

[54] **DEVELOPMENT APPARATUS**

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[58] Field of Search **117/17.5; 118/637, DIG. 24, 118/638**

[56] **References Cited**

UNITED STATES PATENTS

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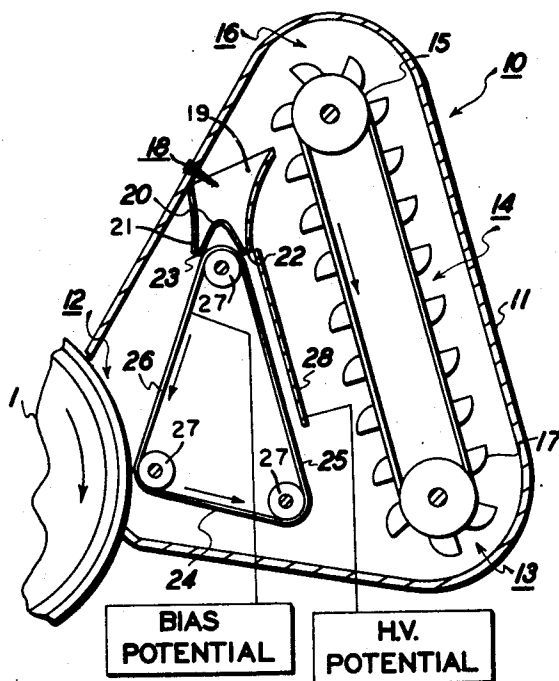
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[57] **ABSTRACT**

An apparatus for developing a surface bearing a latent electrostatic image to be developed wherein developer material is cascaded between the image bearing surface and a movable electrode member. The electrode member carries to the development zone a supply of toner particles on its surface which provides enhanced development results. As the carrier particles in the developer flow become depleted of toner in the development zone, the toner supplied by the endless electrode is attracted to the carrier for retonerization directly in the development zone. Also, the impact of the carrier upon the electrode releases toner from the electrode to effect enhanced development results with a relatively low flow of developer material.

11 Claims, 3 Drawing Figures



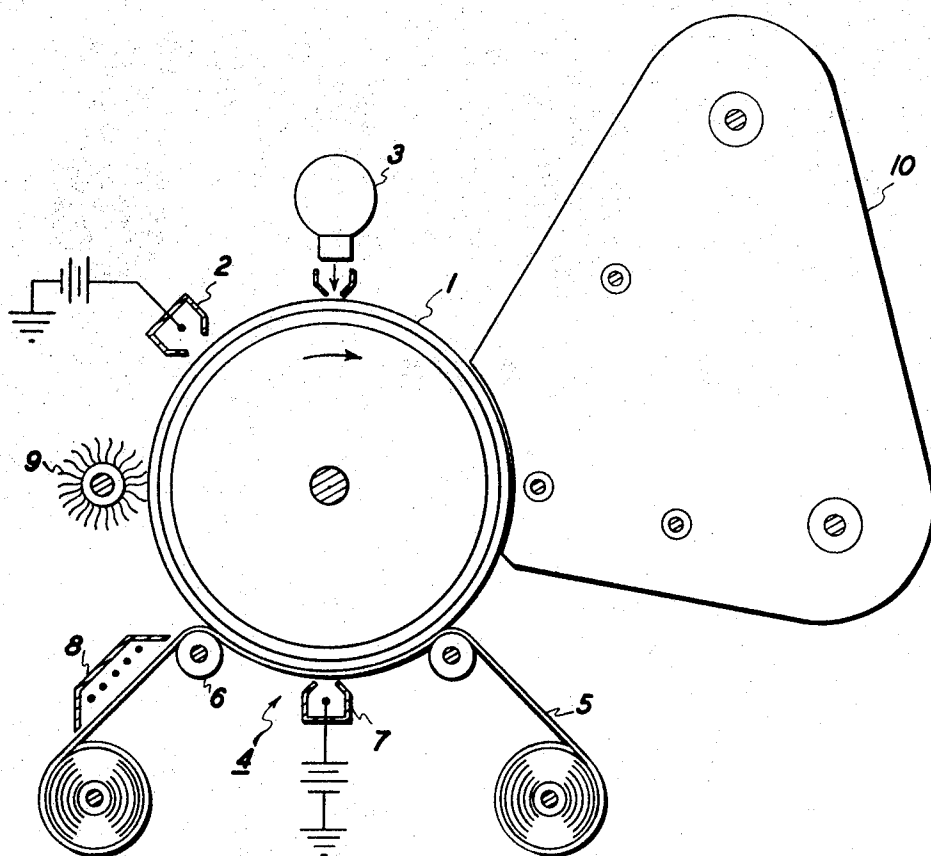


FIG. 1

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FIG. 2

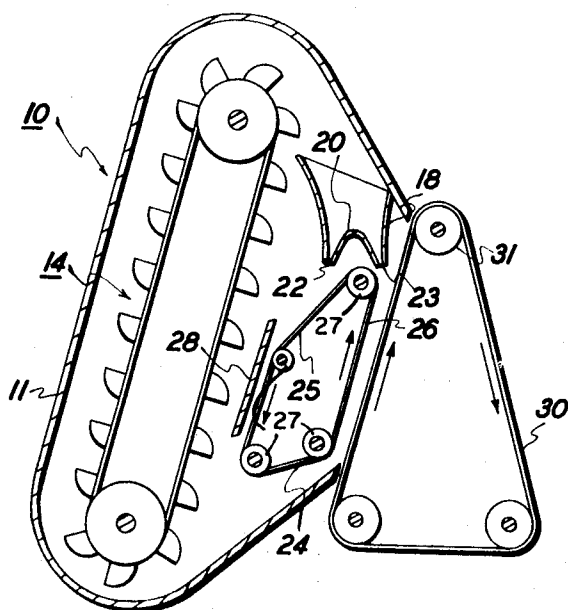
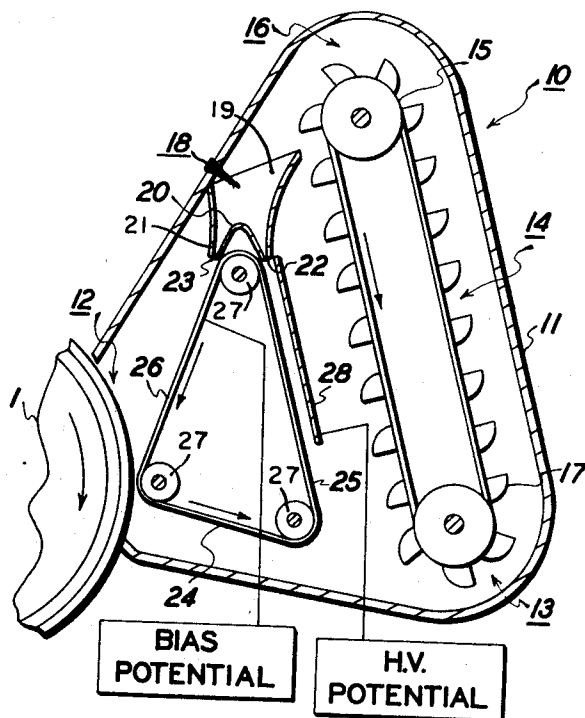


FIG. 3

DEVELOPMENT APPARATUS

BACKGROUND OF THE INVENTION

This invention relates in general to developing a latent electrostatic image and, in particular, to an apparatus for adding excess toner material directly in the development zone.

More specifically, this invention relates to a development apparatus wherein an endless electrode presents a layer of adhering toner to a cascading flow of developer material while it passes an image bearing surface to be developed. As the flowing carrier particles become depleted of toner during development, the endless electrode retonerizes the carrier beads directly in the development zone. Moreover, the inherent impact of the cascading carrier material dislodges free toner from the electrode surface to be attracted by the electrostatic field of the image for enhanced development thereof.

Although not intended to be so limited, for convenience of illustration the development apparatus of the present invention is described in reference to the process of xerography. In xerography, a 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 developer 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 is brought into surface contact with a photoconductive coating and is held there electrostatically in a pattern corresponding to the latent electrostatic image. Thereafter, the developed image may be transferred to a support material to which it may be fixed by any suitable means, such as, heat fusing.

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 particles 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 where 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. Another well known technique of development, referred to as magnetic brush development, is disclosed in the U. S. Pat. No. 3,176,652 to Mott et al., wherein a moving magnetic member strokes developer material comprising a ferro-magnetic carrier and toner into contact with the image bearing surface for development.

Although the aforementioned prior art techniques of development produce satisfactory results, several difficulties are inherent in their use. Cascade development, for example, presents a problem in developing large image areas, since the electrostatic field of the image is stronger at the edges than in the central portion. Therefore, the lines of force at the edges of the image are sufficient to attract toner from the carrier, but in the central portions 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 will result in incomplete development of the central portion of an image while the edges are comparatively better developed.

A solution to the above described solid area development problem presented by some prior art techniques of develop-

ment has been by the use of a development electrode to increase and realign the lines of force emanating from the central portion of an electrostatic image area. The development electrode is positioned adjacent the image surface and is coupled to a selected electrical potential to produce the desired realignment of the lines of force from the image. Therefore, by utilizing such an electrode, toner is more readily attracted to the central portions of the image to create better solid area development and further the field of the electrode aids in suppressing toner depositions in nonimage or background areas of the image bearing surface.

It has been found that the use of a conventional development electrode in development systems such as cascade, magnetic brush, and the like achieves maximum development when the developer flow within the development system is at a maximum level. However, as greater rates of reproduction are achieved in higher speed xerographic machines, it becomes difficult to attain the level of developer flow relative to the image bearing surface necessary for high quality development results. Therefore, it becomes desirable in xerography to provide a development apparatus which achieves the important results of utilizing a development electrode to prevent background deposition of toner and achieve effective solid area development, but which at the same time develops high speed photosensitive surfaces with high quality results.

Further, as developer material passes through the development zone in the prior art development systems, carrier particles become depleted of toner while traversing the image, particularly the developer material passing the more massive image areas in the direction of movement of the developer. Accordingly, the developer flow is not optimally tonerized throughout its travel in the development zone whereby insufficient development of the image can result. Therefore, it becomes advantageous to provide a development system which maintains an optimum amount of toner within a mass of developer material while it contacts an image to be developed.

SUMMARY OF THE INVENTION

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

Another object of this invention is to improve the development of the latent electrostatic image in a development apparatus utilizing a development electrode.

A further object of this invention is to retonerize developer material directly in the development zone.

Still another object of this invention is to present a surface of developer material adjacent a flow of developer material to effect enhanced development of a latent electrostatic image.

A still further object of this invention is to release free toner material from a supply means to both retonerize a flowing supply of developer material and to supply toner to an image to be developed.

These and other objects are attained in accordance with the present invention wherein there is provided a development apparatus that effects enhanced development of a latent electrostatic image with a relatively low flow of developer material. A development electrode mounted for movement adjacent the surface to be developed is provided in the novel apparatus herein described to support a supply of developer material directly in confrontation to the surface to be developed. A flow of developer material comprising carrier and toner particles is introduced into development contact with the latent image between the electrode and the surface to be developed whereupon toner adhering to the electrode supplies toner to the carrier as it is depleted thereof during development. During movement of developer material between the image bearing surface and the electrode of the invention, the developer material deflects off both members and not only picks up toner for retonerization of the carrier as it becomes depleted during development, but the beads further dislodge free toner which is attracted by the electrostatic field of the image for enhanced development thereof. The combined function of the

electrode for releasing free toner for development of the image and retonerizing the carrier particles during development contact of the beads with the image results in high quality development of an image.

The novel development technique of the present invention will produce enhanced development of an image with a relatively low flow of developer material even when the photosensitive surface to be developed moves at high rates of speed. Further, since certain areas of the developer flow normally become stripped of toner during movement past the image bearing surface, the present invention effectively insures that the carrier substantially possesses an optimum supply of toner throughout its course of travel through the development zone. Therefore, the novel apparatus herein disclosed includes the advantages inherent in utilizing a development electrode in a development system for suppressing background deposition of toner and increasing solid area development, but which further effects high quality development of an image with a low flow of developer material even when high speed photosensitive surfaces are being developed.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 2 is a schematic illustration of one embodiment of the development apparatus of the present invention.

FIG. 3 is a schematic illustration of another embodiment of the development apparatus of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown a schematic view of the drum type automatic xerographic reproducing means utilizing the present invention. The central element of the apparatus is a drum 1 mounted for rotation and drivable in a conventional direction by a motor (not shown). The drum 1 comprises an outer surface with a layer of photoconductive insulating material such as vitreous selenium or other suitable surface material. A uniform electrostatic charge is placed on the photoconductive surface of the drum by means of a conventional corona charging device 2. The uniformly charged surface on the drum is then moved to an exposure means 3 which may be any well known device that will expose the charged surface to the copy to be reproduced to thereby form a latent electrostatic image of the copy on the photoconductive drum surface in a manner well known in the art.

Following the formation of a 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 visible image moves to a transfer means 4 and is transferred from the drum to a web 5 of paper or other suitable support medium which is positioned in contact with the drum by rollers 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 web to form a duplicate of the original copy. A cleaning device 9 contacts the photo-receptive surface after it moves past the transfer device to remove any residual image material on the surface prior to a 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 inven-

tion. The development device 10 is mounted by suitable means adjacent the photoconductor drum 1 and includes a housing 11 to bring developer material into contact with the charged electrostatic image lying thereon for development.

The housing 11 includes an open side 12 which confronts the drum 1 to allow developer material within the housing to contact the image bearing surface. A sump 13 is located at the bottom of the housing to support an adequate supply of developer, comprising, for example, carrier particles and electroscopic toner, for circulation therein for development of the image. A conventional developer conveying mechanism 14 is movably mounted on rollers 15 to extend into the sump 13 and carry developer to an elevated position 16 in the housing to allow the transported developer material to drop by gravity to a development and tonerizing position. The conveying mechanism 14 includes a series of buckets 17 which scoop up developer and transport the material to the desired elevated position within the housing. It should be apparent that other conveying mechanisms may be utilized in connection with the present invention such as, for example, magnetic conveyors and the like. The conveying mechanism 14 shown in FIG. 2 is movable in a counterclockwise direction and are drivable by a conventional motor (not shown) coupled to one of the rollers 15.

As the developer material reaches the top position of the housing by means of the conveying mechanism, the individual buckets 17 deposit a load of developer material which then by gravity drops into a feed element 18. The feed element comprises a cup-like member 19 having a two channeled chute member 20 secured at the bottom thereof. The two channeled chute creates and guides two flows of developer therefrom through openings 22 and 23. It is within the scope of the present invention to utilize other flow guiding elements to properly guide the developer to create the aforementioned two flows of developer, if desired. Therefore, it should be apparent that the developer drops by gravity through the feed element 18 and two channeled chute member 20 having two outlets which create two flows of developer material.

An endless belt 24 is mounted directly beneath the two outlets 22 and 23 of the chute to allow the flow of developer therefrom to pass adjacent two separate surfaces 25 and 26 thereof. The belt 24 comprises a conductive material which is coupled to a suitable electrical potential of a magnitude and polarity to function as a development electrode with respect to the image bearing surface. Any selected potential may be utilized in connection with the present invention and it is advantageous to utilize a bias magnitude which suppresses non-image deposition of toner as well as achieves effective solid image area development. Alternatively, the conductive member may be electrically grounded, if desired. The endless belt 24 is mounted in any suitable manner on a series of three rotatably supported rollers 27 to move therewith wherein one of the rollers is coupled to a motor means (not shown) to drive the belt in a desired direction. The belt 24 may be moved either in a clockwise or counterclockwise direction depending on desired development results, but for clarity of illustration the belt is shown to be movable in a counterclockwise direction as shown in FIG. 2.

The flow of developer passing through the opening 22 of chute 20 drops by gravity along the surface 25 of the endless electrode 24. A stationary electrode 28 is stationarily mounted adjacent the movable electrode and is coupled to a high voltage source of electrical potential whereby the developer material emanating from opening 22 passes between the endless electrode 24 and the stationary electrode 28. As the developer material passes therebetween, the electric field created by the high voltage potential coupled to the stationary electrode is selected to strip triboelectrically charged toner from the carrier beads for adherence on the biased movable electrode. Accordingly, the flow of developer from opening 22 supplies toner to the endless electrode so that a layer of toner adheres thereto in an electrostatically charged state. After passing between the endless electrode and the

movable electrode, the developer of the flow returns to the sump to be recirculated in the system. The endless electrode belt 24 thereupon carries the adhering charged toner to a position to confront the image bearing surface of the drum 1.

The other flow of developer material emanating from opening 23 of the chute member 21 flows along surface 26 of the endless electrode and passes between the electrode 24 and the image bearing surface to be developed. Since the electrode carries a layer of charged toner into confrontation with the drum, a supply of toner is available to the carrier particles in the development zone. The polarity of the charge on the toner adhering electrostatically to the electrode is opposite to the triboelectrically charged carrier cascading therebetween. Therefore, as the carrier is stripped of toner by the electrostatic field of the image lying on the drum surface during development, the carrier beads pick up toner from the supply presented by the endless electrode. Such retonerization of the carrier occurs because as the beads cascade along the drum surface, they bounce between the drum surface and the endless electrode and toner is attracted to the carrier from the electrode to maintain an optimum supply of toner on the carrier throughout its path of movement past the image. Thus, in the novel apparatus of the present invention, the carrier particles in the development mixture are highly tonerized throughout their path of movement past the image and enhanced development of the image is effected.

Further, the impact of the carrier beads against the endless electrode dislodges some of the adhering charged toner from the surface thereof to create a cloud of free charged toner to be attracted to the image. The toner released by impact of the carrier beads is then readily attracted by the electrostatic field of the image to further result in very high quality development of an image. Therefore, it should be apparent that the novel development apparatus of the present invention achieves enhanced development over prior art development systems. Not only is the carrier of the developer optimally tonerized throughout its path of travel in the development zone, a cloud-like release of toner from the electrode is also effected adjacent the image to be readily attracted thereto for superior development results. Further, improved development is achieved in the present invention with a relatively low flow of developer material in contact with the image bearing surface even when high speed surfaces are being developed.

Referring now to FIG. 3 there is illustrated another embodiment of the development device 10 of the present invention. A belt 30 having a photosensitive surface is mounted on suitable rollers 31 and drivable in a clockwise direction by a motor (not shown). A latent electrostatic image is created on the belt in the manner described in reference to FIG. 1 for a drum type machine. The other stations illustrated in FIG. 1 may also be utilized in conjunction with the belt form of the photoconductor surface in the embodiment of FIG. 3. The development apparatus 10 of the embodiment illustrated in FIG. 3 is essentially identical to the development apparatus described in reference to FIG. 2. However, the endless electrode member 24 in the embodiment of FIG. 3 is mounted on four rollers 27 to create a longer development zone than as shown in FIG. 2. Therefore, the development material passes in confrontation to the image bearing surface adjacent the tonerized electrode 24 for a greater period of time for effective development. The electrode is illustrated as being movable in the direction of the image bearing surface, but may move in the opposite direction, if desired. The other elements of the development apparatus described in reference to FIG. 2 are utilized in the embodiment of FIG. 3 and function in a similar manner to effect enhanced development.

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 surface to be developed was described for convenience of illustration as being that of a xerographic drum or belt, but the invention may be used to develop other well known photosensitive members in the form of plates, webs or

coated papers. It is further within the scope of the present invention to tonerize the endless development electrode of the present invention by other well known tonerizing means such as, powder cloud, donor member, fluidized bed loading, and the like. Further, the surface member for supplying toner in the development zone may encompass other forms other than a belt type conductive electrode herein described such as, for example, plates or cylindrical members. It should also be apparent from the foregoing that the member carrying toner into the development zone need not be limited to a conductive member as disclosed, but may be, for example, a surface having insulative properties adapted to retain an electrostatic charge deposited thereon by a conventional charging device for attraction of toner to the member.

While the invention has been described with reference to preferred embodiments, 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 teaching of the invention without departing from its essential teachings.

What is claimed is:

1. An apparatus for developing a surface bearing a latent electrostatic image to be developed comprising housing means mounted adjacent an image bearing surface to be developed and adapted to support a supply of developer material including carrier particles having electroscopic toner triboelectrically attracted thereto, said housing means including circulating means operatively connected to the supply of developer material to create a flow of at least part of the developer material past the image bearing surface for effecting adherence of toner thereto for development, and supply means mounted adjacent said image bearing surface for allowing the flow of developer material to pass therebetween and supporting a supply of toner particles on a surface thereof in confrontation to the image bearing surface to add toner to the flow of developer material for tonerization thereof and to release free toner for attraction to the image bearing surface for enhanced development.
2. The apparatus of claim 1 wherein said supply means comprises a conductive member and is coupled to a source of electrical potential.
3. An apparatus for developing a surface bearing a latent electrostatic image to be developed comprising housing means mounted adjacent an image bearing surface to be developed and adapted to support a supply of developer material including carrier particles having electroscopic toner triboelectrically attracted thereto, said housing means including circulating means operatively connected to the supply of developer material to create a flow of at least part of the developer material past the image bearing surface for effecting adherence of toner thereto for development, and supply means comprising a conductive member mounted adjacent said image bearing surface for allowing the flow of developer material to pass therebetween and supporting a supply of toner particles on the surface thereof in confrontation to the image bearing surface to add toner to the flow of developer material for tonerization thereof and to release free toner for attraction to the image-bearing surface for enhanced development.
4. The apparatus of claim 3 further comprising means to move the endless surface past the image bearing surface.
5. The apparatus of claim 4 further comprising tonerizing means positioned adjacent said surface to supply toner for adherence thereon for movement into confrontation to the image bearing surface.
6. An apparatus for developing a surface bearing a latent electrostatic image to be developed comprising

housing means mounted adjacent an image bearing surface for supporting a supply of developer material including carrier particles having electroscopic toner triboelectrically attracted thereto,

said housing means including circulating means operatively connected to the supply of developer material to create a flow of at least part of the developer material past the image bearing surface for effecting adherence of toner thereto for development,

surface means positioned adjacent said flow of developer material and adapted to be moved from a first position to a second position in confrontation to the image bearing surface to allow the flow of developer material to pass therebetween,

tonerizing means mounted adjacent said first position to supply a quantity of toner to said surface means for adherence thereon, and

means to move said surface means from said first position to said second position to bring the quantity of toner adhering to said surface means into contact with the flow of

developer material to add toner thereto and to release toner for adherence to the image bearing surface for increased development thereof.

7. The apparatus of claim 6 wherein said surface means comprises a conductive material and is coupled to an electrical potential.

8. The apparatus of claim 6 wherein said circulation means further comprises means to create a second flow of a part of the supply of developer material past said surface means adjacent said first position.

9. The apparatus of claim 8 wherein said tonerizing means comprises an electrode member coupled to an electrical potential to strip a quantity of toner from the second flow of developer material for adherence to said surface means.

10. The apparatus of claim 6 wherein said surface means comprises a member having an endless outer surface.

11. The apparatus of claim 6 wherein said circulating means directs the flow of developer material into respective impact with the image bearing surface and said surface means.

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