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METHOD FOR DEVELOPING LATENT ELECTROSTATIC IMAGES

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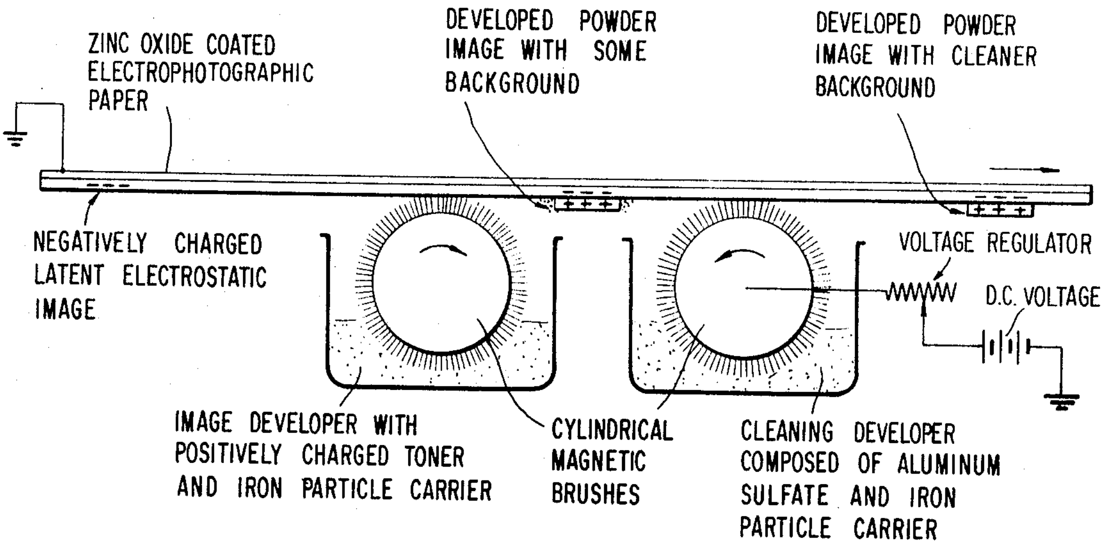

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METHOD FOR DEVELOPING LATENT ELECTROSTATIC IMAGES

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ABSTRACT OF THE DISCLOSURE

This invention relates to a method for developing an electrostatic latent image on an image support which comprises contacting the image with a fusible resin powder to develop the image areas and then contacting the image and support with a mixture of effective amounts of finely divided iron carrier particles and a powder which removes undesired fusible resin particles from the non-image areas of the support, thereby producing a developed image with clean non-image areas.

The toners commonly used in electrophotography comprise natural or synthetic resins in finely divided powder form. When used for the development of latent electrostatic images, such a toner is mixed with somewhat larger particles of a carrier which generally comprises an inorganic material, e.g. iron powder.

Iron powder is particularly effective as a carrier as it can be moved magnetically, for example, by means of a roller magnetized by electric current. The toner present on the surface of the iron powder is thus applied in the desired manner to the surface of the electrostatic image to be developed. Thus, an even application of toner to fairly large solid areas is possible.

It has been suggested to use toners consisting of two components which have approximately the same particle size. One toner component acquires a positive charge during handling and the other toner component acquires a negative charge. The use of these toners gives particularly desirable results with respect to freedom from background and sharpness of images produced therewith.

Although the two component toner system provides developed electrostatic images with cleaner non-image areas than does the single component toner system background still remains.

The present invention provides a method for developing latent electrostatic images in which copies are obtained having much cleaner non-image areas.

In the present invention, a latent electrostatic image is first developed with a single component or double component toner using any of the known methods of development, such as using the toner in admixture with an iron particle carrier and applying the mixture to the image to be developed by means of a magnetic roller or magnetic brush. Alternatively, the image may be developed by cascade development, powder cloud development, or sprinkling the toner on the latent image. The developed electrostatic image, having some toner adhering in the non-image areas, then is passed in contact with one or more magnetic rollers containing another powder in admixture with an iron particle carrier. The developer powder on the second magnetic roller picks up the weakly or loosely bonded colored toner in the non-image areas while leaving

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the strongly bonded colored toner in the image areas. The developed image is then fixed by heat.

The accompanying drawing shows one embodiment of the method of the present invention in which a zinc oxide electrophotographic paper having a negatively charged latent electrostatic image thereon is passed in contact with an image developer comprising a positively charged toner in admixture with an iron particle carrier and the developed powder image, with some toner particles in the non-image areas, is passed in contact with a cleaning developer comprising aluminum sulfate, for example, the admixture with iron particles, the mixture being applied by means of a magnetic brush to produce a developed powder image with clean non-image areas. A bias voltage may be applied for example to the magnetic brush used to apply the cleaning developer to the developed powder image. Of course, the zinc oxide electrophotographic paper can be any other known electrophotographic material such as metallic bases, including aluminum, copper, and the like, having inorganic or organic photoconductors thereon or the base may be paper having photoconductors other than zinc oxide, such as the other known inorganic and organic photoconductive materials. The development of the latent electrostatic image and the application of the cleaning developer to the developed image is performed in the dark.

Among the fusible resin powders which may be employed to develop the image areas are the known resins, such as natural and synthetic resins, including colophony, copals, dammar resin, asphalts, colophony-modified phenol resins, polyacrylic acid resins and polystyrenes, as well as mixtures of these resins. Inorganic and/or organic pigments and dyestuffs may be added to these resins to impart a definite polarity thereto. Examples of suitable substances are carbon black, zinc oxide, titanium dioxide, barium sulfate, minium and dyestuffs such as those listed in Schultz's Farbstofftabellen, vol. I, 7th edition (1931). Also, mixtures of such dyestuffs and/or pigments may be used.

Minute quantities of these substances, e.g. 0.5 percent by weight of carbon black, are often sufficient to impart a polarity to the resins. It is also advantageous to incorporate small quantities of waxes and/or organic compounds of low melting point and their substitution products, e.g. 0.1 to 10 percent, preferably 1 to 5 percent by weight, to the toner component to influence in a desirable direction its melting point and adhesive power.

Waxes suitable for this purpose include natural waxes such as carnauba wax, beeswax, Japan wax, montan wax, ceresine and synthetic waxes such as those marketed by A-wax, OP-wax, SPO-wax, V-wax, O-wax, E-wax, Hard Wax H, Hard Wax W, various waxes known as Ruhrwachse, and particularly the products available as Gersthofener waxes with the codings S, L, O, and OP.

Suitable organic compounds of low melting point include, in particular, substituted and unsubstituted aromatic compounds having melting points between 40 and 150° C., for example naphthols, such as 1-naphthol and 2-naphthol, aromatic compounds such as acenaphthalene, acylamino compounds such as acetanilide, halogenated aromatic compounds, such as p-dibromobenzene, amino compounds such as 2,4-diamino toluene, o-phenylene diamine, phenols such as resorcinol, and diphenylamine and derivatives thereof.

The powder which is admixed with finely divided iron carrier particles and is used as a cleaning developer in the present invention may be organic or inorganic. Exemplary of such powders are those listed in the table below, which table also shows the optimum concentration of the powder in admixture with finely divided iron carrier particles and also the triboelectric polarity of the powder:

	Optimum concentration (precent by weight)	Triboelectric polarity
Kieselguhr	3-15	(−)*
Magnesium trisilicate	5-20	(+)
Aluminum sulfate	5-25	(−)
Aluminum stearate	5-20	(+)
Asbestos	5-20	(−)
Calcium carbonate	5-20	(+)*
Ferric sulfate	5-20	(−)*
Zinc carbonate	1-15	(+)
Sodium phosphate, dibasic	5-25	(+)(−)
Ethylenedinitrilo tetra acetic acid	5-20	(−)*
Zinc stearate	0.5-5	(−)*
Sodium oleate	5-25	(+)(−)
Tetrahdrophthalic anhydride	5-20	(−)
Diphenyl phthalate	5-20	(−)
Para-phenolsulfonic sodium salt	5-20	(+)(−)
Gallic acid	5-20	(+)(−)
Benzoic acid	5-20	(+)(−)
Para acetophenetidine	5-20	(−)
Zinc oxide	5-20	(+)
Benzophenone tetracarboxylic dianhydride	5-20	(−)

NOTE: (+): The finely divided powder is positive in polarity when mixed with iron particles due to the triboelectric effect.
(−): The finely divided powder is negative in polarity when mixed with iron particles due to the triboelectric effect.
(+)*: Both polarities are observed but the greater portion is positively charged.
(−)*: Both polarities are observed but the greater portion is negatively charged.
(+)(−): Both polarities are observed.

The finely divided cleaning developer powders in admixture with iron carrier particles form a soft layer around the magnetic tubes of the magnetic brush so that it does not scratch the unfixed powder image.

The triboelectric characteristics of the finely divided powders when admixed with an iron carrier also constitute a factor in the powder selection. For example, if the colored toner used for developing the image is positive in polarity then the finely divided powder used in the cleaning step should preferably be negative in polarity, and vice versa. However, finely divided powders which show both polarities when mixed with iron carrier particles, or mixtures of two or more different finely divided powders also are useful.

The reasons why a finely divided powder has both positive and negative polarities when mixed with iron carrier particles is not fully understood but may be due to oxidation, one or more organic residues, moisture, dust or other contaminants.

The developer on the first magnetic roller shown in the drawing used to develop the latent image may contains, as is known, one part of toner to 10 to 25 parts of iron particles by weight. Where a double toner is used, the ratio of the fusible toner to the inorganic toner, such as kieselguhr, may vary from about 1 to 1 to 1 to 10, by weight.

For the developer on the second magnetic roller, the ratio of the colorless toner, to the iron carrier particles may vary from 1 to 4 to 1 to 200 preferably from 1 to 5 to 1 to 200 by weight. The preferred particle size of the iron carrier particles is from 50 to 200μ.

The advantages of using a single component colored toner followed by the cleaning action of the magnetic roller in the present invention, as opposed to the use of a double toner applied by a single magnetic roller, is that there is no adhesion of the cleaning toner, such as kieselguhr, to the non-image areas. This eliminates the step of cleaning the kieselguhr from the surface of the final copy and, also, more even image areas can be obtained, especially on large solid areas.

The bias voltage may be applied, depending upon the nature of the toner, to either or both magnetic rollers shown in the drawing to obtain the optimum results. The bias voltage may vary within a wide range depending upon the method of application. For a cleaning device including an electrically conductive magnetic brush and a non-magnetic conductive container, the preferred range is between 200 and 150 volts. DC, however, lower or higher voltages may be used. The connection of the power source to the magnetic brush depends upon the polarity of the finely divided powder in the cleaning developer. For example, if the finely divided powder is negative in polarity then the magnetic brush preferably is connected to the positive terminal, the negative terminal being grounded, and vice versa. For safety, the support of the photoconductive coating is to be grounded if a bias voltage is applied.

The rotation of the magnetic brush which applies the cleaning developer can be in either direction with respect to the direction of travel of the photoconductive surface shown in the drawing, but the surface speed of the rotating cleaning magnetic brush should be greater than the speed of travel of the photoconductive surface if it is in the same direction.

The invention will be further illustrated by reference to the following specific examples:

EXAMPLE 1

A zinc oxide coated electrophotographic paper is negatively charged by means of a corona discharge and then exposed to a light image. The negatively charged latent image is developed with a positively charged colored toner in admixture with an iron particle carrier by means of a magnetic brush. The resulting developed image shows some toner or background in the non-image areas, as is customary.

The electrophotographic paper with the powder image and some background is then brought into surface contact with the cleaning device shown in the drawings which consists of a rotating magnetic brush and a cleaning developer composed of 15 percent of finely divided aluminum sulfate and 85 percent of finely divided iron particles, by weight, whereby nearly all of the toner in the non-image areas is removed without loss of image density. The powder image is then fixed by application of heat, in known manner.

EXAMPLE 2

The procedure of Example 1 is followed except that a basis voltage of 50 volts DC is applied to the cleaning device shown in the drawing with the positive terminal connected to the cleaning device and the negative terminal and the support of the photoconductive coating connected to ground. The cleaning device is insulated from the remainder of the machine.

EXAMPLE 3

An organic photoconductive substance and a binder are dissolved in a solvent and coated on an aluminum substrate. The photoconductive surface is positively charged by means of a corona discharge. The photoconductive aluminum plate is then exposed to a light image. The positively charged latent electrostatic image then is developed with a negatively charged colored toner, using beads as a carrier, by means of the cascade developing method. The developed powder image with some toner particles in the non-image areas is then brought into surface contact with the cleaning device shown in the drawings consisting of a magnetic brush and a cleaning developer which is composed of 16 percent of aluminum stearate and 85 percent of iron particles, by weight. An electrostatic image with much cleaner non-image areas is obtained. The powder image is then fixed by application of heat, in known manner.

EXAMPLE 4

The procedure of Example 3 is repeated except that a bias voltage of 60 volts DC is applied to the cleaning device, which latter is insulated from the remainder of the machine. The negative terminal is connected to the cleaning device and the positive terminal and the aluminum support of the photoconductive coating is grounded.

EXAMPLE 5

A zinc oxide coated electrophotographic paper is processed according to Example 1 wherein a cleaning developer composition is used consisting of 10 percent by weight of tetrahydrophthalic anhydride and 90 percent by weight of finely divided iron particles. This composition is prepared by first grinding the tetrahydrophthalic anhydride to a particle size between 0.5 and 50μ and then intimately mixing with the iron powder.

EXAMPLE 6

A zinc oxide coated electrophotographic paper is processed according to Example 1 wherein as a cleaning developer a mixture of an organic compound, in this case 5 percent by weight of para-acetophenetidine and an inorganic compound, in this case 5 percent by weight of aluminum sulfate, with 90 percent of finely divided iron particles by weight is used.

The method of the present invention also can be applied to "transfer electrophotography," i.e., xerography. In the xerographic process, a xerographic drum comprising a layer of photoconductive insulating material, such as selenium, on a conductive backing is given a uniform positive electrostatic charge over its surface and then exposed to a light image, thereby forming an electrostatic latent image on the photoconductive layer.

Development of the latent image is effected with a negatively charged colored toner brought into surface contact with the photoconductive layer. Thereafter, the developed powder image is transferred to a support to which it may be fixed by application of heat. However, during the cascade developing method employed, quite often the electrically charged colored toners adhere to the non-image areas and result in copies having undesirable background. It is, accordingly, advantageous to contact the powder image immediately after cascade development, but before the transfer of the powder image to a support surface, with the cleaning device of the present invention.

Since the photoconductive insulating layer, such as selenium, is initially positively charged, a negatively charged colored toner is employed. Therefore, the finely divided powder in the cleaning step preferably is positive in polarity when mixed with iron particles. However, as noted above, it is also possible to use powders which exhibit both polarities, or a mixture of two or more different finely divided powders. Alternatively, the cleaning step of the present invention can be performed on a powder image that has been transferred before the image has been fixed. In this case, it is preferable to construct the system in a manner such that the unfixed powder image faces downwardly when it passes over and in surface contact with the cleaning magnetic brush. A basis voltage may be applied advantageously to the magnetic brush of the cleaning device when used both after cascade development or after the image has been transferred.

Another application of the cleaning device can best be described as a "web cleaner." In transfer electrophotography, i.e., xerography, a photoconductive cylindrical drum is continuously rotated through a cycle of sequential operations, including charging, exposure, developing, and transfer, resulting in multiple copies; the photoconductive surface is cleaned by means of the present invention before repeating the cycle. To accomplish this, the residual toner on the photoconductive surface, after transfer of the powder image to the support surface, particularly in

the image areas, is first substantially neutralized, then brought into surface contact with the cleaning device, and finally brushed with a rotating fur brush whereby all residue is collected by vacuum and deposited into a filter bag.

It will be obvious to those skilled in the art that many modifications may be made within the scope of the present invention without departing from the spirit thereof, and the invention includes all such modifications.

What is claimed is:

1. A method of developing an electrostatic latent image on an image support which comprises contacting the image with a fusible resin powder to develop the image areas and then contacting the developed image and support with a magnetic brush containing a mixture of effective amounts of finely divided iron carrier particles and a second powder which removes undesired fusible resin particles from non-image areas of the support, whereby a developed image with clean non-image areas is obtained.

2. A method according to claim **1** in which the second powder is inorganic.

3. A method according to claim **1** in which the second powder is organic.

4. A method according to claim **1** in which the second powder comprises a mixture of inorganic and organic powders.

5. A method according to claim **1** in which the second powder is a metallic salt of an organic acid.

6. A method according to claim **1** in which the second powder is selected from the group consisting of aluminum sulfate, aluminum stearate, tetra hydrophthalic anhydride, diphenyl phthalate, para acetophenetidine and benzophenone tetracarboxylic dianhydride.

7. A method according to claim **1** in which the second powder has a polarity opposite to that of the fusible resin powder.

8. A method according to claim **1** in which the second powder has a negative polarity.

9. A method according to claim **1** in which the second powder has a positive polarity.

10. A method according to claim **1** in which the second powder has both a positive and a negative polarity.

11. A method according to claim **1** in which a bias voltage is applied to the mixture of iron carrier particles and second powder.

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