TONER UNIT FOR PHOTOELECTROSTATIC REPRODUCTION

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References Cited
UNITED STATES PATENTS
3,167,455 1/1965 Laben et al......................118/637

Apparatus for applying toner to an electrostatic image carried by an insulating surface such as the surface of a copy sheet by contacting the surface with a toner mix comprising toner particles and magnetic carrying particles, which apparatus includes a gate disposed in a position adjacent to the moving surface of a magnetic brush unit on which a magnetic brush of toner mix is continuously formed, disrupted and reformed, the gate being adapted for selective movement by a control means so as to govern the advance of toner mix to a toning station where it contacts the image on the copy sheet. A switch is disposed along the path of the copy sheet and adapted to be actuated by the copy sheet and to control the operation of the gate and the operation of the means driving the electrical brush unit. The apparatus prevents toner mix from contaminating the back side of the copy sheet when the leading end thereof is advanced through the toning station.

18 Claims, 6 Drawing Figures
Fig. 2

Fig. 3

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1. Field of the Invention

This invention relates to apparatus for applying toner to an electrostatic image and, more specifically, to apparatus for developing electrostatic images carried on an insulating surface by application of a toner thereto. The term "electrostatic image" is intended to include all electrostatic charge patterns, regardless of their method of formation.

2. Brief Description of the Prior Art

In electrography, electrostatic images are normally formed on an insulating surface and are developed by the application of toner powder thereto. The toned image may be fixed to the insulating surface itself, where it is applied directly to an insulating coating on a copy sheet, or it may be transferred in image configuration to another surface and thereafter fixed to that surface, leaving the insulating surface available for reuse.

Electrostatic images are normally formed on the insulating surface in the following manner. The insulating surface having photoelectrostatic properties is subjected to a corona discharge to impose an electrostatic charge on the photoelectrostatic insulating surface which, as mentioned above, is often in the form of a coating on the copy sheet. The corona discharge is placed on the sheet while the sheet is in darkness. The surface thus charged is then exposed to an optical image in the form of a light pattern to be reproduced. This exposure produces a latent electrostatic image on the insulating surface which is then developed or converted into a visible image by the application of a toner thereto.

It is a well-known commercial practice to utilize triboelectric systems for developing electrostatic images. Such systems involve the mixture of finely divided toner particles with larger magnetic carrier particles whereupon the toner particles are held to the surface of the carrier particles by electrostatic charges. Such electrostatic charges are created by triboelectricization in which friction between different materials leaves the materials with a certain charge, hopefully opposite in sign so that they attract one another. When the toned image is brought into contact with the electrostatic image on the insulating surface, the attraction of the image for the triboelectrically charged toner particles overcomes the attraction of the carrier particles for the toner particles and the toner particles transfer to and remain on the imaged areas.

A number of different systems, including both liquid systems and dry systems, have been employed in the past for applying toner to electrostatic images. Among the dry systems are the cascade system and the magnetic brush system. Cascade systems depend on gravity to move the toner mix over the electrostatic image, and thus, are necessarily speed limiting. In addition, the cascade system requires extensive processing of the toner mix to ensure uniformity of toner concentration therein at least in the portion which is to be cascaded over the imaged surface.

The magnetic brush system involves the formation of a magnetic brush on a moving surface by magnetic attraction of the magnetic particles containing toner particles thereon through an intervening nonmagnetic surface so as to form the magnetic particles on the nonmagnetic surface into a bristlelike formation of particles, referred to as a "magnetic brush." One of the techniques utilized to achieve greater flexibility and control of image density and contrast between imaged and nonimaged areas with magnetic brush systems has been to utilize biasing systems. Thus, an electrical biasing potential in the form of a DC voltage is imposed between the rear surface of the sheet containing the insulating surface, such as the back side of a copy sheet, and the toner mix forming the magnetic brush. Such biasing systems can be utilized in varying ways, depending upon the charge of the toner particles, the charge of the imaged areas, and the technique desired.

In essence, the biasing system comprises the establishment of a unidirectional electric field between the latent electrostatic image carried by the insulating surface and the toner mix comprising the magnetic brush utilized to develop the latent electrostatic image. By varying the strength and direction of the electric field, the contrast of the developed image may be varied, the developed image may be reversed and the spurious deposit of toner particles in the background of the developed image may be controlled. Thus, any desired contrast characteristic over a wide range may be obtained for either the positive or the reverse image. For example, one may simply and quickly adjust the biasing system so that the apparatus produces line prints of high contrast value, continuous tone prints of intermediate contrast value and, in each case, the print may be direct or reverse.

One of the problems involved with electrostatic developing apparatus in the past has been the contamination of the back or nonimaged surface of the copy sheet with toner mix from the magnetic brush. Such toner mix is then carried on the back surface of the copy sheet through the remaining portions of the apparatus, dropping off and generally contaminating the entire apparatus. The result is that copy sheets issuing from the apparatus carry with them a great deal of background material and are generally dirty due to the presence of toner particles and carrier particles. Thus, when the leading end of the copy sheet arrives at the toning station, it is thrust into contact with a magnetic brush carried in a brush unit and generally gathers an accumulation of toner mix on its back surface. The toner mix is gradually spread from the back surface of the leading edge of the sheet over the entire back surface of the sheet during subsequent handling. In addition, when a biasing shoe is employed at the toning station in a position where it contacts the back surface of a sheet being toned, the biasing shoe becomes contaminated with toner mix when the copy sheet is disposed between it and the magnetic brush, as when the toning of one sheet has been completed and the toning of a successive sheet has not yet begun. Of course, this results also in a short in the electrical circuit due to the direct contact of the biasing shoe with the magnetic brush which is conductive.

In accordance with the present invention, these problems are overcome through the use of a gate adapted to move between a position where it allows toner mix to flow to the toning station and a position where it prevents the flow of toner mix to the toning station. The gate is actuated by the copy sheet to be toned so that the operation of the apparatus is automatic.

In the past, magnetic brushes have tended to have somewhat nonuniform cross section along their length. This was evidenced by differences in height and width. The result, however, was that when such magnetic brushes were utilized to develop an electrostatic image, the contrast might vary in portions of the image due to greater contact between the toner mix in the brush and the image is some areas than in others stemming from the nonuniformity.

However, the gate of the apparatus of the present invention reduces or eliminates these nonuniformities by contacting the magnetic brush prior to its arrival at the toning station, whereby the height of the brush is reduced to a uniform height. Thus, the gate serves a doctoring function as well as a flow control function, thereby overcoming some of the problems of the prior apparatus.

Accordingly, it is a chief object and advantage of the present invention to provide a new and improved toner unit for photoelectrostatic reproduction which reduces or eliminates contamination of the photoelectrostatic reproduction equipment by toner mix.

It is a further object and advantage of the present invention to provide a toner unit for photoelectrostatic reproduction which incorporates means for selectively allowing or inhibiting the flow of toner mix toward a toning station.

It is a still further object and advantage of the present invention to provide means for achieving a more uniform magnetic brush in a toner unit for photoelectrostatic reproduction.
SUMMARY OF THE INVENTION

The invention is apparatus for applying toner to an electrostatic image carried by a photosensitive layer coated on a sheet surface by contacting the image with a toner mix comprising toner particles and magnetic or electrically charged particles. The apparatus of the invention includes a magnetic brush unit having a moving surface on which a toner mix is continuously formed, dispersed, and reformed. Toner feeding means are provided for supplying toner mix to the moving surface of the magnetic brush unit. Sheet feed means are provided for moving the copy sheet past the magnetic brush at a toning station where the toner mix contacts the electrostatic image carried thereby. In accordance with the invention, a gate is disposed along a portion of the path of the moving surface between the container and the toning station. The gate is adapted for selective movement between a first position, where it contacts the surface of the magnetic brush unit so as to prevent the advance of toner mix toward the toning station, and a second position, spaced from the moving surface so as to allow the advance of toner mix toward the toning station. Control means are operably connected to the gate for selectively actuating the gate. The control means include an electrical power source, a solenoid operably connected to the gate and an electrical switch connecting the power source to the solenoid. The electrical switch may be disposed along the path of a copy sheet being moved toward the toning station by the sheet feed means and be adapted to be actuated by the copy sheet. Preferably, the apparatus includes drive means operably connected to the magnetic brush unit, and the control means are operably connected to the drive means so as to selectively stop and start the advance of the moving surface. The apparatus in some embodiments also includes a biasing shoe disposed adjacent the toning station and an electrical circuit means arranged to apply a bias voltage between the biasing shoe and the toner mix through the copy sheet.

A key feature of the apparatus of the invention is the gate and the ability to control the gate so as to prevent or allow the movement of toner mix in the form of a magnetic brush to the toning station. An additional feature of the invention is the control of the drive means to the magnetic brush unit. Each one of the above features prevents the toner mix from contaminating the back side of the copy sheet and the remaining portions of the reproduction equipment when sheets are fed intermittently through the toning station. The gate also serves to control the height of the magnetic brush of the toner unit which improves the uniformity of development of the electrostatic image.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional elevation view of one embodiment of the apparatus of the invention;
FIG. 2 is a schematic sectional elevation view of apparatus similar to that shown in FIG. 1, illustrating one embodiment of the biasing circuit;
FIG. 3 is a schematic block diagram of the electrical control circuits utilized in the apparatus shown in FIG. 1; and
FIGS. 4, 5, and 6 are greatly enlarged sectional elevation views of portions of the apparatus as shown in FIG. 1, illustrating sequential stages in the operation of the apparatus of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 of the drawings, toner feed means are shown in the form of a container 10 having an open top and being partially filled with a toner mix 11. The toner mix 11 is a mixture of a powdered resinous toner and particles of a magnetic material such as, for example, iron, which is well known to the art. The toner used for the direct production of copies is colored while that used for the production of a master which is to form a lithographic printing plate may or may not be colored, but is preferably colored to facilitate the visual inspection of the image. The toner may be one which acquires a positive charge in the toner mixture so that it will render visible the negative image areas of a latent electrostatic image and produces a positive copy. Alternatively, the toner may be one which assumes a negative charge in the toner mixture so that it is repelled by the negative image areas and renders visible the background areas of a latent electrostatic image so as to produce a negative reproduction of the original image.

A magnetic brush unit 12 is disposed within the container 10 with its lower periphery immersed in the toner mix 11. The magnetic brush unit 12 has a stationary cylindrical core 13 and a rotatable outer shell 14 which provides a moving surface upon which a magnetic brush 15 of toner mix 11 is formed. The cylindrical core 13 is made of a nonmagnetic material such as, for example, brass, and has a series of six longitudinal grooves 16 cut into its cylindrical surface at equally spaced intervals around approximately two-thirds of its total circumference. These longitudinal grooves 16 carry permanent magnet strips 17 which, from their cross section indicated in the drawing, are, in effect, elongate horseshoe magnets, each one having its north pole 18 along one of its radially outer margins and its south pole 19 along the opposing radially outer margin.

The lengths of these permanent magnet strips 17 govern the width of the magnetic brush 15 formed on the rotatable outer shell or sleeve 14 which comprises the moving surface of the magnetic brush unit 12. Accordingly, these permanent magnet strips 17 should have a length at least equal to the width of the latent electrostatic image which is to be toned.

Preferably, the permanent magnet strips 17 are shorter than the sleeve 14 so that the end sections of the sleeve 14 adjacent the end sections of the core 13 do not form any magnetic brush thereon. This ensures that the marginal areas of the insulating surface will not come into contact with the magnetic toning brush and hence will not pick up residual toner and become dirty in appearance even if they carry a residual electrostatic charge.

The stationary core 13 is mounted such that its rotary position may be adjusted and yet the core 13 may be firmly held in the desired position with respect to the permanent magnet strips 17 in its surface. One arrangement for accomplishing this is shown and described in U.S. Pat. No. 3,358,657, hereby incorporated by reference.

Driving means are shown in the form of a drive motor 20 connected by a belt 21 to a pulley (not shown) on one end of the sleeve 14 of the magnetic brush unit 12 to drive it at the desired rotation velocity, which may vary depending upon the speed at which an imaged insulated surface is to be toned. The drive motor 20 is attached by a bracket 22 to the side wall of the container 10. The drive motor 20 is connected by two wires 23 and 24 to an electrical power source (not shown). The rotation of the cylindrical sleeve 14 within the toner mix 11 forms the magnetic brush 15 on the portion of its outer surface due to movement of the sleeve 14 past the magnetic strips 17 of the stationary core 13. Thus, the magnetic strips 17 create magnetic fields outside of the sleeve 14 through which successive transverse portions of the sleeve 14 move, carrying toner mix 11. The magnetic brush 15 thus formed is continuously disrupted and reformed as the sleeve 14 of the magnetic brush unit 12 rotates, since it exists only on the segment of the surface which is momentarily adjacent the permanent magnet strips 17 of the stationary core 13. The portion of the sleeve 14 adjacent the circumferential portion of the core 13 which has no permanent magnet strips 17 cannot retain any toner mix in the form of a magnetic brush.

By disrupting and reforming the magnetic brush 15, the magnetic brush unit 12 creates an image and circulation of the toner mix 11 and allows excess mix 11 in certain portions of the brush 15 to be worked into adjacent areas to equalize the amount of toner mix 11 along the length of the brush 15. This action also tends to make the concentration of...
toner particles uniform along the length of the brush 15. It should be understood that the brush 15 does not fall apart when it is disrupted and that no substantial portion of the toner mix 11 therein is lost. However, the bristlelike formation of the magnetic particles forming the magnetic brush 15 is altered as the alignment of the brush 15 changes with respect to the magnetic field due to advance along the path of the surface of the sleeve 14 as the sleeve 14 moves past each pole 18 and 19 of each magnetic strip 17. The magnetic strips 17 are sufficiently closely spaced to ensure that continuity of the toner mix 11 in the magnetic brush 15 will be maintained so that the brush 15 can be transferred intact from one magnetic field to a successive magnetic field on the magnetic brush unit 12. This spacing will, of course, vary depending on the strength, size and shape of the permanent magnet strips 17 and the size of the resulting magnetic brush 15. From the above, it will be apparent that by altering the rotary position of the core, the characteristics of the brush 15 can be controlled at any desired location about the periphery of the sleeve 14 of the magnetic brush unit.

To further endure the intermixing of the ingredients of the toner mix 11, a rotary stirring device 25 is preferably disposed in the bottom of the container 10 generally beneath the off-running side of the magnetic brush unit 12. The mechanical stirrer 25 may comprise any suitable form, such as the stirrer 16 shown in the above-referenced U.S. Pat. No. 3,358,637, which provides arms or looped elements which move through and agitate the toner mix 11.

In addition, oftentimes in sections along the length of the magnetic brush 15, toner particles will be removed from the toner mix 11 comprising the magnetic brush 15 leaving a higher concentration of magnetic carrying particles. This will occur particularly where solid image portions are being toned in one section of the width of the apparatus over a considerable length of time. The excess toner mix 11 falling from the off-running side of the magnetic brush unit 12 will form piles of toner mix 11 in container 10 which have a depleted concentration of toner particles. Toner mix used from these piles to form brushes will eventually result in the formation of weak images unless fresh toner mix is intermixed therewith.

In addition, it often becomes necessary to replenish the depleted toner particles in the toner mix 11. However, care must be taken to distribute new toner particles uniformly into the toner mix 11. Otherwise, portions of the toner mix 11 will have a great concentration of toner particles which will result in noticeable effects on the images being toned. In order to insure that the toner mix 11 has a uniform composition along the length of the container 10, a pair of counter rotating, closely spaced, and parallel screw mixers 26 and 27 are provided. These screw mixers are adapted to convey the toner mix 11 in container 10 to opposite ends of the container in a continuous circuitual manner.

A photoelectrostatic copy sheet 28 is carried on a moving perforated belt 30 toward a toning station, indicated generally by reference numeral 31, where the toner mix 11 in the form of the magnetic brush 15 contacts the downwardly facing surface of the copy sheet 28 which carries the latent electrostatic image to be developed. Prior to the toning station 31, the belt 30 moves past a suction box 32 connected by a duct 33 to a source of vacuum (not shown) which imposes a partial vacuum on the interior of the suction box 32. The suction box 32 has a perforated lower wall 34 which permits the vacuum to be effective against the surface of the copy sheet 28 carried on the perforated belt 30 so as to hold the copy sheet 28 against the belt 30 and against the planar lower surface of the perforated plate 34. The belt 30 is separated from the copy sheet 28 and entrained about a guide roller 35 while the copy sheet 28 is fed to the toning station 31 and into contact with the magnetic brush 15. The belt 30 passes over a second guide roller 36 and is entrained over a third guide roller 37 at which point it is brought back into contact with the copy sheet 28 which has passed through the toning station 31. The belt 30 then moves past a second vacuum box 38 which is also connec-

nected by a duct 40 to a source of vacuum (not shown). The box 38 also has a lower perforated wall or plate 41 through which the vacuum is effective to communicate with and hold the copy sheet 28 to the belt 30. A biasing shoe 42 is disposed above the toning station 31 and beneath the guide roller 36. The lower surface of the biasing shoe 42 is arranged to contact the back or upper surface of the copy sheet 28 opposite the imaged surface being toned. The biasing shoe 42 is an elongate conductive strip 43 disposed in an elongate slot in its lower surface so as to present a surface flush with the lower surface. The conductive strip 43 extends across the width of the copy sheet 28 for a distance at least equal to the width of the area which is to be toned. The conductive strip 43 is electrically connected to a terminal 44 on the upper surface of the biasing shoe 42 by means of a conducting strip 45 extending through the shoe 42. The terminal 44 is connected by a wire 46 to ground. The grounded shoe 42 performs a part of the biasing circuit, the other part of which is formed by the conductive toner mix 11 in the container 10 which electrically contacts the container 10. In turn, the container 10 is electrically connected by a terminal 47 on the side of the container 10 to a source of electrical potential (not shown) by a wire 48. FIG. 2 illustrates in greater detail the electrical circuit which accomplishes biasing and shows schematically the source of electrical potential 50 which supplies a DC voltage to the toner mix 11.

If biasing is not employed, the biasing shoe 42 may comprise merely a backing shoe to provide support for the copy sheet 28 being toned. Alternatively the guide rollers 35, 36 and 37 may be eliminated along with the shoe 42, and the belt 21 may be fed past the toning station 31 in contact with the copy sheet 28. However, in that arrangement, it is preferably that no vacuum communicate with the back surface of the belt 21 as it passes through the toning station since the toner mix on the surface of the sleeve 14 would be drawn into and through the belt 21 when no copy sheet 28 covered the openings thereof, such as between successive sheets.

Referring again to FIG. 1, a gate 51 is disposed adjacent the on-running side of the sleeve 14 and is arranged for pivotable movement between a first position where it contacts the moving surface of the sleeve 14 and prevents toner mix 11 from being carried by the sleeve 14 toward the toning station 31 and a second position where it is spaced from the surface of the sleeve 14 so as to permit toner mix 11 in the form of magnetic brush 15 to advance toward the toning station 31 and into contact with the imaged surface of the copy sheet 28. The gate 51 is arranged so that when it is in the second position it regulates the height of the magnetic brush 15 above the surface of the sleeve 14. Thus, it is set so that it interferes with the toner mix 11 coming the radially outermost portion of the magnetic brush 15 in a manner such that it doctors or smooths the outer surface of the magnetic brush 15. This results in a magnetic brush 15 issuing from beneath the gate 51 which has a predetermined height and which then uniformly contacts the imaged surface of the copy sheet 28. Generally, the height of the brush issuing beneath the gate 51 is maintained at about one-eighth inch, although this is not critical.

The gate 51 has an arm 52 depending from one end thereof which is affixed to the gate 51 and adapted to pivot it from one position to the other. The arm 52 is connected to the movable element 53 of a solenoid 54 which is mounted on the upstanding side wall of the container 10 by a bracket 55. The solenoid 54 connects with remaining parts of the control means by two wires 56 and 57. Alternatively, the solenoid 54 might be of the rotary type and be connected to the pivot shaft 58 on which the gate 51 is mounted in order to pivot the gate 51 from one position to the other.

A switch 60 is mounted on the leading side of the biasing shoe 42 and is electrically connected to other elements of the control means in a manner described below. The switch 60 has a downwardly extending trigger element 61 which is disposed in the path of the copy sheet 28 moved by the sheet transfer means perforated belt 30 so that the switch 60 is actuable by
the copy sheet 28. The trigger element 61 rides in contact with the back surface of the copy sheet 28 and returns to its original position in response to spring bias means (not shown) when the control switch 60 after passage of the sheet 28. Of course the switch 60 could be disposed in other positions along the path of the copy sheet 28 or be arranged in a different manner to be activated by the copy sheet 28.

Referring now to FIG. 3, a schematic block diagram is shown illustrating the manner in which the electrical control elements forming the control means are interconnected to each other and to other elements of the apparatus of the invention. Thus, an electrical power source 62 is connected to the control switch 60 mounted on the biasing shoe 42 which is electrically connected both to the drive motor 20 and to the solenoid 54. Thus when the switch 60 is actuated by the leading end of a copy sheet 28, it is arranged to turn on the drive motor 20 and to move the magnetic brush unit 12 operably attached thereto by the drive motor 20 to the power source 62. The control switch 60 operates the solenoid 54 which, in turn, moves the gate 51 from the first position where it contacts the surface of the sleeve 14 to the second position, where it is spaced from the surface of the sleeve 14 by connecting the solenoid 54 to the electrical power source 62. This permits the movement of toner mix 11 in the form of the magnetic brush 15 toward the toning station 31 into contact with the imaged surface of the copy sheet 28. At this point in time, the leading end of the copy sheet 28 has now advanced beyond the conductive strip 43 in the lower surface of the biasing shoe 42 and beyond the point where the leading end might run into the brush 15 in a manner which would contaminate the back surface of the sheet with toner mix 11. In order to adjust the mechanism to insure that the conductive strip 43 of the biasing shoe 42 is covered by the copy sheet 28 prior to movement of toner mix 11 toward the biasing shoe 42, a delay timer 63 is included in the circuit between the control switch 60 and the solenoid 54 so that the electrical signal passing from the electrical power source 62 through the control switch 60 will be delayed for a short period of time before being passed to the solenoid 54 and allowing to actuate the gate 51. This delay timer may be a mechanical switch timer of a type well known to those skilled in the art and preferably is adjustable to allow the timing to be set over a wide interval.

FIGS. 4, 5 and 6 are greatly enlarged fragmentary sectional elevation views showing the sequential stages during the progress of the movement of a copy sheet 28 through the toning station 31. Thus, FIG. 4 shows the position of the elements of the apparatus of the invention as the leading end of the copy sheet 28 approaches the control switch 60. In this position, the toner mix 11 is prevented from advancing toward the toning station 31 of the upper surface of the sleeve 14 by the gate 51 which is in a position where it lightly contacts the surface of the sleeve 14 and scrapes the toner mix 11 therefrom. This prevents any toner mix 11 from contaminating the bottom of the biasing shoe 42 which would otherwise contaminate the back surface of the copy sheet.

FIG. 5 illustrates the position of the elements when the leading end of the copy sheet 28 has actuated the switch 60 and has advanced through the toning station 31 to a point where it centers the conductive strip 43. This prevents the biasing voltage from being shorted electrically due to contact of the conductive toner mix 11 with the conductive strip 43, since the insulating copying paper is disposed therebetween. The signal from the electrical power source 62 passing through the switch 60 has actuated the drive motor 20 so that the sleeve 14 is rotating. In addition, the signal from the electrical power source 62 passing through the switch 60 has actuated the solenoid 54 and has caused the gate 51 to move out of contact with the surface of the sleeve 14 so that the magnetic brush 15 is in a position to advance toward the leading end of the copy sheet 28. The interaction of the delay timer 63 on this signal, however, has ensured that the leading end of the copy sheet 15 will not run into the magnetic brush 15 in a manner which would result in contamination of the back side of the copy sheet 28 at the toning station 31. Instead, the leading end of the copy sheet 28 will have passed the toning station 31 prior to the arrival of toner mix 11. The gate 51 smooths the magnetic brush 15 to give it a uniform height as it issues from beneath the gate 51.

FIG. 6 illustrates the position of elements of the apparatus when the trailing end of the copy sheet 28 has moved past the switch 60. The trigger element 61 returns to its original position and the drive motor is shut off so that the motion of the sleeve 14 gradually stops. It is preferable that the sleeve 14 be permitted to coast to a stop so as to permit any toner mix 11 disposed thereon after the gate 51 is closed to be moved into contact with the trailing end of the copy sheet 28 and to then be returned to the container 10 by dropping off the off running side of the crest of the toner unit 12. Thus, no magnetic strips 17 are disposed in the core 13 adjacent that portion of the toner unit 12 so that no brush is formed and the toner mix is free to fall off of the sleeve 14. The trailing end of the copy sheet 28 covers the conductive strip 43 until all of this toner mix 11 has been removed from the surface of the sleeve 14 in the area of the toning station 31. The signal passed by the switch 60 has also been turned off so that the solenoid 54 returns the gate 51 to its original position where it contacts the surface of the sleeve 14, thereby preventing any further advance of the toner mix 11 on the moving surface of the sleeve 14. This process is repeated for each successive copy sheet 28 fed through the apparatus.

The above description shows an apparatus which is capable of toning a copy sheet to render visible a latent electrostatic image thereon without contamination of the back surface of the sheet with toner mix. The apparatus makes it possible to accurately control the application of toner to the desired portions of the surface of the copy sheet on an automatic basis. Moreover, the gate of the apparatus of the invention insures that the magnetic brush will have a uniform height and also accomplishes further mixing of the toner mix in the magnetic brush to achieve a more uniform distribution of toner particles therein.

From the above description, it will be apparent that various modifications may be made in the apparatus described in detail herein. For example, the arrangement and disposition of the control switch 60 might be altered and any timing differences required could be achieved by delay timers installed at appropriate positions in the electrical circuits, in a manner well known to those skilled in the art. In addition, other means could be employed to feed toner mix to the surface of the magnetic brush unit and the magnetic brush unit could vary in design and manner of operation. For example, the moving surface thereof could be provided by a belt of nonmagnetic material instead of the brass sleeve. Also, the apparatus of the invention could be employed where only portions of the surface of the copy sheet are to be toned, by using gates which extend only across portions of the width of the image to be developed. In view of these and other possible variations, the invention is not intended to be limited to the specific details of the apparatus described herein, except as may be required by the following claims.

What is claimed is:

1. Apparatus for applying toner to an electrostatic image carried by a photoelectrostatic coating on a copy sheet by contacting said image with a toner mix comprising toner particles and magnetic carrying particles, said apparatus comprising:
   a magnetic brush unit having a moving surface on which a magnetic brush of toner mix is continuously formed, disrupted and reformed,
   drive means operably connected to said magnetic brush unit and adapted to advance said moving surface,
   toner feed means for supplying toner mix to said moving surface,
   sheet feed means for moving said copy sheet past said magnetic brush at a toning station where said toner mix contacts the electrostatic image carried thereon,
a gate disposed along a portion of the path of the moving surface between said toner feed means and said toning station, said gate being adapted for selective movement between a first position where it contacts the surface of said magnetic brush unit so as to prevent the advance of toner mix toward said toning station and a second position spaced from said moving surface so as to allow the advance of toner mix toward said toning station, control means operably connected both to said gate for selectively actuating said gate and to said drive means so as to selectively stop and start the advance of said moving surface, and a delay timer connecting said gate to said control means whereby said gate is actuated after a predetermined time interval following operation of said drive means by said control means.

2. Apparatus according to claim 1, wherein the moving surface of said magnetic brush unit is cylindrical, and wherein said toner feed means are adapted to supply toner mix to the lower portion of said cylinder.

3. Apparatus according to claim 1, wherein said sheet feed means comprises a moving perforated belt and suction means for applying a partial vacuum to one surface thereof so as to hold a copy sheet disposed in contact with the other surface of said belt.

4. Apparatus according to claim 1, wherein said control means comprise an electrical power source, a solenoid operably connected to said gate, and an electrical switch connecting said power source to said solenoid.

5. Apparatus according to claim 1, wherein control means are actuated by a copy sheet as it is being moved toward said toning station by said sheet feed means.

6. Apparatus according to claim 4, wherein said electrical switch is disposed along the path of a copy sheet being moved toward said toning station by said sheet feed means and is adapted to be actuated by said copy sheet.

7. Apparatus according to claim 1, wherein said gate extends along the length of said magnetic brush unit in a direction perpendicular to the direction of movement of said moving surface and for a distance at least equal to the width of said electrostatic image.

8. Apparatus according to claim 1, wherein said gate is adapted to interfere with the radially outermost portion of said magnetic brush of toner mix on said moving surface when said gate is disposed at said second position, so as to doctor the excess toner mix from said magnetic brush to form a magnetic brush having a uniform height.

9. Apparatus for applying toner to an electrostatic image carried by a photoselectrostatic coating on a copy sheet by contacting said image with a toner mix comprising toner particles and magnetic carrying particles, said apparatus comprising:

a magnetic brush unit having a moving surface on which a magnetic brush of toner mix is continuously formed, disrupted and reformed, toner feed means for supplying toner mix to said moving surface, sheet feed means for intermittently moving said copy sheet past said magnetic brush at a toning station where said toner mix contacts the electrostatic image carried thereon, said sheet feed means comprising a moving perforated belt and suction means for applying a partial vacuum to one surface thereof so as to hold a copy sheet disposed in contact with the other surface of said belt, a biasing shoe disposed adjacent said toning station, electrical circuit means arranged to apply a bias voltage between said biasing shoe and said toner mix through said copy sheet, a gate disposed along a portion of the path of the moving surface between said container and said toning station, said gate being adapted for selective movement between a first position where it contacts the surface of said magnetic brush unit so as to prevent the advance of toner mix toward said toning station and a second position spaced from said moving surface so as to allow the advance of toner mix toward said toning station, and control means operably connected to said gate for selectively actuating said gate.

10. Apparatus according to claim 9, wherein the moving surface of said magnetic brush unit is cylindrical, and wherein said toner feed means are adapted to supply toner mix to the lower portion of said cylinder.

11. Apparatus according to claim 9, wherein said control means comprise an electrical power source, a solenoid operably connected to said gate, and an electrical switch connecting said power source to said solenoid.

12. Apparatus according to claim 9, wherein said control means are actuated by a copy sheet as it is being moved toward said toning station by said sheet feed means.

13. Apparatus according to claim 9, wherein electrical switch is disposed along the path of a copy sheet being moved toward said toning station by said sheet feed means and is adapted to be actuated by said copy sheet.

14. Apparatus according to claim 9, including drive means operably connected to said magnetic brush unit and adapted to advance said moving surface, and wherein said control means are operably connected to said drive means so as to selectively stop and start the advance of said moving surface.

15. Apparatus according to claim 14, including a delay timer connecting said gate to said control means whereby said gate is actuated after a predetermined time interval following operation of said drive means by said control means.

16. Apparatus according to claim 9, wherein said control means are actuated by said copy sheet as it is being moved toward said toning station by said sheet feed means, said control means being adapted to move said gate to said second position after the leading end of said copy sheet has advanced beyond said biasing shoe, and to move said gate to said first position after the trailing end of said copy sheet has advanced beyond said biasing shoe, whereby contact of said biasing shoe by said toner mix is inhibited.

17. Apparatus according to claim 9, wherein said gate extends along the length of said magnetic brush unit in a direction perpendicular to the direction of movement of said moving surface and for a distance at least equal to the width of said electrostatic image.

18. Apparatus according to claim 9, wherein said gate is adapted to interfere with the radially outermost portion of said magnetic brush of toner mix on said moving surface when said gate is disposed at said second position, so as to doctor the excess toner mix from said magnetic brush to form a magnetic brush having a uniform height.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,641,969 Dated February 15, 1972

Inventor(s) Nils L. Hakanson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 55, "ensure" should be --insure--.

Column 2, line 25, "thrush" should be --thrust--.

Column 4, line 36, "ensure" should be --insure--.

Column 5, line 10, "ensure" should be --insure--.

Column 6, line 33, "preferably" should be --preferable--.

Signed and sealed this 8th day of January 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR. RENE D. TEGTMeyer
Attesting Officer Acting Commissioner of Patents
United States Patent Office
Certificate of Correction

Patent No. 3,641,969 Dated February 15, 1972

Inventor(s): Nils L. Hakanson

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 55, "ensure" should be --insure--.

Column 2, line 25, "thrush" should be --thrust--.

Column 3, line 54, "is" should be --in--.

Column 4, line 36, "ensure" should be --insure--.

Column 5, line 10, "ensure" should be --insure--.

Column 6, line 33, "preferably" should be --preferable--.

Column 2, line 36, "is" should be --in--.

Column 6, line 33, "preferably" should be --preferable--.

Signed and sealed this 8th day of January 1974.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

RENÉ D. TEGTMEYER
Acting Commissioner of Patents