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Weiler

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[54] **DEVELOPMENT METHOD WITH OSCILLATING BRUSH PAD**

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[73] Assignee: **Xerox Corporation,** Rochester, N.Y.

[22] Filed: **Sept. 15, 1971**

[21] Appl. No.: **180,594**

Related U.S. Application Data

[62] Division of Ser. No. 838,952, June 30, 1969, Pat. No. 3,670,701.

[52] **U.S. Cl.** ..... **117/17.5,** 96/1 R, 355/3, 355/17

[51] **Int. Cl.** **G03g 13/08,** G03g 15/08

[58] **Field of Search** ..... 117/17.5; 96/1 R, 96/1 A, 1.4; 118/637; 355/3, 15, 17

[56] **References Cited**

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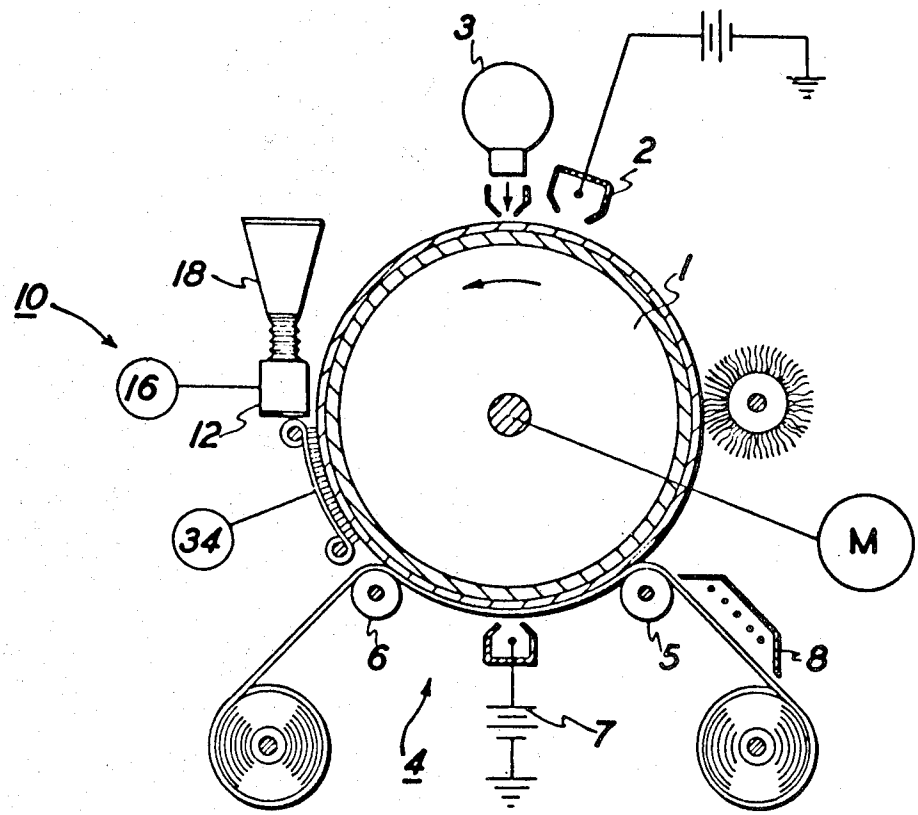
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[57] **ABSTRACT**

A method for developing a latent electrostatic image with electroscopic material wherein development is effected by utilizing a biased toner cloud generator for conveying developer to the image bearing surface and an oscillating brush pad mounted adjacent to and conforming to the shape of the surface to enhance the development of the image. A cloud of toner is generated by oscillating a container supporting developer to release charged toner therefrom and the cloud thereupon contacts the image bearing surface. By then oscillating the brush pad on the surface, toner affixed to the non-image background areas is redistributed to the image to produce a high quality developed image.

3 Claims, 5 Drawing Figures



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SHEET 1 OF 2

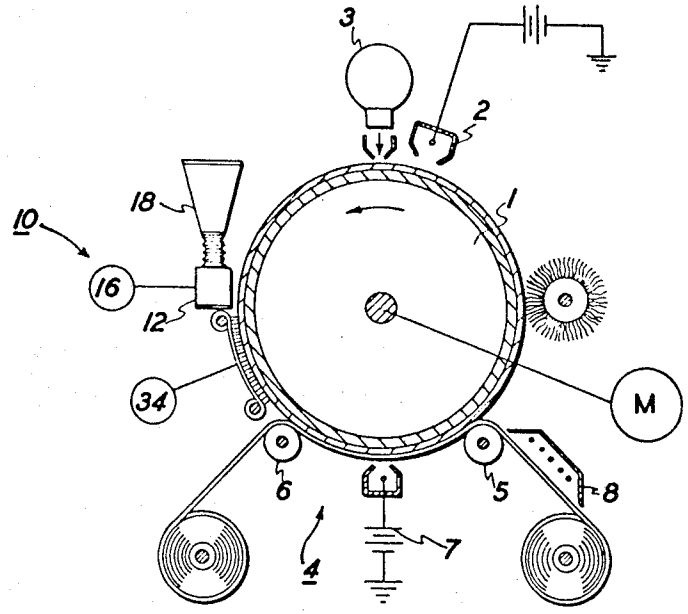


FIG. 1

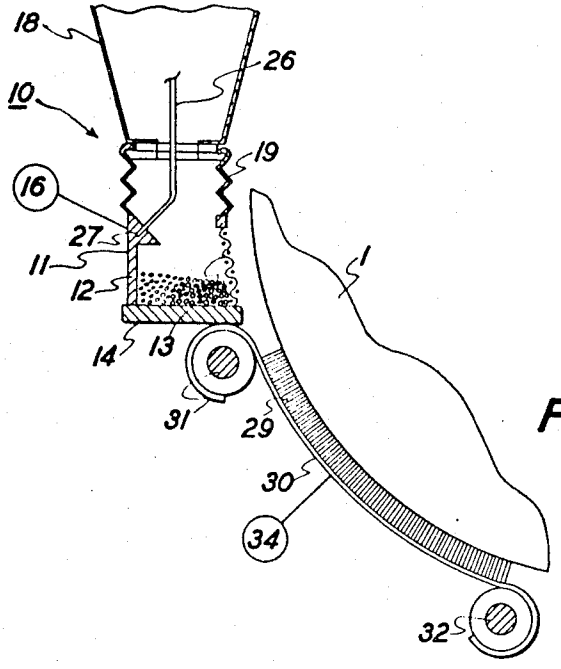


FIG. 2

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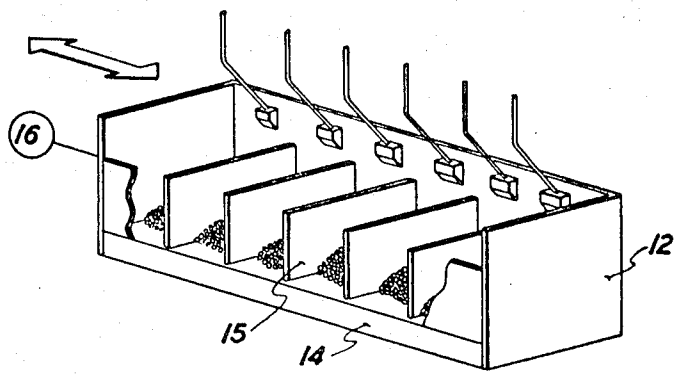


FIG. 3

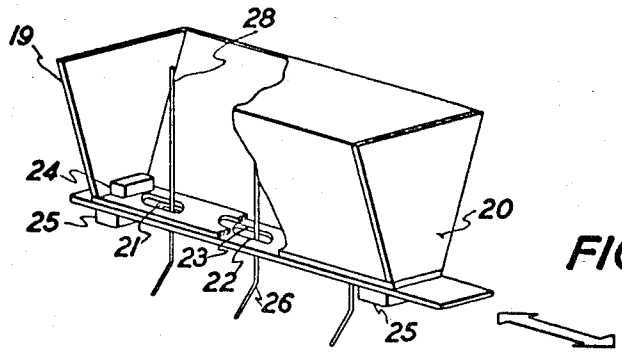


FIG. 4

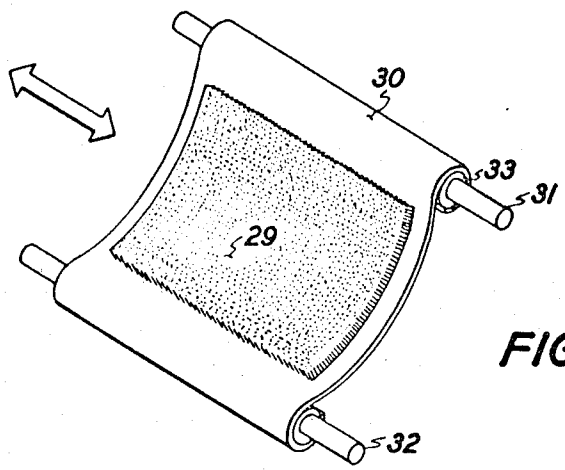


FIG. 5

DEVELOPMENT METHOD WITH OSCILLATING BRUSH PAD

This is a division, of application Ser. No. 838,952, filed 6,30,69, now U.S. Pat. No. 3,670,701.

This invention relates in general to developing a latent electrostatic image and in particular to an improved powder cloud development device.

More specifically this invention relates to a powder cloud development device wherein a biased toner cloud generator conveys a cloud of charged toner onto the surface bearing a latent electrostatic image whereupon a partial development of the image is effected including toner affixed to non-image or background areas. The cloud of charged toner utilized in this invention bonds to the non-image area as well as the image areas due to the residual electrical charge of the non-image areas. By orbiting a brush member against the developed surface, the surface is swept to pick up developer affixed to the background areas and redistributed to the image areas producing a high quality developed image.

In the process of xerography, the xerographic plate comprising a layer of photoconductive material on a conductive backing is given a uniform electric charge on its surface and then is exposed to the subject matter to be reproduced by various projection techniques. This exposure discharges the plate in accordance with the light intensity reaching it thereby creating a latent electrostatic image on or in the plate. Development of the image is effected by developers which may comprise, in general, a mixture of suitable, pigmented or dyed, resin base powder, hereinafter referred to as toner, which is brought into contact with the plate by various well-known development techniques. During such development of the image, the toner powder is brought into surface contact with the photoconductive coating and is held there electrostatically in a pattern corresponding to the latent electrostatic image. Thereafter, the developed xerographic image may be transferred to a support material to which it may be fixed by any suitable means such as heat fusing.

An example of one of the aforementioned techniques for developing the latent image is disclosed in Walkup, U.S. Pat. No. 2,618,551 wherein the toner carried by carrier particles is rolled or cascaded over the latent electrostatic image bearing surface. The carrier particles in such a system are much larger than the individual toner particles and are selected to be of a material that will form a triboelectric bond between the carrier and the toner. In such a relationship the carrier and toner will acquire an opposite electrostatic charge resulting in the toner being charged to a polarity opposite to that of the latent charged image. In practice, each carrier has numerous toner particles attracted thereon allowing them to be transported into contact with the photoconductor whereat the greater electrostatic attraction of the latent image will overcome the triboelectric attraction between the two developer components causing toner to be stripped off the carrier and electrostatically bonded to the charged image to effect development thereof. Such a technique is known in the art as cascade development.

Several difficulties are associated with the cascade development process. For example, in developing large image areas the electric field of the image is stronger at the edges than the central portion. Therefore, the

lines of force (electric field density) at the edges are sufficient to attract toner from the carrier, but in the central portion of the image the toner is not attracted since the field is not strong enough to overcome the triboelectric attraction between the two components of the developer. Such a phenomenon results in an incomplete development in the central portions of the image while the edges are sufficiently developed.

Cascade development also requires a thorough inter-mixing of developer after repeated development of an image. If inter-mixing does not occur, a defect in development appearing as image striations results because of localized carrier material becoming depleted of toner powder. Normally, toner depletion occurs in the cascade development when carrier and toner materials move past the image in one direction across the photoconductor. Since images normally have varying size latent image areas to be developed along the direction of flow, repeated development causes the developer flow moving past the more massive image areas to be depleted of toner in a greater amount than the less massive image areas. Elaborate systems of inter-mixing of the developer, therefore, are required to overcome this toner depletion difficulty.

Further, since the developer is tumbled over the image bearing surface with a substantial impact force in the cascade development technique, it is difficult to achieve even toning of the developed image. The harshness of the impact causes developer already adhering to the electrostatic image to be jarred and moved by the developer being cascaded, thereby producing uneven layers of bonded toner.

In order to overcome the difficulties presented by the cascade method, a technique of developing an image, referred to as powder cloud development, has been given much attention in the prior art. An example of the powder cloud technique is disclosed in the Carlson, U.S. Pat. No. 2,928,575 wherein a powder cloud is created in a generator by air pressure and a charge is placed on the toner by contacting the cloud on the wall of the generator. The charged toner cloud thereupon moves to the vicinity of the charged image to effect the development thereof. Accordingly, the powder cloud method alleviates some of the difficulties in large image area development because the electrostatic field of the image does not have to compete with the triboelectric attraction between the toner and the carrier, as in the cascade system, which allows the toner to more readily affix to the weaker electrostatic attraction of the center portion of the image.

However, other problems are associated with the use of the prior art powder cloud development devices, and an important one of these is the ease at which the charged toner will affix to the non-image or residual charge areas of the photoreceptor. This results in development of what is known as "background areas" and, therefore, while the prior art powder cloud devices achieve more complete development of solid image areas, this method at the same time produces the disadvantages of developing unwanted background areas. In an attempt to prevent development of non-image areas, the prior art employs the use of a development electrode in a powder cloud device to increase the electric field of the image area in order to attempt to insure that the increased strength of the image field would more readily receive toner to the exclusion of the background areas. However, the use of develop-

ment electrodes does not completely alleviate the development of background areas and it remains desirable to overcome the background toner deposition problem presented by existing powder cloud techniques.

Another attempt to solve the aforementioned background development problem has been to create a powder cloud flowing past the image at a sufficient velocity to prevent the toner from being attracted by the weak electric field of the background area while allowing the greater field of the image areas to deflect and attract the toner. It was believed that such a high velocity of toner flow would prevent background development and at the same time insure adequate toner adherence to the charged latent image. The achievement of high velocity toner flow, however, has been difficult to obtain as well as making prior art devices more expensive and complex. Further, the generation of high velocity toner cloud conditions in prior art devices has caused directional effects which appear as streaks in the developed image, since the toner passes the photoconductive surface in only one direction. In order to obtain better quality xerographic development it is necessary to provide a powder cloud device which does not streak the images as in the prior art.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to improve the method and apparatus for development of a latent electrostatic image.

Another object of this invention is to develop a latent electrostatic image and remove developing material in non-image areas.

A further object of this invention is to prevent directional streaking defects in developing latent electrostatic images.

Still another object of this invention is to improve development of a latent electrostatic image by utilizing an apparatus and method to achieve better toning of the developed image.

A still further object of this invention is to improve the dispensing of developer material to a development device.

These and other objects are obtained in accordance with the present invention wherein there is provided a development method and apparatus that effects a combined development of a latent electrostatic image and removal of background. A cloud of charged toner is generated through a screen from a powder cloud generating chamber and is attracted by the electrostatic field of the charged image to the photoconductor drum with both the charged image being developed as well as the non-image or residual charge areas of the surface. The initial development of the charges in image configuration is then swept by a brush member to effect a final high quality development of the image. The sweeping action of the brush removes toner adhering to the weaker electrostatic attraction of non-image background and reapplies it to the partially developed electrostatic image.

This novel development technique of the present invention results in a developed image of high quality wherein solid images are effectively developed and streaking of the image caused by high velocity conditions as encountered, for example, in powder cloud development devices is eliminated. Further, the method and apparatus of the present invention effectively removes toner from background areas to insure that only image areas are developed thereby producing a better quality copy than hereinbefore possible. Also, it has been found that the finishing step of utilizing a sweeping brush results in the development of the image with better toning than other prior art development devices since the toner does not come into contact with the image area surface by an impact as, for example, in cascade development. Therefore, the present invention presents a novel method and apparatus which overcomes several problems normally associated with prior art development techniques.

DESCRIPTION OF THE DRAWINGS

Further objects of the invention together with additional features contributing thereto and advantages accruing therefrom will be apparent from the following description of one embodiment of the invention when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic illustration of a xerographic device utilizing the development device of the present invention.

FIG. 2 is a frontal perspective illustration of the development device of the present invention.

FIG. 3 is an enlarged perspective illustration of the toner dispenser utilized in the development device of the present invention.

FIG. 4 is an enlarged perspective illustration of the toner cloud generator utilized in the development device of the present invention, and

FIG. 5 is an enlarged perspective illustration of the oscillating pad utilized in the development device of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown a schematic view of a drum type automatic xerographic reproducing machine utilizing the present invention. The central element of the apparatus is a drum 1 mounted for rotation and driveable in a conventional direction by a motor M. The drum 1 comprises an outer surface with a layer of photoconductive insulating material such as vitreous selenium or other suitable surface. A uniform electrostatic charge is placed on the photoconductive surface of the drum by means of a conventional corona charge device 2. The uniformly charged surface on the drum is then moved to an exposure means 3 which may be any well known device which will expose the charged surface of the copy to be reproduced to thereby form a latent electrostatic image of the copy on the photoconductor drum surface in a manner well known in the art.

Following the formation of the latent electrostatic image of the copy to be reproduced, the image on the drum will move to a development device 10 according to the present invention (to be hereinafter described in detail) to bring the charged image into contact with developer material, comprising charged toner, to develop the latent image. After development, the visable image moves to a transfer means 4 and is transferred from the drum to a web of paper or other suitable support medium which is positioned in contact with the drum by rollers 5 and 6. A second corona charging device 7 applies a charge to the side of the web opposite the image to facilitate transfer of the toner powder in image form.

The toner image on the web moves past the heating element 8 which permanently affixes the toner to the paper web to form a duplicate of the original copy. A cleaning device contacts the photoreceptor surface after it moves past the transfer device to remove any residual image material on the surface prior to the subsequent reproduction cycle. It should be clear that other modes of charging, exposing, transfer, and fusing may be utilized in connection with the present invention.

Referring now to FIG. 2, there is illustrated an embodiment of the development device 10 according to the present invention. The development device 10 is positioned adjacent the photoconductive drum 1 to bring developer material into contact with the charged electrostatic image lying thereon and includes a toner cloud generator 11 suitably mounted adjacent the drum to supply a sufficient amount of properly charged toner to the electrostatic image. The generator 11 comprises a rectangular open box 12 wherein the side of the box facing the photoreceptor surface is a fine mesh screen 13 which allows toner to pass from the generator to the drum surface. The base 14 of the box supports a series of compartments 15 retaining carrier and toner materials and the particular number of compartments utilized depends on various parameters such as the oscillation rate and amplitude of the box, carrier size and so forth. The box is connected to a motor 16 by a suitable crank linkage (not shown), which acts to oscillate the box in a direction parallel to the axis of rotation of the drum to agitate the material contained within the compartments. Each compartment, during oscillation, causes the developer materials to bounce on the compartment walls releasing the toner as a cloud of charged material. A further charge can be placed on the toner by placing a bias on the walls of the compartments by connecting them to a suitable electrical bias potential.

Therefore, the oscillation of the powder cloud generator box creates a cloud of charged toner which is caused to pass through the fine mesh screen 13 by the attraction of the electrostatic field emanating from the latent image on the photoconductor drum. The form of the compartments 15 as shown in FIG. 3 wherein each of the compartments is positioned at the bottom of the generator box as illustrated. A toner dispenser 18 is positioned above the powder cloud generator to supply toner to the carrier particles retained in the compartments of the generator. A rubber membrane 19 connects the bias cloud generator to the toner dispenser to prevent the toner cloud from escaping from the generator except through the wire mesh screen 13. The rubber membrane 19 also allows the generator to be oscillated relative to the toner dispenser since the toner dispenser is suitably mounted in a stationary position with respect to the generator.

Referring to FIG. 4, the structure of the toner dispenser 18 is more clearly illustrated. The dispenser is in a form of a trough 20 in a V-shaped form and includes at the bottom a series of oblong perforations 21 which allow toner to flow from the dispenser trough. Control of the amount of toner flowing into the toner cloud generator is effected by means of a slide 22 having identical perforations 23 as the perforations 21 in the bottom of the dispenser trough. The slide is retained against the bottom of the V-shaped trough of the dispenser by means of two iron bars 24 located at each end of the bottom of the trough and two magnets 25 suitably mounted beneath the slide to create a magnetic field which tends to hold the slide 22 against the bottom of the toner dispenser. Since the slide protrudes past the slide of the dispenser, it is possible to move the slide along the bottom of the trough. It can be seen that if the oblong perforations of the slide are correspondingly situated relative to the oblong perforations of the bottom of the trough, a maximum amount of toner flow will occur through the corresponding holes. To control a lesser flow of toner from the trough, the slide may be moved to vary the flow area from the trough by the interference of the two oblong perforations of the slide and the bottom of the trough respectively. Therefore, the amount of toner flowing from the dispenser may be controlled from a no flow to a maximum flow condition depending on the relative position of the oblong perforations of the slide with respect to the perforations in the trough bottom.

Flow of toner from the toner dispenser is effected by means of flexible wires 26 which are mounted at one end 27 near the top of the bias cloud generator box 12 and secured thereto. The wires 26 extend through the perforations in the slide and the bottom of the trough and are secured at the other end 28 at the top of the toner dispenser. When oscillation of the toner cloud generator occurs to create a cloud of toner, the movement of the wires with the generator box causes movement of the wires within the toner dispenser which causes a flow of the toner through the oblong perforations of the slide and the bottom of the dispenser.

As previously discussed, charged toner powder cloud generated by the toner generator is attracted to the photoconductor drum by the electrostatic force emanating from the image thereon. However, the charged toner not only attaches itself to the charged image areas, but also is deposited on the background areas of the drum which have a residual charge remaining after exposure. In order to produce the development of the image according to the present invention, a brush as, for example, rabbit fur fixed to a pad 30 is curved to conform to the curvature of the drum and positioned to place the brush in contact therewith. Therefore, after the charged toner has developed the image, the drum moves past the pad 30 supporting the rabbit fur brush 29. The brush is mounted on two support rods 31 and 32 that extend parallel to the axis of rotation of the drum. The pad 30 is secured to four non-conductive bearings which surround the two support rods 31 and 32. The bearings 33 are illustrated as, for example, nylon blocks but other suitable bearings may be utilized.

Referring now to FIG. 5, the pad 30 is oscillated by a motor 34 through suitable linkage so that the bearings ride on the two support rods 31 and 32 and the pad 30 moves in an oscillatory manner parallel to the axis of rotation of the drum thereby causing the bristles of the brush means to have a swirling action in contact with the photoconductive surface. The swirling action of the bristles of the brush against the surface removes toner which has been attached to the background or non-image areas by the toner cloud development and carries the toner to the image areas where the toner is attracted off the fur brush by the greater electrostatic charge in the image areas. Therefore, it should be clear that the fur brush acts to remove toner from the background areas of the image in an efficient manner and

redistributes it to the charged image areas to produce a finished development of the latent electrostatic image. The brush may be connected to a suitable bias potential (not shown) to more effectively pick up toner in non-image areas.

In the above description there has been disclosed an improved device and method for effectively developing a latent electrostatic image supported on a xerographic photoconductive surface. The surface to be developed was described for convenience of illustration as being that of a xerographic drum, but the invention may be used to develop other well-known photoconductive members in the form of plates, belts, webs, or coated papers. It is further within the scope of the present invention to use a particular shape of the support brush and pad which conforms to the particular shape of the surface being developed. Also, it should be clear that the swirling action of the fur brush can be effected by other motions other than an oscillating one as herein disclosed, as for example, by orbiting the fur brush, oscillating the brush in a different direction, and the like. Likewise, other forms of motion of the container for creating the powder cloud in the bias powder cloud generator may be utilized as would be apparent to a person skilled in the art.

While the invention has been described with reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalence may be substituted for elements thereof without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its essential teachings.

What is claimed is:

1. A method of developing a moving support surface bearing a latent electrostatic charge pattern selectively retained thereon in image configuration and residual electrostatic charges in non-image configuration comprising the steps of:

contacting the moving support surface with electrically charged electroscopic toner particles to attract said particles to the latent electrostatic charges in image and non-image configuration to effect development thereof, and thereafter contacting the support surface with a brush pad which conforms to the shape of the surface; and

brushing the electroscopic toner particles with an oscillating movement in a direction generally transverse to the movement of the surface to redistribute the toner particles attracted in non-image configurations to the electrostatic charge pattern in image configuration.

2. The method as recited in claim **1** wherein said support surface is on a rotating drum and the oscillating brushing movement is in a direction generally parallel to the axis of the drum.

3. The method as recited in claim **1** wherein a powder cloud of toner particles is generated for contacting the support surface therewith.

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