United States Patent

Hudson

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[54] **APPARATUS FOR CONTROLLING DEVELOPER CHARGE LEVEL**

[72] Inventor: **Frederick W. Hudson,** West Henrietta, N.Y.

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

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[52] **U.S. Cl.** **118/637,** 117/17.5

[51] **Int. Cl.** **G03g 13/00**

[58] **Field of Search** 118/636, 637; 117/17.5

[56] **References Cited**

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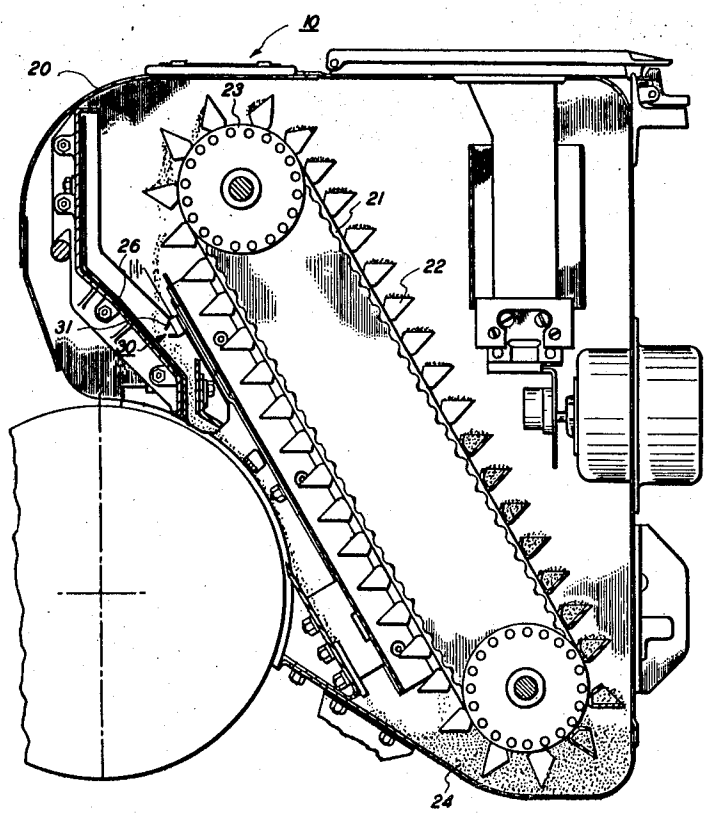
Primary Examiner—Mervin Stein
Assistant Examiner—Leo Millstein
Attorney—James J. Ralabate, Donald F. Daley and Robert Mulcahy

[57] **ABSTRACT**

A method and apparatus for controlling the charge on circulating developer material in a development device. A corona discharge device sprays a corona charge onto the developer material to selectively control the charge on the carrier particles during development for enhanced development results.

9 Claims, 4 Drawing Figures



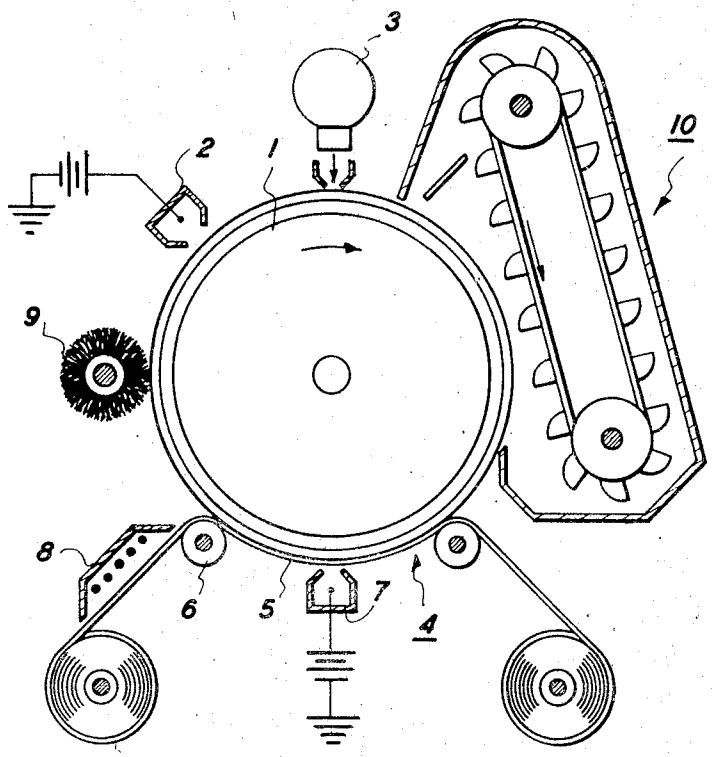


FIG. 1

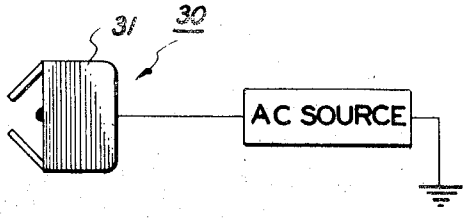


FIG. 3

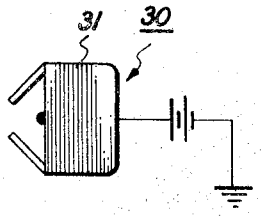


FIG. 4

INVENTOR.
FREDERICK W. HUDSON
BY Donald F. Daley
ATTORNEY

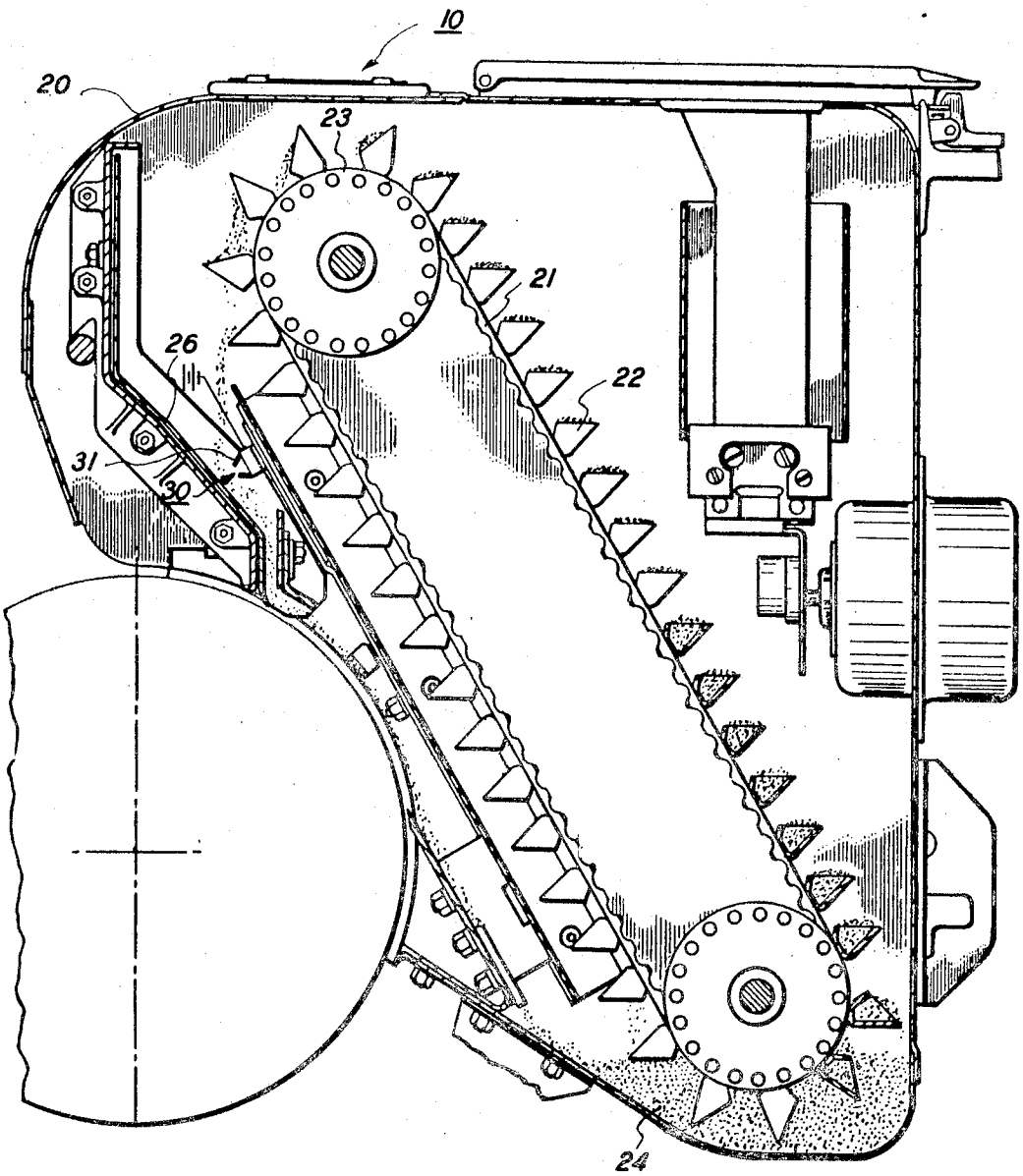


FIG. 2

APPARATUS FOR CONTROLLING DEVELOPER CHARGE LEVEL

BACKGROUND OF THE INVENTION

This invention relates in general to developing a latent electrostatic image and, in particular, to a method and apparatus for controlling the charge on developer materials as they move past a photosensitive surface supporting a latent electrostatic image to be developed.

More specifically, this invention relates to a development apparatus wherein a method and apparatus are provided to apply a charge to the carrier particles in the development mixture as they become depleted of toner during development. Such an application controls the level of charge on the carrier particles in the mixture resulting in enhanced development.

In the process of xerography, a xerographic plate comprising a layer of photoconductive material and a conductive backing is given a uniform electric charge on its surface and then is exposed to 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 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 negative

Various development devices have been utilized in xerography to develop a latent electrostatic image formed on a photosensitive surface. One well-known technique of development is disclosed in U.S. Pat. No. 2,573,881 to Walkup et al. wherein toner carried by carrier particles is rolled or cascaded over the latent electrostatic image-bearing surface. The carrier and toner materials are selected so that a triboelectric attraction exists between them causing the two particles to cling together and acquire an opposite charge. In practice each carrier has numerous toner particles attracted thereon allowing them to be transferred into contact with the photoconductive surface wherein 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.

Optimumly, the carrier particles carry a selected number of toner particles which will efficiently transfer to a latent image lying on the surface to be developed. However, as the developer mixture is utilized for extended periods of time, the toner supported by each carrier particle becomes depleted to result in an electrostatic charge buildup on the carrier particles as the opposite charged toner is stripped therefrom. Such a buildup of charge on the carrier material results in a decrease in the quality of the development of the latent electrostatic image, because the carrier particle generally carries a charge of the same polarity as the image and thus the increase of the level of the charge on the carrier tends to suppress the field of the image in a manner detrimental to desired development.

Further, the charge buildup upon the carrier material increases the attraction of the toner thereon to produce a reduced efficiency in transferring toner to the image and the carrier actually may also attract already transferred toner. This reduced efficiency results in poor leading image edge development as well as other defects. Therefore, because of the greater attraction of the carrier to the toner after depletion thereof and because of the reduction of the strength of the field of the image due to charge buildup on the carrier, undesired development suppression occurs. Also, it has been

found that the buildup of charge on the carrier particle, as toner is depleted therefrom, effects a tendency by the carrier to stick or "bead" to the image-bearing surface. The effect of the beading of the carriers produces a masking of the image which prevents toner from contacting the image surface to achieve desired development. Additionally, an increased charge on the carrier beads causes the particle to be readily attracted to the walls of the developer circulating means which can result in blockage of the developer flow to decrease the amount of toner available for development of an image.

In the prior art it has become necessary to utilize elaborate tonerizing devices to insure that the carrier brings an optimum amount of toner to the image areas to prevent a charge buildup on the carrier material. This technique in the prior art to overcome the aforementioned buildup of charge on the carrier beads by providing means to tonerize the carrier as it is depleted has proven to be a complex method of overcoming the charge buildup problem. Further, the addition of toner to the circulating developer often overtonerizes the mixture by adding an excess amount of toner to the carrier to reduce the attraction therebetween and produce a ready adherence of toner to nonimage or background areas of the surface. Therefore, it is desirable in xerography to provide an apparatus to effectively control the charge on carrier particles to economically remove a maximum quantity of toner from the development mixture without the loss of development quality. Further, it is advantageous in xerographic development to provide a simple and convenient method and apparatus for selectively controlling the charge existing on the carrier particles within the developer mixture for the achievement of enhanced development of a latent electrostatic image.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to develop a latent electrostatic image with an improved apparatus.

Another object of this invention is to eliminate the charge buildup on carrier particles within a developer mixture due to the depletion of toner therefrom.

A further object of this invention is to eliminate sticking of the carrier particles to the image-bearing surface during development.

Still another object of this invention is to selectively control the charge on carrier particles to produce desired development results.

These and other objects are attained in accordance with the present invention wherein there is provided an effective development device which overcomes the charge buildup problem presented by the prior art development systems. The invention comprises a development device wherein there is included a device to spray a charge of desired polarity upon the development material to reduce the charge buildup on the carrier beads therein as toner is depleted from the mixture during development. As previously described, the carrier particles conveying the toner to the image to be developed become depleted of toner after repeated development. As the charged toner is removed from the carrier, the carrier bead itself tends to build up charge which interfers and suppresses development of the image. The utilization of a charge-spraying device of the present invention controls the charge on the carrier in a manner to obtain optimum development results in a system such as, for example, a cascade system. Therefore, as the developer is circulated for development, the charge control means of the present invention sprays an electrostatic charge of a desired polarity upon the developer of the circulating mixture.

In one embodiment according to the present invention, a charge of opposite polarity than the charge on the carrier is sprayed thereon to reduce it to a desired level and maintain a selected bead charge throughout development even as it is significantly depleted of toner. In still another embodiment of the invention disclosed herein, the charge buildup on the carrier may be increased by a predetermined manner by applying a

charge of the same polarity as the carrier potential wherein the bead itself acts similar to a development electrode to prevent deposition of toner to the background areas of the surface and produce improved solid area development because of the realignment of the electrostatic lines of force emanating from the image. Therefore, the method and apparatus disclosed herein results in a control of the charge conditions on the developer in a manner not heretofore possible.

The development method according to the present invention will produce a constant density of development throughout an extended circulation of development mixture even as it becomes depleted of toner without producing the problems presented by prior art techniques. Further, if so desired, the method and apparatus places a charge on the carrier of a level to effect prevention of deposition of toner to background areas and increase solid image development. Accordingly, a control of the electrostatic condition of the development mixture is achieved in a manner not heretofore possible to accomplish improved development of an image.

DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a schematic illustration of a drum-type xerographic machine utilizing the development device of the present invention;

FIG. 2 is a schematic illustration of a development apparatus utilizing an embodiment of charge control device of the present invention.

FIG. 3 is a schematic illustration of another embodiment of the charge control device of the present invention.

FIG. 4 is a schematic illustration of still another embodiment of the charge control device of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, there is shown a schematic view of a drum-type xerographic machine utilizing the development device of the present invention. The central element of the machine is a drum 1 mounted for rotation by suitable means and drivable in a clockwise direction by 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 electric charge is placed on the photoconductive surface of the drum by means of a conventional corona charging device 2. The uniformly charged surface is then moved to an exposure means 3 which may be any well-known device which will expose the charged surface to copy to be reproduced and form a latent electrostatic image of the copy on the photoconductive surface.

Following the formation of a latent electrostatic image of the copy, the image on the drum will move to the development device 10 according to the present invention (to be described in detail later) to bring the latent electrostatic image in contact with developing material comprising carrier particles and electroscopic toner for development thereof. After development the visible image moves to a transfer means 4 and is transferred from the drum to a web 5 of paper or the like which is positioned in contact with the drum by rollers 6. The second corona-charging device 7 applies a charge to the back of the web to facilitate transfer of the toner powder is image form. The toner image on the web then moves past the heating element 8 which permanently affixes the toner to the paper web to form a duplicate of the original copy. A rotating brush 9 contacts the drum surface after it moves past the transfer device to remove any residual image material on the surface prior to the subsequent reproduction cycle. It is 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 developing apparatus according to the present invention. A housing 20 is mounted adjacent the xerographic drum 1 to be developed and includes a suitable conveying mechanism 21 comprising a conveying belt having buckets 22 thereon and mounted on rollers 23 driven by a suitable motor (not shown). The bottom 24 of the housing forms a sump to support carrier and toner material which is circulated in the development apparatus. The conveyor belt having buckets thereon is moved in a counterclockwise direction to carry the development material from the sump to the top of the housing whereupon by gravity the developer material drops from the individual buckets on the conveying belt into a developer chute 26. The developer material is guided by the chute onto the surface of the photoconductive drum 1 whereupon the flow cascades thereon to develop the latent electrostatic image by the stripping of toner from the carrier beads to the image. After the development material passes the image-bearing drum, the mixture drops into the sump 24 for recirculation in the development device. For greater details regarding the conveying and circulation of the developer mixture in the present invention, reference is made to U.S. Pat. No. 3,303,817 disclosing a similar developer-circulating system in a cascade apparatus.

Although not intended to be so limited, the development device is herein described with reference to the development of a positive charged latent image on the drum surface. Therefore, as the triboelectric developer material moves past the image, the negative charged toner is attracted to the latent image for development thereof. Since negatively charged toner is removed from the carrier beads, a positive charge is built up upon the carrier particle as it becomes depleted of toner.

Accordingly, a charge control device 30 comprising, for example, a conventional corona discharge device, is mounted adjacent the developer chute to control the charge buildup upon the carrier particles as they are depleted of toner. Such control is accomplished by applying a charge on the carrier beads by a charge-spraying means. Any suitable charge spraying means is utilized in the present invention such as a conventional corotron 31. In the embodiment illustrated in FIG. 2, corotron 31 is connected to a suitable negative DC potential to apply a negative charge to the positively charged carrier. The magnitude of the electrical potential applied to the corotron is selected to produce a desired charge level upon the carrier as, for example, the level that the carrier possesses when carrying an optimum amount of toner. Also, other potential magnitudes may be selected to effect the elimination or reduction to zero of the charge upon the carrier. It should be apparent from the foregoing that in the development of a negatively charged latent electrostatic image, the polarities may be opposite than as described in reference to this embodiment. In such a case, charge applying device 30 of FIG. 2 would apply a polarity opposite to that existing on the carrier beads to achieve the aforementioned development control. Therefore, through the utilization of the charge-applying device 30 according to the present invention, an electrostatic charge is sprayed upon the developer material to produce selective control of the charge condition existing on development material even after repeated development. With such control of the developer mixture, it is then possible to select and maintain a constant charge upon the carrier particles throughout an extended development interval or select and maintain any variable levels which achieve desired development results under a variety of encountered conditions. Further, by reducing the charge on the carrier, adherence of the carrier to the wall of the circulation means is minimized to prevent blockage of the developer flow being circulated in the development device.

Referring to FIG. 3 there is illustrated a second embodiment of the charge control device 30 of the present invention. The charge control device of FIG. 3 is positioned and operable identically as in the embodiment disclosed in reference to

FIG. 2, except, that the corona-charging device 31 is connected to an AC potential. In FIG. 3 corotron 31 is coupled to an alternating potential of a selected magnitude to result in charge of both polarities being sprayed on the developer material. Such an application of an AC charge results in a lower net carrier bead charge wherein the amount of the reduction on the bead depends on the magnitude of the AC source applied and any magnitude may be selected depending on encountered conditions. If desired, an AC potential may be coupled to the corotron 31 which achieves a zero net charge on the carrier to produce ready development of solid areas and the like.

Referring to FIG. 4, there is illustrated another embodiment of the charge control device 30 according to the present invention. The charge control device of this embodiment is mounted in the development device 10 in an identical manner as previously described in reference to FIG. 2. However, the embodiment of FIG. 4 includes a conventional corona charge device 31 which is connected to a suitable positive potential when the development device is developing a positively charged image. By applying a positive potential to the corotron, the developer material is sprayed with a charge of the same polarity as existing on the carrier bead to thereby create a greater charge thereon. Such a result is desirable to utilize the carrier itself as a development electrode whereby the bead is charged to a level approximately equal to the background potential on the drum surface. In such a case, the field produced by the background areas of the surface will be substantially cancelled out to prevent deposition of toner thereon and the lines of force emanating from the center or solid portions of the image areas are realigned to achieve greater solid area development than heretofore possible with two component developer material without a biased development electrode adjacent the image. Therefore, the charge control device of this embodiment can produce a development electrode effect without or in conjunction with a biased electrode member. Any selected magnitude of the potential may be applied to the corotron of this embodiment depending on the desired development results. It should be apparent that the charge control device of this embodiment would be connected to a negative potential if a negatively charged image is being developed.

In the above description there has been disclosed an improved apparatus for effectively developing a latent electrostatic image supported on a xerographic photosensitive surface. The invention effectively controls the charge level on a carrier bead without disturbing its triboelectric charge relation with the toner carried thereon. 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 photosensitive members in the form of plates, belts, webs, or coated papers. Further, it is within the scope of the present invention to utilize the charge spraying means in any development device which utilizes a circulating developer material other than the cascade system as herein described. Further, the charge applying means illustrated in reference to FIG. 2 and 4 may be other than a corotron and may be any other device capable of applying a charge of a desired polarity and magnitude to developer mixture. Also, it should be apparent from the foregoing that the position of the charge control device illustrated in FIGS. 2 and 4 may be other than adjacent the chute as disclosed and may be positioned in any other location along the circulating path of the developer material in the development device. Similarly, the invention herein disclosed is illustrated utilizing one charge control device, but it is within the scope of the present invention to utilize a polarity of charge-applying means along the path of the circulating developer material depending on the desired development results and the desired degree of control of the charge on the developer material.

While the invention has been described in reference to a preferred embodiment, it will be understood by those skilled in the art that various changes may be made and equivalents 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.

I claim:

1. Apparatus for developing a surface bearing a latent electrostatic image comprising

sump means for supporting a developer for developing said surface including electroscopic toner particles and carrier particles having triboelectrically generated charge of opposite polarity attracting the toner and carrier particles together,

circulating means operatively connected to the sump means for movement of the developer past the latent image bearing surface for development of the surface with toner particles stripped from the developer by the latent electrostatic image and

charge control means for spraying said developer with electrostatic corona charge while the developer is not moving past the latent image bearing surface including an electrical potential source coupled to the control means to spray charge of a desired polarity onto carrier particles to change the triboelectrically generated potential on the carrier particles.

2. The apparatus of claim 1 wherein said charge control means sprays an electrostatic charge having an opposite polarity than the electrostatic charge possessed by the carrier material.

3. The apparatus of Claim 1 wherein said charge control means sprays an electrostatic charge having the same polarity as the electrostatic charge possessed by the carrier.

4. The apparatus of Claim 1 wherein said charge control means sprays an electrostatic charge of both polarities on the carrier material.

5. The apparatus of Claim 1 wherein said charge control means is a corotron.

6. The apparatus of claim 5 wherein said corotron is coupled to a negatve electrical potential.

7. The apparatus of claim 5 wherein said corotron is coupled to an electrical positive potential.

8. The apparatus of Claim 5 wherein said corotron is coupled to an alternating electrical potential.

9. The apparatus of Claim 1 wherein said circulating means includes means to cascade the developer past the image bearing surface.

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