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Sato et al.

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[54] **LIQUID DEVELOPMENT OF ELECTROSTATIC LATENT IMAGE**

[75] Inventors: **Masamichi Sato; Osamu Fukushima; Satoru Honjo; Seiji Matsumoto,** all of Asaka, Japan

[73] Assignee: **Xerox Corporation,** Stamford, Conn.

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[52] **U.S. Cl.** .... **117/37 LE,** 96/1 LY, 355/10

[51] **Int. Cl.** **C03g 13/10**

[58] **Field of Search** .... 117/37 LE; 96/1 LY; 355/10; 118/DIG. 23, 637

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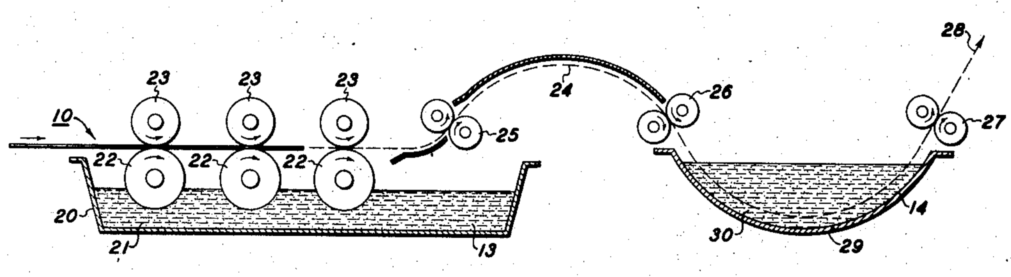
Primary Examiner—William D. Martin
Assistant Examiner—M. Sofocleous

[57] **ABSTRACT**

Electrophotographically produced electrostatic latent images are developed with minimal toner coloration of background or highlights. Residual electrostatic charge or potential is neutralized before development by a uniform application to the latent image surface of particles carrying a charge opposite in polarity from that of the electrostatic image. The quantity and population density of these charged particles are selected to just neutralize said residual potential. These particles are either colorless or have a coloration that is non-contrasting with the image background. After neutralizing the residual potential, development of the latent image is effected by colored toner particles, which will deposit in the image charge areas only.

7 Claims, 4 Drawing Figures



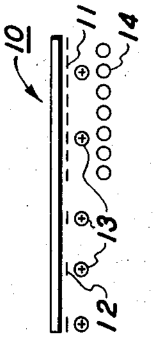


FIG. 1C

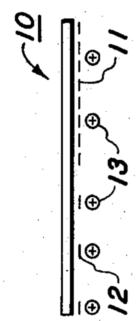


FIG. 1B

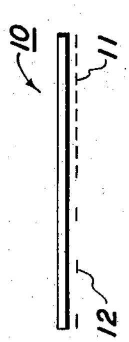


FIG. 1A

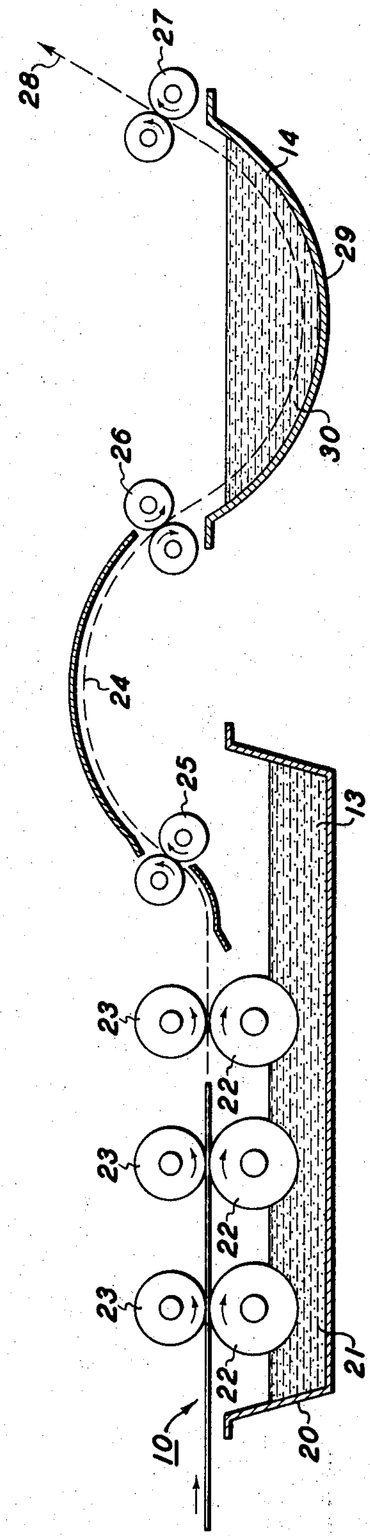


FIG. 2

LIQUID DEVELOPMENT OF ELECTROSTATIC LATENT IMAGE

INTRODUCTION AND BRIEF SUMMARY OF INVENTION

The present invention relates to the development of electrostatic latent images, and more particularly it is concerned with the elimination or minimizing of toner deposition on image background or highlight areas.

In electrophotography it would be desirable for the charge on electrophotographic surfaces to be discharged completely in the image highlight or background areas. In practice however, a residual charge or potential is usually present in these areas, and on development of the electrostatic latent image, this residual charge causes undesirable toner deposition, resulting in background coloration and dull highlights. In one known method of preventing toner deposition due to residual potential, a bias potential is applied from an external source to the conductive backing of the electrophotographic coating during development, to compensate or neutralize the residual potential. The bias potential approach complicates the developing apparatus, and it has a further disadvantage in that toner deposits on the counter electrode, and this tends to smudge the image surface of the electrophotographic material being developed.

In accordance with the present invention the foregoing disadvantages are largely overcome, and developed prints are produced with bright highlights and minimal background toner coloration. These results are attained by applying uniformly over the electrostatic latent image bearing surface of the electrophotographic material, a dispersion of colorless charged particles and causing the particles to uniformly adhere to the image surface area. These charged particles have a charge of opposite polarity from that of the latent image, and are deposited in a quantity and population density selected substantially to just neutralize the residual potential. This first deposition is followed by a usual development process employing conventional colored toner particles. Since the colorless particle deposit substantially neutralizes the residual potential over the image surface, deposition of colored toner on the highlight and background areas during the development process is essentially eliminated. It is stated that the charged particles are colorless. This condition is preferred, but obviously the particles could have a coloration that is not contrasting with the background coloration. For example, if the photoelectric image surface is white, these particles could be white, if desired.

It is apparent that deposition of the colorless particles must be uniform over the entire image area, and it must also be controlled so that it effects only a neutralization of the residual potential. Care must be taken to avoid preferential deposition of this material in development quantities over the image charge areas, for such deposition would diminish the density of the image attainable in the development step. Accordingly, pursuant to the present invention a suspension of the neutralizing particles in a liquid vehicle is applied as a very thin uniform film over the entire latent image bearing surface, and at the same time, a development electrode is placed as close as possible and in parallel relation to said surface so as not to allow the particles to deposit preferentially onto the areas of high charge density. The presence of the electrode placed extremely close to the image surface causes the electric lines of force to orient vertically relative to the image surface, and consequently the particles are constrained to migrate substantially in that vertical direction. In this way a uniform deposition of the particles is obtained. Since this deposition is uniform over the entire image surface and affects only the residual potential, this operation does not diminish the maximum density over background obtained by subsequent development with colored toner.

It is accordingly one object of the present invention to provide for reduced background deposition of toner and brighter highlights in the development of electrostatic latent images on electrophotographic surfaces.

Another object of the present invention is to provide such results by neutralizing the residual potential on the electrophotographic surfaces.

And still another object of the present invention is to effect such neutralization by the uniform deposition over the latent image surface of charge neutralizing particles that do not affect the color rendition of the developer toner particles and do not have a coloration that contrasts with that of the background.

Other objects and advantages of the present invention will become apparent to those skilled in the art from a consideration of the following detailed description of exemplary embodiments of the invention, had in conjunction with the accompanying drawings in which like numerals refer to like or corresponding parts, and wherein:

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a three part drawing depicting an image charge pattern on an electrophotographic surface in part A, the application thereto of residual potential neutralizing particles in part B, and the application of developer toner thereto in part C and

FIG. 2 is a schematic representation of apparatus for practicing the present invention.

DETAILED DESCRIPTION

Referring to FIG. 1, numeral 10 designates a conventional sheet of electrophotographic paper having a photoconductive surface on one side. As is well understood in the art, an electrostatic latent image is formed thereon by first applying a uniform electrostatic charge to the photoconductive surface, and then exposing the surface to an optical image while the back of the sheet 10 is grounded. As a result, the electrostatic charge is discharged in the illuminated areas and retained in the non-illuminated areas, providing an electrostatic latent image.

A negative charge electrostatic latent image is depicted in FIG. 1A. Portion 11 depicts an area that was illuminated during the exposure step, and the charge is removed therefrom except for a small residual charge or potential. During development, a small amount of toner would adhere to portion 12, thereby toning the background, if area 12 is background, or dulling the highlight, if area 12 is a highlight.

In accordance with the present invention, this residual potential is neutralized by applying a small quantity of positively charged particles uniformly over the photoconductive surface of sheet 10. This result is depicted in FIG. 1B, where particles 13 have been uniformly applied over the entire latent image. The concentration of particles 13 is selected so as just to neutralize the residual charge in area **12** of sheet **10**, as shown in FIG. 1B. A similar concentration of charged particles **13** is also present in area **11**, but since the electrostatic charge in area **11** is so much higher than in area **12**, area **11** remains unneutralized. The unneutralized charge in area **11** corresponds to the full image charge, since only the non-image residual charge portion has been neutralized.

In order not to interfere with the subsequently developed image, and indeed to improve it as is the purpose of this invention, the charged particles **13** are selected to be either colorless or of the same color as the surface of paper **10**.

After the residual charge is neutralized by application of particles **13**, the sheet **10** is developed in a conventional way, and colored toner particles **14** are caused to adhere to the surface of sheet **10** in the charged area **11**, as depicted in FIG. 1C. No toner particles adhere in the area **12**, because all residual charge has been fully neutralized by particles **13**. Thus, the background or highlight area **12** remains clear.

FIG. **2** schematically shows an apparatus for practicing the process described above and illustrated in FIG. **1**. Tank **20** contains a dispersion or suspension **21** of positively charged colorless particles **13** in an electrically insulating liquid vehicle. A series of rolls **22** are partially immersed in the dispersion **21** and are paired with companion pressure rolls **23**. Photoconductive sheet **10** is caused to enter the nips of the paired rollers **22** and **23** and to pass therethrough with its electrostatic latent image surface faced downward toward rolls **22**, rolls **22** and **23** rotating in the directions indicated by the associated arrows. As rolls **22** rotate, each carries a film of dispension **21** on its surface to the image surface of sheet **10**, causing a controlled and uniform deposition of particles **13** on the surface of sheet **10**. Rolls **22** are preferably polished stainless steel and function as development electrodes. By this operation, and by control of the concentration of particles **13** in the dispersion **21** and control of the thickness of the dispersion film carried on the rolls **22**, the residual charge or potential on the image surface of electrophotographic sheet **10** is substantially exactly neutralized by the particles **13**, deposited on sheet **10**, as depicted in FIG. 1B.

After the sheet **10** passes the rolls **22** and **23**, it follows a feed path indicated by the dashed line **24** and the arrow **28**. Any excess dispersion **21** carried by sheet **10** is removed by squeeze rolls **25**. The sheet **10** is then directed and fed by rolls **26** into developer tank **29** containing a conventional developer suspension **30** of colored toner particles **14** in an electrically insulting liquid vehicle. After passing through tank **29**, the sheet is extracted and delivered by rolls **27**. In the developer **30**, colored toner particles are attracted to and adhere to the sheet **10** only in the areas having unneutralized charge remaining, as indicated in FIG. 1C by the presence of toner particles **14** in the image charge area **11** of sheet **10**. As will be appreciated by those skilled in the art, those rolls **25** and **26** that come in contact with the electrostatic image on sheet **10** have electrically insulated surfaces, so as not to destroy the latent image.

In the foregoing operations, in order to obtain a completely uniform application of charged particles **13** to the surface of sheet **10**, it would be necessary to have an infinitely small gap between rolls **22** and the surface of sheet **10**. However, as a practical matter a finite gap is always necessary in order to accomodate the presence of a film of dispersion **21**. Therefore, it is impossible to eliminate completely the tendency of the toner particles **13** to adhere somewhat preferentially to the areas of higher or image charge density. From a practical point of view, however, such preferential deposition is negligible, since the amount of toner deposition in the actual development step remains quite dominant. In order to realize a more perfectly uniform deposition of charged particles **13**, one may resort to a method in which a bias potential far larger than the maximum potential in the latent image is applied to the development electrode during the charged particle deposition. It will of course be appreciated by those skilled in the art that before sheet **10** is treated by despersion **21**, it may be prewetted with a suitable electrically non-conducting liquid free of any particles or toner, to prevent mechanical absorption of the dispersion **21** into the porous paper sheet **10**.

To insure proper operation of the present method, it is of course necessary that the charge forming the latent image should decay at only a very slow rate during the processing steps. Since the first coating step does not contribute to the optical density of the finally developed image, but rather to the reduction of highlight or background coloration, dissipation of charge in this phase of the process must be minimized. The rate of charge decay on the surface of sheet **10** depends largely on the composition of the photoconductive insulating coating and on the treating liquid with which the surface is treated. The decay rate is smaller in the more insulating treating liquids, and in those which have a lesser tendency to dissolve or swell the resinous ingredients included in the photoconductive coating. A variety of resinous materials are suitable for the photoconductive coating, when during this development process the coating is wetted with insulating liquids having low dissolving power, such as halogenated and isoparaffinic hydrocarbon solvents. When using insulating liquids such as Decalin, Tetralin, kerosene, or cyclohexane, which have a higher dissolving power, resinous photoconductor compositions having polar structures are desired. Suitable examples include alkyd, epoxyester, or linear polyester resins cross-linked by suitable reagents, such as polyisocyanate compounds. With photoconductive insulating coatings having these binder compositions, surface charges decay very slowly in the insulating processing liquids.

The dispersion **21** used to effect the uniform coating of charged particles can be prepared according to the methods known for the preparation of conventional liquid electrophoretic developers used in electrophotography. Suitable white pigments that may be used for the particles **13** in this dispersion include titanium oxide, zinc oxide and, as the most desirable, various body pigments such as calcium carbonate, alumium hydroxide, barium sulfate, alumium oxide, talc, silica, calcium silicate, magnesium carbonate, magnesium oxide, etc. While no elaborate charge control techniques are necessary so long as the pigment particles have a distinct tendency to be charged in a definite polarity in insulating liquids, any of the known liquid developer charge control techniques may be employed, such as the incorporation of resinous control agent in cases where the electrophoretic property of the pigment particles are unsuitable. Colorless particles **13** may be formed from clear resin particles or low-molecular weight resin powders. The desirable range of particle size is less than several microns in diameter.

To further illustrate the practice of the present invention the following specific examples are presented:

EXAMPLE I

The following ingredients were blended thoroughly by a three roll blender: Aluminum hydroxide (particle size 0.07–0.2 micron) —2,000g.; a varnish obtained by cooking an equal amount of resin modified phenol formaldehyde resin and linseed oil —4,000g.; and Linseed oil—1,000g. Fifteen grams of the resulting paste were dispersed in 1,000ml. of kerosene to form the coating dispersion **21.** A developer **30** was prepared by dissolving 5g. of a commercially available black offset printing ink in 1,000ml. of kerosene/Decalin mixture (1:1). An Electrofax paper having a photoconductive coating comprising photoconductive zinc oxide and alkyd resin binder cured by a polyisocyanate compound, was charged to −100 volts, and exposed to a continuous tone image to form an electrostatic latent image. Both of the above-described suspensions included positively charged particles or toner. The latent image bearing sheet was then processed in the manner described above, first with the dispersion **21** and then with the developer **30.** The resulting image was substantially free of background coloration. Using an optical wedge to generate the image, the background density was 0.05 and the maximum image density was 1.77. For comparison, a corresponding latent image was processed through the developer only, omitting treatment with dispersion **21.** Its background density was 0.11 and the maximum density was 1.83.

EXAMPLE II

Calcium carbonate was used in place of the aluminum hydroxide for the coating dispersion **21** described in Example I. A commercially available black developer for Electrofax copier was used as the liquid developer. The electrostatic latent image was formed on a zinc oxide/resin binder type photoconductive sheet, using an alkyd resin binder cured with cobalt naphthenate. When the electrostatic latent image was treated and developed in accordance with the procedures described above, an excellent image was obtained, free of background coloration.

EXAMPLE III

A methylethyl ketone solution of vinyl chloride/vinyl acetate copolymer (copolymer composition VCl:VAc=70:30, degree of polymerization-260) was poured into kerosene containing linseed oil under agitation by ultrasonic energy. The resulting uniform dispersion was used as the coating dispersion **21.** For developer **30,** a dispersion comprising the following ingredients was first formed:

Microlith Blue 4G-K (Ciba Ltd.)	20g.
Acetone	500ml.
Toluol	300ml.
Methylethyl Ketone	200ml.

(Microlith Blue 4G-K is composed of a blue pigment and vinyl chloride/vinyl acetate copolymer 85:15).

100 ml. of this dispersion was dispersed by means of an ultrasonic blender into the following mixed solvent:

Kerosene	2500ml.
Cyclohexane	7000ml.
Linseed oil	500ml.

The particles in both dispersions were charged negatively. An electrostatic latent image of positive polarity was formed on an organic photoconductive coating mainly comprising polyvinylcarbazol, and it was processed in the manner described hereinabove. An excellent image free of background coloration was obtained.

What is claimed is:

1. A method of developing an electrostatic latent image formed on an electrophotographic surface comprising applying over the image surface a substantially uniform coating of particles having a coloration which does not contrast with the image background coloration, said particles carrying a charge of opposite polarity from that of the image charge, the density of said particles in said coating being selected substantially just to neutralize the residual potential on said surface in background and image highlight areas, and thereafter developing said latent image with a developer having colored toner particles.

2. A method as set forth in claim **1,** wherein the step of applying said coating particles to said image surface includes using a thin film of a dispersion of said particles in an electrically insulating liquid vehicle.

3. A method as set forth in claim **2,** wherein said coating particles are colorless.

4. A method as set forth in claim **3,** wherein said developer is a dispersion of said toner particles in an electrically insulating liquid vehicle.

5. A method as set forth in claim **1,** wherein said developer is a dispersion of said toner particles in an electrically insulating liquid vehicle.

6. A method as set forth in claim **5,** wherein said coating particles are colorless.

7. A method as set forth in claim **5,** wherein the step of applying said coating particles to said image surface includes using a thin film of a dispersion of said particles in an electrically insulating liquid vehicle.

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