ABSTRACT

A portion of a xerographic development material is slowly circulated past a vertically oriented porous wall where it serves as a filter for airborne toner particles flowing there through. Toner enriched development material is returned to the main body of development material for reuse. Toner particles cleaned from residual xerographic images are conveniently transported by airflow entrainment to the development material filter.

11 Claims, 3 Drawing Figures
Toner Recovery System

Cross Reference to Other Applications

Reference is made to application Ser. No. 426,750 filed simultaneously herewith in the name of H. W. Simpson and entitled "Triboelectric Filter and Method of Using It."

Background of the Invention

The aforesaid application Ser. No. 426,750 discloses a technique for filtering airborne electrosopic toner particles by the use of a body of relatively larger carrier beads whose surfaces react with the electrosopic toner particles to develop substantial triboelectric charging therebetween. When the filtering body becomes saturated with collected toner particles, it can be used as a xerographic development mixture.

Our invention implements this filter technique for use in an automatic xerographic printing machine such as an office copier. In accordance with our invention, a filter chamber is constructed of a pair of substantially vertically extending fine mesh or porous walls spaced to form a panel-like chamber of generally uniform thickness. A portion of the developer charge of the printing machine is lifted by suitable conveying means from a sump to the upper end of the filter chamber. A flow control gate at the lower end of the filter chamber is controlled to slowly return developer material from the lower end of the filter chamber to the sump. The development material thus slowly progresses downwardly between the porous side walls of the filter chamber and is returned for mixing with the main body of development material in the sump.

Airborne toner particles are generally detrimental to continued reliable operation of a xerographic copy machine. The developer unit itself is a primary source of such toner particles. Our filter construction makes it practically feasible to apply a sub-atmospheric pressure to the developer unit housing to prevent escape of airborne toner particles from the housing to other areas of the copy machine. Air flow for maintaining the sub-atmospheric pressure within the developer housing passes through the mesh walls of the filter chamber and the body of development material contained therebetween. Toner particles entrained in the air flow are triboelectrically captured by the carrier material of the developer mixture and eventually are returned with the development mixture to the sump for reuse.

The residual image cleaning station of a copy machine traditionally has employed a rapidly moving brush that lifts toner particles into an air stream in a manner similar to a household vacuum cleaner. The toner particles traditionally have been captured by a fibrous bag-like filter which requires periodic replacement. Various proposals have been made for capturing cleaned toner and returning it to the developer station for reuse through various solids conveyor devices.

With use of a filter device constructed in accordance with our invention, in association with the developer unit of the copy machine, it becomes practical to convey the toner laden air stream created in conjunction with a cleaning brush directly to the developer unit thereby enabling the toner particles to be directly captured by the filtering body of developer material. Those skilled in the art will recognize that other sources of airborne toner particles can be purged through use of our invention and the reasonably simple technique of providing an air conduit from the subatmospheric pressure development chamber to the area to be purged.

These and other objects, features and advantages of our invention will be apparent to those skilled in the art from the following more specific description of an illustrative preferred embodiment thereof, wherein reference is made to the accompanying drawings of which:

Fig. 1 is a front cross-sectional view of a copy machine having an improved airborne toner filter constructed in accordance with our invention.

Fig. 2 is a side elevation cross-sectional view of the machine shown in Fig. 1 taken along line II--II thereof, and.

Fig. 3 is a fragmentary cross-sectional view of an alternate preferred embodiment of our invention.

Referring now more specifically to the drawings, Fig. 1 shows a xerographic type copy printing machine 10 having a copy drum 11 that supports a photoconductive imaging surface 12 for movement successively past corona charging unit 13, optical imagewise discharging unit 14, physical toner image development unit 20, transfer corona 15 and residual image cleaning unit 60. A large percentage of the toner image 16 produced at development unit 20 is transferred to copy sheets 17 by the transfer corona 15, however, residual toner material 18 remains on the imaging surface 12 and must be cleaned prior to creation of a new and different image.

Development unit 20 is illustrated as employing a magnetic brush 20a like that disclosed in U.S. Pat. No. 3,754,526 for bringing a development mixture 22 into operative developing relationship with a differential electrostatic charge latent image at the imaging surface 12. The material 22 comprises relatively large carrier beads 23 and relatively small toner particles 24 whose triboelectric relationship is such that substantial charge is developed upon mutual contact. It will be recognized that the filter technique of our invention is also adaptable to other development systems which employ a development mixture of triboelectrically opposite carrier and toner particles.

Development unit 20 includes a developer housing 21 that is formed to define a sump 25 where a primary mixture of development material 22 is maintained. The sump 25 preferably includes one or more mixing devices such as auger 26 to maintain a uniform mixture of the developer material 22. A lifting bucket conveyor 27 is mounted within the developer housing 21 for circulating the developer material 22 from sump 25 to an elevated hopper 28 where it is applied to the magnetic development brush 20. The latter is returned to the sump 25 by gravity where it is reenriched with toner particles in the aforesaid mixing process.

A toner supply unit 29 constructed, for example, in accordance with U.S. Pat. No. 3,572,555 adds toner material to the development mixture in sump 25 as toner is depleted with the production of copies. The mechanism thus far described is merely illustrative of electrophotographic techniques well known to those skilled in the art.

In accordance with our invention we have provided an airborne toner filter unit 30 which is preferably formed as part of the developer housing 21. Filter unit 30 comprises a pair of vertically extending porous mesh walls 31 and 32 substantially uniformly spaced to form a panel-like auxiliary filter chamber 34 that supports
a body of the development material 22. The chamber 34 is located vertically above the level of sump 25 and below the level of hopper 28. The porous walls 31 and 32 provide openings through which air and toner particles 24 can pass but which are substantially smaller than the carrier particles 23. An inlet chute or conduit 36 is connected between the hopper 28 and the upper end of chamber 34 for diverting a portion of the development material lifted by conveyor 27 into the filter chamber 34. An outlet chute 38 is connected between the lower end of filter chamber 34 and the sump 25 for returning developer material to the sump 25. A flow control gate device 40 regulates the amount of material returned to sump 25. One form of gate device is conveniently provided by a cylinder 42 that is closely confined by the adjacent walls of filter chamber 34 and contains a notch or cavity 44. Shaft 42 is driven slowly during rotation of drum 11 by a worm gear 46 and a pinion 48. Each revolution of shaft 42 thus returns the volume of notch 44 of developer material to the sump 25 and thereby allows an equal amount of developer material to enter the inlet chute 36.

To maintain a sub-atmospheric pressure within developer housing 21, the vacuum end of a low speed blower 50 is connected by conduit 52 with the housing 21 downstream of the filter chamber 34. An air flow path is thus established from the interior of developer housing 21 which contains airborne toner particles 54 to the conduit 52 so that toner laden air pulled from the developer housing 21 or elsewhere passes through the filter chamber 34 before being discharged by blower 50 into the atmosphere. It may be desirable to employ a supplementary safety filter 56 downstream of filter chamber 34 to capture any toner particles 54 that might escape filter 30. With developer housing 21 maintained at sub-atmospheric pressure it will be recognized that any air movement through openings of the housing 21 such as those adjacent imaging surface 12 will be into rather than out of the developer housing 21. In operation, development material 22 is normally maintained with a toner concentration that is substantially less than the maximum concentration of which the carrier material 23 is capable. The portion of the development material 22 that is diverted into filter chamber 34 is held in the path of toner laden air flow 58. The substantially uniform thickness of the chamber 34 assures a substantially constant and predictable air pressure drop across the body of filter material therein. As toner is captured by the carrier 23 within chamber 34 and the carrier thus approaches saturation, it is moved progressively downwardly and eventually is reintroduced into sump 25 where its captured tone is readily mixed with the main body of development material 22. The vertical orientation of walls 31 and 32 minimize the tendency for carrier beads to clog the openings in the mesh of walls 31 and 32. It will be recognized that this tendency could be further minimized by a slight inclination of the walls 31 and 32 so that chamber 34 would widen slightly at its lower end.

Cleaning unit 60 comprises a brush 61 in an enclosure 62 which can be constructed and operated like that described in U.S. Pat. No. 3,615,813. Brush 61 acts to dislodge particles of the residual toner image 18 from imaging surface 12 and carry them past a flicker bar 64 where they are ejected into an air stream created by a suitable vacuum source. Whereas U.S. Pat. No. 3,615,813 employs a replaceable filter bag in the vacuum line, our invention provides a return duct 66 connected between cleaning unit enclosure 62 and developer housing 21. Blower 50 thus is placed in effective communication with cleaning unit enclosure 62 and develops the vacuum creating an air flow to entrain airborne toner particles 68 flicked from brush 61 and transport the entrained toner particles 68 into developer housing 21. Once in developer housing 21 the airborne toner particles are further filtered as previously described by the body of developer material in filter chamber 34. It will be recognized that our invention not only eliminates the need for a cleaning station air filter but conveniently provides for the recapture and reuse of toner material collected from the residual image by the cleaning unit 60.

FIG. 3 shows an alternate preferred embodiment where only a lower portion of a developer housing 70 is illustrated. Housing 70 supports a body of developer material 22, like that described above, in a sump 71. The development material 22 is transported past an electrostatic image on a copy drum (not shown) by conveyor 72. The body of development material 22 in sump 71 is mixed and agitated by an auger 73. A porous wall of screen mesh 74 contacts the body of development material 22 in a direction 75 between the horizontal and the nadir such that carrier beads 23 are not held by gravity against the porous wall 74. A conduit 76 is connected to a suitable source of sub-atmospheric pressure (not shown) to draw air from the space 77 within the developer housing 70 through the body of development material in sump 71 and the porous wall 74 which forms the inlet to conduit 76. The development material 22 in the vicinity of porous wall 74 is continually moved during operation by the action of conveyor 72 and mixing auger 73.

Those skilled in the art will recognize that various modifications, additions and deletions can be made to the preferred embodiment thus described. For example, while for compactness and simplicity we prefer to construct the filter chamber 34 as part of the developer housing 21, it will be recognized that an independent filter housing with suitable conveying means could be usefully employed. Thus, the subject matter of our intention is intended to be limited only by the appended claims.

We claim:
1. A xerographic printing machine having an imaging surface, and an image development station comprising a developer housing, means within said developer housing for conveying a developer mixture of relatively large carrier particles and relatively small toner particles into operative development relationship with a differential electrostatic charge image at said imaging surface, wherein the improvement comprises:
   means supporting a packed body of said developer mixture within said developer housing, a source of sub-atmospheric air pressure, conduit means connected between said sub-atmospheric pressure source and said developer housing at a location that establishes a flow of air through said packed body of developer mixture in the direction that air suspended toner particles within said developer housing are drawn into said air flow and through said packed body of developer mixture, said air suspended toner particles in said air flow attaching to the carrier particles in said
3,894,514

5 packed body of developer mixture to become separated from the air.
2. A xerographic printing machine as defined in claim 1 wherein said conduit means comprises a porous wall contacting said body of developer mixture for drawing air through said body without removing carrier particles therefrom.
3. A xerographic printing machine as defined in claim 2 wherein said porous wall contacts said body of developer mixture in a direction between the horizontal and the nadir whereby gravitational forces do not tend to maintain carrier particles in contact with said porous wall.
4. A xerographic printing machine as defined in claim 1 further comprising cleaning means for removing residual toner particles from said imaging surface, said cleaning means comprising an enclosure, an enclosure, and means within said enclosure for dislodging said residual toner particles from said imaging surface and entraining said toner particles into air within said enclosure, wherein the improvement further comprises:
   ducting interconnecting said enclosure with said developer housing whereby said sub-atmospheric pressure draws air bearing toner particles from said enclosure into said developer housing.
5. A xerographic printing machine having an image development station comprising a developer housing positioned adjacent an imaging surface, said developer housing providing a sump for retaining a mixture of development material including relatively large carrier particles and relatively small toner particles, wherein the surface characteristics of said carrier and toner particles are such that substantial triboelectric charge development occurs therebetween upon mutual contact, and means for circulating a portion of said mixture of developer material from said sump into operative development relationship with said imaging surface and back to said sump, wherein the improvement comprises:
   means defining an auxiliary chamber,
   means for slowly moving a packed body of said mixture of developer material through said auxiliary chamber to said sump portion,
   means defining an air flow path through said auxiliary chamber, said air flow path having an upstream portion in communication with a source of airborne toner particles, and
   means for applying a sub-atmospheric pressure to a downstream portion of said air flow path.
6. A xerographic printing machine as defined in claim 5 wherein said auxiliary chamber is positioned adjacent said developer material circulating means and wherein said means for slowly moving a body of said mixture of developer material through said auxiliary chamber comprises:
   means for diverting a portion of said mixture of the developer material being circulated by said developer material circulating means through said auxiliary chamber, and controlled gating means adjacent said auxiliary chamber for regulating the rate of return of the mixture of developer material from said auxiliary chamber to said sump.
7. A xerographic printing machine as defined in claim 6 wherein said means defining an auxiliary chamber comprises a pair of substantially uniformly spaced, vertically extending mesh walls oriented transversely to said air flow path.
8. A xerographic printing machine as defined in claim 6 wherein said source of airborne toner particles comprises a residual image cleaning station.
9. A xerographic printing machine having an image development station comprising a developer housing positioned adjacent an imaging surface, said developer housing providing a sump for retaining a mixture of developer material including relatively large carrier particles and relatively small toner particles, wherein the surface characteristics of said carrier and toner particles are such that substantial triboelectric charge development occurs therebetween upon mutual contact, and means for lifting a portion of said mixture of developer material from said sump to an elevated position where it is placed in operative development relationship with said imaging surface and is returned by gravity to said sump wherein the improvement comprises:
   means defining a vertically oriented auxiliary chamber having an inlet at its upper end and another at its lower end connected with said sump,
   means for diverting a portion of the mixture of developer material being circulated by said developer material lifting means into said inlet of said auxiliary chamber,
   controlled gating means adjacent said auxiliary chamber outlet for regulating the rate of return of the mixture of developer material to said sump,
   means defining a generally horizontal air flow path through said auxiliary chamber, said air flow path having an upstream portion in communication with a source of airborne toner particles, and
   means for applying a sub-atmospheric pressure to a downstream portion of said air flow path.
10. A xerographic printing machine as defined in claim 9 wherein said means defining an auxiliary chamber comprises a pair of substantially uniformly spaced vertically extending mesh walls oriented transversely to said air flow path.
11. A xerographic printing machine as defined in claim 9 wherein said source of airborne toner particles comprises a residual image cleaning station.