United States Patent

Grier

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[45] **Oct. 17, 1972**

[54] **METHOD FOR IMAGE TRANSFER**

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[73] Assignee: **Owens-Illinois,**

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[21] Appl. No.: **46,063**

[52] **U.S. Cl.**.....**101/426,** 101/251, 101/DIG. 13, 117/21, 118/60, 118/202

[51] **Int. Cl.**.....**B41c 3/08**

[58] **Field of Search**..101/DIG. 13, 251, 426; 118/60, 118/202; 117/21

[56] **References Cited**

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[57] **ABSTRACT**

A method and apparatus for image transfer in an electrophotography printing system wherein the removal of solid particulate toner in the form of an image on an image-defining element is accomplished by contacting the toner with a heated transfer roll. The portion of the toner directly contacted by the heated transfer roll softens and interparticle adhesion is increased by the combination of heat and pressure applied by the heated transfer roll. Simultaneously, the portion of the toner directly on the image-defining element becomes relatively less adherent to the surface of the image-defining element to thereby facilitate its transfer from the image-defining element to the heated transfer roll.

1 Claim, 11 Drawing Figures

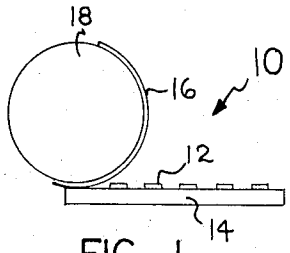


FIG. 1

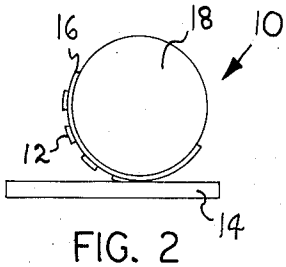


FIG. 2

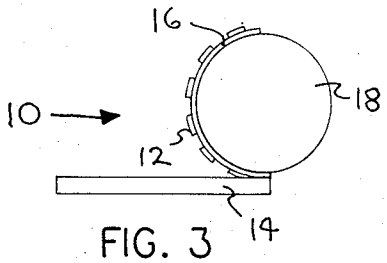


FIG. 3

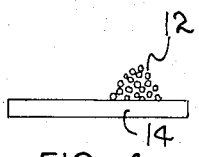


FIG. 4

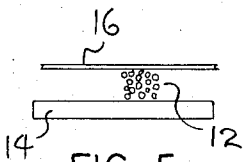


FIG. 5

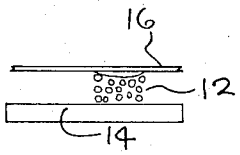


FIG. 6

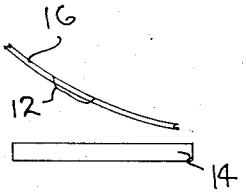


FIG. 7

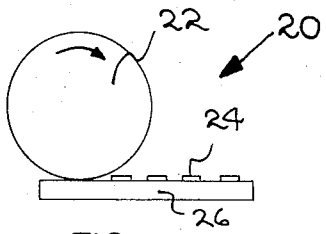


FIG. 8

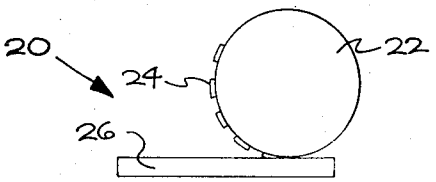


FIG. 9

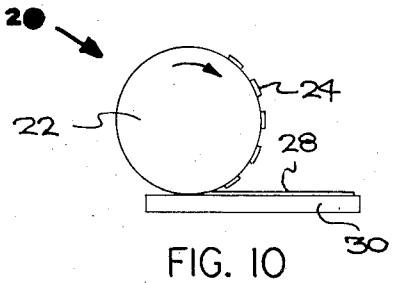


FIG. 10

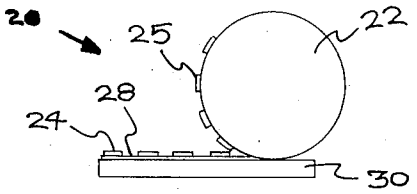


FIG. 11

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METHOD FOR IMAGE TRANSFER

BACKGROUND OF THE INVENTION

This invention relates to novel apparatus and process for the removal of an electrostatically formed particulate solid image from an electrostatic substrate. More particularly, this invention relates to toner transfer apparatus and process utilizing a heated roller to pick up powder images on an image-defining element without producing detectable deterioration of the image-defining element.

The image-defining element may be an integral part of any suitable electrophotography printing system, such as Xerographic system or a persistent internal polarization system. For purposes of explanation the novel image transfer apparatus and method of this invention will be illustrated and described in conjunction with a persistent internal polarization system.

Persistent internal polarization (abbreviated herein as PIP) involves the separation of positive and negative charges in a photoconductive insulating material by subjecting it to irradiation and an electric field. The charges are subsequently trapped and remain fixed or frozen so as to form an internal polarization field for a period of time sufficient to permit toning. PIP and the theory thereof are well known in the electrophotography art. See, for example, Electrophotography, by R. M. Schaffert, The Focal Press, London and New York (1965), pages 59 through 77, and Persistent Internal Polarization, by Kallmann and Rosenberg, The Physical Review, Volume 97, No. 5 (Mar. 15, 1955), pages 1596 through 1,610, both of which are incorporated herein by reference.

In general, a PIP electrophotography system includes a layer of photoconductive insulating material sandwiched between a pair of field producing electrodes. The phenomenon of PIP can be achieved in any material which exhibits the following characteristics:

1. The material must have a high resistivity in the dart (a low density of free charge carriers), whereby it is a good insulator in the absence of irradiation.
2. The material must be photoconductive. In other words, it must have decreased resistivity when excited with appropriate radiation.

Thus, a PIP material is one which will become persistently internally polarized due to the separation of positive and negative charges when it is subjected to irradiation and the action of an electric field.

Typical PIP materials comprise binder dispersions of photoconductors and binder free thin films of photoconductors.

Examples of inorganic photoconductors include appropriately activated zinc sulfide, cadmium sulfide, zinc selenide, cadmium selenide, cadmium oxide, zinc-cadmium selenides, and zinc-cadmium sulfides. Examples of organic photoconductors include anthracene, chrysene, and poly (vinylcarbazole).

Examples of resin binders include cellulose acetate, cellulose ether, cellulose ester, silicones, vinyl resins, alkyds, and/or epoxy resins.

When it is desired to form a latent electrostatic image in the PIP material, it is flooded with radiation and an electric field is applied so as to polarize the PIP layer. After termination of the flooding radiation, the polarity of the electric field across the PIP material is

reversed and the PIP materials exposed to an image or other pattern of activating radiation. The reversal of the electric field will cause rapid depolarization of that portion(s) of the PIP material rendered photoconductive under the influence of the image-wise radiation.

If the exposure to the image is continued for a sufficient time period, the irradiated area of the PIP layer will repolarize and assume a polarization opposite to that of the non-irradiated or dark portion of the PIP layer. Thus, the image is simulated by an internal latent electrostatic image or patten detectable at the surface of the PIP material.

This latent electrostatic image is subsequently developed with charged or dipolar toner particles so as to produce a visible reproduction of the image which is capable of being viewed, photographed, or transferred.

It should be noted that, due to the characteristics of the PIP material, the latent electrostatic image produced in the PIP material will typically remain fixed such that a finite number of reproductions can be made. The image can be erased by overall irradiation with or without an electric field, thereby returning the PIP material to a prepolarized or neutral condition capable of being used for the formation of a new electrostatic image.

The irradiation of the PIP material (for polarization and/or imaging) can be accomplished by means of any form of electromagnetic or particulate radiation or energy, visible or invisible, which will excite the PIP material so as to permit charge separation in an electric field. Such radiation includes visible light, infrared, ultraviolet, x-rays, gamma rays, and beta rays. For printing or copying purposes, the typical radiation is light in the visible range.

In the prior electrophotographic printing and copying art, three different methods have been developed to transfer toner from the image-defining element. These methods involve the use of electrostatic (pulse or corona) attraction, magnetic attraction, or adhesive tape. The electrostatic (pulse or corona) attraction method is the only one used commercially at this time and has a distinct disadvantage in that transfer of the toner to the paper destroys the image and the image-defining element must be re-imaged for each print desired. The magnetic attraction method has proven to be very difficult as the powdered toner material utilized must be magnetic and a high magnetic field is necessary to pull the toner material onto the paper. The adhesive tape method has a severe limitation in that the toner particles remain stuck to the tape and cannot be re-transferred to a second substrate.

SUMMARY OF THE INVENTION

In accordance with this invention there is provided a new and novel toner transfer apparatus and process which overcomes the aforementioned disadvantages associated with toner transfer methods known in the prior art. More particularly, this invention provides a toner transfer apparatus and process which utilizes a heated roller to pick up powder images on an image-defining element without producing detectable deterioration of the image-defining element.

In a specific practice hereof, this invention features the utilization of a heated transfer roll to transfer the solid particulate toner in the form of an image from an

image-defining element to an image-receiving object, such as a sheet of paper. The portion of the toner directly contacted by the heated transfer roll softens and interparticulate adhesion is increased by the combination of heat and pressure applied by the heated transfer roll. Simultaneously, the portion of the toner directly on the image-defining element becomes relatively less adherent to the surface of the image-defining element to thereby facilitate its transfer from the image-defining element to the heated transfer roll.

In operation, the heated transfer roll of this invention may be utilized in two separate ways to transfer the image-wise toner from the image-defining element. A sheet of paper on which it is desired to print the image may be placed in contact with the heated transfer roll prior to the movement of the roll into contact with the toner on the image-defining element. In this procedure the paper becomes preheated and the image-wise toner is transferred directly to the paper on the heated transfer roll. An alternative method of this invention involves the direct transfer of the toner from the image-defining element to the surface of the heated transfer roll followed by the subsequent transfer of the toner from the heated transfer roll to a sheet of paper.

Other features and advantages of the subject invention will become obvious to those skilled in the art upon reference to the following detailed description and the drawings illustrating the preferred embodiments of the invention.

In the drawings:

FIG. 1 is a schematic view of a first embodiment of this invention wherein a sheet of paper is preheated on a heated transfer roll prior to being brought into contact with toner particles in the form of an image on an image-defining element.

FIG. 2 is a schematic view of the embodiment of FIG. 1 showing the heated transfer roll and sheet of paper as they progress across the surface of the image-defining element thereby picking up the toner particles deposited thereon.

FIG. 3 is a schematic view of the embodiment of FIG. 2 showing the heated transfer roll and the sheet of paper after they have completely traversed the surface of the image-defining element and removed the image-wise toner particles therefrom.

FIG. 4 is a highly magnified schematic view of a small portion of toner particles on the image-defining element.

FIG. 5 is a highly magnified schematic view of a small segment of the heated transfer roll and sheet of paper thereon as they initially contact the toner particles of FIG. 4.

FIG. 6 is a highly magnified schematic view showing the effect of the heat and pressure of the heated transfer roll on the toner particles.

FIG. 7 is a highly magnified schematic view of the portion of the sheet of paper of FIG. 6 showing the toner particles completely transferred to the paper from the image-defining element.

FIG. 8 is a schematic view of a second embodiment using the heated transfer roll of this invention to directly remove the image-wise toner particles from an image-defining element.

FIG. 9 is a schematic view of the embodiment of FIG. 8 showing the heated transfer roll after it has completely removed all toner particles from the surface of the image-defining element.

FIG. 10 is a schematic view of FIG. 9 embodiment showing the toner-containing heated transfer roll preparing to transfer the toner to a sheet of paper.

FIG. 11 is a schematic view of the FIG. 10 embodiment showing the heated transfer roll after it has printed the image-wise toner particles onto the surface of a sheet of paper.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the drawings, the numeral 10 refers generally to a system for the transfer of solid particulate toner 12 from an image-defining element 14 to a suitable image-receiving object, such as a sheet of paper 16. The specific embodiment shown in FIGS. 1 through 7 features the positioning of the paper 16 on heated transfer roll 18 prior to bringing the paper 16 into contact with the toner 12 on the image-defining element 14. As explained previously, the image-defining element 14 may be an integral part of any suitable electrophotography printing system and for the purposes of explanation a persistent internal polarization has been selected as the image forming system. In summary, the image-defining element 14 produces a latent electrostatic image which attracts toner particles 12 of the type previously described in the form of the electrostatic latent image.

To quickly understand the operation of the first embodiment of this invention reference should be had to FIGS. 1 through 3. Here, it can be seen that a sheet of paper 16 is placed in contact with a heat transfer roll 18 and together they are progressively rolled across the surface of the image-defining element 14. As can be seen in the transition from FIG. 2 to FIG. 3, the toner particles 12 are completely transferred from the image-defining element 14 to the sheet of paper 16 on the heated transfer roll 18. To more clearly understand the function of the heated transfer roll 18 in this process reference should be had to FIGS. 4 through 7. In FIGS. 4 through 7, the relationship between a small portion of toner particles 12 and a small segment of the sheet of paper 16 is shown in highly magnified form. Specifically, FIG. 4 shows a small group of toner particles 12 attracted to a specific location on the surface of the image-defining element 14. As the sheet of paper 16 initially contacts the toner particles 12 as shown in FIG. 5, the heated transfer roll and paper thereon press the toner particles together. As is shown in FIG. 6, the heat from the heat transfer roll passes through the sheet of paper 16 to cause the toner particles which are closest to the paper to melt and the toner particles which are directly on the surface of the image-defining element to become relatively less adherent to the image-defining element surface. The highly magnified schematic view of FIG. 6 in effect shows a fixed gradient of the toner from the surface of the paper to the surface of the image-defining element. The toner is liquid at the heated paper surface; is sintered in the mid-region, and is compacted at the image-defining element surface. The removal of the toner from the image-defining element surface is completed in FIG. 7 and continued contact of the paper with the heated transfer roll insures complete fixing of the toner on the paper.

An alternate embodiment of a toner particle transfer system utilizing the principles of this invention is shown in FIGS. 8 through 11 and is indicated generally by the numeral 20. In this alternate toner particle transfer system 20, a heated transfer roll 22 is brought directly into contact with toner particles 24, which are in the form of an image on an image-defining element 26. As can be seen in the transition from FIG. 8 to 9, the toner particles 24 are completely transferred to the heated transfer roll 22 as the roll 22 passes over the surface of the image-defining element 26. As shown in FIG. 10, the toner-containing heated transfer roll 22 is then brought into contact with a sheet of paper 28 positioned on a suitable supporting substrate 30. Printing of the toner 24 on the sheet of paper 28 is shown in the transition from FIG. 10 to FIG. 11. Because the toner is wet, penetration of the toner into the paper occurs as shown in FIG. 11. Also, characteristic ink separating results and a residue 25 of toner 24 remains on the heated transfer roll 22.

It should be noted that the heated transfer rolls in each of the embodiments previously discussed may be heated by any suitable means such as the circulation of a hot fluid within the roll or the provision of an electric heat element within the roll. Further, tests have shown that as the temperature of the heated transfer roll increases to an optimum point, the effective transfer of the toner increases. The optimum point occurs when sufficient heat is transferred to result in the gradient shown and described in connection with FIG. 6. In short, it is the function of the heat from the heat transfer roll to change the adhesion characteristics of the toner particles so that they are more attracted to the heated transfer roll or to the heated sheet of paper contained thereon than they are to the surface of the image-defining element.

Thus, this invention provides two alternate embodiments of a unique system for transferring image-wise toner particles from an image-defining element to a suitable image-receiving substrate, such as a sheet of paper. The system of the alternate embodiments of this invention utilizing a heated transfer roll completely eliminates the aforementioned disadvantages associated with the previously developed transfer methods. The subject method does not contaminate the surface of the image-defining element when transferring the toner therefrom as is the case in the electrostatic (pulse or corona) attraction method. In other words, the subject method does not destroy the latent electrostatic image on the image-defining element but rather leaves it intact for continuous transfer cycles without the necessity of re-imaging the image-defining element. Further, the subject method does not necessitate the utilization of magnetic toner particles and a high magnetic field as does the magnetic traction method. In addition, the use of a heated transfer roll to transfer toner particles from an image-defining element to a sheet of paper completely eliminates the non-transferability associated with the use of adhesive tape. It should be noted that the fraction of the toner particles transfer can be controlled in the subject invention by controlling the temperature of the heated transfer roll. This ability to control the amount of toner transfer facilitates the regulation of background control in the transfer image. None of the previously known transfer methods have this ability to regulate the background control.

What is claimed is:

1. A method of transferring solid particulate toner in the form of an image from the surface of an image-defining element to an image-receiving substrate comprising the steps of:

positioning said image-receiving substrate on a heated transfer roll for movement therewith;

traversing said heated transfer roll and said image-receiving substrate across the surface of said image-defining element;

bringing said image-receiving substrate on said heated transfer roll into direct contact with said toner particles on the surface of said image-defining element so that heat from said heated transfer roll is imparted through said image-receiving substrate to said toner particles creating a gradient through said toner particles and changing the adhesion characteristics of said toner particles such that said toner particles have a higher degree of attraction to said image-receiving substrate than to said image-defining element and are transferred to said image-receiving substrate;

and separating said image-receiving substrate from said heated transfer roll after said toner particles in the form of said image have been transferred to said image-receiving substrate.

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