

[54] **CLEANING OF PARTICLES FROM A SURFACE**

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[58] Field of Search..... **134/6, 7, 9; 117/17.5, 37 L, 37 E; 15/100, 219, 256.5; 355/15, 96/1 R**

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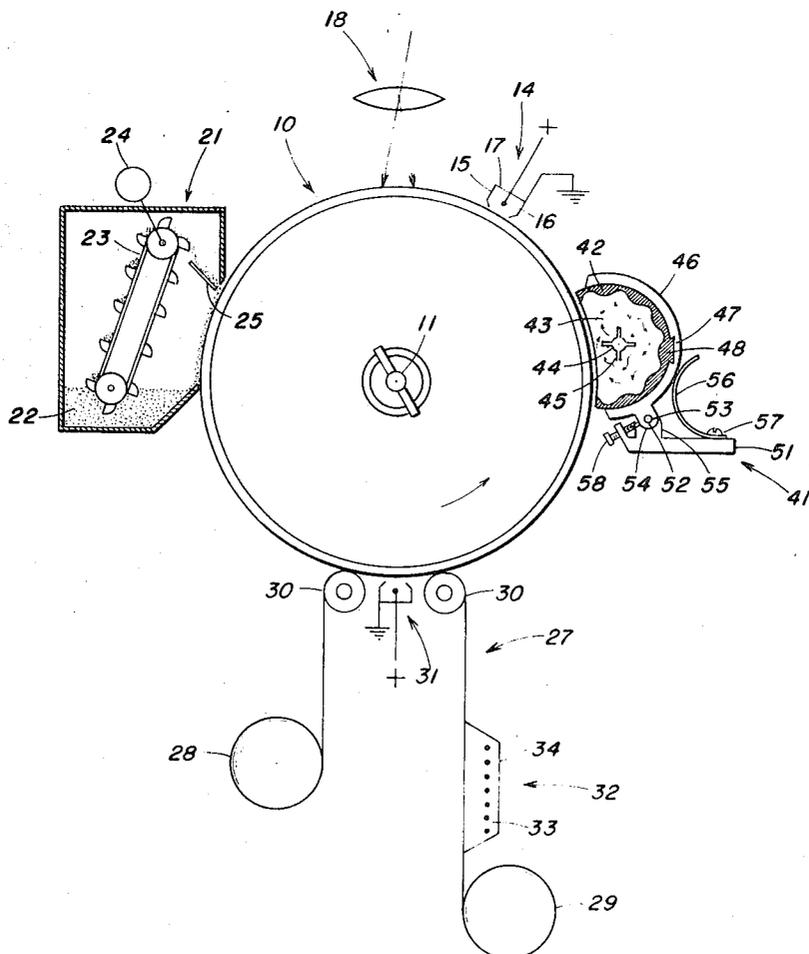
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[57] **ABSTRACT**

Cleaning of particles from a surface, in particular toner particles from an electrostatographic recording surface, by confining a mass of a soft, non-tacky material which becomes fluid upon the application of a low shearing stress, in a housing adjacent to the surface, with the material being in contact with the surface. The mass of material is subjected to shearing stress and caused to flow over and in contact with the surface entrapping the particles in the material and thereby removing the particles from the surface.

9 Claims, 1 Drawing Figure



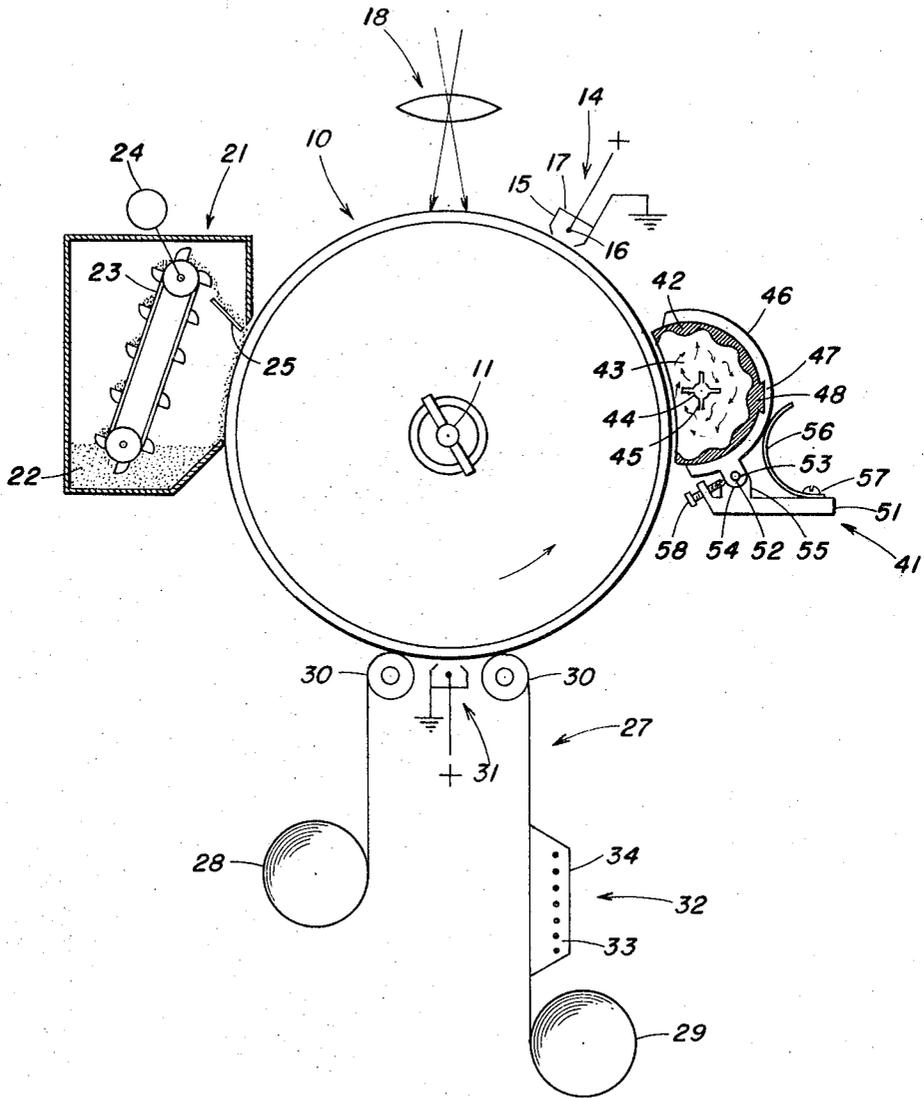


Fig. 1.

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CLEANING OF PARTICLES FROM A SURFACE

BACKGROUND OF THE INVENTION

This invention relates to cleaning of particles from a surface and more particularly to removing residual toner from an electrostatographic recording surface.

The most common electrostatographic process is the electrophotographic process, for example, as disclosed in U. S. Pat. No. 2,297,691 to Carlson. As disclosed in the Carlson Patent, an electrostatographic recording surface, comprising a photo-conductive insulating material on a conductive backing, is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. This exposure discharges the charged areas in accordance with the light intensity which reaches them and thereby creates an electrostatic latent image on or in the photoconductive material.

Development of the latent electrostatic image is usually effected by an electrostatically attractable material, which is generally a thermoplastic resin in the form of finely divided particles usually in the size range from 3 to 20 microns, commonly referred to as toner. In the development of the latent electrostatic image, the toner is brought into surface contact with the latent electrostatic image bearing surface and is held thereon electrostatically in a pattern corresponding to the latent electrostatic image. The developed image is then transferred to a suitable support material, such as paper, and fused thereon to make a permanent image. In the transfer step substantially all of the resin material or toner is caused to adhere to the support material to from the images thereon, but usually a very small percentage of the resin material or toner remains on the surface of the photoconductive material.

The small quantity of resin material or toner remaining on the photoconductive surface will affect future operating steps of the process, and if left remaining thereon has an accumulative effect in that additional toner adheres more readily to the photoconductive surface in both image and non-image areas thereon.

The accumulated toner material is generally removed from the photoconductive surface by the process disclosed in U. S. Pat. No. 2,751,616 to Turner. As disclosed in the Turner Patent, a rotating brush mounted in a hood is rotated in surface contact with the photoconductive surface to dislodge any residual toner adhering thereto. The bristles of the brush are then contacted with a flicking bar mounted in the hood to detach the particles of toner adhering thereto. The hood in which the brush is mounted may be in fluid flow communication with a filter box having a filter mounted therein through an exhaust duct, with the portion of the filter box, downstream of the filter, being suitably connected to a centrifugal blower to draw air from the hood which entrains the toner particles removed from the brush by the flicking bar. The toner particles are separated from the air as the air passes through the filter.

The cleaning system, as hereinabove described, is quite large and is therefore not suitable for small machines. In addition, the power requirements are high as a result of the necessity to operate a blower for providing an air current for removing residual toner. Furthermore, the system is complex requiring not only means for removing toner from the electrostatographic re-

ording surface, but also a vacuum and filter system. Moreover, the use of a rotating brush causes some abrasion to the electrostatographic recording surface as toner loaded brush fibers contact the recording surface.

SUMMARY OF THE INVENTION

An object of this invention is to provide for removing of fine particles from a surface.

A further object of this invention is to provide for cleaning of an electrostatographic recording surface which eliminates the aforementioned disadvantages associated with cleaning with a rotating brush.

Another object of this invention is to provide for compact cleaning of an electrostatographic recording surface.

These and other objects of the invention should be more readily apparent from reading the following description of the invention with reference to the accompanying drawing.

The objects of this invention are broadly accomplished, in one aspect, by causing a mass of solid material which is soft and non-tacky to flow over and in contact with a surface having particles thereon to entrap the particles in the material and thereby remove the particles from the surface. The material is also preferably continuously mixed while flowing over the surface to thereby continually renew the surface of the material which is in contact with the surface from which the particles are being removed. In another aspect, the objects of this invention are accomplished by causing the mass of material to flow over an electrostatographic recording surface to remove residual toner therefrom, thereby eliminating the rotary brush-vacuum cleaning system heretofore employed in the art for such a purpose.

The material employed for cleaning the electrostatographic recording surface of residual toner is a material which is inert with respect to the surface and is non-tacky; i.e., does not stick or adhere to the recording surface when placed in firm contact therewith. The material is also soft in order to prevent abrasion or damage to the recording surface. The material is also preferably resilient and compressible in order to provide for a continuous mixing of the mass of material to thereby continuously present new surface areas in contact with the recording surface. The material employed for effecting such cleaning may be a material which is resilient and compressible at ambient conditions or one which may be made resilient and compressible by effecting heating or cooling thereof.

The solid material is a thixotropic material; i.e., one which has flow properties such that: at rest the material is substantially stiff; i.e., does not flow or only flows at a low rate under the influence of its own weight; and under the influence of low shearing stress the material becomes fluid and undergoes flow as a solid mass to entrap the particles to be removed from the surface; i.e., the material has a dough-like consistency. The thixotropic material is preferably formed from an amorphous non-polar polymer, such as an ethylene-propylene copolymer, low molecular weight polyethylene wax, polyisobutylene, polyethylene, a silicone, etc., filled with an associating filler, such as silica or carbon black, the silica being employed in a quantity to provide sufficient stiffness at rest without preventing flow upon the application of low shearing stress. The thixotropic material could also be a gel-like material formed

by admixing a suitable liquid, such as a mineral oil, with a suitable filler such as silica. Similarly, the material could be a silicone putty; e.g., the putty sold under the mark G-E SS91, by the General Electric Co., but this material has a tendency to flow under its own weight and, therefore, precautions must be taken to prevent loss of the material during inactive periods. The formulation of various thixotropic materials is deemed to be well within the scope of those skilled in the art and no further details in this respect are deemed necessary for a full understanding of the invention. It is to be understood, however, that the solid material is preferably a material which exhibits such flow properties under the conditions employed in an electrostatographic machine; i.e., substantially ambient conditions, in order to eliminate the necessity of providing special environmental controls to provide other than ambient conditions.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a partially schematic, partially in section, view of an embodiment of the invention.

DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

Referring to the drawing, there is illustrated an electrostatographic machine employing an embodiment of this invention. The machine includes an image forming member such as, for example, an electrophotographic cylinder designated 10 and generally including an insulating or photoconductive insulating layer disposed on a conductive backing. The cylinder is rotatably mounted on a suitable axle 11 or other bearing member and is adapted to be rotated by drive means such as, for example, an electric motor (not shown) or the like. Preferably the cylinder, and in particular its conductive backing, is electrically grounded. The image forming or image receiving surface of the electrophotographic cylinder 10 is adapted to be rotated past appropriate electrophotographic processing stations disposed and positioned to form an electrostatic image on the cylinder surface. For example, when used with a photoconductive insulating electrophotographic image surface, the electrophotographic processing stations may include means for charging or sensitizing, exposure means, and cleaning means. Illustrated in the figure is a charging station generally designated 14 at which is positioned a corona discharge electrode 15, desirably one or more high voltage corona discharge wires 16 mounted within a grounded shield 17 and adapted to be connected to a high voltage source such as, for example, a positive polarity direct current source of several thousand volts. In general the voltage applied to the corona discharge electrode will be sufficient to cause air ionization surrounding the corona wires and it is understood that such a corona discharge potential is generally in the order of several thousand volts and usually 5 to 10 thousand volts as disclosed, for example, in Walkup U. S. Pat. No. 2,777,957.

Positioned next adjacent to the charging station is an exposure station generally designated 18 and including suitable means for projecting or otherwise directing a light or optical image onto the surface of the electrophotographic drum. The exposure station may include a slit projection mechanism for exposing onto the drum surface a moving projected image of microfilm or the like, and may include means for projecting onto the

surface documentary or other information or an image corresponding to the face of a cathode ray tube or the like. As is disclosed in Carlson U. S. Pat. No. 2,297,691, the combination of electric field and exposure to activating radiation forms on the drum surface an electrostatic image capable of being developed or made visible by deposition of finely divided charged particles.

A development station for developing the latent electrostatic image, generally designated as 21, is positioned at a subsequent location around the circumference of the drum. The development station, as shown, includes a sump 22 containing the two component developer material comprised of toner and carrier, for example of the type disclosed in U. S. Pat. No. 2,618,551 to Walkup; a conveyor 23, which is driven through suitable drive means by a motor 24; and a chute 25 for transporting developer released from the conveyor to the surface of the drum 10. In operation, the conveyor 23 transports the developer from the sump 22 to the chute 25, and the developer released from the chute 25 cascades over the surface of the drum 10, whereby the toner particles are attracted to the image areas previously formed thereon to render the image visible. The unused developer material which has cascaded over the surface of the drum 10 falls into the sump 22, and the developer material in the sump 22 is periodically provided with toner to replenish the toner used to develop the image.

Although the embodiment is described with reference to a cascade development system, it is to be understood that the latent image may be developed by any one of a wide variety of other development techniques, such as, for example, fur brush development and the like.

Positioned subsequently around the surface of the electrophotographic drum is an image transfer station generally designated 27 including for example a supply roll 28 of transfer material such as, for example, a roll of paper and a take-up roll 29 together with guide means and the like to feed the image transfer material into contiguous relationship with the electrophotographic drum. As illustrated in the figure, suitable guide rolls 30 may guide and optionally drive the transfer web into contact with the electrophotographic drum, and transfer means such as, for example, a corona discharge electrode 31 is positioned to transfer the developer image to the image web at the transfer station. Preferably, the transfer means is a corona discharge electrode of substantially the same construction as is located at the charging station 14 although other transfer means may be employed such as the means disclosed in U. S. Pat. No. 2,807,233. For the usual case of direct or positive-to-positive photographic copy the charging electrode 15 and the transfer electrode 31 are of the same polarity and for the opposite situation of photographic reversal the electrodes are of opposite polarity. Optionally positioned near the transfer station and along the line of travel of the transfer web subsequent to the transfer station is a fusing station generally designated 32 and including a plurality of heating elements 33 suitably contained within a housing 34 and adapted to fuse onto the web surface the image that has been transferred thereto. It is understood that suitable vapor fixing means may be employed as disclosed for example in Carlson U.S. Pat. No. 2,776,907.

Disposed next adjacent to the transfer station and prior to the charging station is a cleaning station, generally designated as 41, for removing residual toner particles from the surface of the drum prior to charging of the drum. The cleaning station is comprised of a hollow hemispherically shaped housing in the form of a replaceable cartridge 42 of a size which is coextensive with the surface of the drum 10; the interior of the cartridge 42 defining a chamber 43 which is open at the end adjacent the surface of drum 10 and has an irregular interior surface to enhance mixing of the material therein. The chamber 10 is filled with a material of the type hereinabove described for removing residual toner from the surface of drum 10.

The interior of chamber 43 is provided with a transverse shaft 44, having radial baffles 45 spaced over the length thereof, which is suitably mounted for rotation therein by an external drive means (not shown) of a type known in the art.

The cartridge 42 is removably mounted in a hemispherically shaped holding member 46, the interior surface of which is provided with a transverse groove 47 which mates with a transverse tongue 48, provided on the exterior surface of the cartridge 42 opposite to the open end thereof. The holding member 46 is shaped so that the exterior surface of the cartridge 42 is contiguous with the interior surface of the holding member 46.

The holding member 46 is pivotally mounted on a support member 51 by means of a pin 52 which extends through apertures 53 in transversely spaced mounting brackets 54 which extend downwardly from cartridge 42 and an aperture (not shown) in a mounting bracket 55 which extends upwardly from support member 51, the brackets 54 of the cartridge 42 being positioned on either side of the bracket 55 of support member 51.

A pressure loading mechanism, comprised of a transverse resilient member 56, is fixedly supported at one end to the support member 51 by a fastening means, such as a screw 57, and is positioned in deformation, at the upper end, in abutment with the holding member 46, thereby urging the pivotally supported holding member 46 toward the drum 10. A stop mechanism, comprised of a set screw 58, rotatably mounted in the support member 51 is positioned with the shank thereof against the bracket 54 of holding member 46, thereby preventing further movement of the holding member 46 toward the drum 10. Thus, a proper positioning of the set screw 58 determines the position of the holding member 46 with respect to the drum 10, with the holding member 46 being maintained in this position by the resilient member 56 urging the holding member 46 toward the drum 10.

In operation, the replaceable cartridge 42 filled with material for cleaning the surface of drum 10 is placed in the holding member 46 with the tongue 48 of the cartridge 42 being placed in the groove 47 of the holding member 46. The set screw 58 is set in a manner such that the holding member 46 holds the cartridge 42 in a position such that the material in the chamber 43 of cartridge 42 is contiguous with the surface of drum 10, and the outer perimeter of the open end of cartridge 42 is closely adjacent to, but not contiguous with the surface of drum 10. The holding member 46 is maintained in this position by the resilient member 56.

The motor (not shown) for rotating shaft 44 is operated upon operation of the motor (not shown) for driving drum 10 and, accordingly, upon rotation of the

drum 10, the shaft 44 in chamber 43 of cartridge 42 rotates the baffles 45, and the combined action of the rotating baffles 45 and the rotating drum 10 contiguous with the material in chamber 43 causes the material to flow within the chamber 43 contiguously over the surface of the drum 10, entrapping any toner remaining thereon. The continuous flow of the material in the chamber 43 of cartridge 42 kneads the material to effect mixing thereof and thereby a new surface of material is continuously passed in contact with the surface of drum 10 to thereby remove remaining toner particles therefrom.

The cartridge 42 may be easily replaced with another cartridge of material, upon the material therein ceasing to operate efficiently, but first loosening the screw 57 and pivoting the resilient member 56 away from contact with the holding member 46, followed by pivoting the holding member 46 away from the drum 10 to provide access to the cartridge 42. The cartridge 42 may be easily lifted from the holding member 46 and another cartridge of material inserted therein.

Numerous modifications and variations of the present invention are possible within the spirit and scope thereof. Thus, for example, in some cases the rotating baffles may be omitted and the material in the housing is caused to flow by contact friction with the surface of the rotating drum. Alternatively, a series of fixed baffles may be provided along the interior surface of the housing to enhance mixing of the material flowing within the housing. It is also to be understood that mixing of the material may be effected in a manner other than with baffles with the mixing preferably being effected in a manner such that the material is kneaded while flowing over the surface.

As a further modification, the interior of the housing for the material may be provided with a suitable heat transfer means to either heat or cool the material therein, with such heating or cooling providing a temperature at which the material has the desired flow properties. The heating or cooling means may be employed in conjunction with or without a rotating baffle to enhance the flow. In general, the use of a heating or cooling means is not preferred as the result of the necessity to maintain such heating or cooling means activated during periods when the machine is not in operation in order for the cleaning material to perform its function immediately upon activation of the machine.

The invention has been particularly described with reference to an electrophotographic process employing a rotating drum, but it is to be understood that the present invention is equally applicable to the cleaning of an electrophotographic surface in a form other than a drum; e.g., a rotating belt.

Similarly, the invention is equally applicable to the removal of residual toner in processes other than an electrophotographic process. Thus, for example, the present invention is applicable to other electrostatographic processes; e.g., an electrostatographic printing process in which a latent electrostatic image is formed by pulsing electrodes, in which the surface upon which an electrostatic image is developed is to be cleaned of residual toner prior to reuse thereof. Consequently, the applicability of the present invention is not limited to any particular electrostatographic recording surface, the manner in which the latent image is formed or the manner in which the toner is employed for developing the image.

Although the invention has particular applicability to the cleaning of an electrostatographic recording surface, it is to be understood that the teachings of the invention are also applicable to removing particles other than toner from surfaces other than electrographic recording surfaces.

The invention will be better described with respect to the following example which further illustrates the present invention, but it is to be understood that the scope of the invention is not to be limited thereby. Unless otherwise specified, all parts are by weight.

EXAMPLE

A toner comprising a styrene-n-butyl methacrylate copolymer, polyvinyl butyral and carbon black, produced as disclosed in Example I of U. S. Pat. No. 3,079,324 to Insalaco is used to develop an electrostatic latent image formed on a flat selenium plate charge to 700 volts. The power image is transferred using 700 volts, and the residual toner on the plate removed by rolling contact with silicone putty (G-E SS91 Silicone Bouncing Putty) at a contact pressure of less than 10 lbs./in.² and a cleaning speed of approximately 2 in./sec.

This is done over approximately ten copy cycles without loss of image quality, indicating effective removal of residual toner from the plate.

The present invention is particularly advantageous in that the cleaning of the electrostatographic recording surface is effected with a simple system which is small and, therefore, may be employed in small machines. Furthermore, power requirements are low as the result of the elimination of the centrifugal blower required to create a vacuum in the brush cleaning type of system. In addition, the cleaning material is easily replaced and is non-abrasive with respect to the electrostatographic recording surface. These and other advantages should be readily apparent from the teachings herein.

Numerous modifications and variations of the present invention are possible in light of the above teachings and, therefore, within the scope of the appended claims, the invention may be practiced in a manner other than as particularly described.

What is claimed is:

- 1. A process for removing toner particles from (a) an electrostatographic recording surface, comprising: flowing over and in contact with the surface a mass of a soft, non-tacky, thixotropic, solid material to entrap the particles on the surface within the material.
- 2. The process as defined in claim 1 and further comprising: continuously mixing said mass of solid material

to present new surface areas in contact with the surface.

- 3. A process for removing residual toner from an electrostatographic recording surface, comprising: confining a mass of an inert, soft, non-tacky solid material which is substantially stiff at rest and flows as a solid mass upon the application of a low shearing stress adjacent to the recording surface with a portion of the mass being in contact with the recording surface; and

subjecting said material to a shearing stress to cause said material to flow over and in contact with said recording surface to entrap said toner particles within the material and thereby remove said toner particles from the surface.

- 4. The process as defined in claim 3 and further comprising mixing said material while a portion of said material is flowing over said recording surface to thereby continuously renew the surface of the material passed in contact with the recording surface.

- 5. The process as defined in claim 4 wherein at least a part of shearing stress is applied by relative movement between said material and said recording surface.

- 6. An apparatus for removing residual toner particles from (a) an electrostatographic recording surface, comprising:

a housing, said housing having an open-end adjacent a surface having residual particles, said housing containing a mass of a soft, inert, non-tacky solid material which is substantially stiff at rest and flows as a solid mass upon the application of a shearing stress, a portion of said material being in contact with the surface at the open-end of the housing, whereby upon relative movement between the surface and housing said mass of material flows over said surface entrapping the particles retained on the surface to thereby remove the particles from the surface.

- 7. The apparatus as defined in claim 6 wherein said surface is an annular electrophotographic recording surface.

- 8. The apparatus as defined in claim 7 and further comprising: mixing means in the housing to mix said material contained therein and thereby renew the surface of material passed in contact with said recording surface.

- 9. The apparatus as defined in claim 8 and further comprising: a resilient member in contact with said housing biasing said housing toward the recording surface to maintain said material in the housing in pressure contact with said recording surface.

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