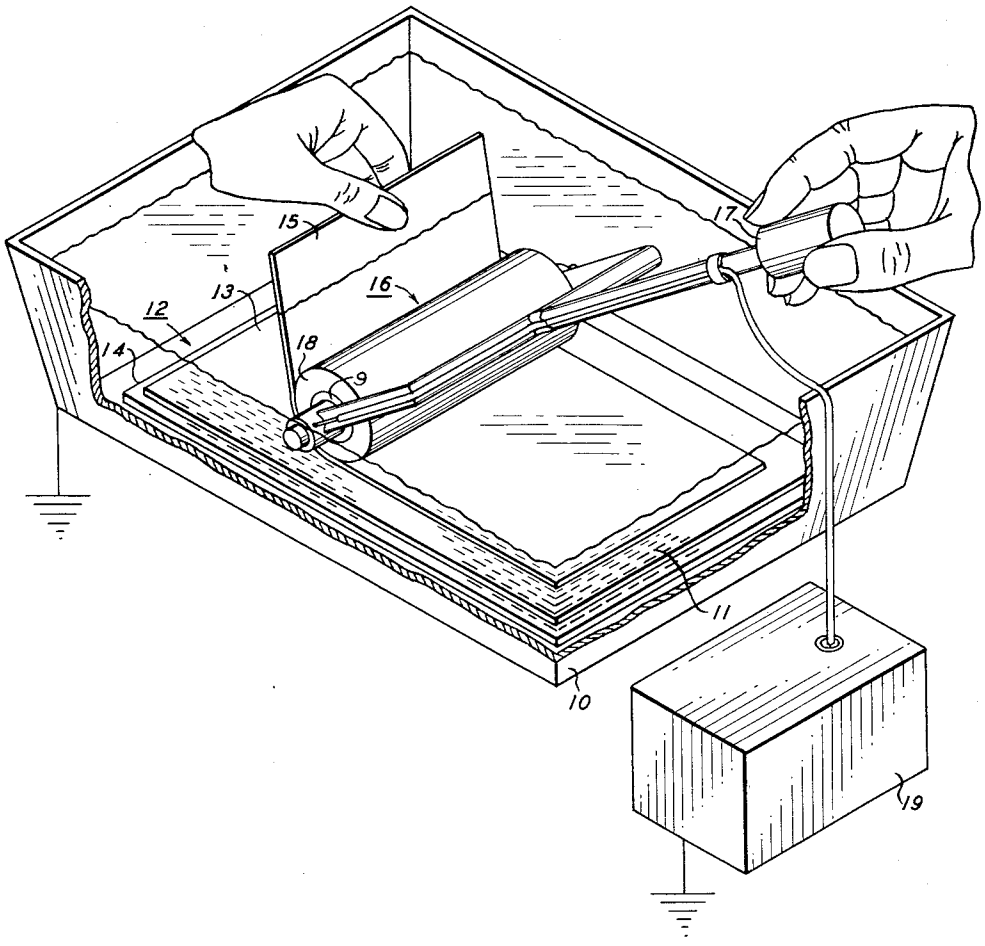
Feb. 4, 1964 H. H. HUNTER 3,120,446

METHOD OF TRANSFERRING A DEVELOPED SOLID PARTICULATE IMAGE

Filed Feb. 1, 1961



INVENTOR.
HARVEY H. HUNTER
BY Stanley Z. Cole
ATTORNEY

United States Patent Office

3,120,446

Patented Feb. 4, 1964

3,120,446

METHOD OF TRANSFERRING A DEVELOPED SOLID PARTICULATE IMAGE

Harvey H. Hunter, Columbus, Ohio, assignor, by mesne assignments, to Xerox Corporation, a corporation of New York

Filed Feb. 1, 1961, Ser. No. 86,524
15 Claims. (Cl. 117—17.5)

This invention relates to xerography, and more particularly to the transfer of xerographic images.

In the art of xerography it is conventional to form an electrostatic latent image on a xerographic plate including a photoconductive insulating layer and to develop the latent image on the xerographic plate by the selective electrostatic attraction thereto of suitable finely divided particles. Some development techniques, known to the art and in commercial use, which share the common characteristic that the particles are maintained and applied in a dry condition, involve the use of finely divided powder materials either by themselves or in conjunction with other particles. Another form of xerographic development is known as liquid immersion development and is accomplished by immersing a latent image bearing member in a suspension of finely divided marking material suspended in a volatile insulating liquid. This development method is particularly attractive for many applications, since it involves only relatively simple apparatus and since it has proven capable of developing images of extremely high resolution and with a minimum of apparent graininess.

In most, although not all applications of xerography, it is desired to transfer the deposited developer powder pattern from the xerographic plate to some other and more suitable support member, such as a sheet of paper. Various methods of accomplishing image transfer are known and include the use of specially coated papers or the like which have adhesive properties toward the powder image, the use of electrostatic fields to transfer the powder pattern, and the like. These transfer procedures are quite effective when used with images produced by conventional dry development processes and such transfer methods enjoy wide commercial use. It has been found, however, that these methods applied to images produced by liquid immersion development effect only incomplete transfer resulting in images which are low in density, blotchy in appearance and of low resolution. The reasons for such low quality transfer are not fully known, but it is believed that the dry development methods deposit on the xerographic plate particles which are effectively surrounded by a thin air film and thus are readily removable from the plate. In liquid immersion development, however, the liquid of the developer evaporates as the plate is withdrawn from the developer, apparently causing the particles to adhere to one another and to the plate in a very intimate manner. In addition, it is both possible and advantageous to use unusually fine developer particles in the liquid immersion process, and these tend to adhere more tenaciously to a xerographic plate than the somewhat larger particles generally used in dry developing processes.

Now, in accordance with the present invention, there is provided an improved method for transferring images. The novel method of transfer of this invention is particularly applicable to developed images formed by a liquid process, and it is accordingly a principal objective of the present invention to provide improved xerographic transfer methods to transfer liquid developed images. Also, in accordance with the present invention, there is provided an improved method of producing more complete transfers than has heretofore been possible when transferring images developed using dry development techniques. Accordingly it is a further objective of this invention to define novel and improved transfer methods for dry developed images. These, as well as subsidiary objectives, will become apparent from the following specification and from the drawing which represents a partially schematic view of image transfer being carried out according to the invention.

The starting point of a xerographic process is generally the formation of an electrostatic latent image. Methods are known whereby such images may be formed on ordinary insulating materials, and such images may be utilized in conjunction with the present invention. A more common xerographic method involves the use of a xerographic plate including a photoconductive insulating layer as the latent image bearing member. The photoconductive insulating material may comprise a vitreous material, such as vitreous selenium, which may optionally be formed on a conductive or other support layer. Other forms of photoconductive insulating materials are known including dispersions of photoconductive pigments such as zinc oxide in an insulating resin binder. Such layers may also be formed on suitable supports which may or may not be highly electrically conductive. Depending upon the nature of the photoconductor and support, xerographic plates may be either rigid or flexible. If rigid, they may be in the form of flat plates, cylinders or other shapes, and if flexible, they may be in the form of sheets, webs or the like. The present invention operates with a plate in any of these forms.

A latent electrostatic image may be formed on a xerographic plate by uniformly electrostatically charging the photoconductive insulating layer by any of the known and conventional means and then selectively dissipating the charge by exposing the xerographic plate to a pattern of light and shadow as in a camera.

The latent electrostatic image may be developed or made visible by numerous methods, but since transfer according to the present invention is particularly valuable in connection with images formed employing a liquid immersion method of development, a technique of developing the latent image employing liquid immersion development will be described. However, it is to be recalled that the principles of transfer are also applicable to an image developed using dry development techniques, and it is intended to encompass such transfers within the scope of this invention. In all applications the liquid employed should, of course, not be a solvent for the developed image.

In order to accomplish liquid development, the xerographic plate bearing the latent image is immersed in or otherwise contacted with a liquid developer material comprising a dispersion of finely divided particles in a liquid carrier. The carrier liquid must be a highly insulating material in order to avoid discharge of the electrostatic latent image. Additionally, it should not be excessively viscous and should be at least moderately volatile, since the desired result of the development process is a dry image. This is most readily achieved by allowing the liquid to evaporate from a developed image leaving only the dry particles behind. Many different liquids are suitable for use as carrier liquids in liquid development. A particularly useful class of materials comprises refined petroleum hydrocarbons having a volatility at least about as great as that of kerosene, and preferably not more than about that of gasoline. Such materials are widely available and variously known as mineral spirits, petroleum naphtha, Stoddard solvent, etc. Suitable liquids other than petroleum hydrocarbons are known including but not limited to carbon tetrachloride and such other liquids may also be employed.

A wide variety of different types of powdered materials

may be employed as the solid component of the developer mixture. One useful class of materials comprises finely divided mineral pigments including fine metallic powders. Another useful class of materials comprises pigmented or unpigmented resin particles similar to toners which are widely used in conventional xerographic practice. These resinous materials may be ground to a fine particle size, or, where particularly fine particles are desired, they may be formed by spray drying a solvent solution of the resin material. In general, particles used in liquid development have a particle size of a few microns at most. When dispersed in the carrier liquid, the particles acquire either positive or negative electrostatic charge, depending upon the particular choice of powder and liquid materials. In accordance with conventional xerographic principles, a powder having a polarity, when mixed in the carrier liquid, opposite to that of the latent image pattern is employed when it is desired to develop the charged areas of the latent image and particles of like polarity, when mixed in the carrier liquid, are selected when unchanged area development is desired. A further component in the form of a soluble film forming materials, such as linseed oil, is sometimes included in the developer mixture to increase the permanence of the developed image. For general information on liquid development, reference may be had to British Patent 755,486, U.S. Patent 2,899,335 and U.S. Patent 2,913,353.

In carrying out the present invention the first step is the formation of an electrostatic latent image. This is generally carried out by electrostatically charging a xerographic plate and exposing it to a pattern of light and shadow. The latent image is then developed by immersing or otherwise wetting it with a liquid developer material of the type already described. In accordance with conventional techniques, the xerographic plate would then be removed from the developer material and evaporation of the carrier liquid would soon leave a dry powder image on the plate. Such an image is useful for many purposes but, as already pointed out, cannot be readily transferred to a further support.

In accordance with an improved form of transfer, however, and as illustrated in the drawnig, the developed xerographic plate is reimmersed into the liquid carrier of the developer dispersion and while so immersed is contacted with a sheet of paper or other transfer member. In the drawing, there is shown a tray **10** which is partly filled with carrier liquid **11** and is which is immersed a xerographic plate **12** including a photoconductive insulating layer **13** overlying a support layer **14**. A transfer member **15** such as paper or the like is shown being rolled into contact with plate **12** by a roller **16**. Roller **16** includes an insulating handle **17** and a conductive rubber cylindrical element **18** overlying a conductive core **9**. The operative portion of the roller **16** is maintained at a potential in the range of from 1,000 to 3,000 volts D.C. through a connection to a power supply **19**. The support layer **14** of plate **12** is simultaneously maintained at zero potential through its contact with tray **10** which in this embodiment is both electrically conductive and electrically grounded. The electrical field established between paper **15** and plate **12** causes the developer particles on plate **12** to transfer to paper **15**. Since these developer particles are wetted by the liquid of carrier liquid **11**, they are not tightly bonded to plate **12** except by electrostatic forces which are readily overcome by the potential applied to roller **16**. After roller **16** has passed over paper **15**, the paper may be separated from plate **12** and upon evaporation of the carrier liquid from the paper, there is formed a dry developed image on the paper. It is desirable, but not essential, to maintain an image bearing plate in darkness through the transfer process, and this is particularly so when transferring following uncharged area type development. Of course, if the image bearing member is not light sensitive, precautions need not be taken against exposure to light.

A particularly useful roller **16**, used in connection with the above method and the improved methods of the present invention, included an electrically conductive silicone rubber cylindrical element 2 inches in diameter over a 1-inch diameter metal core. The roll had a durometer hardness of 42 and the electrical resistance was of the order of 10^5 ohms for a 6-inch long member measured between the metal core and a flat metal plate in contact with the outside of the roll while the roll was under an applied force of 10 pounds.

The figure represents only a specific embodiment of image transfer with respect to both methods and material. Thus, transfer member **15** is generally representative of a class of transfer materials which are characterized as having at least an insulating surface or substantially insulating surface. Ordinary paper is sufficiently insulating for use with this transfer method. In addition to ordinary paper, one can employ either paper or metals coated with insulating plastics or the like. Such coatings are chosen to be insoluble in the carrier liquid to avoid image deterioration which otherwise results. The transfer material should also have a smooth surface to permit intimate contact with the surface of plate **12**. A particularly suitable paper has been found to be Kromekote cast-coated paper manufactured by the Champion Paper and Fiber Company, Hamilton, Ohio. Sheets of "Mylar" polyester film have also been used successfully. While plate **12** is shown as being immersed in the developer tray, it is only necessary in carrying out this transfer method that the developed image and area of its contact with the plate be wet, and thus, transfer may, for example, be effected outside of the developer after wetting the image and before the liquid has evaporated.

The illustrated and described conductive rubber roller in conjunction with a conductive tray is merely one way in which intimate contact can be established between transfer member **15** and plate **12** while establishing a strong electric field between them. Other forms of rollers or even flat, conductive plates may be substituted for roller **16**, and a variety of means may be used to maintain support layer **14** at a different potential from that of roller **16** or its equivalent. In accordance with conventional xerographic practice, transfer can also be effected by passing a corona charging device adjacent to paper **15** while it is in contact with plate **12**. This can be accomplished while plate **12** is moist, but cannot readily be carried out where the plate and transfer member are actually immersed beneath the surface of a liquid bath at the time of transfer.

Particle transfer from the xerographic plate to the transfer material is carried out in the foregoing procedure through the agency of an electric field which is maintained between the plate and transfer material through potentials applied to external rollers, electrodes, or the like. It is, however, also possible to effect transfer in accordance with the present invention by electric fields generated internally of the plate-transfer member combination rather than externally thereof. In accordance with this further embodiment, the developed xerographic plate is removed from the developer bath and is uniformly electrostatically charged. Such charging may be performed by any conventional form of corona charging apparatus or the like, but is most conveniently performed in the same apparatus previously used to charge the plate in connection with the described process of electrostatic latent image formation. The potential to which the plate and the image thereon are charged is not critical and may be on the order of several hundred volts. Since this is the same range of potentials generally used in connection with charging a plate for image formation, the same charging apparatus as previously used may be employed for this second charging without any readjustment thereof. The plate is then contacted with a sheet of paper or other transfer material in the same general manner as described above and shown in the drawing. If the plate bearing

the developed image was wetted prior to this charging operation transfer may be carried out without further wetting. However, if the surface of the xerographic plate is not very wet appearing, it may be desirable to reimmerse the plate and transfer member in a bath of dielectric liquid. With this embodiment it is however, not necessary to apply a potential to roller **16** from power supply **19**, and it is instead only required that the xerographic plate and the transfer material be brought into contact and that the backs or outer surfaces of the plate and paper or other transfer member be brought to about the same electrical potential. This may conveniently be accomplished by the same apparatus shown in the drawing. In this embodiment the developer particles are transferred from the plate to the paper by the electric fields resulting from the uniform charge layer previously deposited on the xerographic plate. It is also permissible to apply a potential to roller **16** or to deposit uniform charge on the outer surface of the transfer member as through the use of a corona discharge electrode or the like in connection with this embodiment of the invention. It has been found that slightly superior or slightly inferior results are obtained with the added roller potential, depending upon the particular developer materials employed, the potential applied and the like. Best results to date in connection with this invention have resulted following charging of the developed plate and then immersed transfer employing a grounded roller.

The invention has thus far been described in terms of a developed image formed using liquid immersion developing techniques. All embodiments discussed, however, have been employed starting with an image developed using dry development techniques such as cascade, powder cloud and the like. In such cases it is found that more complete transfers result when compared to dry transfer techniques.

The above procedures have been found to create transferred images of high density, a high degree of uniformity and very high resolution when used with a wide variety of xerographic plates, carrier liquids and powder materials. There is, however, a tendency with the above methods to deposit background, i.e., a uniform deposition of powder, in addition to the powder corresponding to the electrostatic latent image if the carrier liquid becomes dirty with developer particles. This background problem can be avoided or overcome by refreshing the carrier liquid or by using a clean batch free of developer particles. Since a clean carrier bath is free of particles, the only particles which transfer are those particles electrostatically adherent on the xerographic plate, and there results a background-free transferred image.

The invention has been described in terms of certain physical forms of apparatus, but it is to be understood that such description was for illustrative purposes only rather than by way of limitation. Transfer according to the present invention may be carried out with various forms of development apparatus, various forms of xerographic plates, various means for contacting the xerographic plate with the transfer material and various means for applying electric fields therebetween. While the invention has been described in terms of a manual operation, it is apparent that it can be adapted to various forms of automatic processing equipment. These and various other modifications lie within the scope of the invention and are intended to be encompassed within the appended claims.

What is claimed is:

1. The method of transferring a developed solid particulate image from an image bearing surface comprising contacting the developed image and the image bearing surface with a developer-free, electrically insulating liquid incapable of dissolving said image, positioning a transfer web across the developed image and image bearing surface while said image continues to be wet with said insulating liquid, and applying an electrostatic field between said developed image and said transfer web to cause movement of said still wet developed image to said transfer web.

2. The method of claim 1 in which said electrostatic field is applied by rolling a roller at a raised potential across the rear surface of said transfer web.

3. The method of claim 1 in which said electrostatic field is applied by depositing charge on the rear surface of said transfer web from a corona discharge electrode.

4. The method of claim 1 in which the developed image comprises a dry developed image.

5. The method of claim 4 in which said dry developed image is developed employing a dry development technique.

6. The method of claim 1 in which said electrostatic field is applied by first corona charging the image bearing surface prior to positioning the transfer web across the image bearing surface and then applying a uniform electrostatic potential across the rear surface of said transfer web while said transfer web is across said image bearing surface.

7. The method of claim 6 in which said uniform electrostatic potential is applied across said transfer web by corona discharge.

8. The method of claim 6 in which said uniform electrostatic potential is applied across said transfer web by a contacting electrode at a bias potential.

9. The method of transferring a developed solid particulate image from an image bearing surface to a transfer web comprising contacting the developed particulate image and the image bearing surface with a particle-free, volatile, electrically insulating liquid in which said image, said surface and said web are each insoluble, positioning a transfer web across the developed image and image bearing surface while said image continues to be wet with said insulating liquid, applying an electrostatic field between said developed image and said transfer web to cause movement of said still wet developed image to said transfer web, then separating said transfer web from said image bearing surface with said transfer web bearing said developed image, and allowing said volatile liquid to evaporate from the transferred developed image.

10. The method of transferring a developed particulate image from a surface bearing such image comprising wetting the developed image and the image bearing surface with a particle-free, electrically insulating liquid incapable of dissolving said image, uniformly electrostatically charging said image and image bearing surface while said image and surface remain in a wet condition, positioning a transfer web having an insulating surface across the developed image on said image bearing surface while said image and said surface continue to be wet with said insulating liquid, and separating said transfer web from said image bearing surface with said transfer web bearing said developed image.

11. The method of claim 10 including applying a grounded roller against the back surface of said transfer web prior to separating said transfer web from said image bearing surface.

12. The method of claim 10 including applying a uniform electrostatic potential from a corona discharge electrode to the back surface of said transfer web prior to separating said transfer web from said image bearing surface.

13. In an image reproducing process wherein an electrostatic image bearing surface is developed by the selective electrostatic deposition thereon in image configuration of a pattern of finely divided solid particles from a suspension of said particles in a volatile, electrically insulating liquid, the improvement comprising removing the developed image bearing surface from said suspension into a bath of volatile, particle-free, electrically insulating liquid incapable of dissolving said particles, and electrostatically transferring said pattern of finely divided particles to a contacting transfer sheet while at least the

image bearing member is wet by said volatile particle-free insulating liquid.

14. The improvement in the process of claim 13 including using the same electrically insulating liquid as employed in the suspension of particles as the volatile insulating liquid in the both of volatile particle-free insulating liquid.

15. In an image reproducing process wherein an electrostatic image bearing surface is developed by the selective electrostatic deposition thereon in image configuration of a pattern of finely divided particles from a suspension of said particles in a volatile insulating liquid, the improvement comprising removing the image bearing surface from said suspension to a bath of volatile, particle-free, electrically insulating liquid incapable of dissolving said particles, while maintaining the image bearing surface in a moistened condition contacting said pattern of finely divided particles on the image bearing surface with a transfer material including at least an insulating layer facing the image bearing member, establishing an electric field between the image bearing member and the transfer material while at least the image bearing member is wet by said insulating liquid, and separating the transfer member from the image bearing member.

References Cited in the file of this patent

UNITED STATES PATENTS

2,551,582	Carlson	May 8, 1951
2,940,847	Kaprelian	June 14, 1960
2,951,443	Byrne	Sept. 6, 1960
2,959,153	Hider	Nov. 8, 1960

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,120,446 February 4, 1964

Harvey H. Hunter

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 20, for "unchanged" read -- uncharged --; column 7, line 6, for "both" read -- bath --.

Signed and sealed this 8th day of September 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,120,446 February 4, 1964

Harvey H. Hunter

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 20, for "unchanged" read -- uncharged --; column 7, line 6, for "both" read -- bath --.

Signed and sealed this 8th day of September 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents