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3,734,724

DEVELOPED IMAGE TRANSFER

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13 Claims

ABSTRACT OF THE DISCLOSURE

Developed images carried on a photoconductive element are transferred by first applying a repelling potential to a conductive receiving member, contacting the member with the developed image, and uniformly exposing the element to actinic radiation while applying an external bias potential.

This invention relates to electrophotography and more particularly to the transfer of developed images from an electrophotographic element to a receiving member which can be used as a lithographic master.

Elements useful in the electrophotographic process commonly comprise an electrically conductive support bearing a stratum including a photoconductive insulating layer which has an electrical resistivity substantially greater in the dark than in light actinic thereto. Such elements can be used in electrophotographic processes, for example, by first adapting the element in the dark to obtain a uniformly high resistivity in the photoconductive insulating layer, and electrostatically charging the element in the dark to obtain a relatively high potential which may be either negative or positive in polarity. The element can then be exposed to a light pattern which lowers the resistivity and thereby the charge density of the illuminated areas imagewise in proportion to the intensity of illumination incident upon the illuminated areas. An electrostatic latent image is thus obtained. Visible images can be formed from the electrostatic latent image in any convenient manner, such as by dusting with finely divided, fusible toner particles which bear an electrostatic charge opposite that remaining on the surface of the photoconductive insulating layer. Thereafter, the toner particles can be transferred to a receiver and fused thereto thus providing a permanent image.

It has been suggested that developed images on a selenium photoconductive element could be transferred to a metal lithographic plate. However, such transfer had to be carried out at a very high electrical potential which causes electrical breakdown of the photoconductive layer. The breakdown spots in turn result in the formation of unwanted spots on the lithographic plate and finally on the reproductions made from the plate. Another suggestion has been to subject the toner image on the photoconductor to a corona discharge. The charged toner image is then placed in contact with a lithographic plate and the toner transfers thereto. Toner transfer is not always complete and smudging of the image often results during transfers according to such prior systems.

Accordingly, there is a need for a system for transferring developed images to receiving members which minimizes the possibility of electrical damage to the photoconductive layer and which results in good transfer of toner.

It is, therefore, an object of this invention to provide a novel transfer method for use in electrophotography.

It is another object of this invention to provide a novel process for preparing lithographic plates using electrophotographic techniques.

A further object of this invention is to provide novel electrophotographic transfer procedures which are oper-

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ated at low electrical potentials thereby minimizing the possibility of electrical breakdown of the photoconductor.

It is a still further object of this invention to provide a novel method for transfer of developed images from a transparent photoconductive element to a metal receiver, which method reduces smudging of the transferred image.

These and other objects and advantages are accomplished through the use of an electrophotographic element in conjunction with a charged receiver. According to this invention, an electrostatic latent image is formed on a transparent electrophotographic element and the latent image developed by known techniques. A receiver member is then biased to an electric potential such that the member has a polarity of electrical charge which is the same as the charge on the toner. The charged receiver and image-bearing element are placed in face to face contact, the repelling potential on the receiving member terminated, a low electrical transfer potential is applied which has a polarity opposite that of the toner and the element is given a uniform exposure.

The electrophotographic elements used in the present invention are comprised of a transparent support such as poly(ethylene terephthalate) cellulose acetate or the like photographic film supports, typically having coated thereon a transparent conductive coating such as high vacuum evaporated nickel, cuprous iodide, a conducting polymer as described, for example, in U.S. Pat. No. 3,007,901 and similar materials. The conducting support is in turn overcoated with a photoconductive layer typically comprised of a binder and an organic photoconductor. Of course, polymeric photoconductors can be used without the need for a separate binder. A wide variety of organic photoconductors can be used in the elements of this invention. Useful materials would include organic amine photoconductors which have a common structural feature of at least one amino group such as those described in U.S. Pat. No. 3,240,597, issued Mar. 15, 1966 and U.S. Pat. No. 3,180,730, issued Apr. 27, 1965. Similarly, the photoconductive substances of Fox U.S. Pat. No. 3,265,496, issued Aug. 9, 1966 are useful. Polarylalkane photoconductors are also particularly useful in the present invention. Such photoconductors are described in U.S. Pat. No. 3,274,000 and in copending application of Sues and Goldman, entitled Photoconductive Compositions Containing Organic Photoconductors, Ser. No. 627,857, filed Apr. 3, 1967, now U.S. Pat. 3,542,544. Photoconductors of this latter type include leuco bases of di- or triarylmethane dye salts, 1,1,1-triarylmethanes wherein the alkane moiety has at least two carbon atoms, and tetraaryl methanes, there being substituted an amino group on at least one of the aryl groups attached to the alkane and methyl moieties of the latter two classes of photoconductors which are non-leuco base materials. 4-diarylamino-substituted chalcones are also useful in elements according to the present invention. The following table comprises a partial listing of U.S. patents disclosing further organic photoconductive compounds and compositions which are also useful.

Inventor:	U.S. Patent No.
Hoegl et al.	3,037,861
Sues et al.	3,041,165
Schlesinger	3,066,023
Bethe	3,072,479
Klupfel et al.	3,047,095
Neugebauer et al.	3,112,197
Cassiers et al.	3,133,022
Schlesinger	3,144,633
Noe et al.	3,122,435
Sues et al.	3,127,266
Schlesinger	3,130,046
Cassiers	3,131,060

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TABLE—Continued

Inventor:	U.S. Patent No.
Schlesinger	3,139,338
Schlesinger	3,139,339
Cassiers	3,140,946
Davis et al.	3,141,770
Ghys	3,148,982
Cassiers	3,155,503
Cassiers	3,158,475
Tomanek	3,161,505
Schlesinger	3,163,530
Schlesinger	3,163,531
Schlesinger	3,163,532
Hoegl	3,169,060
Stumpf	3,174,854
Klupfel et al.	3,180,729
Klupfel et al.	3,180,730
Neugebauer	3,189,447
Neugebauer	3,206,306
Fox	3,240,597
Schlesinger	3,257,202
Sues et al.	3,257,203
Sues et al.	3,257,204
Fox	3,265,496
Kosche	3,265,497
Noe et al.	3,274,000

The transparent electrophotographic element prepared with materials such as those described above is then used in the formation of an image. In general, such images can be produced by any of the now well-known electrophotographic processes such as the xerographic process. In a process of this type, an electrophotographic element is held in the dark and given a blanket electrostatic charge by placing it under a corona discharge. This uniform charge is retained by the photoconductive layer of the element because of the substantial dark insulating properties of the layer, i.e., the low conductivity of the layer in the dark. The electrostatic charge formed on the surface of the photoconductive layer is then selectively dissipated from the surface by imagewise exposure to light by means of a conventional exposure operation such as, a contact printing technique, lens projection of an image and the like to thereby form an electrostatic latent image in the photoconductive layer. Exposing the surface in this manner forms a pattern of electrostatic charge by virtue of the fact that light energy striking the photoconductor causes the electrostatic charge in the light-exposed areas to be conducted away from the surface in proportion to the intensity of the illumination in a particular area.

The charge pattern produced by exposure is then developed by suitable well-known development techniques such as by treatment with a medium comprising electrostatically responsive marking particles having optical density. The electrostatically responsive developer particles can be in the form of a dust or powder of a pigment or they can be in the form of a pigment in a resinous binder, commonly termed a toner. The toner material can be applied to the element bearing the charge pattern by any of a variety of means. One typical development means is cascade development wherein toner and carrier material therefor such as glass beads, resin particles, iron balls, etc., are poured over or otherwise contacted with the element bearing the electrostatic latent image. Another useful means is the magnetic brush development technique which involves a developer mix prepared of toner in admixture with suitable magnetically responsive carrier such as magnetic iron oxide, powdered iron, etc. After development of the electrostatic latent image, a particulate developed image remains on the photoconductive element. In accordance with the procedures of this invention, the developed image on the photoconductive element can readily be transferred to a suitable lithographic plate for use in formation of a lithographic master.

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After development of the image-bearing element, an electrically conductive receiver sheet is provided for receiving the developed image. This sheet is typically comprised of a thin metal sheet such as aluminum. Of course, any of a wide variety of metal sheets, foils or foil laminates could be used. Other useful metals would include tin, nickel, chromium, stainless steel, copper and the like. Typically the metal receiver sheet is in the range of from about 0.005 to about 0.025 inches in thickness. In accordance with a preferred embodiment of this invention, the receiver sheet ultimately becomes a lithographic printing master. Such receiver sheets are commercially available and in general, comprise a thin metal sheet, which may have a water-receptive surface. Such metal plates are typically made of aluminum which may be surface-treated to provide water-receptive surfaces as are necessary in lithographic printing. Nonmetallic receiver sheets can also be used in this invention such as a paper receiver having a conductive backing layer thereon.

Next, in accordance with this invention, a repelling potential is applied between the receiver and the conductive layer of the element such that the receiver has a polarity opposite that of the electrostatic charge on the surface of the electrophotographic element. This repelling potential is typically in the range of from about 50 to 250 volts, positive or negative depending upon the charge on the toner material. By the term "repelling potential" is meant an electrical potential maintained between the image-bearing element and the receiver such that the receiver has a polarity the same as that of the charge on the toner material. The repelling potential can also be described as an electrical potential between the two members referred to above such that the receiver has a polarity opposite that of the charge holding the toner on the image-bearing element. The toner material is thus repelled from the receiver by means of this repelling potential. The repelling potential is maintained until the receiver is positioned in intimate face to face contact with the developed image-bearing element and serves to prevent premature transfer until both elements are properly positioned. After the receiver and image-bearing element are in face to face contact, the two members can be moved slightly in relation to one another while the repelling potential is applied without disrupting the developed image. Once the element and receiver are finally positioned in such face to face contact, the repelling potential is turned off and a transfer potential is applied by, for example, simply reversing the polarity and increasing the magnitude of the potential. The resulting transfer potential is insufficient to cause electrical damage to the electrophotographic element. This potential typically has a value of about 400 to 600 volts, positive or negative depending upon the original charge on the toner material. At this point, the transparent element is given a flooding photo-release exposure through the support side thereof in order to discharge the electrostatic latent image forces holding the developed image in place. This biasing potential is preferably continued until the receiving member is stripped away from the electrophotographic element. This procedure results in virtually complete transfer of all toner carried on the electrophotographic element and in general, the images produced by this method are sharper than those produced by other procedures. Of course, where substantially complete transfer is not necessary, good images can be obtained without the photo release exposure. In this latter process, the sensitive element need not be transparent. The voltages used in effecting the transfer in either instance can be widely varied but are of a magnitude insufficient to cause electrical damage to the electrophotographic element.

After the developed image has been transferred to the receiving member or lithographic plate by the procedures of this invention, the image can be permanently fixed to the plate by simply heating the plate to cause fusion of the toner or marking particles. After fixation of the

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transferred image to the metal plate, the plate is generally treated with a conventional conversion solution such as an aqueous gum arabic-phosphoric acid solution which completely wets the non-image areas, thereby preventing ink from adhering thereto. The sheet is then used as a lithographic printing master on a conventional offset printing press.

The following examples are included for a further understanding of the invention.

EXAMPLE 1

A control transfer is conducted in accordance with the following procedure. A transparent electrophotographic element prepared from a conductive poly(ethylene terephthalate) film support having coated thereon an organic amine photoconductor in a polycarbonate binder is placed on a vacuum frame having an inserted glass window. The photoconductor is charged to a uniform surface potential of -720 volts by means of a corona wire charger. The charged element is then given an image-wise exposure through the support side to form an electrostatic latent image. The latent image is developed using a magnetic brush developer mixture comprising a toner of carbon black in a polystyrene resin in admixture with a carrier containing ferromagnetic material. The developer mix is applied to a hand-held magnet to form a small magnetic brush. The magnetic brush is biased at -40 volts with respect to the conducting layer of the photoconductive element during development. This small bias potential has the effect of reducing the background on the photoconductive surface. A wrong-reading developed image is produced on the photoconductive element. The developed image is transferred to a grained aluminum plate by electrically grounding the conductive layer of the element and pressing the aluminum plate carefully into contact while raising the potential of the aluminum plate to -1 kv. and separating the aluminum plate from the photoconductor. The resulting right-reading powder image is heat-fused in an oven to give a hard durable black image. This plate is then treated with a gum arabic-phosphoric acid solution at a pH of 3 to convert it to a useful lithographic plate.

EXAMPLE 2

The transfer of powder in Example 1 is sufficient to form a visible image; however, complete transfer of the developed image is not obtained. It appears that the residual charge in the image areas holds back a portion of the toner thereby preventing a complete transfer. Thus, in order to overcome the residual charge potential, a similar developed image of an electrophotographic element is transferred by the following procedure. A grained aluminum plate is placed in face to face contact with the developed image-bearing element prepared as in Example 1. Next, the photoconductive layer is exposed through the transparent support to a white light flooding photo-release exposure. In this instance, an electrical bias potential of only -500 volts is needed to obtain transfer of the developed image. In this instance, the toner transfer is virtually complete. However, any inadvertent contact, sliding or relative motion between the electrophotographic element and the receiver member prior to application of the transfer or bias potential results in a poor quality image which has smeared areas.

EXAMPLE 3

In order to avoid smearing of the transferred image, the following procedure is conducted in accordance with this invention. A developed image is prepared on a transparent electrophotographic element in accordance with the procedures of Example 1. Next, a grained aluminum receiver sheet is provided and a repelling potential of $+100$ volts is applied to the aluminum plate prior to and until it is positioned in contact with the developed element for final transfer. At this time, the elec-

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trophotographic element is given a flooding photo-release exposure through the transparent support thereof and a transfer potential of -500 volts is applied to the aluminum plate. The plate is separated from the element while the transfer potential is still being applied. The resultant image is considerably sharper than the images prepared as above and in general, there is much less tendency to smear the image during repeated transfers utilizing techniques of this example. The final transferred image is then fused in an oven and the image-bearing aluminum plate is treated with a gum arabic-phosphoric acid solution at a pH of about 3 to render the non-image areas oleophobic. The resultant lithographic master is then used in a standard lithographic offset press to form lithographic images. The quality of these images is very good. The procedure of this example is repeated several times and quality images result with no apparent smearing.

EXAMPLE 4

Heretofore, the image exposure has been made through the transparent support of the photoconductive layer, but this is coincidental and not a necessary limiting condition. In the present example, the photoconductor is charged to an initial potential of -720 volts, but the exposing image is projected onto the front surface of the photoconductor. Again, the latent image is developed by magnetic brush and dry toner with a development bias of -40 volts applied to the brush. A grained aluminum receiver sheet held at $+100$ volts repelling potential is positioned in contact with the developed powder image. The potential on the metal sheet is switched to the -500 volts transfer potential, while a flooding exposure is given through the base of the photoconductive layer to complete the transfer of the powder image to the metal sheet. A heat-fusing step is given to fix the image. The resultant image is sharp with good density. Substantially no toner is left on the photoconductive layer after transfer.

EXAMPLE 5

The procedure of Example 4 is repeated on a similar, but opaque photoconductive element and without the use of a flooding exposure. The resultant image is sharp with good density; however, a slight amount of toner is left on the photoconductive layer.

The examples described above have utilized a dry developer; however, a liquid developer can also be used. Suitable liquid developers are now well-known in the art and described, for example, in U.S. Pat. No. 2,907,674. The transfer techniques of the present invention when used with liquid developers could result in even greater image sharpness and resolution than obtainable with most dry developers.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

I claim:

1. In a process of transferring a developed electrophotographic marking particle image formed on an electrophotographic element to an electrically conductive surface of a receiver member, said image being attracted to said element by electrostatic forces of one polarity, the improvement comprising

- (a) applying an electrical repelling potential between said element and said surface such that said surface has an electric potential of a polarity opposite to that holding said image,
- (b) positioning said surface adjacent said developed image and in contact therewith,
- (c) applying an electrical transfer potential by reversing the polarity of the potential on said surface, and
- (d) separating said surface from said element whereby the marking particle image is transferred to said surface.

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2. A process as described in claim 1 wherein the electrical transfer potential is of greater magnitude than the electrical repelling potential.

3. A process as described in claim 1 wherein said electrical transfer potential has a magnitude of about 400 to 600 volts.

4. A process as described in claim 1 wherein said electrical repelling potential has a magnitude of about 50 to 250 volts.

5. A process as described in claim 1 wherein the developed image is formed of a dry particulate material.

6. A process as described in claim 1 wherein the receiver member is comprised of a thin metal sheet.

7. A process as described in claim 1 wherein the receiver member is comprised of a thin metal sheet and wherein the transfer image is permanently fixed to said metal sheet.

8. A process as described in claim 1 wherein (a) the receiver member is comprised of a thin metal sheet, (b) the transfer image is permanently fixed to said metal sheet, and (c) said metal sheet is rendered oleophobic in the non-image areas.

9. A process as described in claim 1 wherein the receiver member is a grained aluminum lithographic plate.

10. A process for forming a lithographic printing master comprising the steps of:

- (a) forming an imagewise charge pattern on a transparent electrophotographic element,
- (b) developing said pattern with a developer composition containing marking particles to form a visible image attracted to said element by electrostatic forces of one polarity,
- (c) providing a receiving member having an electrically conductive metal surface;
- (d) applying an electrical repelling potential between said metal surface and said element such that said metal surface has an electrical potential of a polarity opposite to that holding said image,
- (e) positioning said metal surface adjacent to and in contact with said image while said repelling electrical potential is being applied,
- (f) applying an electrical transfer potential by reversing the polarity of the electrical potential previously applied to said metal surface,
- (g) uniformly exposing said element to actinic radiation to reduce the electrostatic forces holding said image to said element,
- (h) separating said metal surface from said element whereby the image is transferred to said metal surface,
- (i) fixing said image to said metal surface and
- (j) rendering the non-image areas of said metal surface oleophobic.

11. A process as described in claim 10 wherein said electrical transfer potential is of greater magnitude than the electrical repelling potential.

12. A process for forming a lithographic printing master comprising the steps of:

- (a) forming an imagewise charge pattern on a transparent electrophotographic element,
- (b) developing said pattern with a developer composition containing toner particles to form a visible

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image comprised of toner particles attracted to said element by electrostatic forces of one polarity,

- (c) providing a receiving member having an electrically conductive grained aluminum surface,
- (d) applying an electrical repelling potential between said surface and said element such that said surface has an electrical potential of a polarity opposite that of the forces holding said toner particles,
- (e) positioning said surface adjacent to and in contact with said image while said electrical repelling potential is being applied,
- (f) terminating said repelling potential and applying a transfer potential of a polarity opposite that of the repelling potential and having a magnitude greater than that of the repelling potential,
- (g) uniformly exposing said element to actinic radiation to reduce the electrostatic forces holding said toner particles to said element,
- (h) separating said surface from said element while the transfer potential is still being applied whereby the image is transferred to said surface,
- (i) fixing said image to said surface and
- (j) rendering the non-image areas of said surface oleophobic.

13. A process for transferring developed electrographic images comprising the steps of:

- (a) forming an imagewise charge pattern on an electrophotographic element,
- (b) developing said pattern with a developer composition containing toner particles to form a visible image comprised of toner particles attracted to said element by electrostatic forces of one polarity,
- (c) providing a receiver member having an electrically conductive surface,
- (d) applying an electrical repelling potential between said surface and said element such that said surface has an electrical potential of a polarity opposite that of the forces holding said toner particles,
- (e) positioning said surface adjacent to and in contact with said image while said electrical repelling potential is being applied,
- (f) terminating said repelling potential and applying a transfer potential of a polarity opposite that of the repelling potential and having a magnitude greater than that of the repelling potential,
- (g) separating said surface from said element while the transfer potential is still being applied whereby the image is transferred to said surface, and
- (h) fixing said image to said surface.

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