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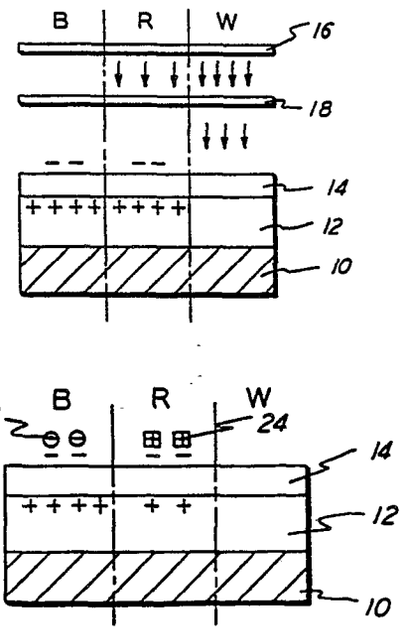
(54) Electrophotographic printing.

(57) A method of electrophotographic printing in which an original document (16) having two different colors (B, R) is reproduced. Electrostatic latent images of opposite polarities are developed with marking particles having opposite polarities and different colors. The marking particles are transferred to a copy sheet and permanently affixed thereto, forming a bicolor copy of the original document.



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Electrophotographic printing

This invention relates generally to a method of electrophotographic printing, and more particularly concerns reproducing an original document having information in two different colors.

In the process of electrophotographic printing, a photoconductive surface is charged to a substantially uniform level. The photoconductive surface is imagewise exposed to record an electrostatic latent image corresponding to the informational areas of the original document being reproduced. Thereafter, a developer mixture is transported into contact with the electrostatic latent image. Toner particles are attracted from the carrier granules of the developer mixture onto the latent image. The resultant toner powder image is then transferred from the photoconductive surface to a copy sheet and permanently affixed thereto.

With the advent of multi-color electrophotographic printing, a plurality of developer units is utilized. In this type of system, each developer unit contains discretely colored toner particles. The light image of the colored original document is optically filtered to form a single color light image. This single color light image creates a single color electrostatic latent image on the photoconductive surface. The single-color electrostatic latent image is then developed with toner particles of a color complementary in color to the color of the filtered light image. In this way, three single-color toner powder images are successively developed on the photoconductive surface. Each single color toner powder image corresponds to the complement of one of the colors of the information contained in the original document. These toner powder images are successively transferred to the copy sheet in superimposed registration with one another to form a multi-color copy corresponding to the original document being reproduced. Thereafter, the composite toner powder image is permanently affixed to the copy sheet.

It is highly desirable to produce color copies at high speeds. Moreover, it has been found that frequently original documents contain highlighted portions, e.g. the original document has information in black and red. Thus, it is advantageous for the electrophotographic printing machine to reproduce both the black regions and the red regions in a single pass. By 'single pass' is meant that a composite electrostatic latent image having regions corresponding to the red information

and black information is recorded on the photoconductive surface. This composite electrostatic latent image is then developed with black and red toner particles so as to produce a two-color toner powder image. This two-color toner power image is subsequently transferred to the copy sheet and permanently affixed thereto. In this way, a highlighted color copy of the original document may be readily produced at relatively high speeds. Numerous approaches have been devised for producing color copies. The following disclosures appear to be relevant:

U.S. Patent No. 4,097,139
Patentee: Hauser et al.
Issued: June 27, 1978

U.S. Patent No. 4,230,783
Patentee: Aoki et al.
Issued: October 28, 1980

Hauser et al. describes an electrophotographic printing machine in which two successive electrostatic latent images are formed on a photoconductive surface. A first removable developer unit is initially loaded with developer material of one color for developing the first latent image therewith. Thereafter, a second developer unit replaces the first developer unit and develops the second electrostatic latent image with developer material of another color. Prior to developing the second electrostatic latent image, the first electrostatic latent image is transferred to a copy sheet. Then, the second electrostatic latent image is transferred to the copy sheet. After both powder images have been transferred to the copy sheet, the powder images are permanently affixed thereto forming a color highlighted copy.

Aoki et al. discloses a process of electrophotographic printing in which the photoconductor is initially charged, imagewise exposed through a color filter in one of the three additive primary colors, and discharged by being charged to the opposite polarity or with an alternating current. The photoconduetor is then uniformly illuminated with white light to record an electrostatic latent image thereon. Simultaneously with the imagewise exposure and discharge, the photoconductor is exposed to infrared light rays.

In accordance with one aspect of the features of the present invention, there is provided a method of electrophotographic printing in which

an original document having information in two different colors is reproduced. A first electrostatic latent image corresponding to the information in one of the colors of the original document, and a second electrostatic latent image corresponding to the information in the other of the colors of the original document are recorded on a light-sensitive member. The first electrostatic latent image and the second electrostatic latent image are of different polarities. The first electrostatic latent image and the second electrostatic latent image are developed with marking particles having different polarities and colors.

Other apsects of the present invention will become apparent as the following description proceeds and upon reference to the drawings, in which:

Figure 1 is a schematic elevational view showing charging of the photoconductive surface;

Figure 2 is a schematic elevational view depicting exposing the charged photoconductive surface to a cyan-filtered light image of the original document;

Figure 3 is a schematic elevational view illustrating exposing the charged photoconductive surface to a red-filtered light image of the original document; and

Figure 4 is a schematic elevational view showing development of the electrostatic latent images recorded on the photoconductive surface with oppositely-charged marking particles.

For a general understanding of the features of the present invention, reference is had to the drawings. In the drawings, like reference numerals have been used throughout to designate identical elements. Figures 1 through 4, inclusive, schematically depict the electrophotographic printing process of the present invention. It will become evident from the following discussion that this process is equally well suited for use in a wide variety of machines. The electrophotographic printing process of the present invention is not necessarily limited in its application to the particular method depicted herein.

The present invention relates to a two-color electrophotographic printing process, and, in particular, to a two-color image forming process wherein latent images corresponding to each color of a bicolor document are formed and developed with toner particles of different polarities. The toner particles are of a color corresponding to the colors contained within the original document. The resulting two-color toner powder image is then transferred to the copy sheet and subsequently permanently affixed thereto. In this way, a two-color copy is formed from the original document.

In general, the process of obtaining two-color copies from an original document composed of two colors, e.g. black and red, utilizes a light-sensitive member comprising a light-sensitive layer with an insulating layer being superimposed thereover. The amount of charge remaining at the boundary between the insulating layer and the light-sensitive layer in the black portion, the red portion and the white portion is changed. The potential in the white ground portion is adjusted to about 0 volts. Electrostatic latent images having opposite polarities are formed in the black and the red portions. The latent images are developed with the correspondingly colored toner particles. These toner particles have a polarity opposite to the polarity of the respective electrostatic latent images. In this way, a two-color toner powder image is developed on the light-sensitive member.

Referring now to Figure 1, a light-sensitive member comprising a base plate 10, a light-sensitive layer 12 and an insulating layer 14 is initially charged. In this case, when there is no injection of charges from base plate 10, the light-sensitive member is substantially uniformly illuminated simultaneously with or directly after charging. By way of example, base plate 10 is made from an electrically conductive material. Light-sensitive layer 12 is made from a photoconductive material such as a selenium alloy. Insulating layer 14 is made preferably from a high abrasion-resistant electrostatic charge-retentive material with high resistivity and transmissivity to the photoconductive layer. Examples of such material include polycarbonate resins, polyethylene resins and polyester resins.

With continued reference to Figure 1, the light-sensitive member is negatively charged. This induces a positive charge at the interface between light-sensitive layer 12 and insulating layer 14. If there is injection charging from base plate 10, there is no need to substantially uniformly illuminate the light-sensitive member during the charging. However, if there is no injection

charging from the plate, the light-sensitive member must be illuminated simultaneously with or immediately subsequent to charging.

Referring now to Figure 2, an original document 16 comprising black (B), red (R) and white (W) regions is illuminated and the resultant light image thereof transmitted through a cyan optical filter 18 onto the charged light sensitive member. Simultaneously therewith, the light-sensitive member is positively charged so that the net potential is about 0 volts in the white region with the potential in the red and black regions becoming a net positive.

Turning now to Figure 3, original document 16 is re-exposed through red filter 20. The red-filtered light image radiates the light-sensitive member and the positive charge leaves the interface in the red region converting it to a negative charge while the white region remains at about 0 volts with the black region remaining positive. Thus, two electrostatic latent images are recorded on the light-sensitive member, one having a positive polarity in the black region and the other a negative polarity in the red region.

Turning now to Figure 4, there is shown development of the negative and positive electrostatic latent images with toner particles having opposite polarities. Thus, black toner particles having a negative polarity are attracted to the electrostatic latent image corresponding to the black region, i.e. the electrostatic latent image having a positive potential. Similarly, red toner particles having a positive polarity are attracted to the negative electrostatic latent image, i.e. the electrostatic latent image corresponding to the red region in the original document. In this way, the electrostatic latent image is developed with black and red toner particles. These toner particles have different polarities and are attracted to the respective electrostatic latent images which have polarities opposite therefrom. In this way, a two-color toner powder image is formed on the light-sensitive member which corresponds to the color and content of the informational regions contained within the original document.

Subsequent to developing the electrostatic latent images with the respective toner particles, the light-sensitive member, with the toner particles adhering thereto, is substantially uniformly illuminated. This illumination inverts the polarity of the electrostatic latent image in the black region. Thus, the surface potential of the light-sensitive member in the black region is converted to a negative potential. Then, an A.C. potential superimposed over a D.C. potential having the same polarity as the potential of the black

and red portions of the electrostatic latent image is applied to the light-sensitive member. After the A.C. discharge and negative D.C. charge have been applied to the toner particles adhering to the light-sensitive member, the toner particles are transferred to a copy sheet. The resultant toner powder image transferred to the copy sheet has both red and black regions. This two-color toner powder image is then permanently affixed to the copy sheet by, for example, the application of heat thereto.

As an alternative embodiment, after the electrostatic latent images have been developed with the respective black and red toner particles, this two-color toner powder image is charged with a negative D.C. potential. Thereafter, the two-color toner powder image is transferred to the copy sheet and permanently affixed thereto. In this latter embodiment, an A.C. charge is never applied to the two-color toner powder image adhering to the light sensitive member. Other than the foregoing distinction, this latter embodiment is substantially the same as the former embodiment.

It is thus clear that the method of electrophotographic printing of the present invention forms a two-color copy of a two-color original document in a single pass. In this way, color-highlighted copies may be readily reproduced from color-highlighted original documents. Inasmuch as the printing process heretofore described is a single pass process, the printing machine operates at higher speeds than those heretofore utilized.

In recapitulation, the electrophotographic printing process of the present invention charges the light-sensitive member, exposes the charged light sensitive member to a cyan-filtered light image, i.e. the complementary color of the color contained within the original document, recharges the light sensitive member, re-exposes the original document through a red filter, i.e. the color corresponding to the color contained within the original document, and develops the resultant electrostatic images with oppositely-charged black and red toner particles. The developed two-color toner powder image adhering to the light-sensitive member is then substantially uniformly illuminated and discharged. Thereafter, the two-color toner powder image is transferred to the copy sheet and permanently affixed thereto resulting in a highlighted color copy corresponding to the color content of the original document.

Claims

1. A method of electrophotographic printing for reproducing an original document (16) having information in two different colors, including the steps of:

forming, on a light-sensitive member (10), a first electrostatic latent image corresponding to the information in one of the colors in the original document, and a second electrostatic latent image corresponding to the information in the other of the colors in the original document, with the first electrostatic latent image and the second electrostatic latent image being of opposite polarities, and

developing the first electrostatic latent image and the second electrostatic latent image with marking particles (22, 24) having opposite polarities and different colors.

2. A method according to claim 1, including the step of illuminating substantially uniformly the light-sensitive member having the marking particles thereon.

3. A method according to claim 2, including the step of applying a substantially-constant charge to the light-sensitive member substantially simultaneously with said step of illuminating.

4. A method according to claim 2 or 3, including the step of applying a substantially constant charge having an alternating charge superimposed thereover to the light-sensitive member after said step of illuminating.

5. A method according to any preceding claim, including the step of transferring the marking particles from the light-sensitive member to a sheet of support material.

6. A method according to any preceding claim, wherein the image-forming step includes the steps of:

charging the light-sensitive member to a substantially uniform potential;

exposing the charged light-sensitive member to an image of the original document filtered through an optical filter corresponding in color to a complement of one of the colors in which information is displayed on the original document;

re-charging, substantially simultaneously with said step of exposing, the light-sensitive member, with the polarity of the charge during said step of re-charging being of opposite polarity to the polarity of the charge during said step of charging, and

re-exposing the charged light-sensitive member, after said steps of exposing and re-charging, to an image of the original document filtered through an optical filter corresponding in color to the other color in which information is displayed.

7. A method according to claim 6, wherein said step of exposing includes the step of filtering the light image of an original document comprising red and black information through a cyan filter.

8. A method according to claim 7, wherein said step of re-exposing includes the step of filtering the light image of the original document through a red filter.

9. A method according to claim 8, wherein said step of developing includes developing the first electrostatic latent image with red marking particles, and the second electrostatic latent image with black marking particles.

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FIG. 1

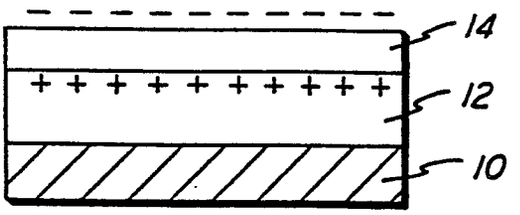

FIG. 2

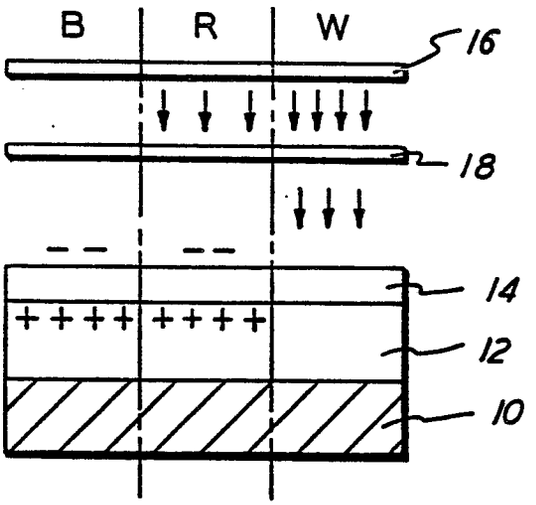

FIG. 3

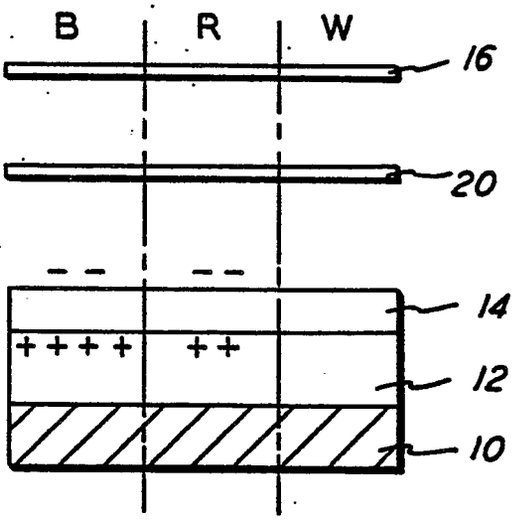

FIG. 4