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3,489,557

## PROCESS OF ELECTROSTATICALLY SCREENING A COLOR CATHODE-RAY TUBE

Howard George Lange and Song Whan So, Chicago, Ill.,  
assignors, by mesne assignments, to Zenith Radio Cor-  
poration, a corporation of Delaware

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5 Claims

### ABSTRACT OF THE DISCLOSURE

A method of electrostatically screening a color cathode-ray tube is disclosed. Phosphor particles are deposited on the cap section of the tube by a charge, expose, develop process. After phosphor deposition, small inert particles are deposited to reduce the capability of the developed image to retain particles of a next applied phosphor material.

The present invention is directed to an improvement in the process of electrostatically screening the image area of a color cathode-ray tube.

Electrostatic screening of color cathode-ray tubes is described in an application of Howard Lange, Ser. No. 481,316, filed Aug. 20, 1965 and assigned to the assignee of the present invention. It is most attractive because of the short processing time required in comparison with the more familiar process of slurry screening, also because of its saving in phosphor materials for the reason that a much smaller quantity of phosphor is utilized in electrostatic screening than in slurry screening.

In screening by electrophotography or electrostatically, the image area of a color cathode-ray tube is first provided with a conductive layer and then with a superposed layer of a photoconductor. A corona device scans the photoconductive layer to establish thereon a uniform charge and a latent charge image is then created in the photoconductor by exposing selected portions thereof to actinic radiation or light. While the process is of general application to color tubes in which the elemental areas of primary phosphor may have any of a variety of configurations, it is particularly attractive in the fabrication of the dot triad type of shadow mask tube. In the screening of such a tube, the exposure of the photoconductor takes place through the shadow mask so that the areas which are to represent phosphor deposits of a particular color are selectively discharged by the exposure. The resulting latent image is developed by the application of a toner including a phosphor and preferably a surfactant so that the phosphor responds to the electric fields of the photoconductor and is deposited on the discharged areas of the photoconductor. Utilization of this general process three times, with suitable adjustment of the position of the exposing light source, produces the dot triads of the shadow mask tube.

The present invention is a further development of that general process and is directed most particularly to minimizing cross contamination which is the depositing of a phosphor of one color into a previously applied phosphor dot of another color.

Accordingly, it is an object of the invention to provide an improved process of electrostatic screening for a color cathode-ray tube, in which cross contamination is minimized.

In practicing the invention, after the process described above has been carried out and a color image has been developed on the photoconductive layer covering the image area of the tube, the screening process continues by the application over the image area of an inert material. That material is chosen to have a particle size that

is small relative to the particle size of the applied phosphor so that the inert particles are directed by the electric field of the residual charge of the photoconductor to overcoat the developed image. Preferably, the overcoat is comprised of a material that bakes out in the succeeding processing steps of the color tube.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The organization and sequence of performance of the steps of the invention method, together with further objects and advantages thereof, may best be understood by reference to the following detailed description.

A color cathode-ray tube lends itself to electrostatic or electrophotographic screening since the envelope is a two piece structure having a screen or cap section and a companion funnel or cone section. The cap may be likened to a flanged dish and it may have any desirable cross section but is usually round or rectangular. The cone has the same cross section as the cap and is dimensioned so that its large end may fit precisely with the free end of the flange of the cap section to facilitate their integration by frit sealing. The opposite or small end of the cone accommodates the neck of the tube which houses the electron gun or guns for generating scanning electron beams. Since this application is addressed to screening, the remaining description will be confined to processing the cap section in order to establish a tri-color screen of the dot triad type.

The cap section and in particular the inner surface thereof which constitutes the image area of the tube is first made chemically clean in any well known manner and is then provided with a conductive layer which has a resistivity less than  $10^{10}$  ohms per square unit and preferably less than  $10^8$  ohms per square unit; the lower the resistivity the better. A suitable material for the conductive layer comprises a polymer of a predominant amount of a vinylbenzyl quaternary ammonium compound as described in U.S. Patent 3,011,918, issued Dec. 5, 1961 to Lloyd H. Silvernail et al. Such a material is available commercially from Dow Chemical Company under the trade designation QX-2611.7. A quantity of this material diluted with water is spin coated over the panel of the tube in process at a speed of about 60 r.p.m. to apply a uniform coating of approximately .003 inch thickness over the entire screen surface. This layer is dried with heat.

The next step in the screening process is the application over the image area of a layer of a photoconductive material superposed on the conductive layer. A formulation for this layer which has been successfully employed is as follows:

|                                                          |     |
|----------------------------------------------------------|-----|
|                                                          | ML. |
| 10% solution of polyvinyl carbazole in monochlorobenzene | 150 |
| 0.154% solution of anthroquinone in monochlorobenzene    | 30  |
| 10% solution of a plasticizer in monochlorobenzene       | 20  |
| Monochlorobenzene                                        | 460 |

A commercial form of polyvinyl carbazole is obtainable under the designation M-170 from Badische Anilin & Soda Fabrik A.G. A suitable commercially available plasticizer is Plastolein 9066 LT marketed by Emery Industries, Inc.

The photoconductive layer may be applied by spinning, flowing, spraying or the like and the desired viscosity may be obtained by the amount of monochlorobenzene employed. This layer may have a thickness of approximately 0.0003 inch and is preferably air dried.

As described in a concurrently filed application of Joseph C. Drozd, Ser. No. 534,633, the photoconductor may be pretreated for optimum results, that is to say, treated before a color image is developed thereon. In particular, the photoconductor may be rinsed with a surfactant or it may receive a pre-exposure of actinic light. In fact, it may be subjected to both pretreatments.

The photoconductor, pretreated if desired, is now prepared for the development of a color image and for this purpose a corona charging device is placed in close proximity to the photoconductive surface and energized to establish a uniform high charge over the photoconductive layer. If the color tube is of the dot triad type, a charge image is now established by exposing the charged photoconductive layer to actinic light through the shadow mask. This exposure takes place in a lighthouse with a source of actinic energy or light that is positioned to simulate the center of deflection of the electron gun that is to energize the phosphor elements of the particular color instantaneously being applied and a correcting lens may be interposed in the optical system to compensate for possible errors of registration of the beam relative to the phosphor elements as disclosed in Patent 3,003,874 issued Oct. 10, 1961, in the name of S. H. Kaplan.

For convenience, it will be assumed that the first exposure is for the green phosphor and the light source is, therefore, positioned to simulate the green electron gun of the tube. The portions of the photoconductive layer upon which the actinic light impinges are discharged, that is to say, these areas of the photoconductor lose the charge they have previously been given, whereas the other areas of that layer retain their charged condition. As a consequence of the exposure, there is established on the photoconductive layer a latent negative charge image of the elemental areas of the screen that are to be assigned to green.

The next step is the development of that image with a developer or toner comprising a carrier liquid, green phosphor and a surfactant which preferably is the same as that employed in the rinse of the pretreating step of the process. The surfactant is selected to establish a charge on the phosphor particles which is of the same polarity as the charge of the photoconductive layer so that the phosphor ingredient of the developer is rejected by the charged portions of the layer and is deposited in the uncharged areas. In this fashion, the deposit of green phosphor dots takes place and they may be fixed by heat or a fixing agent as described in the Lange application.

In accordance with the invention and in order to minimize cross contamination, the next step in the process comprises applying over the image area of the tube panel an inert material having particles which are small in size relative to the particle size of the phosphor so that they may be directed by the electric field of the residual charge of the photoconductive layer to overcoat the developed image. More particularly, it is proposed that the image area be rinsed immediately after development of the aforescribed latent image with a liquid containing fine resin particles. One rinse that has been used satisfactorily is formulated in accordance with the following:

|                                                                      |     |
|----------------------------------------------------------------------|-----|
|                                                                      | ML. |
| 5% solution of polyvinyl carbazole in solution in methylene chloride | 2.4 |
| Methylene chloride                                                   | 20  |

To this is added 400 ml. of trifluorotrichloroethane (Freon TF).

In formulating the rinse, one uses 100 ml. of the above and adds 300 ml. of an aliphatic hydrocarbon liquid such as Shell Sol 71 and 2 ml. 1% solution of a surfactant, such as Pluronic L101 in Freon. The Freon precipitates the resin so that it is effectively in suspension in a carrier liquid with which the image area is rinsed. Preferably, the surfactant of the after rinse is the same as that used

in the developer so as to avoid the possibility of interaction.

After this rinse, which causes the resin particles to fill any voids or irregularities of the first applied phosphor dots, the tube panel is in condition for screening with the next succeeding color. This color phosphor is applied in generally the same manner by first recharging the photoconductive layer, exposing it once again to actinic light through the shadow mask, and then developing the consequent latent image by the application of a toner comprising the next color phosphor. Of course, the exposure step requires that the exposing light source be properly positioned, in a manner now well understood in the art, so that the second family of phosphor dots is properly positioned on the image area of the tube panel relative to the first series of dots. If desired, the second deposited phosphor dots may now also be treated with an after rinse of a liquid containing fine resin particles as protection against cross contamination during the screening of the third series of phosphor dots.

The mechanism of applying the third series of phosphor dots is again the same as that just described with suitable adjustment in position of the exposing light source. After the three interlaced series of dots shall have been screened, they may be fixed by the application of heat or a suitable fixing agent and the panel is now ready to be advanced to the next processing step which usually entails filming preparatory to aluminizing that is of no concern to the present invention and therefore will not be discussed.

It has been found that the resin after-rinse materially reduces cross contamination. While the mechanism of its protection is not thoroughly understood, it is believed that the following explanation is applicable.

Immediately after the development of the first family of phosphor dots, and before the photoconductive layer has been recharged, that layer has a residual charge in all of the areas which have not been discharged by exposure to actinic light. It is customary experience that the phosphor dots are not strictly uniform and may have irregularities such as voids. Irregularities of this type in the environment of the residual charge on the photoconductor give rise to field gradients which, if not neutralized in one fashion or another, tend to cause some of the phosphor particles of the next succeeding toner applied to the panel to be deposited in these voids of the previously developed dots and result in cross contamination. The application of an after-rinse liquid carrying very fine resin particles in suspension and applied immediately after the development of any series of dots, tends to neutralize or eliminate field gradients within the dots. More specifically, it is believed that the fine resin particles of the after rinse are moved by the residual electric field of the photoconductive layer and deposited in the voids that may be present in the dot patterns, thereby minimizing the field gradients and reducing the opportunity for the next succeeding phosphor to be deposited over the previously formed phosphor dots. It is customary to employ phosphor particles in electrostatic screening having a particle size in the range from 1-15 microns; to achieve the full benefits of the invention, the resin particles should be small relative to the individual phosphor particles; accordingly the resin particles of the after rinse which are to respond to and be displaced by the residual electric fields of the photoconductor may have a size of one micron or less.

The inert material of the after rinse must be chosen of such character as to avoid interference with the light output of the tube. It is distinctly preferable that it be such as to volatilize during the bakeout process which usually follows screening. It is convenient to use resin as described because it has the desired small particle size and bakes out readily in the tube processing. Other illustrative resins that may be used in powdered form include Lucite and nitrocellulose. An organic crys-

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talline material, such as anthracene, is also suitable. While it is distinctly preferable to employ filler materials that bake out in the subsequent processing steps of the color tube, this is not a limitation of the present invention. Inert materials such as iron oxide may be used even though it does not bake out. Of course, the carrier liquid of the rinse must be compatible with the photoelectric screening process. For example, it must not adversely affect the photoconductive layer of the tube panel in process.

Reference may be had to the aforesaid Lange application, Ser. No. 481,316, for illustrative formulations of the conductive and photoconductive layers and the toner or developer. These constitute no part of the present invention.

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.

We claim:

1. In the process of electrostatically screening the image area of a color cathode-ray tube, in which a photoconductive layer is applied to said area and in which a plurality of different phosphor materials are deposited seriatim upon respective and non-overlapping portions of said photoconductive layer by electrostatic deposition in which said photoconductive layer is first charged and, for each of said phosphor materials, is then exposed by actinic energy through the color-selection electrode of the tube to establish a latent image of the deposition pattern for the phosphor material under process which image is thereafter developed by a toner including particles of the phosphor under process as an ingredient, the improvement which comprises:

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applying over said image area, after the first of said phosphor materials has been electrostatically deposited onto its assigned portions of said photoconductive layer, an inert material having particles which are one micron or less in size and are small in size relative to the particle size of said first phosphor to overcoat the developed image and reduce the capability of the developed image to retain particles of the next applied phosphor material.

2. The process improvement in accordance with claim 1 in which said inert material is suspended in a liquid and is applied by rinsing said image area of said tube with said liquid.

3. The process improvement in accordance with claim 1 in which said inert material is of a character to volatilize during a subsequent bakeout process of said tube.

4. The process improvement in accordance with claim 2 in which said inert material is a resin.

5. The process improvement in accordance with claim 4 in which said resin is a suspension of polyvinyl carbazole in a mixture of methylene chloride and trifluoro-trichloroethane.

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GEORGE F. LESMES, Primary Examiner

J. C. COOPER III, Assistant Examiner

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