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Colt et al.

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[54] PROCESS FOR TRANSFERRING DRY DEVELOPED ELECTROGRAPHIC IMAGES

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[52] **U.S. Cl.** .....**117/17.5,** 96/1.4, 101/463, 101/468, 101/DIG. 13, 117/33, 117/37 LE

[51] **Int. Cl.** **G03g 13/16**

[58] **Field of Search**.....117/17.5, 37 LE, 33; 101/463, 101/468, DIG. 13; 96/14

[56] **References Cited**

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[57] **ABSTRACT**

A process of transferring dry developed electrographic images is described which results in the transfer of substantially all of the toner powder from an image-bearing element to a receiver sheet. This process involves moistening the receiver prior to placing it in contact with the dry element bearing a developed image. This process is useful in forming lithographic printing plates.

12 Claims, No Drawings

PROCESS FOR TRANSFERRING DRY DEVELOPED ELECTROGRAPHIC IMAGES

This invention relates to electrography and more particularly to methods of transferring dry developed electrostatic charge patterns to conductive receiver materials, as well as relating to methods of forming lithographic plates.

In the art of electrophotography, it is known to form and dry develop an electrostatic charge pattern and transfer the resultant powder image to a suitable receiver of paper or other relatively soft insulating material. Attempts have also been made to transfer such powder images from a photoconductive element to a metal receiving member. However, these latter attempts have generally been less than satisfactory. In particular, the percentage of transfer of toner particles is often quite low or else the transferred image is smudged. Furthermore, this difficulty of getting complete transfer is increased even more if smaller sized particles, needed for high resolution, are used. Still another problem encountered in such prior transfers is that of damage to the photoconductive element. There is always a danger of damaging the photoconductive surface when transfer of a dry developed image is involved. When the transfer is being made to paper or some other relatively soft material such as some polymers, the paper or other material will deform slightly when pressed in contact with the particles of toner. This deformation of the receiver minimizes the danger of damage to the photoconductor surface.

However, when using a metal receiving sheet, there is little or no tendency for the receiver to deform. Consequently, when the receiver is pressed in contact with the developed image, the toner particles are pressed against the photoconductive surface in a nonuniform manner. Such pressure may cause immediate localized damage or may cause a more gradual degradation of the properties of the photoconductive element. Damage or degradation of this type is, of course, highly undesirable as it quickly shortens the useful life of an otherwise reusable photoconductive element.

Accordingly, there is a need in the art for a simple method of transferring dry developed images to metal receiving sheets, which method results in good quality transferred images while minimizing the possibility of damage to the element initially carrying the developed image.

It is, therefore, an object of this invention to provide a new method of transferring dry developed images to metal receiver sheets in a manner which is simple and which reduces the possibility of damage to the member carrying the developed image.

Another object is to provide a new method for transferring powder images which method results in a high percentage of transfer of the toner powder.

A further object of the invention is to provide a new method of transferring dry developed images which results in sharp images of high quality and resolution.

Still another object of this invention is to provide a new rapid method for preparing quality lithographic plates.

These and other objects and advantages of the invention are accomplished by the utilization, in a prescribed manner, of a liquid transfer medium. In accordance with this invention, a method is described which results in a transfer of substantially all of the toner powder from a developed photoconductive member to a metal receiving sheet.

We have now discovered procedures for transferring a dry developed image from an image-bearing element to a metal or other conductive receiving sheet which are uncomplicated and which result in a very high percentage of transfer of the toner material to the receiver.

According to this invention, an electrostatic latent image is first formed on an image-bearing element; the image is developed and then transferred to a receiving sheet which has previously been moistened with a liquid transfer medium. The image-bearing elements used in the present invention can take a variety of forms. In general, this element will be in the form of an electrophotographic element. Such electrophotographic elements are typically comprised of a conducting support having coated thereon a photoconductive composition. Such elements are well known in the art and particularly useful ones employ a photoconductive layer comprised of an organic or inorganic photoconductor in an electrically insulating resin binder. An element of this type is given a uniform surface charge by, for example, subjecting the element to a corona discharge while maintaining the element in the dark. Next, the element is exposed to a pattern of actinic radiation. This exposure causes reduction in the surface potential in accordance with the relative energy contained in the radiation pattern. This charging and exposing sequence results in the formation of an electrostatic charge pattern on the photoconductive element.

Another useful image-bearing element is comprised simply of a sheet of an electrically insulating material such as poly(ethylene terephthalate). An electrostatic charge pattern can be placed on such an element by charge transfer of a pattern carried on a photoconductive element as described above. In addition, an electrostatic charge pattern can be applied by placing a stencil over the insulating sheet and subjecting it to a corona discharge. The insulating sheet in this instance can be provided with a permanent conductive backing or it can be simply placed in contact with a separable conductive backing.

The resultant electrostatic charge pattern formed on the image-bearing element is now ready for development by any of the known dry development techniques such as cascade or magnetic brush development. Magnetic brush development is particularly useful where it is desired to obtain good development of large solid areas. In general, this technique utilizes apparatus of the type described, for example, in U.S. Pat. No. 3,003,462 and often comprises a nonmagnetic rotatably mounted cylinder having fixed magnetic means mounted inside. The cylinder is arranged to rotate so that part of the surface is immersed in or otherwise contacted with a supply of developer mix. The granular mass comprising the developer mix is magnetically attracted to the surface of the cylinder. As the developer mix comes within the influence of the field generated by the magnetic means within the cylinder, the particles thereof arrange themselves in bristlelike formations resembling a brush. The bristle formations of developer mix tend to conform to the lines of magnetic flux, standing erect in the vicinity of the poles and lying substantially flat when said mix is outside the environment of the magnetic poles. Within one revolution the continually rotating tube picks up developer mix from a supply source and returns part or all of this material to the supply. This mode of operation assures that fresh mix is always available to the copy sheet surface at its point of contact with the brush. In a typical rotational cycle, the roller performs the successive steps of developer-mix pickup, brush formation, brush contact with the photoconductive element, brush collapse and finally mix release.

In magnetic brush development of electrostatic images, the developer is commonly a triboelectric mixture of fine toner powder comprised of dyed or pigmented thermoplastic resin such as a polystyrene resin, for example, with coarser carrier particles of a soft magnetic material such as "ground chemical iron" (iron filings), reduced iron oxide particles or the like. Toner powders suitable for use in this invention are typically prepared by finely grinding a resinous material and mixing with a coloring material such as a pigment or a dye. The mixture is then ball-milled for several hours and heated so that the resin flows and encases the coloring material. The mass is cooled, broken into small chunks and finely ground again. After this procedure, the toner powder particles usually range in diameter from about 0.5 to about 25μ with an average size of about 2 to about 15μ.

The resin material used in preparing the toner can be selected from a wide variety of materials, including natural resins, modified natural resins and synthetic resins. Exemplary of useful natural resins are balsam resins, colophony and shellac. Exemplary of suitable modified natural resins are colophony-modified phenol resins and other resins listed

below with a large proportion of colophony. Suitable synthetic resins are all synthetic resins known to be useful for toner purposes, for example, polymers, such as vinyl polymers including polyvinyl chloride, polyvinylidene chloride, polyvinyl acetate, polyvinyl acetals, polyvinyl ether and polyacrylic and polymethacrylic esters; polystyrene and substituted polystyrenes or polycondensates, e.g., polyesters, such as phthalate resin, terephthalic and isophthalic polyesters, maleinate resin and colophony-mixed esters of higher alcohols; phenol formaldehyde resins, including colophony-modified phenol formaldehyde condensates, aldehyde resins, ketone resins, polyamides and polyadducts, e.g., polyurethanes. Moreover, polyolefins, such as various polyethylenes, polypropylenes, polyisobutylenes and chlorinated rubber are suitable. Additional toner materials which are useful are disclosed in the following U.S. Pat. Nos.: 2,917,460; Re. 25,136; 2,788,288; 2,638,416; 2,618,552 and 2,659,670.

Color material can be incorporated into toners to render electrostatic images toned therewith more distinct or visible. The coloring material additives useful in suitable toners are preferably dyestuffs and colored pigments. These materials serve to color the toner and thus render it more visible. In addition, they sometimes affect, in known manner, the polarity of the toner. In principle, virtually all of the compounds mentioned in the Color Index, Vol. I and II, Second Edition, 1956, can be used as colorants. Included among the vast number of suitable colorants would be such materials as Nigrosin Spirit soluble (C.I. 50415), Hansa Yellow G. (C.I. 11680), Chromogen Black ETOO (C.I. 14645), Rhodamine B (C.I. 45170), Solvent Black 3 (C.I. 26150), Fuchsine N (C.I. 42510), C.I. Basic Blue 9 (C.I. 52015), etc.

After development of the image-bearing element, a receiver sheet is provided for receiving the developed image. This sheet is typically comprised of a thin aluminum plate. Of course, any of a 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. In general, the metal receiver sheet is from about 0.005 to about 0.025 inches in thickness. Additionally, the sheets are electrically conductive; however, the present invention can also be used to make transfers to insulating and poorly conducting materials as well.

This receiver sheet is then moistened with a liquid transfer medium prior to contact with the developed image. The liquid transfer medium is generally comprised of an electrically insulating organic liquid. Suitable liquids for this purpose include a variety of organic materials all of which must be sufficiently inert so that they do not have any detrimental degree of solvent action on the toner material forming the developed image or on the image-bearing member. Of course, liquids which are solvents for the toner could be used if the process of the invention is operated rapidly enough to prevent any substantial solvent action. Useful liquids would include many hydrocarbon and substituted hydrocarbon liquids, for example, alkanes, including substituted and cycloalkanes such as cyclohexane, n-hexane, carbon tetrachloride, trichlorotrifluoroethane, pentane, trimethylpentane, octane, nonane, n-heptane, etc., and aromatic compounds such as benzene, dimethylbenzene, etc. Various organic distillates such as kerosene, mineral spirits, Isopar G (a narrow-cut isoparaffinic fraction of high purity, b.p. 160° to 180° C. Humble Oil Co.), etc., having boiling points in the range of about 150° to 250° C. Mixtures of various liquids can also be used. Useful liquids generally have an electrical resistivity in excess of about 10^9 ohm-cm. In addition, these liquids should have a rate of evaporation slow enough that a thin film of the liquid will remain intact during the transfer procedure. The liquid should, however, be sufficiently volatile such that the receiver sheet and image-bearing member can be dried within a reasonable time after transfer. In all cases, the liquid used is free of any particulate matter other than any dust or lint that may possibly be present.

In accordance with this invention, the liquid transfer medium is applied to the dry receiver sheet so as to form a very thin, continuous film of liquid on the sheet. The liquid can be applied in a variety of ways such as by swabbing, spraying, dipping and other means capable of forming a thin, continuous film. After the receiver has been suitable moistened, it is placed in the proximity of the image-bearing member and an electrical potential is applied across the receiver and the dry developed image-bearing member. The moistened side of the receiver is then placed in contact with the side of the image-bearing member carrying the developed image while the potential is still being applied. This potential is typically in the range of from about 300 to about 700 volts and is generally positive with respect to the image-bearing member; however, this will vary depending upon the polarity of toner material used to develop the electrostatic latent image.

To ensure good contact between the moistened receiver and the image-bearing member, roller pressure is generally applied. This can be done by hand or mechanically using a roller which extends the width of the receiver sheet. After rolling the receiver and image-bearing member into intimate contact, the receiver is carefully peeled back and off of the electrophotographic element. The developed image is thereby transferred from the member to the receiver.

Using the technique of the present invention, a very high percentage of the toner particles are transferred to the receiver. Measurements show that in excess of 90 percent of the toner particles are transferred when using the procedures of this invention. After transfer, the toner image is fixed to the receiver. Fixation is generally accomplished by heating the image on a hotplate or with an infrared source. The heat applied evaporates any residual transfer medium and causes the particles to fuse thereby forming a permanent image.

The present invention is particularly suited to the preparation of lithographic printing masters. In accordance with this embodiment, an electrostatic latent image is developed by any dry development technique and then transferred to a metal lithographic plate by the technique of this invention. Such lithographic printing masters are commercially available and, in general, comprise a thin metal sheet, usually having 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. Once the developed image has been transferred to the lithographic plate by the procedures of this invention, the image can be permanently fixed to the plate by simply heating the sheet such that the toner particles fuse thereto. After fixation of the transferred image to the metal plate, the plate is generally treated with a desensitizing agent such as gum arabic, etc., to ensure that the nonimage areas are rendered hydrophilic. The sheet is then used as a lithographic printing master in a standard lithographic offset printing press.

In addition to being useful in the transfer of developed images to metal plates such as lithographic plates, the present invention is also well suited for transferring dry developed images to paper receiving elements. Once again, this embodiment of the invention is also particularly well suited for the formation of lithographic printing masters. In particular, the metal receiving sheet can be replaced with a paper sheet having a lithographic surface such as the commercially available Kodak EV Master Plate. In this embodiment, a metal plate, such as an aluminum plate is used as a backing for the paper sheet. Prior to contact of the developed image, the paper sheet is moistened with the liquid transfer medium as in the embodiments utilizing utilizing a metal receiver. After an appropriate potential is applied, the sandwich of moistened paper and metal backing plate are then contacted with the dry developed image in accordance with the procedure set forth above. The liquid transfer medium is dried and the image is fused by the application of heat. The resultant paper lithographic printing master can then be used in accordance with standard lithographic procedures. This embodiment, of course, is not limited only to transfer to paper receivers having a lithographic surface. This embodiment can also be utilized to transfer dry developed images to standard paper receiving sheets as are well known in the art of electrophotography.

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

EXAMPLE 1

An electrophotographic element is provided which comprises an organic photoconductor 4,4'-benzylidene bis(N,N-diethyl-m-toluidene) dispersed in a polymeric binder and carried on an electrically conducting support formed of poly(ethylene terephthalate) having a thin conducting layer thereon. This element is dark adapted and subjected to a corona discharge until the surface potential is −400 volts. The element is then exposed to a test object comprised of a picture having both fine line and screen dot detail with an exposure of 500 foot candles for 6 seconds at *f*/16. The resultant electrostatic latent image on the element is developed by darkness by a magnetic brush development technique. The developer used is comprised of iron carrier particles and smaller colored toner particles which charge positively with respect to the carrier. The toner particles have an average size of about 2 to 5 microns and are comprised of a black colorant such as carbon black dispersed in a thermoplastic styrene resin. Next, a thin sheet of anodized aluminum is aligned in edge contact with the electrophotographic element and a potential of 400 volts is applied between the aluminum sheet and the element with the sheet being negative. The element and sheet are then rolled into intimate surface contact using light pressure. The aluminum sheet is then separated and heated to 160° C. to fuse the transferred toner particles. An image is apparent on both the electrophotographic element and on the aluminum plate. Measurements show that only 40 percent of the toner particles are transferred from the electrophotographic element to the aluminum plate.

EXAMPLE 2

The control procedure of Example 1 is repeated using the same materials only prior to contact between the electrophotographic element and the aluminum sheet, the aluminum sheet is swabbed with a solution of an isoparaffinic hydrocarbon liquid (Isopar G, supra) in accordance with the process of this invention. Next, a −400 volt potential (with respect to the element) is applied to the moistened aluminum sheet as in Example 1. While the potential is still being applied, the side of the aluminum sheet having a thin, continuous layer of liquid over its entirety is placed adjacent to and pressed in contact with the dry developed image on the electrophotographic element. On separation of the sheet from the electrophotographic element, virtually all of the toner powder image is transferred to the aluminum sheet. Measurement shows that more than 90 percent of the toner image is transferred. Only a slight trace of an image remains on the electrophotographic element. After transfer, the aluminum plate is fused as above and then both the control plate of Example 1 and the plate prepared according to the invention are treated with a gum arabic desensitizer and placed in a standard lithographic offset press for use in formation of printed images. The printed image using the control plate is weak and grainy; whereas, the print from the plate of the invention has a high maximum density and good uniformity throughout.

Examples 3 through 6 are included for comparative purposes.

EXAMPLE 3

An image is developed on an electrophotographic element as in Example 1. A receiver sheet similar to that of Example 1 is moistened with Isopar G and placed in contact with the developed element. The receiver and element are rolled into intimate contact. Next, an electrical potential of 400 volts is applied and the receiving sheet is separated from the electrophotographic element. A degree of transfer of the toned image is obtained; however, considerable smearing occurs in the image. This procedure is repeated several times with each transferred image obtained being smeared. When the receiver sheet is fused and used on the lithographic offset press, the printed images obtained therefrom also show this smearing throughout.

EXAMPLE 4

The procedure of the control in Example 1 is repeated again. However, this time the liquid transfer medium is applied to the developed image carried on the electrophotographic element. The potential is applied between the receiver and the elements and the two are rolled into contact and separated. A transferred image is obtained; however, the image is smeared considerably with some areas of complete loss of detail and some areas of total image loss.

EXAMPLE 5

The procedure of Example 4 is repeated again using no potential applied between the element and the receiver. Virtually no discernible image is obtained.

EXAMPLE 6

A dry developed image is prepared as in Example 1 and the liquid of Example 2 is applied to the developed image. Next, a receiving sheet as in Example 1 is placed into contact with the entire image on the electrophotographic element. The 400-volt potential is then applied between the receiver and the element and pressure is applied by the use of a roller. The receiving sheet is separated from the element. A transferred image is obtained; however, the image is quite faint with considerable smudging and areas of complete image loss.

The basic procedures of the present invention can also be utilized in the formation of paper lithographic printing masters as shown in the following example.

EXAMPLE 7

A test object similar to that in Example 1 is used in exposing an electrophotographic element which has been charged to −600 volts. An exposure is made at *f*/16 for 2 seconds at an illumination of 1,000-foot candles. The electrostatic latent image is developed as in Example 1. Next, a paper plate having a lithographic surface (Kodak EV Master Plate) is placed in contact with the element. An aluminum plate is placed in contact with the back of the paper plate and a potential of 650 volts is applied between the metal and the electrophotographic element. With the potential applied, the aluminum backed paper sheet is rolled in contact with the developed image and separated. The identical process is repeated only prior to contact of the paper with the dry developed electrophotographic element, the paper is moistened with a thin, continuous film of the liquid transfer medium of Example 2. The potential is then applied, the receiving sheet is rolled into contact with the developed element and the two are separated. As in Example 1, the control element using no liquid transfer medium shows only partial transfer of the developed image (only about 40 percent transfer); whereas, more than 90 percent transfer of the developed image is obtained when the receiver sheet is moistened prior to contact with the developed image.

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.

We claim:

1. In a process of transferring a dry developed powder image on an image-bearing element to a receiver sheet, the improvement which comprises the sequential steps of moistening said receiver sheet with a thin film of an electrically insulating liquid transfer medium which is not a solvent for said image-bearing element, applying an electric potential between said element and said moistened sheet, placing said moistened sheet in contact with the dry powder image while the potential is being applied, and separating said sheet from said element thereby transferring the developed powder image to said sheet.

2. The method as described in claim 1 wherein the transfer medium applied is a slowly evaporating hydrocarbon having a volume resistivity of greater than about 10^9 ohm-cm.

3. A method as described in claim 1 wherein the receiver sheet is comprised of an electrically conducting metal.

4. The method as described in claim 1 wherein following the step of separating said sheet from said element the residual transfer medium is removed and the transferred powder image is fixed to said receiving sheet.

5. A process for producing lithographic plates comprising the steps of forming an imagewise charge pattern on an image-bearing element, developing said pattern with a dry developer composition comprised of particulate toner material and dry carrier material, moistening a receiver sheet with an electrically insulating organic liquid which is not a solvent for the image-bearing element, applying an electric potential across said moistened sheet and said dry, developed image-bearing element, placing said moistened sheet in face-to-face contact with said dry, developed image-bearing element while maintaining said potential, separating said sheet from said element whereby the developed image is transferred to said sheet, fixing the transferred image and rendering the nonimage areas water receptive.

6. A process as described in claim 5 wherein the receiver sheet is comprised of an electrically conductive metal.

7. A process as described in claim 5 wherein the charge pattern is subjected to magnetic-brush development.

8. A process as described in claim 5 wherein the liquid applied to said receiver sheet is a slowly evaporating hydrocarbon having a volume resistivity of greater than about 10^9 ohm-cm.

9. A process as described in claim 4 wherein the image-bearing element is an electrophotoconductive element containing an organic photoconductor.

10. A process for producing lithographic plates comprising the steps of forming an imagewise charge pattern on an electrophotographic element, developing said charge pattern with a dry developer composition comprising particulate toner material and dry carrier material, providing a receiver sheet comprised of an electrically conductive metal, moistening said sheet with a liquid transfer medium consisting essentially of an electrically insulating liquid which is not a solvent for said image-bearing element and which comprises an organic distillate having a boiling point in the range of from about 150° to 250° C., applying an electric potential across said moistened sheet and said dry, developed electrophotographic element, placing said moistened receiver sheet with the moistened surface in face-to-face contact with the dry developed image-bearing surface of said element while maintaining said electric potential, applying pressure to said sheet while in contact with said element and transferring the said developed image to said sheet, separating said sheet, fusing the transferred image and rendering the nonimage areas water receptive.

11. A process as described in claim 10 wherein said charge pattern is developed by magnetic-brush techniques and wherein said liquid transfer medium has a volume resistivity of greater than about 10^9 ohm-cm.

12. A process as described in claim 11 wherein said receiver sheet is comprised of a metal selected from the group consisting of aluminum, chromium, copper, nickel, stainless steel and tin.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,647,499 Dated March 7, 1972

Inventor(s) Ralph S. Colt; Kenneth F. Seil

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 1, "4" should read --5--.

Signed and sealed this 5th day of September 1972.

(SEAL)
Attest;

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents