# United States Patent [19]

**Ashton et al.**

[11] **3,893,415**

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[54] **DEVELOPING APPARATUS**


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**Related U.S. Application Data**

[63] Continuation of Ser. No. 199,481, Nov. 17, 1971, abandoned.

[52] **U.S. Cl.** ..... **118/637**; 355/3 DD

[51] **Int. Cl.** ..... **G03g 13/06**

[58] **Field of Search** .... 118/636, 637, 638, DIG. 24; 117/17.5; 355/3, 3 DD



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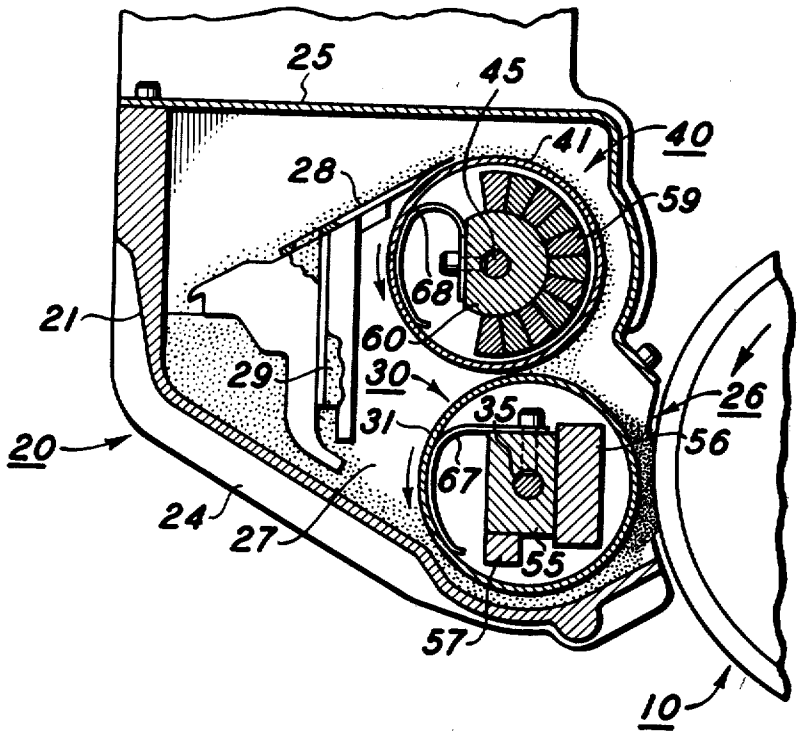
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[57] **ABSTRACT**

An apparatus for improving the developability of a magnetic brush developing system by providing an electrically neutral entrance and exit flow region through which developer material passes as it enters and leaves the development zone. A second mode of operation is also provided for enhancing the system's ability to develop input images of relatively low density.


**17 Claims, 3 Drawing Figures**



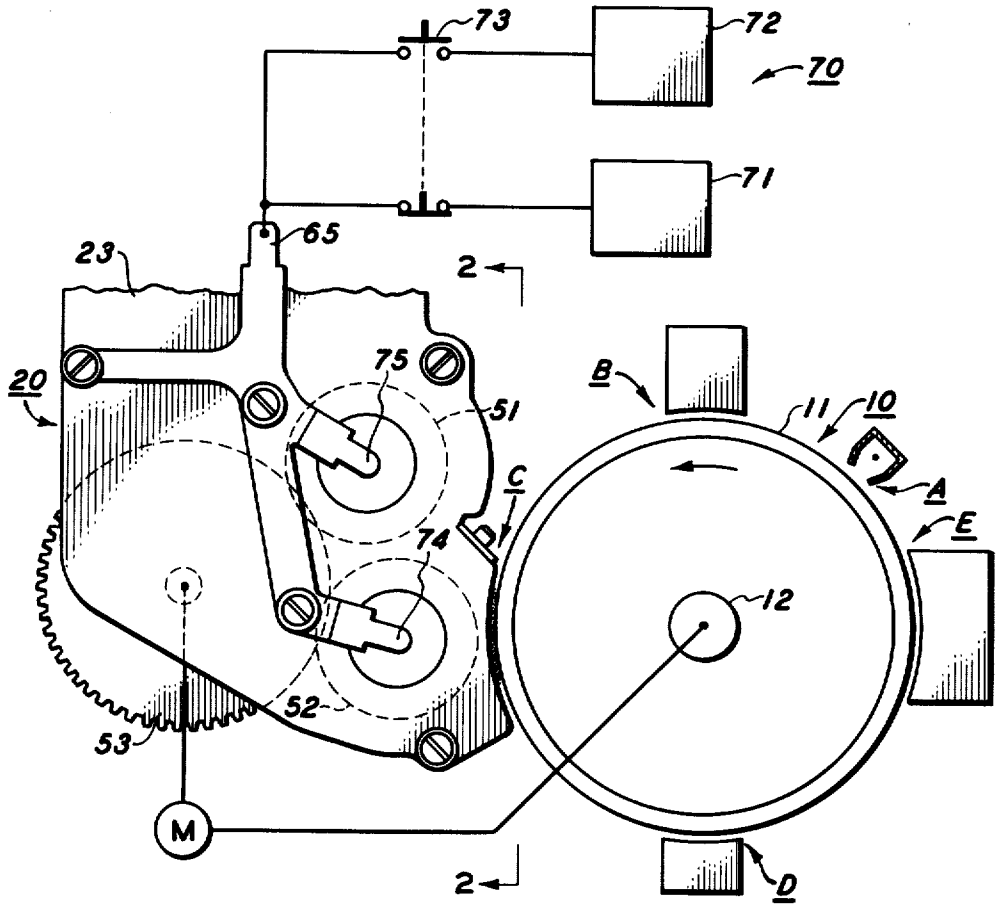



FIG. 1

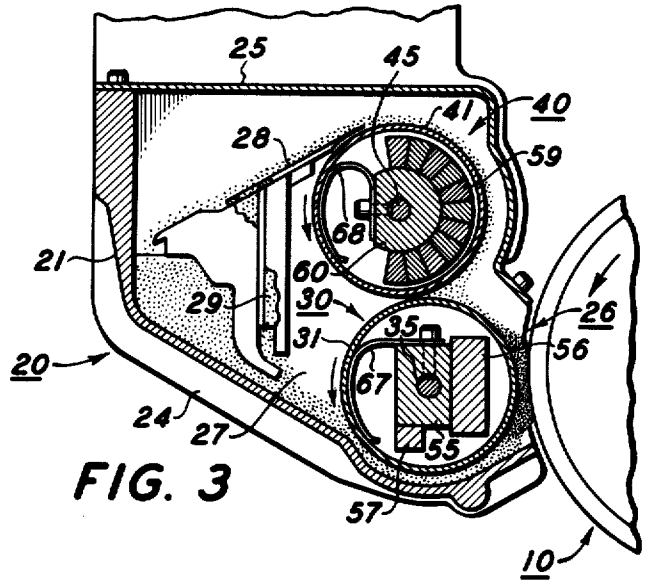



FIG. 3

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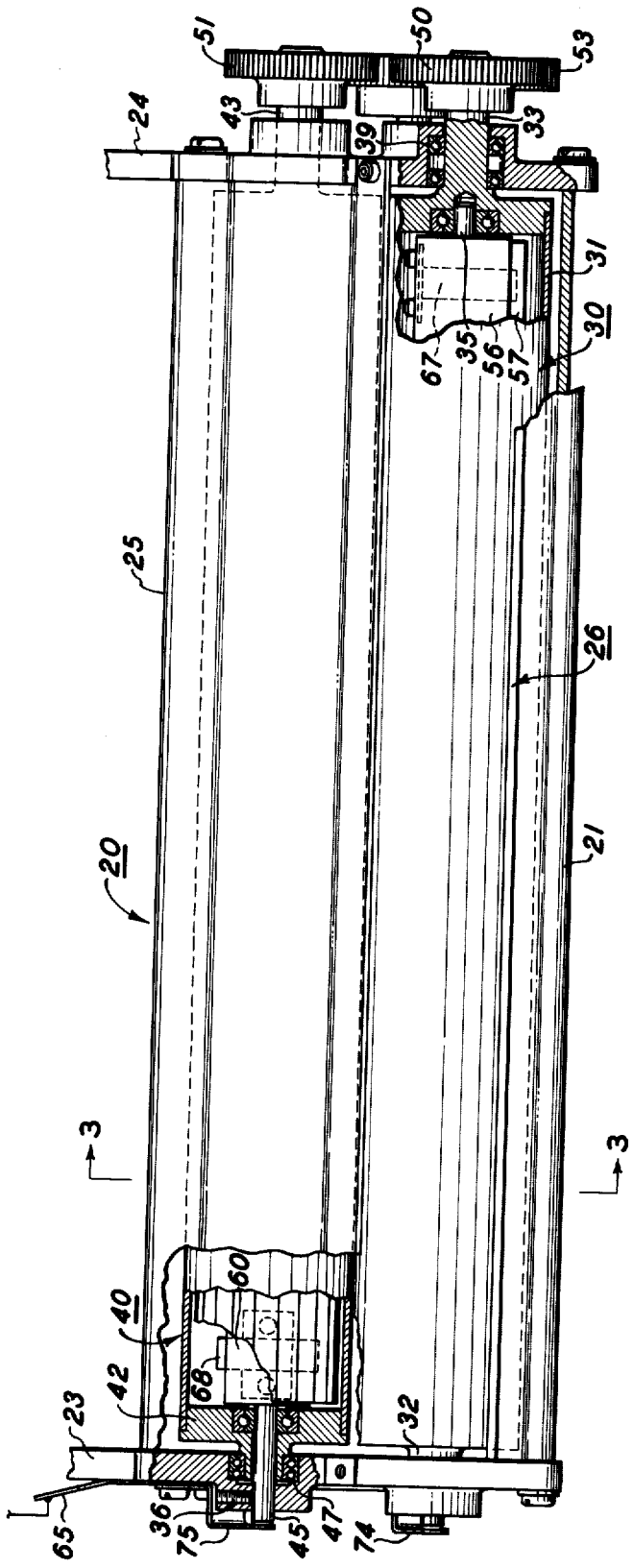

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FIG. 2

# DEVELOPING APPARATUS

This is a continuation of application Ser. No. **199,481,** filed Nov. **17, 1971** now abandoned.

This invention relates to a xerographic developing apparatus and, in particular, to means to enhance the developability of a magnetic brush developing system.

In the art of xerography, as originally disclosed by Carlson in U.S. Pat. No. **2,887,691,** a xerographic plate, generally formed by placing a photoconductive surface upon a conductive backing member, is charged uniformly in the dark and the charge plate surface then exposed to a light image containing original input scene information to be reproduced. Under the influence of the light image, the charged photoreceptor is caused to become conductive in the light struck regions so as to selectively dissipate the charge thereon in accordance with the original light image thus recording the original input scene information in the form of a latent electrostatic image. The latent image can be made visible by any number of known development techniques known and used in the art which generally act to bring oppositely charged toner particles into operative relation with the imaged plate whereby the toner particles are electrically attracted to and held in the charged imaged regions. Generally, the amount of toner encaptured within the imaged regions on the plate surface is proportional to the electrical density of, among other things, the image being developed. Regions of low charge density are generally recorded on the plate as visible images of low toner density while those regions having a greater charge density are recorded as proportionately more dense or darker toner images. In most xerographic processes, the developed input scene information is generally transferred from the photoconductive plate to a sheet of final support material, such as paper or the like, and the toner images affixed thereto to form a more or less permanent record of the original subject matter.

Magnetic brush development, because of its many inherent advantages, has long been a prominent form of image development used in the xerographic art. In this particular developing technique, a brush of developer material being made up of a permeable carrier material having non-permeable toner particles electrically supported thereon is created by bringing the material into the flux field of a permanent magnet or the like. Under the influence of the magnetic force field, the permeable carrier granules are caused to align themselves along the lines of flux to form a brush-like structure. Development of an image bearing plate is then accomplished by sweeping or brushing the fibers across the plate surface whereby the charged toner particles are electrically transferred from the brush to the image plate areas thus making the image visible.

As disclosed by Greig, in U.S. Pat. No. **3,117,884,** the developability of the magnetic brush system may be considerably enhanced by electrically controlling the deposition of toner particles on the plate surface during the developing process. A development electrode, consisting of a conventional developer applicator roll as generally known and used in the art, is placed within the active development zone. An electrical control bias is placed upon the electrode that enchances the system's developability, particularly in its ability to produce good solid area development, and which, simultaneously therewith, serves to inhibit development in the non-imaged or background region on the plate. In most



cases, it is desirous to place the electrode bias potential at some level which is sufficiently high enough to inhibit the deposition of toner particles in the non-imaged or background regions of the plate but sufficiently low enough to allow development of those recorded imaged regions containing original input scene information. Because of the nature of the electrostatic recording process, however, valuable input scene information will oftentimes be recorded on the plate at a potential that is very close to the recorded background potential and, as a consequence, this information is not recovered due to the effect of the electrical control field.

Although the activity of the toner material, as it moves through the development zone, can be electrically regulated by use of a control field, it is further believed that the control field can adversely influence the behavior of the toner within the entrance and exit regions to the development zone. Because of the electrodes interaction with other structure within these regions, electrical force fields are created which tend to electrically agitate the fine toner particles moving into and out of the active zone of development. This, in turn, leads to the deposition of unwanted toner particles on the plate resulting in the production of dirty copy, that is, copy containing a high level of toner in the background regions.

It is therefore an object of the present invention to improve the developability of a xerographic developing apparatus.

Another object of the present invention is to improve the development of a xerographically created image by means of magnetic brush development.

A still further object of the present invention is to prevent the deposition of unwanted spurious toner particles upon the non-imaged regions of a xerographic plate during the developing process.

Yet another object of the present invention is to minimize the agitation of developer material as it enters and leaves the active development zone of a magnetic brush developing system.

A still further object of this invention is to provide a magnetic brush developing system having a low density image developing capability.

These and other objects of the present invention are attained by providing a magnetic brush developing system with an electrically neutral developer entrance and exit region to the active development zone. A continuous development electrode is positioned within the active development zone and the electrode arranged to extend outwardly into the developer entrance and exit regions of the system. A conductive member is positioned adjacent to the extended portions of the electrode in both the exit and entrance regions and cooperates therewith to provide a relatively enclosed flow path for the developer moving into and out of the zone of development. The conductive members and the electrode are all connected to a common adjustable source of power and the elements placed at substantially the same bias potential. Further means are provided to regulate the bias potential placed on the biasable elements so as to enhance the system's ability to develop low density input images.

For a better understanding of the present invention as well as other objects and further features thereof, reference is had to the following detailed description of

the invention to be read in connection with the accompanying drawings, wherein:

FIG. 1 is a schematic illustration of an automatic xerographic reproducing machine employing the developing apparatus of the present invention;

FIG. 2 is a plane view in partial section of the developing apparatus illustrated in FIG. 1 embodying the teachings of the present invention;

FIG. 3 is a sectional view taken along lines 3-3 in FIG. 2.

Referring now to FIG. 1, a xerographic drum 10 is arranged to operatively communicate with a circulating toner-carrying magnetic brush development system. Because the practice of xerography is well-known in the art, the various processing stations for making a xerographic copy from an original are herein represented as blocks A through E. It should be understood, however, that the xerographic drum 10 be provided with a conductive substrate upon which is placed an outer coating of photoconductive material 11. The drum is arranged to move in an endless path about a shaft 12 wherein a uniform charge is initially placed on the photoconductive surface by means of a corona generator or the like within charging station A. The charged surface is then irradiated with a light image composed of original input scene information at exposure station B wherein the uniform charge on the drum is selectively dissipated so as to record original input scene information thereon in the form of a latent electrostatic image. Next subsequent thereto, the image bearing drum surface is passed through a magnetic brush developing system at developing station C which applies toner particles onto the imaged plate areas thereby making the latent electrostatic image visible. Next, in the direction of drum rotation, the toner bearing drum surface is passed through an image transfer station D where a sheet of final support material is brought into contact with the developed image and the image electrically transferred from the plate surface to the support sheet. Finally, at station E, any residual toner particles remaining on the drum surface after the completion of the transfer operation are removed and the photoconductor is placed in a condition to be once again recycled through the xerographic processing station.

Referring now more specifically to FIGS. 2 and 3, electrically isolated magnetic brush developing apparatus 20 of the present invention is contained within a housing 21 and the housing substantially enclosed by means of end walls 23, 24 and a top cover plate 25. Preferably, at least the main housing of the developer unit and the cover plate attached thereto are fabricated of a conductive, non-permeable, material such as aluminum or the like capable of supporting an electrical bias thereon. The cover plate is adapted to cooperate with the main body of the housing to provide an elongated opening 26 in the side wall of the unit which is positioned adjacent to the moving photoconductive drum surface 11. The opening extends longitudinally at least across the entire photoconductive layer carried on the drum surface and provides a means through which a magnetic developing brush, which is formulated within the developer unit, can operatively communicate with the latent electrostatic image carried on the photoconductive surface.

Basically, the developer housing contains (1) a single magnetic brush forming unit, generally designated 30, which is positioned adjacent to the elongated opening 26 and (2) a magnetic developer lifting unit, generally designated 40, which is positioned directly above, and in parallel alignment with, the brush forming unit. As clearly illustrated in FIG. 3, developer material that is stored within the sump region 27 of the housing moves down into the restricted entrance region 19 to the developing zone formed between roller 31 and the complementary bottom surface of housing 20, and is initially picked by the brush forming unit, passed through the active development zone and eventually transferred to the lifting mechanism which transports the material to the top of the unit. Here the developer material is released from the lifting mechanism and deposited upon an inclined chute 28, where, under the influence of gravity, the material is allowed to move down the chute where it ultimately falls into a series of cross mixing baffles 29. The cross mixing baffles are arranged within the developer housing to interrupt and redirect the downward flow of the developer material in order to create sufficient agitation between the toner particles and the carrier beads to triboelectrify the toner particles, and to uniformly redistribute the toner material across the entire width of the housing. Upon leaving the cross mixing baffles, the now properly charged and uniformly distributed developer material is allowed to fall back into the sump 27 where it can be once again used in the development process.

Structurally, both the magnetic brush forming unit 30 and the magnetic developer lifting unit 40 are generally made up of an outer applicator roll member that is arranged to substantially enclose a magnetic flux generating device. The lower magnetic brush forming unit 30 includes a cylindrical sleeve 31 being closed and supported at both ends by means of end caps 31 and 33 while the upper magnetic lifting roll unit is similarly constructed of a cylindrical sleeve 41 being supported upon end caps 42 and 43. The two units are rotatably supported between the end walls 23, 24 of the developing system by means of similar support structure in the manner illustrated in FIG. 2. The right hand end caps 33, 43, respectively, are each journaled for rotation within a bearing 39 supported in right hand end wall 24 while the left hand end caps 32, 42 are each similarly mounted to freely rotate within the left hand end wall 23 the end cap 42 being journaled in a bearing 47. Fixed shafts 35, 45 are rotatably supported within the end caps of each magnetic unit and the shafts locked against rotation by means of a set screw 36. It should be noted that the right hand end caps 33, 43 of the two units extend through the end wall of the housing and have affixed thereto pinion gears 50 and 51, respectively. The pinion gears are arranged to mesh with a single drive gear 53 which serves to drive the upper and lower cylindrical roll unit about their respective stationary shafts in the direction indicated at a predetermined rate.

The lower cylindrical sleeve 31 encompasses a magnetic brush forming unit made up of a non-permeable mounting element 55 rigidly affixed to the stationary support shaft 35. The mounting element carries two direction magnets, a larger brush forming magnet 56 and a smaller pickup magnet 57. The brush forming magnet is positioned on the stationary shaft so that its main flux field is directed at the xerographic drum in a substantially horizontal direction. In practice, the flux field is arranged to pass through the non-permeable sleeve 31 of the brush forming unit, through the opening 26 in

the developer housing, and then into operative communication with the moving photoconductive drum surface. The smaller pickup magnet **57** is secured to the bottom surface of the mounting element with its flux field directed towards the sump region of the developer housing. The poles of the two directional magnets are oppositely arranged in regard to the rotating sleeve **31.** The pickup magnet **57** is arranged so as to draw developer material from the sump **27** and hold the material against the rotating surface of the sleeve whereby the material is brought into the developing zone. The brush forming magnet on the other hand is adapted to erect the developer material delivered into the developing zone away from the sleeve surface and direct it towards the xerographic plate where it can be used to accomplish image development.

The magnetic developer lifting unit **40** also has a series of small magnetic poles **59** arranged within the sleeve **41.** The poles are supported in a semi-circular manner upon a conductive support bracket **60** which is affixed to the stationary support shaft **45.** Each adjacent pole in the series is oppositely aligned in relation to the pole next to it whereby a series of relatively strong magnetic links are provided extending from approximately a **6** o'clock sleeve position to about an **11** o'clock sleeve position. Because of the pole arrangement, a magnetic network is formed about the outer periphery of the rotating non-permeable sleeve member that is capable of securely holding developer material against the sleeve in a manner that enables the sleeve to carry the material upwardly to the top of the developer housing. The flux fields associated with both the magnetic brush forming unit and the magnetic developer lifting unit are coupled together within the regions separating the two units so that the developer material being moved out of the developing zone by sleeve **31** is magnetically transferred to the lifting unit sleeve **41** without the need to resorting to bulky mechanical handling devices and the like.

In operation, cylindrical sleeve **31,** associated with the magnetic brush forming unit **30,** is driven sequentially through the developer sump and the active development zone. In the sump region, the developer material is attracted into contact with the rotating sleeve surface by means of the pickup magnet provided. The material is then carried on the surface of the rotating body into the main flux field of the brush forming magnet wherein the developer particles are caused to align themselves along the main lines of flux to form a brush-like structure. Because of the magnet arrangement, the brush fibers extend outwardly through the developer housing into operative communication with the rotating photoconductive drum surface. As the xerographic drum rotates in the direction indicated the brush fibers are caused to be drawn over the photoreceptor as it is moved through the development zone. As a consequence, toner particles are electrically transferred from the brush fibers to the imaged regions on the plate by means of the classical magnetic brush developing mechanism thereby rendering the images visible. The developer material continues to move through the active development zone and is brought into the developer exit region in close proximity with the lifting unit sleeve **41.** Here, the developer material moves across the magnetic bridge linking the two units and is secured against sleeve **41** which, in turn, carries it to the top of the developer housing and deposits it upon the incline chute **28.** As previously noted, the chute directs the developer material into the cross mixing baffle where it is subsequently returned to the developer sump region.

As disclosed in the previously noted Greig patent, an electrical force field can be used in conjunction with a magnetic brush forming flux field to enhance the developability of the magnetic brush system. Conventionally, the electrode is generally placed within the active development zone in close proximity to the xerographic plate surface and an electrical bias having a potential somewhere close to the background potential recorded on the plate surface is applied thereto. Background is a term of art used to define those regions on the photoconductive plate which, although carrying a weak potential, nevertheless contain no input scene information. Although these specific background regions are reduced to a relatively low charge potential during the xerographic exposure process, they can, under certain conditions, attract and hold randomly dispersed toner that are brought in contact therewith. By biasing the development electrode to a potential somewhat greater than the background potential found on the plate surface, an electrical force field is established within the development zone which tends to pull toner away from the plate when a background region is moved therethrough, thereby suppressing background development. When a latent image is brought into the development zone, the image force field becomes the dominant factor in the system and the toner in this region is attracted toward the plate. As pointed out by Schaffert in "Electrophotography", published by the Focal Press, beginning at page **27,** during image development the development electrode also cooperates with the xerographic plate to contour the electrical fields associated with the latent electrostatic image and thus enhance the developability of the system, particularly with regard to the system's ability to develop large solid areas of charge.

Although the development electrode does provide a helpful control device for use in the magnetic brush developing system, it is felt that it also introduces two undesirable results which the present invention is uniquely designed to overcome. First, the electrode is capable of coacting with structure other than the xerographic plate which is positioned in close proximity to the developing zone. As a consequence, relatively strong electrical force fields are created, particularly in those regions where developer is entering and leaving the development zone, which are capable of agitating or disturbing the toner particles in close proximity with the xerographic plate resulting in the production of unwanted background development. Secondly, because the electrode is generally biased at some level above background, valuable input data which is recorded upon the plate at or about the background level is lost and cannot be recovered.

The apparatus of the present invention for overcoming the difficulties found in the prior art includes upper sleeve member **41** and lower sleeve member **31,** as well as the developer housing **21** and its associated cover plate **25,** are all connected to a common source of biasing power in the manner illustrated in FIG. **1.** An adjustable biasing source **70,** made up of a normal power supply **71** and a low input power supply **72,** is electrically connected through means of a switching network **73** to a conductive strip **65** which, in turn, is secured to one side wall of the housing. The strip is terminated at

two points by spring contacts **74** and **75** which are urged into electrical communication with the ends of shafts **35** and **45**, respectively. Electrical energy from the power unit passes through the shaft **35** and is carried to the cylindrical sleeve **31** via support member **55** and sliding contact **67**. Similarly, the energy delivered to shaft **45** is passed to cylindrical sleeve **41** via support member **60** and sliding contact **68**.

As can be seen through means of the electrical network, both the cylindrical roll members **31, 41**, as well as the developer housing **21** and the cover plate **25**, are biased to the same charge potential. As a consequence, the developer material sees an electrically neutral flow zone as it moves from the developer sump region into the active development zone and as it leaves the development zone and is carried upwardly to the top of the developer housing. The toner particles moving through the electrically neutral entrance and exit regions therefore experience little or no electrical agitation and as a result the material tends to flow into and out of the development zone with a minimum amount of free toner being generated thereby reducing the system's ability to produce unwanted background development.

It should be further noted that the present apparatus is also provided with two distinct modes of operation. In the first, or normal, mode of operation, all the biasable elements, i.e. the sleeves **31, 41**, housing **21** and cover plate **25**, are placed at the same bias potential which is somewhat greater than the background charge potential generally recorded on the xerographic drum and preferably below the charge potential at which a preponderance of the original input scene information is recorded thereon. In this manner as explained above, background development is suppressed while image development is enhanced. In the second, or low density input, mode of operation, the bias potential applied to all the biasable elements is reduced below the background potential. This results in some background being developed, however, the low density input images containing original input scene information that are ordinarily lost are now made visible. To accomplish this result, a multiple power supply **70** is herein provided having at least two biasing sources **71, 72** connected to the biasable elements by means of the previously mentioned electrical network and a switching arrangement **73**. When the switch **73** is in the position shown in FIG. **1**, normal biasing source **71** is placed in electrical communication with the biasable members and the system functions in a conventional or normal mode of operation. Depressing the switch takes biasing source **71** off the line and substitutes therefore a second source of biasing power **72** which serves to place the biasable members at a second or lower bias potential which brings out the low density input images.

In the xerographic reproducing device herein disclosed, it is contemplated that the photoreceptor be initially charged to a relatively high potential and that the average input scene information be also recorded on the plate at a relatively high potential. Initially, the photoconductor is charged to a level between **+700** and **+1000** volts. During exposure, the background charge is reduced to a level somewhere between **+100** and **+300** volts. The development electrode is positioned within the active development zone at a distance of between **0.060** and **0.080** inches from the moving photoconductive plate surface. Development of the photoconductor, which is moving at about **3.45** ips., is accomplished by passing developer material through the active development zone at a rate of approximately **15** ips. In the normal mode of operation, the biasable elements are all placed at a bias potential somewhere between **50** and **100** volts above the recorded background potential normally found on the plate. While in the second mode of operation, the bias potential is reduced to a level somewhat below background potential and generally at approximately **100** volts below background potential.

While this invention has been described with reference to the structure disclosed herein, it is not necessarily confined to the details as set forth and this application is intended to cover any modifications or changes that may come within the scope of the following claims.

What is claimed is:

**1.** Apparatus for developing a latent electrostatic image that is recorded upon an image retaining plate including

a magnetic brush forming unit for establishing a brush like structure of developer material which is placed in operative communication with the image retaining plate within a developing zone,

means to move a flow of developer material into the developing zone,

a development electrode positioned within the development zone and being arranged to extend into the region wherein the developer material moves into said developing zone,

a conductive member complementary with the extended portion of the developing electrode and positioned adjacent thereto within the entrance region to the developing zone and being arranged to cooperate with the development electrode to provide a substantially enclosed flow path through which developer material passes as it enters said developing zone, and

means to electrically bias the electrode and the conductive member to substantially the same potential to provide an electrically neutral flow path through which the developer material enters the developing zone.

**2.** The apparatus of claim **1** further including switching means being operatively associated with said electrical biasing means to change the bias level applied to said electrode and to said conductive member.

**3.** The apparatus of claim **2** wherein said switching means is arranged to bias said development electrode and said conductive member to a first potential being greater than the background potential recorded on the plate when said switching means is in a first operative position and to a potential at or below the first potential when in a second operative position.

**4.** The apparatus of claim **1** wherein said development electrode comprises the non-permeable cylindrical roll member substantially enclosing the brush forming unit and being arranged such that the outer surface of the roll passes sequentially through a supply of developing material and the flux field of the brush forming unit.

**5.** In a magnetic brush developing apparatus of the type having a stationary brush forming magnet positioned adjacent to a moving image retaining plate and having means for transporting permeable developer material through the flux field of said magnet to create a brush-like structure of developing material that is in

operative communication with the moving plate within a developing zone, the apparatus further including

a development electrode constructed of a conductive non-permeable material being positioned in the developing zone and extending therefrom into the regions wherein the developing material enters and leaves the developing zone,

a pair of conductive members each of which is positioned adjacent to an extended portion of the development electrode within the entrance and exit regions to the developing zone, being arranged to cooperate with said electrode to provide a flow path through which the developer material moves as it enters and leaves said developing zone, and

biasing means to electrically bias said development electrode and each of the conductive members to substantially the same potential.

**6.** The apparatus of claim **5** further including switching means operatively associated with said biasing means and being arranged to vary the bias potential on said development electrode and on said conductive members.

**7.** The apparatus of claim **6** wherein said switching means is arranged to vary the bias potential between a first potential which is greater than the background potential recorded on the image retaining plate and a second potential which is variable up to said first potential.

**8.** The apparatus of claim **7** wherein said first potential is between **50** and **100** volts above the background potential recorded on the plate.

**9.** The apparatus of claim **5** further including a lifting means positioned adjacent to the exit to said development zone and being adapted to elevate the developing material leaving the developing zone to a height substantially above the development zone.

**10.** The apparatus of claim **9** wherein said lifting means has a magnetic flux generating mechanism associated therewith for magnetically coupling said lifting means to the brush forming means whereby the developer material leaving the developing zone is magnetically transferred to said lifting means.

**11.** The apparatus of claim **10** wherein said lifting means is electrically coupled to said biasing means and placed at a potential substantially the same as the potential on said development electrode and said conductive members.

**12.** In a magnetic brush developing apparatus having a conductive non-permeable roller rotatably supported about a stationary brush forming magnetic structure, the roller being arranged to move a quantity of developer material through the magnetic flux field of the magnetic structure to create a brush like structure of developer material for developing an image retaining plate within a developing zone, the apparatus further including

a lifting mechanism positioned adjacent to the region wherein developer material leaves the developing zone, said lifting mechanism having a magnetic means magnetically coupled to the developing apparatus whereby developer material leaving the developing zone is transferred to said lifting mechanism and transported to an elevation substantially above the developing zone,

a pair of conductive members, one of said members positioned adjacent to the conductive non-permeable roller at the entrance to the development zone and said other member being positioned adjacent to the lifting means at the exit to said development zone whereby the developer entrance and exit regions to the developing zone are substantially enclosed,

biasing means to electrically bias said conductive members, the conductive non-permeable roller and the lifting mechanism to substantially the same potential.

**13.** The apparatus of claim **12** further including switching means operatively associated with said biasing means and being arranged to vary the bias potential applied to the bias members.

**14.** The apparatus of claim **12** wherein said switching means is arranged to vary the bias potential between a first potential which is greater than the background potential recorded on the image retaining plate and a second potential which is variable up to said first potential.

**15.** The apparatus of claim **14** wherein said first potential is between **50** and **100** volts above the background potential recorded on the plate.

**16.** In a magnetic brush developing apparatus having a development electrode in a development zone and means to bias the electrode to a predetermined potential, the improvement wherein said apparatus further includes: means for providing an electrically neutral flow path through which developer material enters and leaves the development zone; conductive members arranged to cooperate with the development electrode to provide substantially enclosed flow paths through which the developer material passes as it enters and leaves the developing zone, and means to bias the conductive members to substantially the same polarity and potential as the development electrode.

**17.** The apparatus of claim **16** further including means to change the bias upon said developing electrode and said conductive members.

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