

[54] CLEANING APPARATUS

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 [22] Filed: Nov. 8, 1971
 [21] Appl. No.: 196,538

Related U.S. Application Data

- [63] Continuation of Ser. No. 873,870, Nov. 4, 1969, abandoned.
 [52] U.S. Cl. 15/1.5, 15/256.52
 [51] Int. Cl. G03g 15/00
 [58] Field of Search 15/1.5, 3, 4, 102, 100, 256.5, 15/256.52, 256.51, 256.53; 118/70, 637, DIG. 23; 117/17.5; 134/1, 9; 355/15; 317/262 A; 95/1 A; 68/13; 96/88

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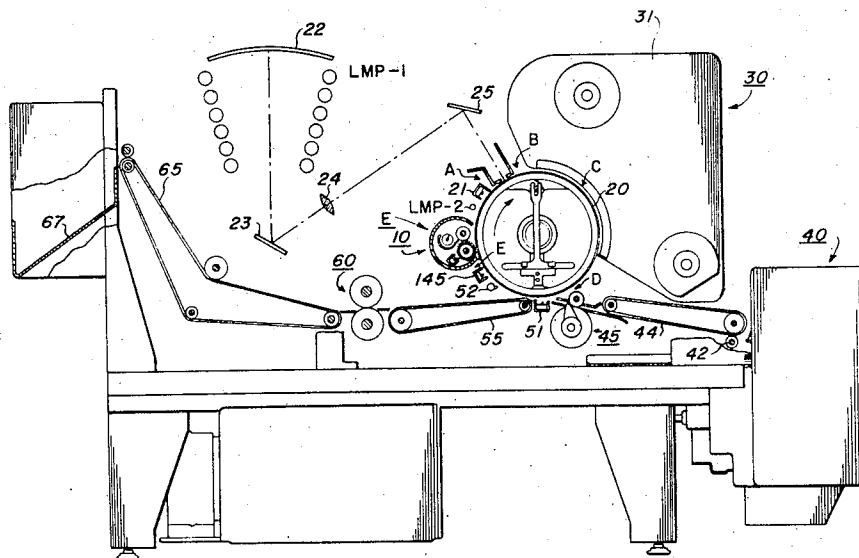
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[57]

ABSTRACT

Apparatus is herein disclosed for cleaning residual toner particles from a photosensitive member. A fibrous brush is arranged to move in an endless path to first wipe the brush fibers across the member and then over a biased transfer roll. Prior to contacting the transfer roll, the brush fibers and toner collected thereon are subjected to a corona discharge capable of charging the toner and fibers to a polarity opposite to that of the transfer roll wherein sufficient electrostatic contrast is produced to effect an efficient transfer of toner from the brush to the roll surface.

8 Claims, 5 Drawing Figures



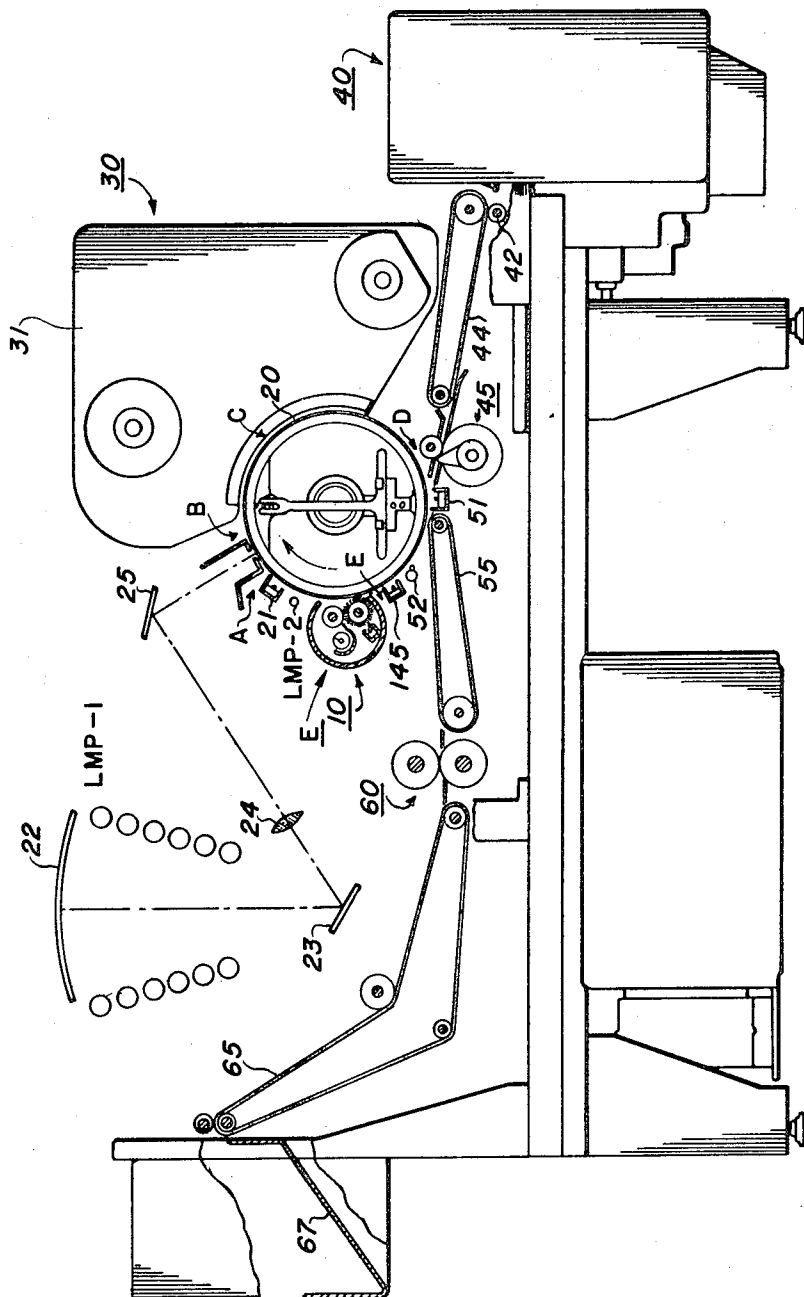


FIG. 1

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FIG. 2

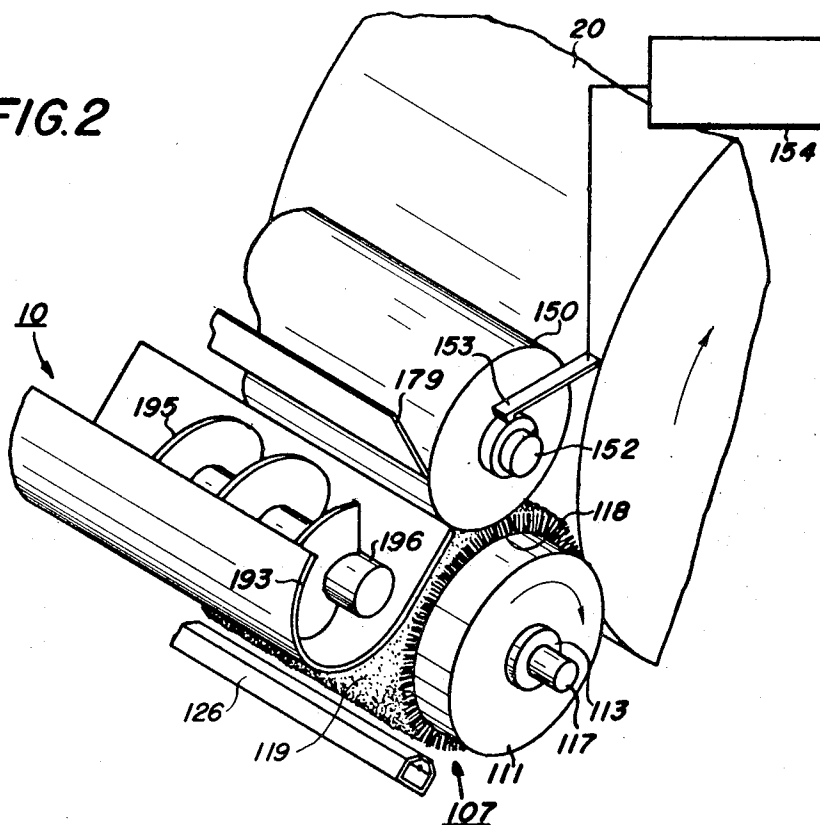
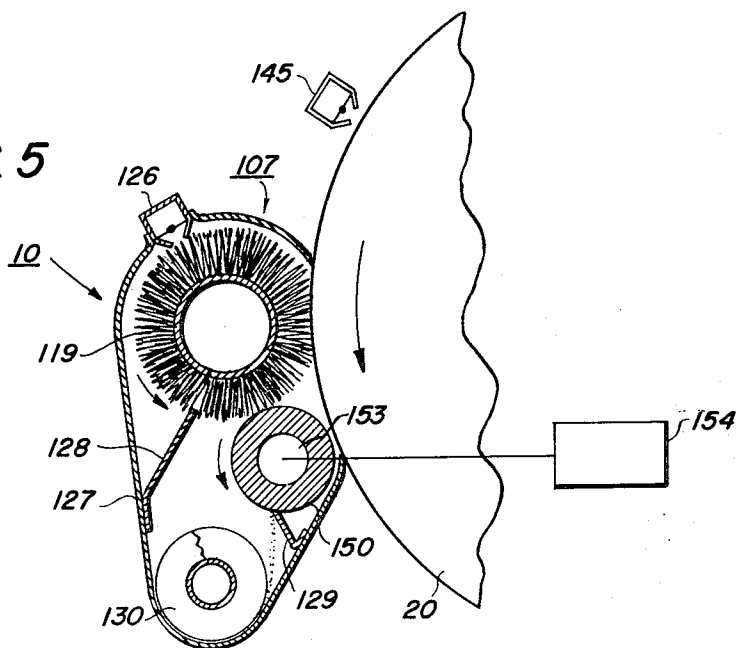


FIG. 5



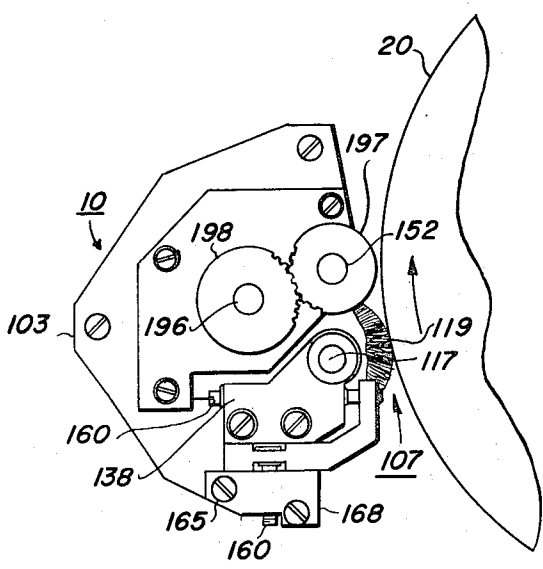


FIG. 3

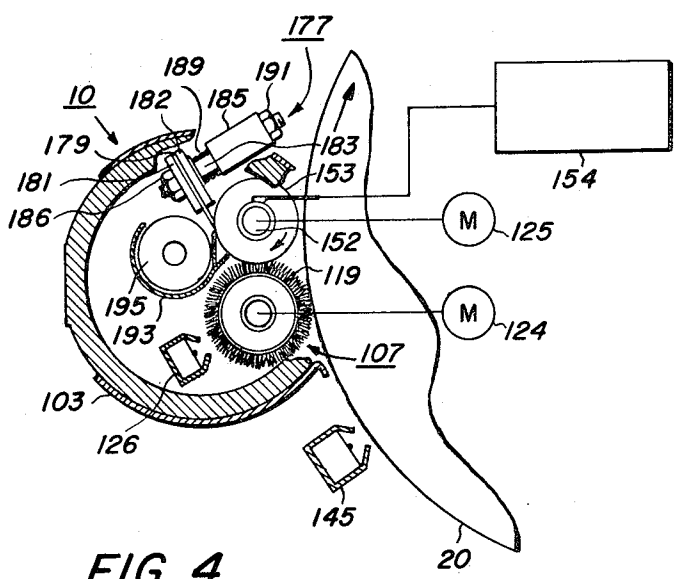


FIG. 4

CLEANING APPARATUS

This application is a continuation of Ser. No. 873,870, filed Nov. 4, 1969, and now abandoned.

This invention relates to apparatus for removing particulate material from a surface upon which the material is supported.

More specifically, this invention relates to improved apparatus for cleaning charged toner particles from an electrostatic recording surface of the type suitable for use in the automatic xerographic reproducing process. In the xerographic process, a uniform electrostatic charge is placed upon a photoconductive member and the charged member then exposed to a light image of an original so as to selectively dissipate the charge to form a "latent electrostatic image" of the original. The latent image is then developed by depositing finely divided charged toner particles upon the photoconductive surface: the charged toner being electrostatically attracted into the imaged areas to create a visible replica of the original. The developed image is then usually transferred from the photoconductive member to a final support material and the toner image fixed thereto to form a permanent record corresponding to the original.

In the practice of automatic xerography, a reusable photoconductive plate is generally arranged to move in an endless path through the various processing stations wherein a visible toner image is formed on the photoconductive surface. The toner image is then transferred to a final support material, such as paper or the like, and the photoconductor prepared to be used once again in the reproducing process. Although a preponderance of the toner image is transferred to the final support material during the transfer operation, some toner material is unavoidably left behind on the photoconductive surface as residuum. This residual toner must be removed from the plate in some manner to avoid degrading subsequent copies reproduced on the photoconductor.

One of the most successful and widely used methods of cleaning residual toner material from a photoconductive plate is by means of the conventional brush cleaning technique as disclosed by Walkup in U. S. Pat. No. 2,832,977. In the Walkup device, a rotatable brush is mounted in close proximity to the photoconductive surface to be cleaned and the brush rotated so that the brush fibers continually wipe across the photoconductor in a manner to produce the desired cleaning. In order to reduce the dirt level within the machine, a vacuum system is provided which pulls loosely held residual toner particles from the brush fibers and exhausts the toner from the apparatus. To assist the vacuum system in removal of the toner material, Walkup treats his brush fibers with a neutralizing ion spray which is intended to negate any triboelectrification generated when the brush wipes across the photoconductive surface. Although the Walkup vacuum and neutralization system is capable of reducing the dirt level by removing loosely held soils from the brush fibers, it has been found that the brush nevertheless becomes contaminated after extended usage to a point where the brush must be replaced within the cleaning system.

With the advent of new processing techniques and materials, machine speeds have now reached a level

where the conventional brush cleaning technique can no longer be effectively utilized. In order to overcome some of the difficulties found in the art, while at the same time preserving the advantages of brush cleaning, Fisher et al., in copending application Ser. No. 755,268, discloses cleaning apparatus adapted for use in a high speed automatic reproducing machine. In Fisher, a fibrous cleaning brush, similar to that disclosed by Walkup, is used to remove residual toner particles from a photoconductive surface. However, after the photoconductive surface is cleaned, a second cleaning operation is performed on the brush in which residual toner material collected on the brush is electrostatically transferred from the brush fibers to a biased transfer member. In order to create the proper electrostatic relationship between the cleaning members, Fisher supports his fibrous brush upon a non-conductive core and biases the core in a manner to attract toner from the photoconductive surface toward the brush. Although the biased core arrangement has proven to perform satisfactorily, it has been found that a more efficient cleaning operation can be affected when an electrostatic relationship is established between the brush fiber and the transfer member.

SUMMARY OF THE INVENTION

It is therefore, an object of this invention to improve cleaning apparatus for removing particulate material from a support surface.

Another object of this invention is to improve biased brush cleaning apparatus for removing charged toner particles from a photoconductive support surface.

A still further object of this invention is to enhance the electrostatic transfer response of a biased brush cleaning apparatus.

Yet another object of this invention is to improve the efficiency of a bias brush cleaning system.

These and other objects of the present invention are attained by means of an electrically isolated brush member arranged to move in an endless path so that the brush fibers wipe first across a support surface to remove particles supported thereon and then across a biased transfer member, a corona generator positioned intermediate the support surface and the transfer member being arranged to induce a charge in the brush fibers and particles collected thereon of a polarity opposite the polarity of the biased transfer roll whereby the collected particles are efficiently transferred from the brush to the roll.

For a better understanding of the 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 conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic sectional view of an automatic reproducing machine incorporating the cleaning apparatus of the present invention and illustrating the processing components in section to better present a machine environment for the present invention;

FIG. 2 is a partial perspective view with parts broken away illustrating details of the cleaning apparatus of the present invention;

FIG. 3 is an end view of the cleaning apparatus shown in FIGS. 1 and 2;

FIG. 4 is a side elevation in section illustrating further details of the present cleaning apparatus;

FIG. 5 is a sectional side elevation illustrating a second embodiment of the cleaning apparatus of the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to FIG. 1, there is shown schematically a high speed automatic xerographic reproducing machine incorporating cleaning apparatus in accordance with the present invention.

The automatic reproducing machine comprises an electrostatic recording plate 20 including a photoconductive or light receiving surface which is placed on a conductive backing and formed in the shape of a drum. The photosensitive drum is mounted on a shaft and the shaft journaled for rotation in the machine frame. Although not shown, means are provided to rotate the drum in the direction indicated by the arrow to cause the photoconductive surface to pass sequentially through a plurality of processing stations. For the purpose of the present disclosure, the several xerographic processing stations in the path or movement of the drum surface are described functionally as follows:

A charging station, at which a uniform positive electrostatic charge is placed on the photoconductive surface by means of a corona charging device 21 comprising an array of one or more discharge electrodes extending transversely across the drum surface;

An exposure station B, at which a light or radiation pattern of the originals to be reproduced is projected onto the drum surface to dissipate the charge thereon in the exposed areas thus forming a latent electrostatic image of the original;

A development station C, at which a xerographic developing material, including charged toner particles having a potential opposite that of the electrostatic latent image, are cascaded over the moving drum surface whereby the toner particles are caused to adhere to the latent image making the image visible in the configuration of the original being reproduced;

A transfer station D, at which the developed powder image is electrostatically transferred from the photoconductive surface to a final support material; and

A drum cleaning and discharge station E embodying the teachings of the present invention, at which residual toner is removed from the drum surface and the operation of which will be explained in a greater detail below.

In practice, the original to be reproduced is placed upon stationary transparent platen 22 where the document is uniformly illuminated by means of two banks of lamps, herein generally referred to as LMP-1, each bank being arranged along an opposing side of the platen. The illuminated original is scanned by means of an oscillating mirror assembly adapted to focus a flowing light image of the original upon the moving drum surface. The mirror assembly includes a stationary object mirror 23 mounted below the platen which reflects a light image of the original through a fixed lens element 24 onto a movable image mirror 25. The image mirror is arranged to oscillate in timed relation with the moving drum to focus successive incremental reflected areas at the platen through a slotted light shield 26 onto the photoconductive surface in synchronization with

the drum to create an undistorted light image of the original.

Adjacent to the exposure station is a developing station C in which is positioned a developer apparatus 30 including a housing 31 having a sump area for accumulating a quantity of two component developer material. Although not shown, a bucket type conveyor is used to carry the developer material from the developer sump to the upper part of the housing where the developer is cascaded over the photoconductive surface to effect image development.

Positioned next and adjacent to the developer station in the direction of drum rotation is an image transfer station D including a sheet feeding mechanism arranged to deliver cut sheets of final support material seriatim into contact with the moving drum surface. The sheet feeding mechanism includes a sheet supply tray 40 adapted to feed individual sheets from a stack into advancing rollers 42. The advancing rollers cooperate with a moving vacuum belt transport 44 to convey the sheets one by one to a sheet registration mechanism 45 positioned next to the transfer station. The sheet registration mechanism momentarily arrests and aligns each individual sheet of material and then forwards the sheet into moving contact with the drum surface in registration with the previously formed powder image thereon. The transfer of the xerographic powder image from the drum surface to the final support material is then affected by means of a corona transfer device 51 similar to that employed at the charging station.

In operation, the electrostatic field created by the corona transfer device causes the support material to become electrostatically bonded or tacked to the drum surface whereby the support material is made to move in synchronous relation with the drum surface. To remove the final support material from the drum there is positioned a stripping apparatus 52 immediately subsequent to the transfer station. A device of this type is disclosed in U. S. Pat. No. 3,062,536 to Rutkus et al. and includes a plurality of small diameter orifices capable of being supplied with an aeriform fluid under pressure. A pulsator is adapted to release jets of pressurized air through the outlet orifices against the drum surface slightly in advance of the arrival of the support material. The pulse is of sufficient duration to lift the leading edge of the sheet from the drum surface so that the sheet falls in contact with an endless vacuum conveyor belt 55. The vacuum conveyor operatively engages the leading edge of the sheet to complete the stripping operation and transport the sheet to a fixing device 60.

At the fixing station the powder image is permanently fixed to the sheet by means of combined heat and pressure energy supplied by the coacting rolls shown in FIG. 1. After image fixing, the copy sheet is carried by means of a conveyor 65 to a discharge station where the individual copies are collected external the reproducing apparatus in a catch tray 67.

The next and final station in relation to the motion of the drum surface is the cleaning station, generally referenced by the number 10, and which embodies the apparatus of the present invention. Referring now specifically to FIGS. 2-4 there is shown in greater detail the cleaning apparatus of the instant invention.

Cleaning apparatus 10 comprises a housing 103 secured by any suitable means to the machine frame which partially encloses an elongated cylindrical brush, generally designated 107. The brush assembly includes a core 111 and two axially aligned end shafts 117 which rotatably support the brush in the housing. The end shafts are journaled for rotation in insulating bearings 113 and bearings secured in the end walls of housing 103. A fibrous brush material 118 is securely affixed to the outside surface of core 111 with the brush fibers 119 extending outwardly in a radial direction from the core member. Although not shown, one of the end shafts 117 extends external of housing 103 and is connected by any suitable non-conductive means to a drive means 124 (FIG. 2) capable of rotating the core mounted brush in the direction indicated. The brush is supported within the housing so that the brush fibers contact the outer drum periphery and are caused to wipe across the photoconductive surface as the brush is rotated. In order to obtain a more efficient wiping action, it is desirable generally to move the brush fibers in opposition to the motion of the photoconductive surface so that the brush can be driven within a relatively wide range of operating speeds, either above or below the peripheral speed of the drum surface, while at the same time producing efficient removal of the toner particles. Preferably, the peripheral speed of the brush is held within a range from about one-half to about three times that of the drum surface speed. Alternately, the brush member can be driven in the same direction as the drum surface, however, it should be clear that in this arrangement the brush must be driven at a higher speed than the drum surface to produce a relative motion between the two which is sufficient to permit the brush fibers to perform the cleaning operation.

Preferably the fibers 119 of the cleaning brush are made from a suitable non-conductive material which is relatively insensitive to changes in humidity. Typical cleaning fiber materials are acrylic velvets, orlon, polypropylene, nylon, rayon, acetates, mohair, arnel, glass, dynel, dacron, cotton fibers, and other natural and synthetic fibers or filamentary materials and mixtures thereof. Furthermore, to enhance the attraction of the toner particles to the cleaning fibers, the fibers may be made of, or coated with, a material having a triboelectric attraction relative to the toner materials. Typical materials having such a relationship are described in U. S. Pat. No. 2,618,551 to Walkup, U. S. Pat. No. 2,618,552 to Wise, and U. S. Pat. No. 2,638,416 to Walkup and Wise. The cleaning fibers 119 desirably have mechanical properties capable of producing a good wiping action as they are pulled across the drum surface whereby the toner particles are loosened and encapsured in the brush fibers. The cleaning fibers may extend to any suitable length, and this length can effectively range from about one-sixteenth of an inch to about five-sixteenths of an inch for most of the materials herein described. A range from about one-eighth of an inch to about three-sixteenths of an inch for fiber densities ranging from about 10,000 to 750,000 fibers per square inch, however, is desirable.

As shown in FIG. 1, a pre-cleaning corotron 145 is positioned downstream in the direction of drum travel from the image transfer station and is arranged to act upon the drum surface prior to the drum entering the

brush cleaning station. The pre-cleaning corotron basically functions to neutralize any residual charge remaining on the drum surface after transfer and also will reduce the electrostatic bond holding the residual toner to the drum thereby aiding in the removal of the toner in the cleaning station. Corotron 145 can be either an AC or DC device, however, an AC corotron is preferred in most xerographic embodiments. In practice, it has been found that the current ranging from about 2 to 10 micro amps for a corona generating device as herein disclosed is sufficient to produce the required neutralization of the surface charge and to reduce the electrostatic bond holding the toner to the photoconductive surface to a level wherein the toner can be readily cleaned from the drum surface by the cleaning brush. The corona generating device 145 is suitably powered by any suitable source of AC voltage as are known and used in the art.

The residual toner, after being treated by corotron 145, is then moved on the drum surface into operative communication with the cleaning brush 107 wherein the toner particles are transferred from the drum surface to the brush fibers. Cleaning of the drum surface is believed to take place primarily by means of a mechanical transfer mechanism. It should be noted that a positive charge is induced in the toner material as it moves under corotron 51 so that any unneutralized particles entering the cleaning station will most probably be positively charged. However, as will be explained below, the brush fibers moving into contact with the drum surface are at a negative potential so that an electrostatic relationship is established between the fibers and the residual toner which aids in the removal of the toner from the drum surface.

Regardless of the transfer mechanism involved, the residual toner particles on the drum surface are removed from the drum surface and deposited onto the fibers. Most of the preferred brush materials herein disclosed are removed sufficiently in the triboelectric scale from known photoconductive materials so that a triboelectric charge generally is induced in the hair fibers as they are wiped across the drum surface. Unavoidably, therefore, the toner particles collected on the brush tend to become electrostatically bonded to the brush fibers. A corona discharge device 126 is arranged to spray the toner collecting brush fibers with an ion discharge of sufficient magnitude and polarity to at least neutralize the charge on the brush fibers and to reduce electrostatic bond between the fibers and the toner material. Here again the corona generator can be either an AC or DC device. Because the generator will be exposed to stray dirt producing particles which may impede the operation of the device, it is desirable to use a self cleaning corotron as disclosed by HUDSON in U. S. Pat. No. 3,324,291. In the alternative, the generator can be formed of a series of pin-like discharge electrodes capable of being excited to produce a corona discharge at the tips of the individual pins. For efficiency of operation, it is preferred that the ion discharge produced be of a magnitude sufficient to drive both the toner material and the brush fibers to a relatively high level. Furthermore, the charge induced in the toner material and the brush fibers should be opposite in polarity to the charge induced by the transfer corotron so that the brush fibers, when brought into contact with

the drum surface, are in a condition to electrostatically assist in the cleaning process.

After the toner particles have been treated with the corona discharge, the toner particles are removed from the brush to prevent the particles from being redeposited or dragged across the drum surface. To accomplish this task, there is an electrically biased transfer roll 150 positioned in the path of the cleaning fibers 119 which is connected to an external source of power 154, the source of power being arranged to bias the roll to a polarity opposite to that induced on the toner particles and the brush fibers. The charge on the transfer roll is also of sufficient magnitude to establish a directional electrostatic force field capable of acting on the toner particles so as to force the particles from the brush fibers to the roll surface. Transfer roll 150 is mounted for rotation on a shaft 152 to move in the direction opposite that of the cleaning brush in order to produce good relative movement therebetween. It should be understood, of course, that here again the roll may be rotated in a reverse direction by making appropriate changes in the speed of the associated cleaning members to produce the desired relative motion between the two members.

Transfer roll 150 is made from any suitable conductive material and may be fabricated in the form of a web, or cylinder, and can even be a solid single piece member. The roll is electrically biased by means of a brush member 153 connected to a DC voltage source 154 capable of biasing the roll surface to a polarity opposite that induced in the brush fibers. The DC voltage applied to the transfer roll may range from about 0 volts to about 5,000 volts. With an interference between the brush fibers and the periphery of the roll surface from about one-fourth to about one-half the length of the hair fibers, efficient toner migration is noted when the transfer roll is biased to approximately 4,000 volts.

To vary the interference between the cleaning fibers 119 and the surface of the transfer roll, adjusting screws 160 are provided in housing 103 which, when turned, enable support plate 138 and shaft 117 supported thereon, to be moved towards or away from the transfer roll surface. Tightening screw 165, received in support plate 168, assures that shaft 117 will be held firmly in place during the cleaning operation.

The drive mechanism 125 for the (FIG. 4) transfer roll is arranged to move the roll at a speed ranging from about the speed of the brush assembly to more than double the speed of the brush assembly at its upper limit. It has been found that when the bias roll is moved opposite in direction to that of the cleaning brush at approximately the same speed an efficient transfer of toner between the two members is produced. Driving forces to the bias roll can be transmitted in any suitable manner such as a timing belt or pulley operatively connected to the drive motor 125.

In order that the transfer roll present a continuous cleaning surface to the brush and also be facilitate recovery of the residual toner particles so that they may be returned and reused in the development system, a scraper assembly 177 is positioned in the path of movement of roll 150. Scraper assembly 177 comprises a resilient blade member 179 secured in contact with the roll surface by blade holder elements 181, 182. Blade

holder elements 181, 182 are connected to the housing 103 by one or more adjustable bolt members 183, each of which is received through an insulating block member 185 secured to the housing. A nut 186 constrains the blade holder elements against a compressive spring 189 seated against insulating block 185. In this manner, the contact pressure of the blade member 179 against the roll surface can be adjusted by simply turning nut 191 received by bolt number 183 until the desired pressure is obtained.

As the toner particles are removed from the surface of transfer roll by the blade element, the particles are collected in a tray 193. The toner is then removed from the tray by means of an auger 195 which is rotatably mounted on shaft 196. The auger is driven from the transfer roll shaft 152 through means of gears 197, 198 connected to shaft 152 and 196, respectively. As auger 195 rotates through the toner material collected in the tray the material is forced towards a collection of reservoir area where the toner is collected and from which the toner is transported by any suitable means back to the development station.

FIG. 5 illustrates a second arrangement embodying the teachings of the present invention in which the brush member 107 is positioned in the upper part of the cleaning housing 127. As the brush rotates in the direction indicated, toner particles are removed from the drum surface 20 in the manner herein described. A corotron 126 is positioned to treat the brush fibers downstream from the drum cleaning zone prior to the fibers contacting biased transfer roll 150. The transfer roll is electrostatically biased by means of a suitable source 154 acting through commutator 153. The surface of the roll is cleaned by a flexible doctor blade 129 which causes the toner to fall into the sump areas of the cleaning housing 127. An auger 195 is rotatably supported in the sump of the housing and is arranged to remove the residual toner to a remote collecting station. In this embodiment, a flicker bar 128 is secured to the side wall of the housing and arranged to penetrate into the fibrous brush material. As the brush is rotated, the flicker bar mechanically dislodges the toner particles from the brush fibers so that these particles either fall into the sump or are easily transferred to the biased roll.

While this invention has been described with reference to the structure disclosed herein, it should not be confined to the details as set forth since it is apparent that various modifications to this apparatus can be made. This application is intended to cover such modification or changes that may come within the purposes of the improvement or the scope of the following claims.

What is claimed is:

1. Apparatus for removing a finely divided particulate material from a surface to which said material is loosely adhering including,
 - an electrically isolated brush member arranged to move in an endless path and being positioned so that a portion of the fibers of said brush member are in contact with said surface,
 - means to move said brush at a rate wherein the brush fibers wipe across said surface to remove charged particles therefrom,

a first corona generating device positioned adjacent to said brush and being arranged to induce a charge of a first polarity in said brush fibers and the removed particles collected thereon,
 an electrically biased transfer roll member positioned to move in an endless path in contact with a portion of the charged brush fibers and the removed particles collected thereon, and
 a blade member riding in contact with the roll surface and being adapted to mechanically remove particles from the surface of said roll member.

2. Apparatus for removing a finely divided particulate material from a surface to which said material is loosely adhering including,
 an electrically isolated brush member adapted for movement about an endless path with a portion of the fibers of said brush member being in contact with a portion of said surface,
 means for producing a relative movement between said surface and said brush member to wipe the fibers of said brush member across said surface to remove charged particulate material therefrom,
 corona generating means positioned adjacent said brush member adapted when energized to induce a charge of a predetermined polarity on the fibers of said brush member and said particulate material collected thereon,
 an electrically isolated transfer member adapted for movement about an endless path with a portion of said transfer member contacting a portion of the fibers of said brush member,
 means for electrically biasing said transfer member to a polarity opposite to the polarity of said brush member and said particulate material thereon to produce an electric field between said transfer member and said brush member for transferring particulate material on said brush member to said transfer member, and
 means supported in contact with said transfer member for mechanically removing particulate material from said transfer member.

3. Apparatus for removing a finely divided particulate material from a surface to which said material is loosely adhering including,
 an electrically isolated brush member adapted for movement about an endless path with a portion of the fibers of said brush member being in contact with a portion of said surface,
 means for producing a relative movement between said surface and said brush member to wipe the fibers of said brush member across said surface to remove charged particulate material therefrom,
 corona generating means positioned adjacent said brush member adapted when energized to induce a charge of a predetermined polarity on the fibers of said brush member and said particulate material collected thereon,
 an electrically isolated transfer member adapted for movement about an endless path with a portion of said transfer member contacting a portion of the fibers of said brush member,
 means for electrically biasing said transfer member to a polarity opposite to the polarity of said brush member and said particulate material thereon to produce an electric field between said transfer

member and said brush member for transferring particulate material on said brush member to said transfer member,
 means supported in contact with said transfer member for mechanically removing particulate material from said transfer member, and
 means for collecting particulate material removed from said transfer member and for transporting the collected particulate material to a supply reservoir.

4. In a xerographic reproducing apparatus in which charged toner particles are deposited by a development system onto the surface of a photoconductive member to render a latent electrostatic image of the image to be reproduced visible and the developed image is then transferred to a support member, apparatus for removing residual toner particles from the photoconductive member comprising,
 an electrically isolated brush member adapted for movement about an endless path with a portion of the fibers of said brush member being in contact with a portion of the surface of said photoconductive member,
 means for producing a relative movement between said photoconductive member and said brush member to wipe the fibers of said brush member across the surface of said photoconductive member to remove charged toner particles therefrom,
 corona generating means positioned adjacent said brush member adapted when energized to induce a charge of a predetermined polarity on the fibers of said brush member and said toner particles collected thereon,
 an electrically isolated transfer member adapted for movement about an endless path with a portion of said transfer member contacting a portion of the fibers of said brush member,
 means for electrically biasing said transfer member to a polarity opposite to the polarity of said brush member and said toner particles thereon to produce an electric field between said transfer member and said brush member for transferring toner particles on said brush member to said transfer member,
 means supported in contact with said transfer member for mechanically removing toner particles from said transfer member, and
 means for collecting toner particles removed from said transfer member and for returning the collected toner particles to the development system.

5. The apparatus of claim 1 wherein the brush member is moved in opposition to the movement of the moving surface.

6. The apparatus of claim 5 further including means to collect particles removed from said roll surface.

7. The apparatus of claim 1 further including a second corona generating device positioned adjacent to said moving surface and being adapted to induce a neutralizing charge over said surface prior to said particles moving into contact with said rotating brush.

8. The apparatus of claim 7 further including mechanical means positioned between the said first corona generating device and said bias transfer member being adapted to mechanically dislodge loose-

ly held particles from the brush surface prior to the brush contacting said transfer member.

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