere on coating 21. In the process of the invention, the toner applies an insulating resin coating 21c over the exposed elemental portions 21g, 21b, 21r to facilitate discriminating between the images of the elemental areas of the screen intended to receive phosphor and images of the portions of the screen that separate such elemental areas. Polystyrene and polyethylene are insulating resins suitable for coating 21c.

In the next processing step the photoconductive layer or coating 21 is recharged and is again exposed but now to a flooding beam of ultraviolet light to develop the desired images of the spaces which intervene coated portions 21g, 21b, 21r. The screen, having been recharged, may be exposed either from the coated side as indicated by the full-line arrows or from the other side as indicated by the broken-line arrows although it is preferred to expose from the coated side since in this case the photoconductor under the resin is not discharged resulting in a greater charge differential between the two areas than if the exposure were from the opposite direction. In either case, all exposed portions of the photoconductor layer become discharged while insulating layer 21c remains charged; the photoconductor under layer 21c, (namely, portions 21g, 21b, 21r) may or may not be discharged depending upon which direction the screen is exposed from. A toner bearing the light-absorbing material and a surfactant of appropriate polarity to be repelled by the portions of layer 21 that have retained a charge, is now flowed over the faceplate to the end that black surround material 13a deposits in the spaces between coated portions 21c. For electrophotographic screening, the black surround material should preferably be a nonconductor and a suitable material is ceramic black pigment. The toner conveying the light absorbing material or pigment to constitute the black surround may also advantageously include an insulating resin so that the deposits of light absorbing material are themselves nonconductive and may retain a charge. The condition of faceplate 10 at this juncture is that represented in FIG. 10 having as an exposed layer deposits 21c of resin and deposits 13a of light-absorbing material filling the spaces between resin deposits 21c. The faceplate is now in condition to receive phosphor materials in assigned ones of the elemental areas that have been protected against the deposit of light absorbing material 13a by resin coating 21c.

The phosphor materials are applied one at a time and this may also be accomplished electrophotographically. To that

end, the coated faceplate represented in FIG. 10 is once again brought to a uniform charge throughout its screen area and is then exposed through faceplate 12 from a source of ultraviolet light. If one is applying the green phosphor first, the light source is positioned to simulate the electron gun of the tube that is assigned to excite the green phosphor dots of the screen. While this exposure will not fully discharge the elemental areas of the photoconductor underlying the set of resin deposits 21c over which green phosphor is to be applied, nevertheless, the exposure reduces the charge thereof below the charge that is retained by both the unexposed resin deposits 21c and the black surround deposits 13a. The change in charge condition is sufficient that a toner, polarized to be repelled by the unexposed portions of the photoconductive layer, will deposit in the exposed ones of resin deposits 21c. If the toner carries green phosphor in suspension, these elemental portions of the photoconductive layer will be coated as desired. The same general procedure may be adopted for applying blue and red phosphors in other assigned ones of the resin coated elemental areas 21c. It should be noted that it is of no serious consequence that the deposit of phosphor material is not severely restricted to the resin area 21c intended to receive it. That is to say, the phosphor may overlap into the contiguous screen area which is coated with the light-absorbing black surround material 13a. This may be tolerated because the screen is viewed from the uncoated side and phosphor which overlaps the black surround material makes no effective contribution to the reproduced image. After the three phosphor materials have been applied, and the tube is otherwise processed, the conductor and photoconductive layers as well as the resin material are deleted in the final bakeout step.

It is not necessary that the screen in the condition represented in FIG. 1 receive phosphor material through electrophotographic deposition. If desired, the screen may be baked at a temperature of 440° C. after having received the application of light-absorbing or black surround material 13a and this step will remove all of the coating materials on the faceplate other than the light-absorbing material which will have been deposited over the elemental parts of the screen where it is desired. The phosphor material may be then applied by conventional slurry screening techniques employing water soluble photosensitive resists having phosphor in suspension as an ingredient. Before applying a slurry of such a resist, however, the light-absorbing material 13a is spray coated with a potassium silicate solution and heated to approximately 130° C. for 15 minutes to fix this deposit in position and cause it to become insensitive or unaffected by the water soluble slurry coatings to be used in applying the three different phosphor materials. When the phosphor screening is completed, whether accomplished electrophotographically or through photosensitive resists, the screen is completed by conventional filming and aluminizing processes which constitute no part of the present invention and, therefore, need not be described in detail. They are well understood in the screening art.

Experiences in the preparation of black surround screens of the type under consideration indicate the possibility of erosion of the black surround material during the screening of the phosphor material when, as in the preferred sequence of method steps, the black surround is applied to the faceplate before the phosphor material is deposited. If this is encountered, pigment may reach portions of the faceplate from which it has been excluded in laying down the light-absorbing or pigment material, leading to undesirable contamination. If the light-absorbing material has been applied in the manner explained in discussing FIGS. 3 and 4, the possibility of erosion may be greatly minimized by heating faceplate 10 to a temperature of approximately 300°, similar to the above-described process step for rendering the clear PVA deposits opaque since it also provides a surface hardness which will keep the pigment or black surround material confined to its assigned elemental areas of the faceplate.

It may be preferable to avoid the additional baking step and this may be accomplished by the application of a surface film of a lacquer or nitrocellulose to the black surround deposits or a thin film of sensitized PVA may be applied to the faceplate and subjected to a flooding beam of ultraviolet light which will cause the coating over the black surround material 13a to harden, serving again to retain this material in its assigned position on the faceplate. This process of protecting against cross contamination is described and claimed in a concurrently filed application of Constantin Szegho et al. Ser. No. 773,832, filed Nov. 6, 1968, assigned to the assignee of the present invention.

A similar process step may advantageously be taken in preparing a black surround screen where the deposits or dots of the various phosphor materials are first laid down. If the phosphor material is applied in a photosensitive resist, the faceplate may be subjected to a heat treatment of approximately 300° C. for a period of 30 minutes to achieve surface hardening, or a thin film of sensitized PVA may be applied and then exposed only behind the phosphor dots. Each is an effective expedient for providing the phosphor dots with a surface hardness which resists the tendency of such deposits otherwise to attract particles of the light-absorbing pigment which, of course, results in cross contamination.

The described methods of screening permit the application of sharply defined areas of light-absorbing pigment to the faceplate since the particles of pigment are finer than the average particle size of the phosphor material. Also, the tolerances for applying phosphor are relieved because, having first applied the light-absorbing material to appropriate elemental areas of the screen, the phosphor deposits may overlap the light-absorbing material without any adverse effect. The faceplate is viewed only from the front and only the phosphor deposits in the elemental areas of the faceplate which are not covered with light-absorbing material are effective in image reproduction. Additionally, it is easier to obtain optimized phosphor coatings and optimum brightness because it is not necessary to indulge in compromises in screening thicknesses that have heretofore been required for the purpose of obtaining close control of phosphor dot size. In the described methods, as explained, the actual size of the phosphor dots is of no particular consequence.

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

I claim:

1. The method of forming on the screen of a color image reproducing device a multiplicity of interleaved sets of deposits of different phosphor materials separated from one another by light-absorbing material, which method comprises the following steps:

coating said screen with a removable layer of a photosensitive material, having only volatilizable ingredients, and having a surface characteristic that may be altered by exposure to actinic energy;

exposing selected portions of said screen to actinic energy to establish in said layer latent images of elemental areas of said screen that are separated from one another and are to receive said phosphor materials;

developing said latent images of said elemental areas;

rendering said developed images opaque to actinic energy;

covering said screen and developed images with a second layer of a photosensitive material, including as an ingredient an inorganic pigment material having light-absorbing capabilities and also having the property of becoming insoluble in said solvent in response to exposure to actinic energy;

flooding said screen with actinic energy from the side thereof opposite that which is covered by said second layer;

treating said screen with said solvent to remove all of said second layer that covers said developed images;

depositing said phosphor materials over respectively assigned ones of said developed images of said elemental areas;

and baking said screen to remove the residuum of said removable layer from said screen.

The method in accordance with claim 1 in which:

the first photosensitive layer is of a material which becomes opaque to actinic energy upon being raised to a predetermined temperature,

and in which said screen is heated to said predetermined temperature after said latent images of said elemental areas have been developed and prior to the application of said second layer.

3. The method in accordance with claim 2 in which:

said first layer comprises a material which is soluble in said solvent of said second layer but becomes insoluble upon exposure to actinic energy and further acquires a surface hardness upon being heated to said predetermined temperature.

4. The method in accordance with claim 3 in which:

the material of said first layer is polyvinyl alcohol, and in which said screen is heated to above 175° C. but below the decomposition temperature of about 380° C.