United States Patent

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[54] **IMPROVED METHOD OF REMOVING THE RESIDUAL TONER PARTICLES FROM A PHOTOCONDUCTIVE SURFACE**
4 Claims, 4 Drawing Figs.

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[51] Int. Cl. G03g 13/14
[50] Field of Search 96/1.3, 1.4, 1; 117/17.5; 15/1.5

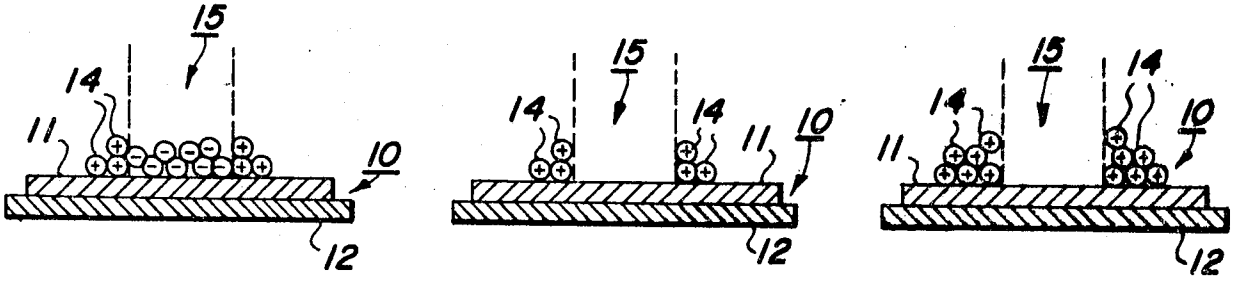
[56] References Cited

UNITED STATES PATENTS

3,375,806	4/1968	Nost	118/637
3,444,369	5/1969	Malinaric	250/65

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ABSTRACT: An improved method of producing xerographic copies which includes the steps of charging a photoconductor with an electrostatic charge, exposing the charged photoconductive surface to discharge portions of the charge in a configuration of image and nonimage areas corresponding to the copy to be reproduced, developing the photoconductive surface with developer material including carrier and electroscopic toner particles triboelectrically arranged and transferring the toner particles from the photoconductive surface to a backing material. The improvement comprises simultaneously cleaning residual toner images from the drum surface and reuse of these residual toner images during image development then transferring the toner particles as aforementioned, and then charging the residual toner particles with a corona having a polarity opposite to the charging polarity on the drum surface prior to drum exposure and recharge to convert positively charged residual toner particles to a negative charge thereby preparing the particles for cleaning by development in the development zone by the carrier.



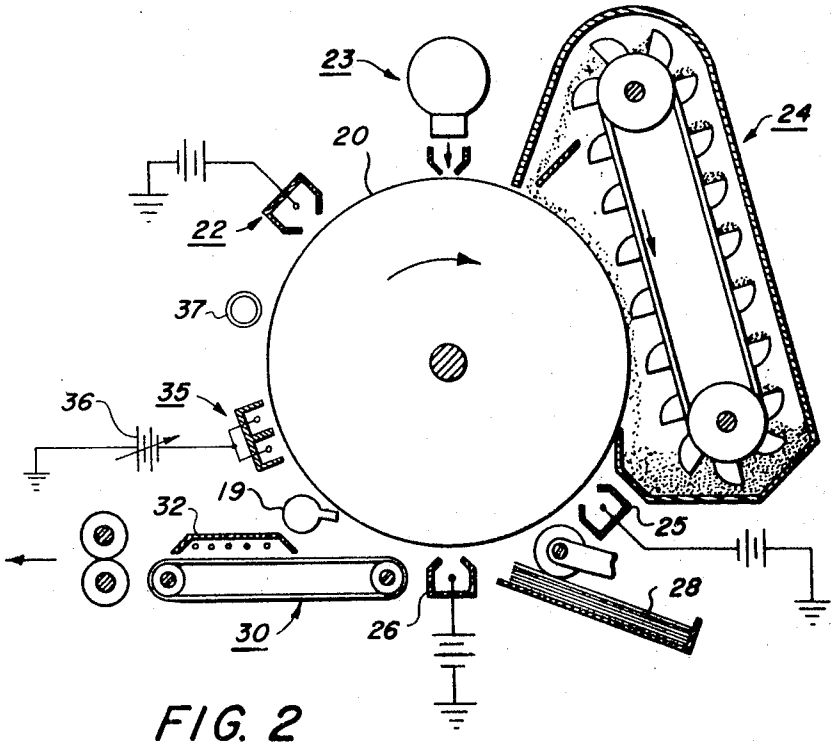


FIG. 2

PRIOR ART

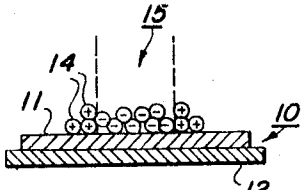


FIG. 1a

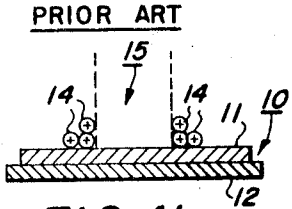


FIG. 1b

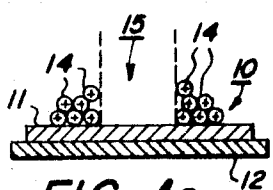


FIG. 1c

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IMPROVED METHOD OF REMOVING THE RESIDUAL TONER PARTICLES FROM A PHOTOCONDUCTIVE SURFACE

This invention relates to improved electrostatic imaging and more specifically to an improvement over the development of electrostatic latent images and the removal of the residual toner images from a support surface.

It is universally known that a commercially successful mode of development employed in automatic xerographic apparatus described in Walkup U.S. Pat. No. 2,618,551 comprises a developer generally consisting of toner and a granular material called "carrier," which by mixing triboelectrically acquire charges of opposite polarity, is gravitationally cascaded over the xerographic plate carrying the electrostatic latent image. Although carrier typically comprises spherical particles, in various other systems, the carrier may be in various forms and substances including flat platelets, cubical solids, synthetic and natural fibers, metallic filings, and other. In addition to the cascade development system, magnetic brush, liquid developer, fluidized bed, powder cloud and other development systems are well known.

A commercially successful mode of cleaning employed in automatic xerographic apparatus is described in U.S. Pat. Nos. 2,751,616 and 2,832,977, wherein a brush with bristles which are soft and of suitable triboelectric characteristics, and yet sufficiently firm to remove residual toner particles from the xerographic plate, is used to whisk residual toner images from the surfaces of the xerographic plate. In addition, webs or belts of soft fibrous materials or tacky materials, and other cleaning systems are known.

In spite of the successes that have been achieved in cleaning, the prior art solutions to the problems in the development and cleaning steps in the xerographic process are not entirely satisfactory. For example, cleaning still typically requires bulky apparatus and a separate and distinct cleaning station. Experience has shown that the greater the xerographic process, the greater danger of toner powder escaping throughout the mechanism and dusting the operating apparatus. Many cleaning systems typically require more than one pass through the cleaning station, requiring more time for cleaning the xerographic plate and thereby making the cleaning step one of the limiting factors in the operating time of the xerographic cycle. Also, typically development and cleaning must be performed at different areas of the xerographic plate, which requires more apparatus to ensure that the portion of the xerographic plate being used to reproduce the desired image is correctly registered at each of the xerographic stations.

Experience in the art of photoconductors has shown that the greater the number of passes necessary to clean or develop the surface of said photoconductor, the fewer the number of cycles through which said photoconductor or xerographic plate can be used with acceptable image quality. The surface of the photoconductor is partially abraded by multiple passes through development or cleaning steps, and scratches in the surface of the plate may mechanically pick up toner particles thereby darkening the background areas of desired images. In addition, increased numbers of passes through development or cleaning stations tend to increase toner consumption and to impair toner concentration in the development system. Each of these effects contributes to reduced image quality in the prior art systems.

Effects to solve the above problems have led to new and different imaging systems, such as, the system for simultaneous development of electrostatic latent images and removal of residual toner images from the image support as described in copending application Ser. No. 789,031, filed on Dec. 31, 1968 in the name of Volkers et al. Unfortunately, toner particles in the developer material are not uniformly charged to the same polarity such that complete removal of the residual toner images can be accomplished by the development system. As a result the residual images build up and deposit onto the copy sheet as unwanted background.

The present invention is intended to overcome the above disadvantages and to be an improvement over the system of the aforementioned copending application.

It is, therefore, an object of this invention to improve electrostatic imaging systems.

It is also an object of this invention to provide a method for development of latent images and removal of residual images on a support surface.

It is another object of this invention to provide a system for the simultaneous development and cleaning of an electrostatic latent image support surface or electrostatographic surface.

It is another object of this invention to provide a system for the simultaneous development and cleaning of essentially the same area of an electrostatographic surface such as xerographic plate.

It is another object of this invention to provide a system for the simultaneous development and cleaning at essentially the same area of a xerographic plate at the same station in a xerographic apparatus.

It is another object of this invention to clean the surface of a xerographic plate in a single cleaning pass.

It is another object of this invention to improve image quality of copies made by the xerographic process.

It is yet another object of this invention to increase toner efficiency in the xerographic process.

It is another object of this invention to prolong the life of the photoconductive insulating layer of the xerographic plate, or any other exposed surface of the xerographic plate or support surface.

It is still another object of this invention to eliminate unwanted background in xerographic copy.

The foregoing objects and others are accomplished in accordance with this invention, which for the substantially simultaneous removal of residual images comprising residual toner particles from the xerographic plate and development of electrostatic latent images on essentially the same area of said plate. Essentially, the principle upon which this invention is founded is that by converting the polarity of the residual toner particles to a negative polarity after transfer, the residual toner particles remaining on the plate surface after transfer are now negative will remain so for a period while the xerographic plate does not thereby enabling efficient development cleaning in the development zone.

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed disclosure which should be read in conjunction with the accompanying drawing in which:

FIGS. **1**(*a*), **1**(*b*), and **1**(*c*) show side schematic views of the xerographic plate of the prior art at the time of development, transfer, and transfer after extended use, respectively, and

FIG. **2** is a schematic side view of xerographic apparatus adapted for continuous and automatic operation to carry out the method of the instant invention.

Referring now to FIGS. **1**(*a*), **1**(*b*), and **1**(*c*) there is shown a typical xerographic plate **10** including a photoconductive layer **11** and backing layer **12** made out of suitable material and having electroscopic toner particles **14** thereon electrostatic image formation. Toner particles **14** normally have a negative charge for development of the image areas designated by numeral **15**. However, due to some toner particles having a positive charge is a tendency for these particles to deposit on the edges of the image areas where the greatest difference is in the potential of the electrostatic latent image formed on the plate is found to exist. When the toner particles are transferred to copy sheet, the residual image remaining on the plate is predominantly the positive particles as seen in fig. **1**(*b*). After repeated use of the plate, these positively charged particles build up as indicated in FIG. **1**(*c*) and deposit on the copy sheet as unwanted background unless removed. It has not been possible to remove these particles by development cleaning the carrier beads in the development zone are also positively charged and do not scavenge them from the plate.

Referring now to FIG. 2 which discloses a xerographic apparatus showing the steps used in the xerographic process, but embodying the improved system of the present invention there is shown a drum **20** with photoconductor layer adapted for rotation past processing stations. As the surface of the drum advances during a xerographic cycle, a corona discharge device **22** initially said surface at a charging station. The charged surface then advances through an exposure station **23** where the light and shadow image desired to be copied is projected onto the surface of the drum **20**.

The charged and exposed surface of the drum now bearing the electrostatic latent image corresponding to the light and shadow image projected thereon, then advances into the combination development-cleaning station **24** according to the present invention as will be described more fully hereinafter. Development and cleaning are carried out by a cascade of developer comprising toner and carrier which develops electrostatic latent images and at the same time removes residual images comprising toner particles, typically adhering to the surface of the drum in essentially the same area as will become more apparent.

The area of the surface just cleaned and developed then preferably advances through a corona generating device **25** which recharges the drum surface in preparation for the transfer step. At the transfer station, the developed image is transferred to a sheet of suitable backing material **28**, such as, paper by another corona generating device **26**. The transferred image is then passed through a fixing station on a belt transport **30** where a heating device **32** permanently affixes the developed image onto the backing material.

In accordance with the present invention, the drum surface from which the image now supported on the backing material was transferred, continues to advance through the cycle, but now supporting only the residual image of toner particles remaining after the transfer step which are to be removed from the development zone as will become more apparent. Positioned after the transfer station is a dual negative corotron **35** which is connected to a high level DC voltage supply **36** of negative polarity to impart a negative charge to the positively charged residual toner particles thereby converting all the image particles to a negative charge. The drum surface then passes a discharge lamp **37** which serves to return the drum surface to its normal residual voltage but not the residual toner particles which remain negative to the fact that the residual toner particles have a much longer time constant than the drum surface. When the drum surface passes the charging corotron **22**, the photoconductive surface is able to charge up to the required potential but the residual toner particles are not thereby enabling the particles to remain negative and to be removed by carrier in the cascading two-component developer. It will be appreciated that the drum surface is cleaned in the development zone and the residual toner particles intermixed with the developer material and recharged in proper triboelectric relation with the carrier for reuse in the system. The drum is now ready for another cycle which repeats the aforementioned steps.

It has been found that a negative preclean current ranging from 10 microamperes to about 40 microamperes and preferably about 20 microamperes performs well when a positive charge current of about 100 microamperes is applied at the drum charging station. At these values, the drum surface charges to about 330 volts and the residual toner to about 207 volts until the drum surface discharges to about 130 volts leaving a greater negative charge on residual toner than on the drum surface. As the drum passes the charging station a charge current of 100 microamperes provides a 1000 volt charge on the drum surface for a proper exposure. If the preclean current is too high, then the drum charging must be increased, and it has been determined that a 1000 volt surface charge is desirable for a proper exposure and print out. It should be noted that the preclean current is supplied from a variable source of potential to accommodate varying conditions of operation.

In the past the residual toner particles had to be physically removed at a separate cleaning station or if simultaneous development and cleaning were attempted, copy quality would drop off rapidly in time. By the present invention, the xerographic reproduction system is more efficient in that the removal of the residual image and its subsequent reuse in the system is effectuated. It should be readily appreciated how this invention contributes to the overall quality of copies as well as the efficiency of the copier system.

It has also been found that the toner particle size can be a significant factor. Toner particle size affects the efficiency of the electrostatic transfer of toner to latent electrostatic images and the transfer of residual toner from the xerographic plate back to the carrier. It has been found that both processes become more efficient with larger toner particle sizes. At a given toner concentration, smaller toner particles tend to cover more of the surface of the carrier beads thereby leaving less free bead surface available for development-cleaning or scavenging. The smaller toner particles are also less susceptible to being physically knocked from the plate surface. It has therefore been found advantageous to use toners having a particle size distribution which contains minimal amounts of relatively small toner particles. Toner particles may be classified as to particle size in a classifier for fine dry powders such as the Sharples K8 Super Classifier, manufactured by the Sharples Company, 424 West Fourth Street, Bridgeport, Pa. In the Sharples scale, toner particles are measured in microns. Toners with particles of average size by number in the range of about 1 to about 20 microns, with negligible numbers of particles of size less than 5 microns, gives results preferred over those of average size in the range of about 4 to about 7 microns, with about 50 percent of the particles of a size less than 5 microns. Toners in both of the above ranges give development-cleaning efficiencies which are preferred over those attainable with particles of average size in the range of about 2 to about 3 microns, with about 90 percent of the particles less than 5 microns in diameter. The smaller toner particles will still perform the development-cleaning, although the build up of toner-film on the apparatus typically accelerated.

Another parameter is toner concentration in the developer mixture. The concentration of toner affects development-cleaning primarily in the development part of the process. The cleaning will go on, but if the toner concentration is too high, the cleaned residual images will be redeveloped as quickly a they are cleaned. Hence, the limiting concentration at one end is development capability (i.e. sufficient toner to develop electrostatic latent images) while the other end point is the limit of the cleaning ability of the system. These concentration limitations depend on the degree of quality to be copy desired. Toner concentration is conveniently expressed in terms of mass per unit surface area, said surface being the surface of the carrier particles or beads. The advantageous cascade development-cleaning system of the present invention produces satisfactory results in toner concentration ranges of about 0.1 to about 0.4 mg. of toner per sq. cm. of carrier surface. At toner concentrations lower than about 0.1 mg./sq. cm., development in extended unexposed areas of the image pattern still occurs, but image tone uniformity tends to fall off rapidly. At higher toner concentrations the ability to clean is reduced. The reduction in cleaning capability may in part be due to increases in the amount of residual toner retained as the residual image. It is also thought that there is increased redevelopment of the residual image at these higher toner concentrations. A preferred range of toner concentration in the developer mixture is about 0.2 to about 0.3 mg./sq. cm. These concentrations indicate that it is most desirable to closely control the toner concentration, preferably by automatic means.

Problems related to higher toner concentration include toner impaction and toner agglomeration, which may greatly reduce image quality.

It has been found that the addition of small amounts of dry solid hydrophobic lubricants effectively controls toner impac-

tion and agglomeration. Such lubricants include metallic salts of fatty acids such as zinc searate, and other materials such as colloidal pyrogenic silica particles such as "Cab-O-Sil," available from the Cabot Corporation, or various mixtures of such materials, An extensive group of such lubricants is recited in copending application Ser. No. 702,306, filed Feb. 2, 1968. A preferred range of concentration for the lubricant is in the range of about 0.1 to about 1 percent by weight of toner.

The other component in the developer is a granular material called "carrier" which by mixing with the toner particles triboelectrically acquires charge of polarity opposite that acquired by the toner. Carrier granules may be any shaped solid particle from flat platelets to cubes to spherical beads. The carrier may be made of any suitable material such as glass, plastic, metal or other granular material. Carrier granules of average size in the range of about 30 to about 1000 microns perform satisfactorily. A preferred range of carrier particles size is in the range of about 100 to about 600 microns.

The advantageous system of the present invention is useful in any electrostatographic process having an electrostatic latent image support surface. In the preferred process, xerography, the electrostatic latent image support surface is the surface of a photoconductive insulating layer. Selenium in its amorphous is found to be a preferred photoconductive insulating material for use in xerography because of its extremely high quality image making capability, relatively high light response, and capability to receive and retain charged areas at different potentials and of different polarity. Any suitable photoconductive insulating layer may similarly be used in the practice of the invention. However, it is found that the invention system performs more satisfactorily if the electrostatic latent image support surface is quite smooth. Typical photoconductive insulating layers include; amorphous selenium, alloys of sulfur arsenic or tellurium with selenium, selenium doped with materials such as thallium, cadmium sulfide, cadmium selenide, etc., particulate photoconductive materials such as zinc sulfide, zinc cadmium sulfide, French process zinc oxide, phthalocyanine, cadmium sulfide, cadmium selenids, zinc silicate, cadmium sulfoselenide, linear quinacridones, etc. dispersed in an insulating materials include: belends, copolymer, terpolymers, etc. of photoconductors and nonphotoconductive materials which are either copolymerizable or miscible together to form solid solutions and organic photoconductive materials of this type include: anthracene, polyvinylanthracene, anthraquinone, oxadiazole derivatives such as 2,5-bis-(p-amino-phenyl-1), 1,3,4-oxadiazole; 2-phenylbenzoxazole; and charge transfer complexes made by complexing resins such as polyvinylcarbazole, phenolaldehydes, expoxies, phenoxies, polycarbonates, etc., with Lewis acid such as tetrachlorophthalic anhydride; 2,4,7-trinitrofluorenone metallic chlorides such as aluminum zinc or ferric chlorides; 4,4-bis (dimethylamino) benzophenone; chloranil; picric acid; 1,3,5-trinitrobenzene; 1-choloroanthraquinone; bromal; 4-nitrobenzaldehyde; 4-nitrophenol; acetic anhydride; maleic anhydride; boron trichloride; maleic acid, cinnamic acid; benzoic acid, tartaric acid; malonic acid and mixtures thereof.

In addition to the advantageous use of the inventive system for simultaneously developing and cleaning an electrostatic latent image support surface, it is clear that the system of the present invention may also be used as a separate cleaning system. Thus, a one-pass cleaning system using developer as the functional cleaning medium, also shows that the advantageous development-cleaning system of the present invention can be used as both a development system and a cleaning system, in any two-cycle electrostatographic process. In such two-cycle, which cycle is solely for the purpose of removing residual toner images from the electrostatic latent image support surface. Unlike the dual station system described in the preceding paragraph, the two-cycle system achieves all of the objects of the preferred system, except that the recycling may involve slightly more complicated mechanisms and electrical circuits.

Although the description of the preferred embodiments of the inventive system has been primarily directed to the use of the inventive system in a xerographic process, it is appreciated and intended that the advantageous system of the present invention be incorporated in any suitable electrostatographic process.

Although specific components and proportions have been stated in the above description of the preferred embodiments of the development-cleaning system, other suitable materials and variations in the various steps in the system as listed herein, may be used with satisfactory results and various degrees of quality. In addition, other materials and steps may be added to those used herein and variations may be made in the process to synergize, enhance or otherwise modify the properties of the invention. For example, various photoconductive materials may be used in xerographic plates, and various photoconductor thicknesses may require somewhat different parameter settings for preferred results.

It will be understood that various other changes in the details, materials, steps, and arrangements of parts which have been herein described and illustrated in order to explain the nature of the invention, will occur to and may be made by those skilled in the art, upon a reading of this disclosure, and such changes are intended to be included within the principle and scope of this invention.

What is claimed is:

1. In a method of producing xerographic copies which include the steps of charging a photoconductive surface with an electrostatic charge, exposing the charged photoconductive to discharge potions of the charge and a configuration of image and nonimage areas corresponding to the copy to reproduced, developing the photoconductive surface with developer material including carrier and electroscopic toner particles in triboelectric relation and then transferring the electroscopic toner particles onto a backing material, the improvement which comprises applying a high level corona charge onto the residual toner particles remaining after transfer and the photoconductive surface, then directing illumination onto the photoconductive surface then applying a corona charge of the photoconductive surface, then applying a corona charge opposite in polarity from the first mentioned charge to obtain a selected charge on the photoconductive surface prior to exposure, then exposing the photoconductive surface and residual toner particles to discharge portions of the surface in configuration of image and nonimage areas as aforementioned, and then advancing the photoconductive surface into the development area for simultaneous development and cleaning of the residual toner particles by cascading developer material including carrier whereby the residual toner particles are intermixed with the developer material for reuse in the development area.

2. A method according to claim 1 wherein said high-level corona charge is applied from about a 20 microamperes current where charging the photoconductive surface is applied from about a 100 microamperes current.

3. A method according to claim 1 wherein said high-level corona charge is supplied from a variable DC source to obtain optimum performance under varying conditions.

4. The method according to claim 1 wherein said photoconductive surface is formed in the shape of a drum and rotated past processing stations repeating the aforementioned steps continuously to produce multiple copies automatically and continuously.

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