

Description

The present invention relates to an apparatus and method for electrophotographically manufacturing a screen assembly and, more particularly, to utilization of a grid-developing electrode for manufacturing a screen assembly for a color cathode-ray tube (CRT) using dry-powdered, triboelectrically-charged screen structure materials.

A conventional shadow-mask-type CRT comprises an evacuated envelope having therein a viewing screen comprising an array of phosphor elements of three different emission colors arranged in a cyclic order, means for producing three convergent electron beams directed towards the screen, and a color selection structure or shadow mask comprising a thin multi-apertured sheet of metal precisely disposed between the screen and the beam-producing means. The apertured metal sheet shadows the screen, and the differences in incidence angles permit the transmitted portions of each beam to selectively excite only phosphor elements of the desired emission color. A matrix of light-absorptive material surrounds the phosphor elements.

U.S. Pat. No. 3,475,169, issued to H. G. Lange on Oct. 28, 1969, discloses a process for electrophotographically screening color cathode-ray tubes. The inner surface of the faceplate of the CRT is coated with a volatilizable conductive material and then overcoated with a layer of volatilizable photoconductive material. The photoconductive layer is then uniformly charged, selectively exposed with light through the shadow mask to establish a latent charge image, and developed using a high molecular weight carrier liquid bearing, in suspension, a quantity of phosphor particles of a given emissive color that are selectively deposited onto suitably charged areas of the photoconductive layer. The charging, exposing and deposition processes are repeated for each of the three color-emissive, i.e., green, blue, and red, phosphors of the screen.

An improvement in electrophotographic screening is described in U.S. Pat. No. 4,921,767, issued to P. Datta et al. on May 1, 1990, wherein the method thereof uses dry-powdered, triboelectrically-charged screen structure materials having at least a surface charge control agent thereon, to control the triboelectrical charging the materials. Such a method decreases manufacturing time and cost, because fewer steps are required for "dry-processing" of both the matrix and phosphor materials. A drawback of the described method is that some cross-contamination or background deposition may occur, because of electrostatic field variations near the photoconductor which do not effectively repel all the positively charged phosphor particles from selected regions of the photoconductor, as described below.

Accordingly, a need exists for a means of electro-

photographically manufacturing screen assemblies using dry-powdered, triboelectrically-charged phosphor materials, without cross-contamination of the different color-emitting materials.

In accordance with the present invention, an apparatus for electrophotographically manufacturing a luminescent screen assembly on a substrate, for use within a CRT, includes means for developing a latent image formed on a photoconductive layer using a dry-powdered, triboelectrically-charged screen structure material. The photoconductive layer overlies a conductive layer in contact with the substrate. A novel grid-developing electrode is spaced from the photoconductive layer by a distance that is large relative to the smallest dimension of the latent image. The electrode is biased with a suitable potential, to influence the deposition of the charged screen structure material onto the charged photoconductive layer. A method for electrophotographically manufacturing the screen assembly utilizes the grid-developing electrode.

In the drawings:

FIG. 1 is a plan view, partly in axial section, of a color cathode-ray tube made according to the present invention.

FIG. 2 is a section of a screen assembly of the tube shown in FIG. 1.

FIG. 3a shows a portion of a CRT faceplate having a conductive layer and a photoconductive layer thereon.

FIG. 3b shows the charging of the photoconductive layer on the CRT faceplate.

FIG. 3c shows the CRT faceplate and a portion of a shadow mask during a subsequent exposure step in the screen manufacturing process.

FIG. 3d shows the CRT faceplate and a novel grid-developing electrode during a developing step in the screen manufacturing process.

FIG. 3e shows the partially completed CRT faceplate during a later fixing step in the screen manufacturing process.

FIG. 4 shows the orientation of the electric field lines from a charged portion of the photoconductive layer on the CRT faceplate during one step in a screen manufacturing process, when the novel grid-developing electrode is not utilized.

FIG. 5 shows portions of the CRT faceplate and the novel grid-developing electrode, which are within circle A of FIG. 3d, during a matrix developing step in the screen manufacturing process.

FIG. 6 shows the orientation of the electric field lines from a charged portion of the photoconductive layer on the CRT faceplate during a subsequent step in the screen manufacturing process, when the grid-developing electrode is not utilized.

FIG. 7 shows portions of the CRT faceplate and the novel grid-developing electrode, which are within the circle A of FIG. 3d, during a phosphor developing

step in the screen manufacturing process.

FIG. 1 shows a color CRT 10 having a glass envelope 11 comprising a rectangular faceplate panel 12 and a tubular neck 14 connected by a rectangular funnel 15. The funnel 15 has an internal conductive coating (not shown) that contacts an anode button 16 and extends into the neck 14. The panel 12 comprises a viewing faceplate or substrate 18 and a peripheral flange or sidewall 20, which is sealed to the funnel 15 by a glass frit 21. A three-color phosphor screen 22 is carried on the inner surface of the faceplate 18. The screen 22, shown in FIG. 2, preferably is a line screen which includes a multiplicity of screen elements comprised of red-emitting, green-emitting and blue-emitting phosphor stripes R, G, and B, respectively, arranged in color groups or picture elements of three stripes or triads, in a cyclic order and extending in a direction which is generally normal to the plane in which the electron beams are generated. In the normal viewing position for this embodiment, the phosphor stripes extend in the vertical direction. Preferably, the phosphor stripes are separated from each other by a light-absorptive matrix material 23, as is known in the art. Alternatively, the screen can be a dot screen. A thin conductive layer 24, preferably of aluminum, overlies the screen 22 and provides a means for applying a uniform potential to the screen, as well as for reflecting light, emitted from the phosphor elements, through the faceplate 18. The screen 22 and the overlying aluminum layer 24 comprise a screen assembly.

Returning to FIG. 1, a multi-apertured color selection electrode or shadow mask 25 is removably mounted, by conventional means, in predetermined spaced relation to the screen assembly. An electron gun 26, shown schematically by the dashed lines, is centrally mounted within the neck 14, to generate and direct three electron beams 28 along convergent paths through the apertures in the mask 25 to the screen 22. The gun 26 may, for example, comprise a bi-potential electron gun of the type described in U.S. Pat. No. 4,620,133, issued to A.M. Morrell et al. on Oct. 28, 1986, or any other suitable gun.

The tube 10 is designed to be used with an external magnetic deflection yoke, such as yoke 30, located in the region of the funnel-to-neck junction. When activated, the yoke 30 subjects the three beams 28 to magnetic fields which cause the beams to scan horizontally and vertically in a rectangular raster over the screen 22. The initial plane of deflection (at zero deflection) is shown by the line P-P in FIG. 1 at about the middle of the yoke 30. For simplicity, the actual curvatures of the deflection beam paths in the deflection zone are not shown.

The screen 22 is manufactured by an electrophotographic process that is described in the above-cited U.S. Pat. No. 4,921,767 and schematically represented in FIGS. 3a through 3e.

A photoconductive layer 34 overlying a conductive layer 32 is charged in a dark environment by a conventional positive corona discharge apparatus 36, schematically shown in FIG. 3b, which moves across the layer 34 and charges it within the range of +200 to +700 volts, +200 to +500 volts being preferred. The shadow mask 25 is inserted into the panel 12, and the positively charged photoconductor is exposed, through the shadow mask, to the light from a xenon flash lamp 38 disposed within a conventional three-in-one lighthouse (represented by lens 40 in FIG. 3c). After each exposure, the lamp is moved to a different position, to duplicate the incident angle of the electron beam from the electron gun. Three exposures are required, from three different lamp positions, to establish a latent charge distribution or image on the photoconductive layer 34, i.e., to discharge the areas of the photoconductor where the light-emitting phosphors subsequently will be deposited to form the screen. Such exposed areas of the latent image are typically about 0.20 by 290mm for a 19V screen and about 0.24 by 470mm for a 31V screen.

When there are no other charged materials or conducting electrodes in proximity to the photoconductive layer 34, the latent image from the three exposures produces a latent image field adjacent to the layer 34, as represented by curving electric field lines 46, shown in FIG. 4, that extend from the unexposed positively charged regions to the exposed discharged regions. By convention, the direction of the field lines is the direction of the force experienced by a positively-charged particle; the force on a negatively-charged particle is in the reverse direction. The electric field lines 46 are substantially parallel to the photoconductive layer 34 over the regions where the surface charge varies most abruptly in position, and are substantially normal to the surface at those portions of the photoconductive layer 34 where the latent image has little spatial variation. When the lateral spacing, i.e., the width of the unexposed regions between the light-exposed regions, is in the range of 0.10 to 0.30mm, typically about 0.25mm, and the initial surface potential is in the preferred range of +200 to +500 volts, the peak magnitude of the latent image field at the photoconductive layer 34 is in the range of tens of kilovolts per centimeter (kV/cm). The three light exposures from three different lamp positions produce exposed regions that are typically several times wider than the unexposed regions; as a result, the normal field components at the surface are substantially stronger in the narrow unexposed regions than in the wider exposed regions. The magnitude of the latent image field near the surface of the photoconductive layer 34 diminishes rapidly with distance away from the surface, and it is reduced to peak values of a few tenths of a kv/cm at a separation equivalent to about 3/4 the period of the latent image pattern (about 0.19mm).

After the exposure step of FIG. 3c, the shadow mask 25 is removed from the panel 12, and the panel is moved to a first developer 42 (FIG. 3d) containing suitably prepared dry-powdered particles of a light-absorptive black matrix screen structure material. The black matrix material may be triboelectrically-charged by the method described in above-cited U.S. Pat. No. 4,921,767.

The developer 42, shown in FIG. 3d, includes a novel grid-developing electrode 44, typically made of a conductive mesh having about 6 to 8 openings per cm, which is spaced from the photoconductive layer 34 to facilitate the development thereof as described below. While 6 to 8 openings per cm are preferred, 100 openings per cm have been used successfully.

The spacing of the electrode 44 from the photoconductive layer 34 should be at least twice the lateral period of the openings in the mesh, so that the field created by the electrode 44 is sufficiently uniform. Additionally, the spacing should be great enough to provide a substantially uniform normal field component, as described below, beyond the range of the latent image field represented by the electric field lines 46. Typical spacings between the layer 34 and the electrode 44 range from 0.5 to 4cm, with 1cm to 2cm being preferred. Such spacings are large relative to the smallest dimension of the latent image produced on the layer 34. The electrode 44 is especially useful for developing both the black matrix and the phosphor patterns as described below.

During development, negatively-charged matrix particles 48, shown in FIG. 5, are expelled into the volume adjacent to the grid-developing electrode 44. The resulting body of space charge creates a substantially uniform, normal electric space charge field component 50 outside the grid-developing electrode 44. This space-charge field component 50 is directed away from the photoconductive layer 34 and acts to propel the negatively-charged matrix particles 48 through the opposing drag forces of the ambient air toward the photoconductive layer 34. The magnitude of the space-charge field may range from a few tenths of a kV/cm to several kV/cm; it is governed by the geometry of the developer 42 and the physical properties of the negatively-charged matrix particles 48. In particular, the space-charge field strength is proportional to the flow rate with which the negatively-charged matrix particles 48 leave the developer 42, and it is substantially independent of any potentials in the approximate range of zero to -2000 volts that might be applied to the grid-developing electrode 44. The purpose of the grid-developing electrode 44 is to establish a spatially uniform equipotential surface, controlled by an externally applied potential or bias voltage, near the photoconductive layer 34. By this means, the space-charge field lines 50 are terminated, and a separate, substantially uniform normal field component 52, in the volume between the photoconductive

layer 34 and the grid-developing electrode 44, becomes proportional to the difference between the potential applied to the electrode 44 and the spatial average of the positive potential from the latent image on the layer 34, and becomes inversely proportional to the distance from the layer 34 to the electrode 44. This uniform field component 52 adds vectorially to the existing latent image field near the surface of the photoconductive layer 34, as shown in FIG. 5, producing a negligible degree of distortion to the field lines 46 of the latent image field. This negligible distortion does not, however, intensify the latent image field nor straighten the field lines 46 associated with the image field. The resultant electric field undergoes a transition in a narrow zone 54 located at a distance from the photoconductive layer 34 approximately equal to three-fourths of the repeat period of the latent image pattern (typically less than 1mm). The grid-developing electrode 44 must be positioned beyond this distance, for the proper operation of the developing process. At distances greater than the distance to the transition zone 54, the electrical force on the approaching negatively-charged matrix particles is dominated by the substantially uniform field component 52 controlled by the grid-developing electrode 44. At lesser distances, i.e., between the photoconductive layer 34 and the transition zone 54, the rapidly strengthening latent image field becomes dominant.

In the above-cited U.S. Pat. No. 4,921,767, in which no grid-developing electrode is used, the substantially uniform space-charge field from the body of negatively-charged matrix particles extends directly to the latent image field near the surface of the photoconductive layer 34. Fluctuations in the flow rate with which matrix material is expelled from the developer 42 produce correlated fluctuations in the magnitude of the space-charge field. When the space charge field is too strong, it may reverse the direction of the repelling component of the latent image field, in the unexposed region at the surface of the photoconductive layer 34, and thereby cause the particles to land at undesired, i.e., unexposed, locations on the photoconductive layer. A somewhat weaker space charge field does not reverse the repelling component of the latent image field, but may shift the location of the field transition zone too close to the photoconductive layer 34. When such a shift occurs, negatively-charged matrix particles with high mass density, high triboelectric charge and/or large size, may acquire enough momentum toward the photoconductive layer 34 to traverse the narrow space of repelling forces and thereby land at the above-described undesired locations. In the present invention, the grid-developing electrode 44 is located at a distance substantially beyond that of the transition zone 54, to provide a controlled, substantially uniform electric field component 52 beyond the range of the latent image

field. Such a location for the grid-developing electrode 44 shields the latent image field, represented by field lines 46, from the effects of the space charge field 50 created by the space charge of the particles expelled by the developer 42. The bias voltage on the grid-developing electrode 44 may be adjusted, by taking into consideration the desired flow rate of material from the developer 42 and the physical properties of the negatively-charged matrix particles, to minimize the deposition of matrix particles on the undesired locations of the photoconductor. The potential applied to the grid-developing electrode 44 should be more negative than the spatial average of the potential from the latent image, in order that the substantially uniform field component 52, outside the transition zone 54, acts to attract the negatively-charged matrix particles 48 to the photoconductive layer 34. Useful values for the potential on the grid electrode 44 range from zero to about -2000 volts. If the uniform electric field component 52, established by the grid-developing electrode 44, is weaker than the electric field 50 from the body of space charge, the grid field cannot support a material flow rate as high as the rate at which negatively-charged matrix particles are expelled from the developer 42. Consequently, the grid-developing electrode 44 will collect a fraction of the negatively-charged matrix particles, while the remaining fraction will continue toward the photoconductive layer 34 at a lower flow rate commensurate with the reduced field intensity between the grid-developing electrode 44 and the photoconductive layer 34. Conversely, if the uniform electric field component 52 between the grid-developing electrode 44 and the photoconductive layer 34 is equal to or stronger than the electric field 50 of the space charge, few negatively-charged matrix particles 48 will be collected by the grid-developing electrode 44. The particles 48 will tend, instead, to pass through the openings of the grid-developing electrode 44 and to be accelerated to the new flow velocity associated with the higher electric field component 52. Negatively-charged matrix particles are propelled through the transition zone 54 and attracted to the positively-charged, unexposed area of the photoconductive layer 34, to form the matrix layer 23, by a process called direct development.

Infrared radiation may then be used, as shown in FIG. 3e, to fix the particles 48 of matrix material by melting or thermally bonding the polymer component of the matrix material to the photoconductive layer, to form the matrix 23.

The photoconductive layer 34 containing the matrix 23 is uniformly recharged to a positive potential of about 200 to 500 volts, for the application of the first of three color-emissive, dry-powdered phosphor screen structure materials. The shadow mask 25 is re-inserted into the panel 12, and selective areas of the photoconductive layer 34, corresponding to the

locations where green-emitting phosphor material will be deposited, are exposed to visible light from a first location within the lighthouse 40 to selectively discharge the exposed areas. The first light location approximates the incidence angle of the green phosphor-impinging electron beam. When there are no other charged materials or conducting electrodes in proximity to the photoconductive layer 34, the latent image from the single exposure produces a latent image field represented by curving electric field lines 46', shown in FIG. 8, that extend from the unexposed positively-charged regions to the exposed discharged regions. The electric field lines 46' are substantially parallel to the photoconductive layer 34 over the regions where the surface charge varies most abruptly in position, and they are substantially normal to the surface at those portions of the photoconductive layer 34 where the latent image has little spatial variation. When the lateral spacing between the light-exposed regions where green-emitting phosphor material will be deposited is in the range of 0.30 to 0.90mm, typically 0.76mm, and the initial surface potential is in the preferred range of +200 to +700 volts, the peak magnitude of the latent image field at the photoconductive layer 34 is in the range of tens of kV/cm. Unlike the three superimposed light exposures from three lamp positions previously used for the black matrix pattern, the light exposure from a single lamp position produces exposed regions that are typically several times narrower than the unexposed regions; as a result, the normal field components at the surface are substantially stronger in the narrow exposed regions than in the wider unexposed regions. The magnitude of the electric field near the surface of the photoconductive layer 34 diminishes rapidly with distance away from the surface, and it is reduced to a peak value of a few tenths of a kV/cm at a separation equivalent to about 3/4 the period of the latent image pattern for the green-emitting phosphor locations.

After the exposure of the locations where the green-emitting phosphor will be deposited, the shadow mask 25 is removed from the panel 12, and the panel is moved to a second developer 42 having a grid-developing electrode 44 and containing suitably prepared dry-powdered particles of green-emitting phosphor. The phosphor particles are surface-treated with a suitable charge controlling material, as described in U.S. Pat. No. 4,921,727, issued to P. Datta et al. on May 1, 1990, and U.S. Pat. Appln. Serial No. 287,358, filed by P. Datta et al. on Dec. 21, 1988.

The positively-charged green-emitting phosphor particles are expelled from the developer, repelled by the positively-charged areas of the photoconductive layer 34 and matrix 23, and deposited onto the discharged, light-exposed areas of the photoconductive layer 34, in a process known as reversal developing. As shown in FIG. 7, the expulsion of a substantial

quantity of positively-charged green-emitting phosphor particles 48' into the volume adjacent to the grid-developing electrode 44 creates a separate, nearly uniform, normal electric space charge field component 50' outside the grid-developing electrode 44. This space-charge field component 50' is directed toward the photoconductive layer 34 and acts to propel the positively charged, green-emitting phosphor particles 48' through the opposing drag forces of the ambient air to the vicinity of the photoconductive layer 34. The magnitude of the space-charge field may range from a few tenths of a kV/cm to several kV/cm, and is governed by the geometry of the developer and the physical properties of the positively-charged, green-emitting phosphor particles. In particular, the space-charge field strength is proportional to the flow rate with which the positively-charged, green-emitting phosphor particles 48' leave the developer 42, and it is substantially independent of potentials in the approximate range of zero to +2000 volts that might be applied to the grid-developing electrode 44. The grid-developing electrode 44 is positively biased to a voltage in the range of +200 to +1600 volts, depending on the spacing between the electrode 44 and the photoconductive layer 34. The closer the spacing, the lower the voltage required to establish the desired substantially uniform electric field 52' between the electrode 44 and the photoconductor layer 34. The strength of this field 52' establishes the desired velocity of the phosphor particles as they approach the previously described electric field transition zone 54', which lies typically less than about 1mm from the surface of the photoconductor layer 34. In the absence of a grid-developing electrode, the propelling effect of the space-charge field from the body of positively-charged phosphor particles expelled by the developer 42 may be strong enough to substantially reduce the repelling effect of the latent image field in the exposed region of the photoconductive layer 34. The resultant normal component of the latent image field near the surface of the photoconductive layer 34 may not be effective to repel the positively-charged, green-emitting phosphor particles, in reversal development, from the areas of the photoconductive layer that should be free of green phosphor. Accordingly, cross-contamination occurs, unless the grid-developing electrode 44 is utilized during phosphor development.

The positive potential applied to the grid-developing electrode 44 is adjusted according to the desired flow rate of phosphor material from the developer 42, and according to such physical properties as size, mass density, and charge of the green-emitting phosphor particles, in order to minimize the deposition of particles in undesired locations. The potential applied to the grid-developing electrode 44 should be more positive than the spatial average of the potential from the latent image, in order that the substantially

uniform field 52' outside the transition zone 54' attracts the positively-charged phosphor particles 48' to the photoconductive layer 34. If the field 52' established by the grid-developing electrode 44 is weaker than the field 50' from the body of space charge, the grid field cannot support a material flow rate as high as the rate at which phosphor particles 48' are expelled by the developer 42. Consequently, the grid-developing electrode 44 will collect a fraction of the positively-charged phosphor particles, while the remaining fraction continues toward the photoconductive layer 34 at a lower flow rate commensurate with the reduced field intensity between the grid-developing electrode 44 and the photoconductive layer 34. Conversely, if the field 52' between the grid-developing electrode 44 and the photoconductive layer 34 is equal to or stronger than the field 50' of the space charge, few positively-charged phosphor particles will be collected by the grid-developing electrode 44. The particles 48' will, instead, pass through the openings of the grid-developing electrode 44 and be accelerated to the new flow velocity associated with the higher field 52'. The phosphor particles 48' are thus propelled through the transition zone 54' and attracted to the discharged, exposed areas of the photoconductive layer 34. The deposited green-emitting phosphor particles are fixed to the photoconductive layer as described below

The photoconductive layer 34, matrix 23 and green phosphor layer (not shown) are uniformly recharged to a positive potential of about 200 to 700 volts, for the application of the blue-emitting phosphor particles of screen structure material. The shadow mask is reinserted into the panel 12, and selective areas of the photoconductive layer 34 are exposed to visible light from a second position within the light-house 40, which approximates the incidence angle of the blue phosphor-impinging electron beam, to selectively discharge the exposed areas. The shadow mask 25 is removed from the panel 12, and the panel is moved to a third developer 42 containing suitably prepared dry-powdered particles of blue-emitting phosphor. The phosphor particles are surface-treated, as described above, with a suitable charge controlling material, to provide a positive charge on the phosphor particles. The dry-powdered, triboelectrically-positively-charged, blue-emitting, phosphor particles are expelled from the third developer 42, propelled to the transition zone 54' by the controlled, substantially uniform field 52' of the biased grid-developing electrode 44; repelled from the positively-charged areas of the photoconductive layer 34, the matrix 23 and the green phosphor material; and deposited onto the discharged, light-exposed areas of the photoconductive layer. The deposited blue-emitting phosphor particles may be fixed to the photoconductive layer, as described below.

The processes of charging, exposing, developing

and fixing are repeated again for the dry-powdered, red-emitting, surface-treated phosphor particles. The exposure to visible light, to selectively discharge the positively-charged areas of the photoconductive layer 34, is from a third position within the lighthouse 40, which approximates the incidence angle of the red phosphor-impinging electron beam. The dry-powdered, triboelectrically-positively-charged, red-emitting phosphor particles are expelled from a fourth developer 42, propelled to the transition zone 54' by the controlled, substantially uniform field 52' of the grid-developing electrode 44; repelled from the positively-charged areas of the previously deposited screen structure materials; and deposited onto the discharged areas of the photoconductive layer 34.

The phosphors may be fixed by exposing each successive deposition of phosphor material to infrared radiation, which melts or thermally bonds the polymer component to the photoconductive layer 34. Subsequent to the fixing of the red-emitting phosphor material, the screen structure material is filmed and then aluminized, as is known in the art.

The faceplate panel 12 is baked in air, at a temperature of 425°C for about 30 minutes, to drive off the volatilizable constituents of the screen, including the conductive layer 32, the photoconductive layer 34 and the solvents present in both the screen structure materials and in the filming material. The resultant screen assembly may possess higher resolution (as small as 0.1mm line width obtained using a resolution target), higher light output than a conventional wet processed screen, and greater color purity because of the reduced cross-contamination of the phosphor materials.

In prior applications of electrophotography to office copying machines (see, e.g., U.S. Pat. No. 2,784,109, issued to Walkup on Mar. 5, 1957), a developing electrode is used. The use is to eliminate the edge-enhancement effects encountered in the development of uniformly charged, i.e., unexposed or partially exposed, areas that are substantially larger than the width of the line strokes in typical printed lettering, which are typically of the order of 0.5 to 1.0mm. In these applications, the electrode is spaced substantially closer to the photoreceptive layer than the diameter of the area to be uniformly developed, i.e., the unexposed areas, and the applied potential is large enough to significantly straighten the curving electric field lines near the edges of the charged image areas. Such an electrode is not required for developing small dark areas such as lines, letters, characters and the like, which have a size comparable to the smallest dimension of the phosphor and matrix lines of a CRT screen. In contrast to this usage, the grid-developing electrode 44 used for electrophotographically manufacturing the screen assembly of a color CRT in the present invention is structurally and functionally different from the electrode used in a

copy machine. The novel grid electrode 44 is placed at a distance (typically 0.5 to 4.0cm) from the photoconductive layer 34 that is relatively large compared to, e.g., equal to or greater than six times, the characteristic size of the smallest dimension of the unexposed latent image areas (approximately 0.75mm for phosphor, and 0.25mm for matrix) and lies outside the effective range of the spatially varying latent image field (46 and 46'). Furthermore, the magnitude of the potential applied to the grid electrode 44 is purposely restricted to a range of values which produce little distortion of the highly localized latent image field, so that intensification and straightening of the field lines does not occur.

The novel grid-developing electrode 44 provides a more uniform deposition of phosphor, without cross-contamination, than is possible in dry-powder processes without such an electrode. The electrode also provides means for tailoring the amount of phosphor deposited on different areas of the faceplate, analogous to the conventional slurry screening process where screen weight variations are achieved by controlling slurry thickness and the light intensity distribution of the lighthouse. In the present process, screen weight is controlled by the bias potential applied to the grid-developing electrode 44 and the distance between the electrode 44 and the photoconductive layer 34 on the faceplate 18. The grid-developing electrode is generally contoured to conform to the curvature of the faceplate; however, it can be tailored to compensate for non-uniformities in the phosphor developing apparatus or to achieve a desired non-uniformity in phosphor screen weight. Additionally, the apparatus and process described herein may be utilized to screen a variety of tube sizes on the same developer with only a change in the size of the grid-developing electrode.

Claims

1. An apparatus for electrophotographically manufacturing a luminescent screen assembly (22,24) on a substrate (18), for use within a CRT (10), said substrate having a conductive layer (32) in contact therewith and an overcoating of a photoconductive layer (34) having a latent image established thereon and producing a latent image field (46,46') adjacent thereto, said apparatus including

means (42) for developing said latent image on said photoconductive layer with a dry-powdered, triboelectrically charged screen structure material (48,48'),

a grid-developing electrode (44) spaced from said photoconductive layer by a distance that is large relative to the smallest dimension of said latent image and beyond the range of said la-



and fixing are repeated again for the dry-powdered, red-emitting, surface-treated phosphor particles. The exposure to visible light, to selectively discharge the positively-charged areas of the photoconductive layer 34, is from a third position within the lighthouse 40, which approximates the incidence angle of the red phosphor-impinging electron beam. The dry-powdered, triboelectrically-positively-charged, red-emitting phosphor particles are expelled from a fourth developer 42, propelled to the transition zone 54' by the controlled, substantially uniform field 52' of the grid-developing electrode 44; repelled from the positively-charged areas of the previously deposited screen structure materials; and deposited onto the discharged areas of the photoconductive layer 34.

The phosphors may be fixed by exposing each successive deposition of phosphor material to infrared radiation, which melts or thermally bonds the polymer component to the photoconductive layer 34. Subsequent to the fixing of the red-emitting phosphor material, the screen structure material is filmed and then aluminized, as is known in the art.

The faceplate panel 12 is baked in air, at a temperature of 425°C for about 30 minutes, to drive off the volatilizable constituents of the screen, including the conductive layer 32, the photoconductive layer 34 and the solvents present in both the screen structure materials and in the filming material. The resultant screen assembly may possess higher resolution (as small as 0.1mm line width obtained using a resolution target), higher light output than a conventional wet processed screen, and greater color purity because of the reduced cross-contamination of the phosphor materials.

In prior applications of electrophotography to office copying machines (see, e.g., U.S. Pat. No. 2,784,109, issued to Walkup on Mar. 5, 1957), a developing electrode is used. The use is to eliminate the edge-enhancement effects encountered in the development of uniformly charged, i.e., unexposed or partially exposed, areas that are substantially larger than the width of the line strokes in typical printed lettering, which are typically of the order of 0.5 to 1.0mm. In these applications, the electrode is spaced substantially closer to the photoreceptive layer than the diameter of the area to be uniformly developed, i.e., the unexposed areas, and the applied potential is large enough to significantly straighten the curving electric field lines near the edges of the charged image areas. Such an electrode is not required for developing small dark areas such as lines, letters, characters and the like, which have a size comparable to the smallest dimension of the phosphor and matrix lines of a CRT screen. In contrast to this usage, the grid-developing electrode 44 used for electrophotographically manufacturing the screen assembly of a color CRT in the present invention is structurally and functionally different from the electrode used in a

copy machine. The novel grid electrode 44 is placed at a distance (typically 0.5 to 4.0cm) from the photoconductive layer 34 that is relatively large compared to, e.g., equal to or greater than six times, the characteristic size of the smallest dimension of the unexposed latent image areas (approximately 0.75mm for phosphor, and 0.25mm for matrix) and lies outside the effective range of the spatially varying latent image field (46 and 46'). Furthermore, the magnitude of the potential applied to the grid electrode 44 is purposely restricted to a range of values which produce little distortion of the highly localized latent image field, so that intensification and straightening of the field lines does not occur.

The novel grid-developing electrode 44 provides a more uniform deposition of phosphor, without cross-contamination, than is possible in dry-powder processes without such an electrode. The electrode also provides means for tailoring the amount of phosphor deposited on different areas of the faceplate, analogous to the conventional slurry screening process where screen weight variations are achieved by controlling slurry thickness and the light intensity distribution of the lighthouse. In the present process, screen weight is controlled by the bias potential applied to the grid-developing electrode 44 and the distance between the electrode 44 and the photoconductive layer 34 on the faceplate 18. The grid-developing electrode is generally contoured to conform to the curvature of the faceplate; however, it can be tailored to compensate for non-uniformities in the phosphor developing apparatus or to achieve a desired non-uniformity in phosphor screen weight. Additionally, the apparatus and process described herein may be utilized to screen a variety of tube sizes on the same developer with only a change in the size of the grid-developing electrode.

Claims

1. An apparatus for electrophotographically manufacturing a luminescent screen assembly (22,24) on a substrate (18), for use within a CRT (10), said substrate having a conductive layer (32) in contact therewith and an overcoating of a photoconductive layer (34) having a latent image established thereon and producing a latent image field (46,46') adjacent thereto, said apparatus including
 - means (42) for developing said latent image on said photoconductive layer with a dry-powdered, triboelectrically charged screen structure material (48,48'),
 - a grid-developing electrode (44) spaced from said photoconductive layer by a distance that is large relative to the smallest dimension of said latent image and beyond the range of said la-



tent image field, and

means for electrically biasing said electrode with a suitable potential, to influence the deposition of said charged screen structure material onto said photoconductive layer.

screen structure materials onto said charged photoconductive layer.

5 Patentansprüche

2. The apparatus according to claim 1, wherein said grid-developing electrode (44) comprises a conductive mesh having a multiplicity of openings therethrough.
3. The apparatus according to claim 2, wherein said openings are substantially rectangular and substantially uniform in size within said grid-developing electrode (44).
4. The apparatus according to claim 1, wherein said means for electrically biasing is for applying a potential of between about -2000 to +2000 volts to said grid-developing electrode (44).
5. A method of electrophotographically manufacturing a luminescent screen assembly (22,24) on a substrate (18), for use within a CRT (10), including the steps of:
 - a) coating said substrate with a conductive layer (32);
 - b) overcoating said conductive layer with a photoconductive layer (34);
 - c) establishing an electrostatic charge on said photoconductive layer;
 - d) exposing selected areas of said photoconductive layer to visible light, to affect the charge thereon and to establish a latent image having exposed and unexposed areas, said latent image producing a latent image field (46,46') adjacent to the photoconductive layer; and
 - e) developing said photoconductive layer with dry-powdered, triboelectrically charged screen structure materials (48,48') having a surface charge control agent thereon to control the triboelectrical charging thereof, wherein said developing step includes the step of:
 - i) locating a grid-developing electrode (44) at a distance from said photoconductive layer that is large relative to the smallest dimension of said unexposed latent image areas and beyond the range of said latent image field, so that the field created by said grid-developing electrode does not substantially affect said latent image field; and
 - ii) electrically biasing said grid-developing electrode with a suitable potential within the range of -2000 to +2000 volts, to influence the deposition of said charged

1. Vorrichtung zur electrophotographischen Herstellung einer Leuchtschirmanordnung (22, 24) auf einem Substrat (18) zur Verwendung in einer Kathodenstrahlröhre (10), wobei das Substrat eine leitfähige Schicht (32) aufweist, mit der sie in Berührung steht, und eine Beschichtung mit einer photoleitfähigen Schicht (34), auf der ein latentes Bild ausgebildet ist, das ein Feld des latenten Bildes (46, 46') erzeugt, das an ihr anliegt, wobei die Vorrichtung umfaßt Mittel (42) zur Entwicklung des latenten Bildes auf der photoleitfähigen Schicht mit einem trocken-pulverförmigen, triboelektrisch aufgeladenen Bildschirmmaterial (48, 48'), eine Gitterentwicklungselektrode (44), die sich von der photoleitfähigen Schicht in einem Abstand befindet, der groß ist relativ zur kleinsten Abmessung des latenten Bildes, und jenseits der Reichweite des Feldes des latenten Bildes, und Mittel zur elektrischen Vorspannung dieser Elektrode mit einem geeigneten Potential, um die Ablagerung des aufgeladenen Bildschirmmaterials auf der photoleitfähigen Schicht zu beeinflussen.
2. Vorrichtung nach Patentanspruch 1, in der die Gitterentwicklungselektrode (44) ein leitendes Netz mit einer Vielzahl von Öffnungen umfaßt.
3. Vorrichtung nach Patentanspruch 2, in der die Öffnungen im wesentlichen rechteckig und von im wesentlichen gleichförmiger Größe innerhalb der Gitterentwicklungselektrode (44) sind.
4. Vorrichtung nach Patentanspruch 1, in der die Mittel zur elektrischen Vorspannung dazu dienen, ein Potential von ungefähr -2000 bis +2000 Volt an die Gitterentwicklungselektrode (44) anzulegen.
5. Verfahren zur electrophotographischen Herstellung einer Leuchtschirmanordnung (22, 24) auf einem Substrat (18) zur Verwendung in einer Kathodenstrahlröhre (10), folgende Schritte umfassend:
 - a) Beschichtung des Substrates mit einer leitfähigen Schicht (32);
 - b) Bedecken der leitfähigen Schicht mit einer photoleitfähigen Schicht (34);
 - c) elektrische Aufladung der photoleitfähigen Schicht;
 - d) Belichtung ausgewählter Bereiche der photoleitfähigen Schicht mit sichtbarem Licht, um



ihre Ladung zu beeinflussen und ein latentes Bild aus belichteten und unbelichteten Flächen auszubilden, wobei das latente Bild ein an der photoleitfähigen Schicht anliegendes Feld des latenten Bildes (46, 46') erzeugt; und e) Entwicklung der photoleitfähigen Schicht mit trockenpulverförmigem, triboelektrisch aufgeladenem Bildschirmmaterial (48, 48'), das mit einem Stoff zur Regulierung der Oberflächenladung versehen ist, um seine triboelektrische Ladung zu regulieren, wobei dieser Entwicklungsschritt die folgenden Schritte umfaßt:

i) Anordnen einer Gitterentwicklungselektrode (44) in einem Abstand von der photoleitfähigen Schicht, der groß ist im Vergleich zur kleinsten Abmessung der unbelichteten Bildflächen, und jenseits der Reichweite des Feldes des latenten Bildes, so daß das durch die Gitterentwicklungselektrode erzeugte Feld das Feld des latenten Bildes nicht wesentlich beeinflusst; und

ii) elektrisches Vorspannen dieser Gitterentwicklungselektrode mit einem geeigneten Potential im Bereich von -2000 bis +2000 Volt, um die Ablagerung des aufgeladenen Bildschirmmaterials auf der aufgeladenen photoleitfähigen Schicht zu beeinflussen.

Revendications

1. Dispositif pour fabriquer par électrophotographie un montage d'écran luminescent (22, 24) sur un substrat (18) pour utilisation à l'intérieur d'un tube cathodique couleur (10), ledit substrat ayant une couche conductrice (32) en contact avec celui-ci et un revêtement d'une couche photoconductrice (34) ayant une image latente constituée sur celle-ci et produisant un champ d'image latente (46, 46') adjacent, le dit dispositif comprenant des moyens (42) pour développer l'image latente sur la couche photoconductrice avec une matière de structure d'écran en poudre sèche, chargée triboélectriquement (48, 48'), une électrode de développement de grille (44) écartée de la couche photoconductrice d'une distance qui est grande par rapport à la plus petite dimension de l'image latente et au-delà de la plage du champ d'image latente et des moyens pour polariser électriquement l'électrode avec un potentiel approprié pour influencer le processus de dépôt de la matière de structure d'écran chargée sur la couche photoconductrice.

2. Dispositif selon la revendication 1 dans lequel

l'électrode de développement de grille (44) comprend une maille conductrice ayant une multitude d'ouvertures.

3. Dispositif selon la revendication 2 dans lequel les ouvertures sont en grande partie rectangulaires et en grande partie de taille uniforme dans l'électrode de développement de grille (44).

4. Dispositif selon la revendication 1 dans lequel les moyens pour polariser électriquement sont prévus pour appliquer un potentiel situé entre environ -2000 et +2000 volts à l'électrode de développement de grille (44).

5. Processus pour fabriquer par électrophotographie un montage d'écran luminescent (22, 24) sur un substrat (18) pour utilisation à l'intérieur d'un tube cathodique couleur (10) comprenant les étapes de :

a) revêtement du substrat avec une couche conductrice (32) ;

b) revêtement de la couche conductrice avec une couche photoconductrice (34);

c) constitution d'une charge électrostatique sur la couche photoconductrice ;

d) exposition de zones sélectionnées de la couche photoconductrice à la lumière visible pour y affecter la charge et pour constituer une image latente ayant des zones exposées et des zones non exposées, l'image latente produisant un champ d'image latente (46, 46') adjacent à la couche photoconductrice et

e) développement de la couche photoconductrice avec des matières de structure d'écran (48, 48') en poudre sèche, chargées triboélectriquement, ayant un agent de contrôle de charge de surface pour contrôler le processus de charge triboélectrique, ladite étape de développement comprenant les étapes de :

i) positionnement d'une électrode de développement de grille (44) à une distance de la couche photoconductrice qui est grande par rapport à la plus petite dimension des zones d'image latente non exposées et au-delà de la plage du champ d'image latente si bien que le champ créé par l'électrode de développement de grille n'affecte pas considérablement le champ d'image latente et

ii) polarisation électrique de ladite électrode de développement de grille avec un potentiel approprié à l'intérieur de la plage de -2000 à +2000 volts pour influencer le processus de dépôt des matières de structure d'écran chargées sur la couche photoconductrice chargée.