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XEROGRAPHIC DEVELOPMENT APPARATUS

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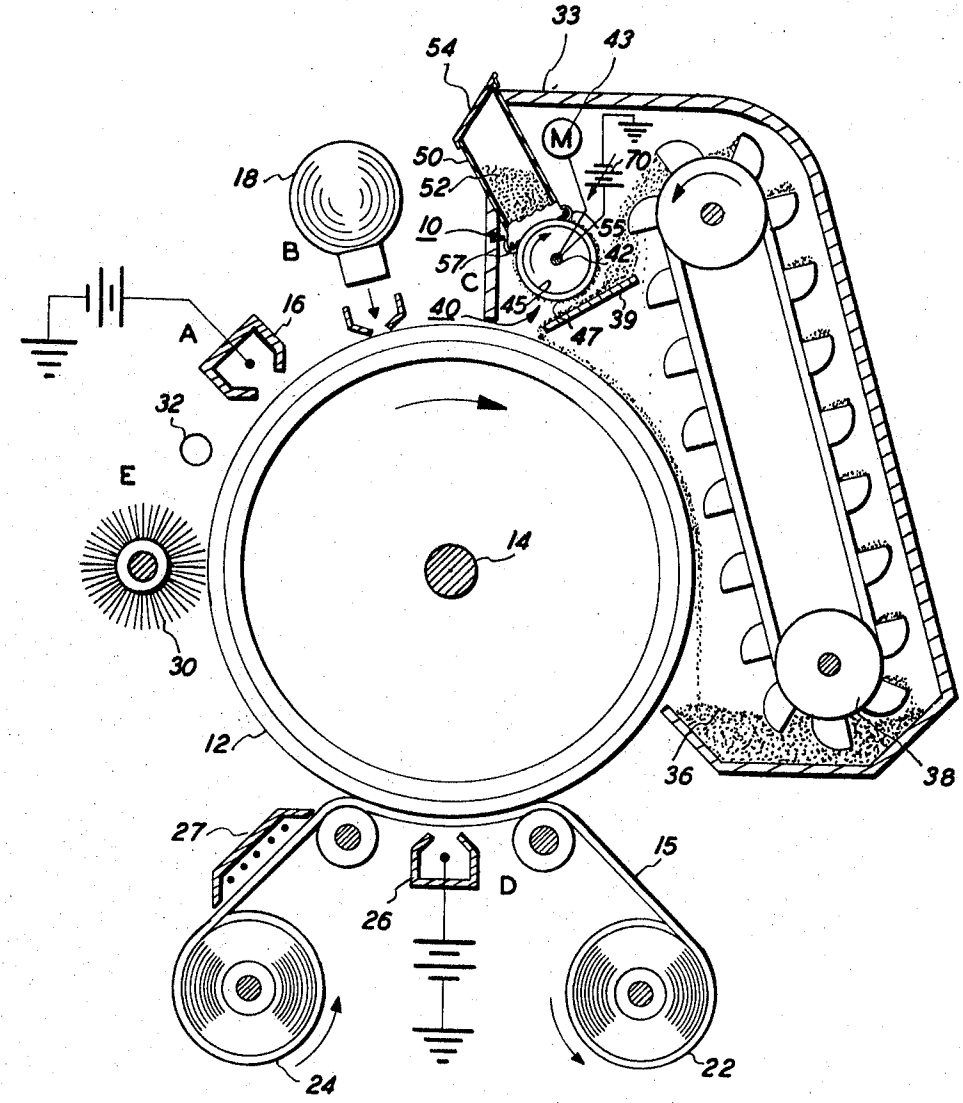

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XEROGRAPHIC DEVELOPMENT APPARATUS

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ABSTRACT OF THE DISCLOSURE

A xerographic developer apparatus for controlling the toner concentration by varying the electric potential on an intermediate roller. The roller is attached to a hopper which dispenses the toner. When the carrier granules cascade over the roller, which is covered with toner, they electrostatically attract and frictionally rub off some of the toner. The amount removed is a function of the variable potential placed on the roll.

This invention relates in general to electrostatic copying and, in particular, to apparatus for maintaining optimum toner concentration in developer materials utilized in electrostatic copying devices.

In the process of xerography, as disclosed, for example, in U.S. Patent No. 2,297,691 to Carlson, a xerographic plate comprising a layer of photoconductive insulating material on a conductive backing is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually conventional projection techniques. This exposure discharges the plate areas in accordance with the light intensity that reaches them, and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is effected with an electrostatically charged, finely divided material, such as an electroscopic powder, which is brought into surface contact with the photoconductive layer and is held thereon electrostatically in a powder image pattern corresponding to the electrostatic latent image. Thereafter, the developed xerographic powder image is usually transferred to a support surface, such as a sheet of copy paper to which it may be fixed by any suitable means.

Since the disclosure in Carlson, many improvements have been made in xerographic devices and techniques and, as a result both manual and automatic machines for carrying out xerographic reproduction processes are in wide commercial use. The present invention constitutes a further improvement in the development process for automatic xerographic systems to further extend such systems to modern day usage.

A commonly used developing material in electrostatic copying devices consists of a pigmented resinous powder referred to as "toner" and a coarse granular material called "carrier." The carrier is removed in the triboelectric series from the toner so that a charge is generated between the powder and the granular carrier upon mutual interaction. Such charge causes the toner to adhere to the carrier. The carrier, besides providing a charge to the toner, permits mechanical control so that the toner can readily be brought into contact with the exposed xerographic surface. The toner particles are electrostatically attracted to the electrostatic image to produce a visible powder image.

The quality of the developed image may be affected by the ratio of toner particles to carrier commonly referred to as toner concentration. For example, if there is a deficiency of toner, the image areas will be unable to attract sufficient toner to fully develop the image resulting in light images. On the other hand, if there is an excess amount of toner in a developer material, the image

areas become overly dark with quantities of toner becoming attached to non-image areas. The reason for this is that the attractive force holding toner particles on a carrier bead is inversely proportional to the number of particles on such bead. Therefore, with fewer toner particles on a carrier bead, these particles will be strongly attracted and will not be readily given up to the charge on the latent image. In the case of a high number of toner particles on a carrier bead, the force of attraction is markedly decreased often to the point where even residual charge on non-image areas is sufficient to attract the toner particles.

Heretofore, various attempts to control toner concentration have generally been directed to the periodic addition of raw toner into the developer mixture to supplant the toner lost by deposition on the image. Normally, this was accomplished by adding toner intermittently on the basis of a time cycle or by a device which measured either the developer concentration directly or the density of the developed image.

While such systems are somewhat satisfactory, they have certain obvious shortcomings. For example, when toner is added to the developer material it is generally added equally across the length of the development zone. If, however, the images being reproduced have large solid areas in one portion, as in the middle, then the developer material would have a reduced toner concentration at this locality. The addition of toner to developer across the entire length of the development zone would not rectify this inbalance. Furthermore, these developer systems need time to react to a localized depletion of toner caused by the development of dense image areas. Such time delay has been known to detract from the quality of the print. Obviously this problem is only aggravated in the case of time regulated toner dispensers. With the advent of high speed copiers and the demand for higher quality prints, the problem of maintaining a proper toner concentration becomes increasingly apparent.

Now in accordance with the present invention it is possible to maintain the toner concentration in a two component developer mixture at a predetermined optimum degree continuously and automatically. More than this, the toner concentration is maintained across the entire development zone to obviate the problem of sporadic development. Generally speaking, this is accomplished by adding toner in response to and in proportion to the electrostatic property of the developer mixture prior to its movement into contact with the latent electrostatic image to be developed.

It is therefore an object of the invention to improve toner dispensing apparatus.

Another object of the invention is to dispense toner particles into a two component developer mixture equal to the amount of toner depleted through the development of the images.

Another object of the invention is to achieve optimum control for the toner concentration of developer material.

A further object of the invention is to maintain optimum toner concentration in a developer material uniformly across the development zone irrespective of the type images developed.

A still further object of this invention is to selectively regulate toner dispensing in an automatic copying machine so as to maintain high quality prints continuously.

For a better understanding of the invention as well as other objects and further features thereof reference is had to the following detailed description to be read in conjunction with the accompanying drawing in which the figure is a schematic representation of a preferred embodiment for carrying out the invention.

The underlying principle of the instant invention is the attractive electrostatic force exhibited by a carrier on a

toner particle due to their relative locations on the triboelectric scale. As carrier attracts toner to its surface, its electrostatic attraction for additional toner decreases in proportion to the amount of toner already being held on its surface. In effect then, the addition of toner to carrier is self-regulating. Once the carrier can electrostatically accept no more toner, it is said to be saturated. This saturation level is normally greater than the optimum toner concentration level desired in two component development systems. It has been found that by employing a competing electrostatic force, the attraction of the toner to the carrier may be controlled to produce a optimum toner concentration during development. It can readily be appreciated that by controlling toner concentration, it is possible to achieve selective development of the electrostatic images.

Referring now to the drawing there is shown a xerographic system adapted for continuous and automatic operation employing a toner dispenser generally designated **10** constructed in accordance with the invention. As is usual in xerographic systems, a xerographic surface **12** formed in the shape of a drum is mounted on a shaft **14** for movement to pass the several xerographic processing station in a direction indicated by the arrow. The elements of the systems are conventional with the exception of those at the developing station which forms the basis of the present invention. For the purpose of the present disclosure, the several xerographic processing stations in the path of movement of the xerographic surface may be briefly described as follows:

A charging station A at which a uniform electrostatic charge is deposited on the xerographic surface by a corona charging device **16.**

An exposure station B at which the light or radiation pattern of copy to be reproduced is projected onto the drum surface by an optical projector **18** to dissipate the drum charge in the exposed areas thereof to thereby leave a latent electrostatic image of the copy to be reproduced.

A development station C at which a xerographic developing material, including the aforementioned toner particles, is moved into contact with the drum surface to form a powdered image. Toner particles consumed during the developing operation are replenished by toner dispenser **10** as will be explained hereinafter.

A transfer station D, at which the xerographic powder image is electrostatically transferred from the drum surface to a transfer material **20** transported on reels **22** and **24** by another corona charging device **26.** The image is permanently affixed to transfer material **20** by a fuser **27.**

A drum cleaning and discharge station E, at which the drum surface is contacted by a brush **30** to remove residual toner particles remaining thereon after image transfer, and at which the drum surface is exposed to a relatively bright light source **32** to effect substantially complete discharge of any residual electrostatic charge remaining thereon.

It is believed that the foregoing description is sufficient for the purposes of this application to show the general operation of the xerographic system. For further details concerning the specific construction of a typical xerographic apparatus as shown, reference is made to the U.S. Patent No. 3,049,968.

As illustrated in the figure, development station C includes a housing **33** having a lower or sump portion for accumulating developer material **36.** Developer material **36** preferably takes the form of any suitable electroscopic toner mixed with a suitable granular carrier. Typical compositions for this mixture and for toners per se are more fully described in U.S. Patents 2,618,551 to Walkup, 2,618,552 to Wise, 2,638,416 to Walkup and Wise, 2,788,288 to Rheinfrank, 2,753,308 to Landrigan, 2,891,011 and 3,079,342 to Insalaco, and Re. 25,135 to Carlson. The size and color of the toner particles depend upon the purpose intended as, for example, the size of xerographic toner in U.S. Patent 3,079,342 is about 1 to about 30 microns. These toners usually consists of an electroscopic resin and a colorant, such as, any suitable organic or inorganic pigment or dye. The carrier granules, on the other hand, generally range from 250 to 650 microns.

Mounted within the developer housing is a bucket-type conveyor **38** used to carry the developer material to the upper portion of the developer housing from where the developer material is cascaded over a chute **39** onto the drum. As the developer material cascades over the drum, toner particles of the developer material adhere electrostatically to the previously formed electrostatic latent image area on the drum to form a visible xerographic powder image. Heretofore, toner particles consumed during development were replenished by a gravity drop toner dispenser positioned adjacent the conveyor on the side remote from the xerographic drum.

In accordance with the present invention, toner particles are replenished to developer material **36** automatically in proportion to the amount consumed by toner dispenser **10.** Toner dispenser **10** comprises a cylindrical roller **40** mounted on a shaft **42** journaled in housing **33** above chute **39.** Shaft **42** is connected to a motor **43** for rotating the roller in the direction indicated by the arrow. Cylindrical roller **40** extends parallel to chute **39** and is coextensive with drum **12** as well as the buckets of conveyor **38.** As shown in the figure the roller is formed of an inner core **45** made of conductive material and an outer cover **47** made of material having triboelectric characteristics similar to the carrier granules mentioned above for a purpose to be described.

Spanning cylindrical roller **40** in abutting relationship therewith is a hopper **50** for containing a supply of toner particles **52** to replenish toner particles depleted from developer material **36.** Hopper **50** has a lid cover **54** at the top portion through which toner particles can be supplied. At the bottom is an elongated opening through which cylindrical roller **40** is received along its longitudinal extent. Rotary seals **55, 57** are journaled at the bottom of the hopper ends to provide a suitable mating surface for the hopper with cylindrical roller **40** as it is rotated on its shaft.

As cylindrical roller **40** rotates a small amount of toner material is removed from hopper **50** due to the attraction of the toner to the triboelectric properties exhibited by cover **47** of the roller. It will now be appreciated that as the developer material **36** moves past the toner laden roller, denuded carrier granules will attract toner **52** in proportion to the amount of toner depleted therefrom.

It is believed that the transfer of toner particles **52** from cylindrical roller **40** to carrier granules in developer material **36** will continue until such time as the electrostatic attraction of the carrier granules equals that of cover **47.** At this time the developer material **36** has reached its toner saturation level.

In order to permit regulation of the toner saturation level and hence selective development of images, a variable DC potential source **70** is connected to core **45** of cylindrical roller **40.** Thus if lighter or darker images are required, potential source **70,** which has a polarity opposite to the toner, is raised or lowered, respectively, to vary the electrostatic attraction of toner **52** to cover **47** of the roller. It has been found that voltages ranging from about 3000 to 6000 volts are effective with cover thicknesses ranging from about .001" to about .007". Optimum voltage will depend upon such factors as the particular thickness of cover **47** and the relative speed at which the developer material passes the roller.

By the invention described above, it is possible to maintain a developer mixture toned to an optimum degree continuously and automatically. Undertoning is prevented by virtue of the carrier's ability to remove toner from the dispenser in proportion to toner used which, in effect, results in each carrier granule being a self-regulating toner recipient. Conversely the overtoning of the developer

mixture is prevented by regulating the bias potential on the dispenser roller thereby effecting the ease by which toner particles may be transferred to the denuded carrier granules. Moreover, selective toner dispensing is achieved across the development zone which has not been possible heretofore. Toner dispensing of this nature has the ability to respond virtually instantaneously to changes in toner concentration caused by varying degrees of development. Thus with the present invention an improved copying system is achieved simply and cheaply to produce higher quality prints.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the drawing and specification shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In an apparatus for developing latent electrostatic images with developer material comprising finely divided electroscopic toner particles and relatively larger carrier granules triboelectrically removed from the toner particles, an improved apparatus for dispensing toner particles comprising

guide means arranged to direct developer material including carrier granules at least partially covered by electroscopic toner particles for movement toward a development zone,

roller means mounted for rotation on an axis extending transverse to the path of movement of the developer material and closely spaced thereto,

said roller means including a core portion and a cover portion, said cover portion having essentially the same triboelectric property as said carrier granules, and

hopper means positioned adjacent said roller means enclosing a supply of toner particles to be dispensed, said hopper means terminating in an elongated opening overlying said cover portion to its longitudinal extent whereby upon rotation of said roller means a predetermined portion of enclosed toner particles is transported into close proximity with the developer material path for electrostatic deposition on individual carrier granules in an amount inversely proportional to the coverage of toner particles thereon.

2. Apparatus according to claim 1 wherein said core portion is electrically conductive and is coupled to a DC source of potential of a polarity opposite to the triboelectric polarity of said toner particles.

3. Apparatus according to claim 2 wherein said source of potential has a variable output to control the flow of toner particles from said roller means to said carrier granules.

4. An electrostatic copying machine of the type wherein a photoconductive member sensitive to electromagnetic radiation is moved in a predetermined path along which

processing stations are disposed the combination comprising

a charging station for providing a substantially uniform electrostatic charge upon the surface of the photoconductive member,

an exposure station for exposing the charged surface to an electromagnetic radiation image to form a latent electrostatic image thereon,

a development station for developing the latent image, said development station comprising

guide means arranged to direct two-component developer material including carrier granules at least partially covered by finely divided electroscopic toner particles triboelectrically removed from the carrier granules for movement toward a development zone,

roller means mounted for rotation on an axis extending transverse to the path of movement of the developer material and closely spaced thereto,

said roller means including a core portion and a cover portion, said cover portion having essentially the same triboelectric property as said carrier granules, and

hopper means positioned adjacent said roller means enclosing a supply of toner particles to be dispensed, said hopper means terminating in an elongated opening overlying said cover portion to its longitudinal extent whereby upon rotation of said roller means a predetermined portion of enclosed toner particles is transported into close proximity with the developer material path for electrostatic deposition on individual carrier granules in an amount inversely proportional to the coverage of toner particles thereon.

5. Apparatus according to claim 4 wherein said core portion is electrically conductive and is coupled to a DC source potential of a polarity opposite to the triboelectric polarity of said toner particles.

6. Apparatus according to claim 5 wherein said source of potential has a variable output to control the flow of toner particles from said roller means to said carrier granules.

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