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G. T. SEVERYNSE

3,668,008

IONIZED AIR CLEANING DEVICE

Filed June 4, 1969

2 Sheets-Sheet 1

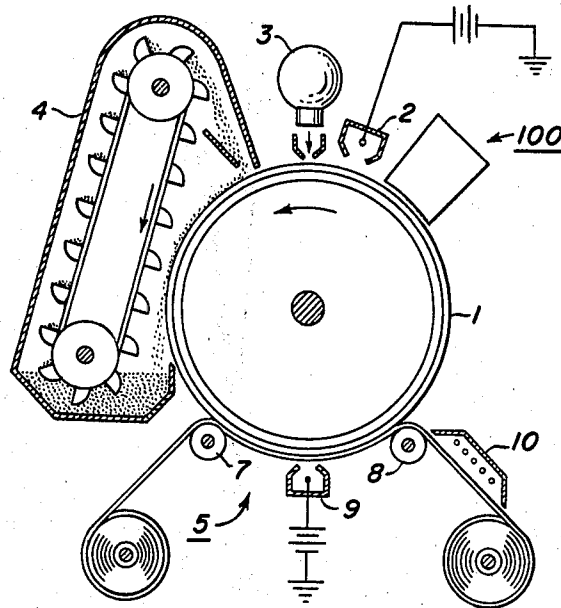


FIG. 1

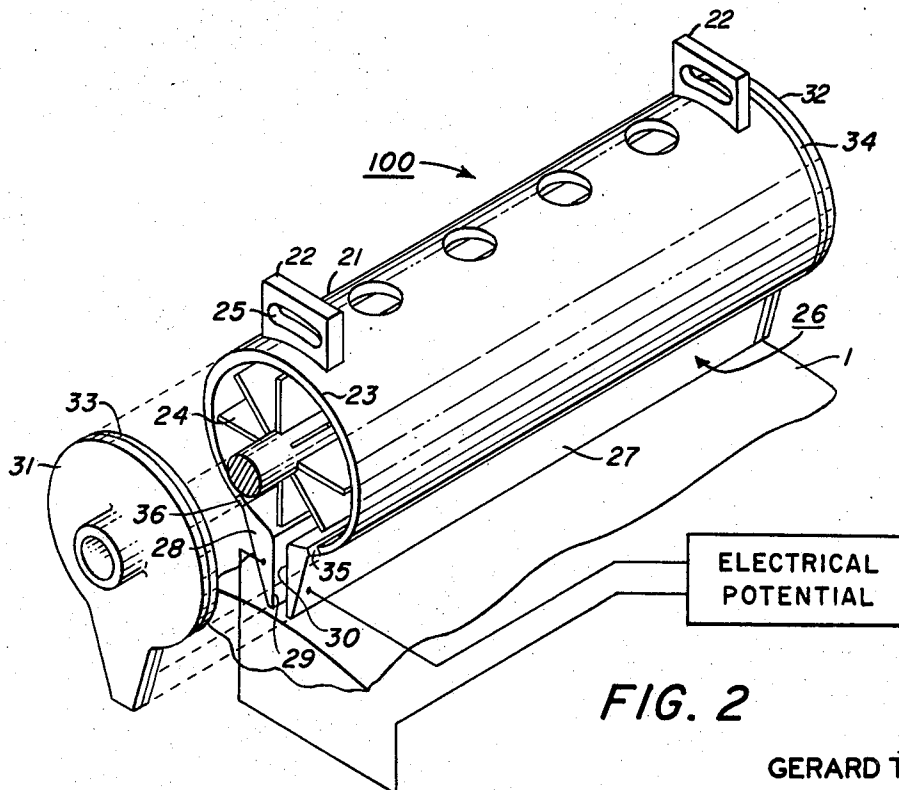


FIG. 2

INVENTOR
GERARD T. SEVERYNSE

BY

Donald F. Deacy
ATTORNEY

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G. T. SEVERYNSE

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2 Sheets-Sheet 2

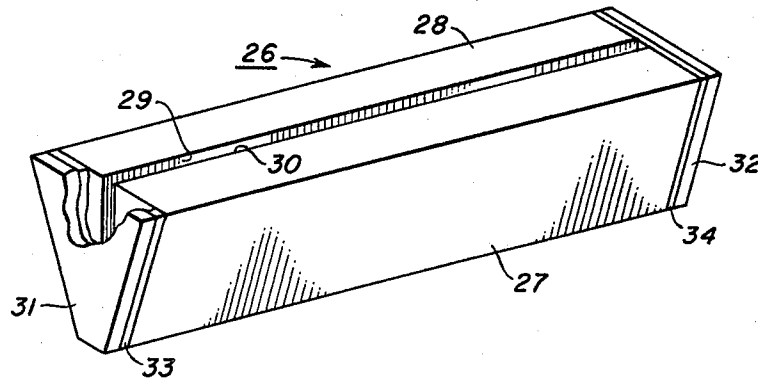


FIG. 3

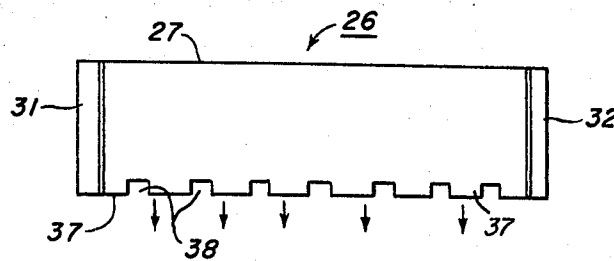


FIG. 4

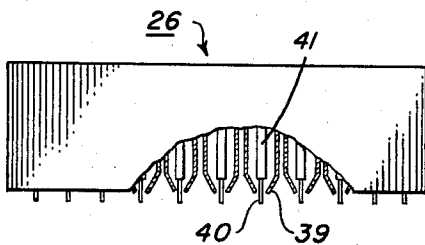


FIG. 5

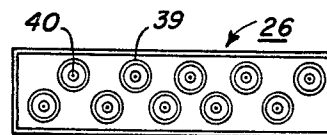


FIG. 6

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3,668,008

IONIZED AIR CLEANING DEVICE

Gerard T. Severynse, Fairport, N.Y., assignor to

Xerox Corporation, Rochester, N.Y.

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U.S. Cl. 134-1

8 Claims

ABSTRACT OF THE DISCLOSURE

Method and apparatus for cleaning a residual toner powder image bearing surface after transfer of substantially all of a charged toner image therefrom to a support medium. A flow of ionized air is directed to the surface and neutralizes any charge on the residual particles remaining on the surface after image transfer to allow the particles to be readily removed. A nozzle is utilized to direct the flow against the surface and ionizes the air flowing therethrough by applying a potential between two electrically insulated opposite sides of the nozzle.

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for cleaning residual toner powder from an electroscopic toner powder image bearing surface and, in particular, to an improved method and apparatus for neutralizing the charge on residual toner powder on a photoconductive insulating surface to facilitate easy removal of the particles.

More specifically, the invention relates to a cleaning method and apparatus adapted to clean residual toner powder images from a photoreceptor wherein ionized air flows to the surface to be cleaned and neutralizes the particles thereon to allow the particles to be readily removed. Neutralization of the particles is effected by creating an air flow through a nozzle which ionizes the flow to form ions of positive and negative polarities. The flow is directed onto the surface to neutralize the particles thereon. The nozzle ionizes the air by producing a corona discharge between the two parallel walls of the nozzle thereby ionizing the air flowing therebetween. The air, after passing from the ionizing nozzle, impinges against the residual particles on the surface to neutralize the charge on the particles and the flow itself carries off the neutralized material. Alternatively, the ionized flow may be directed against the surface to neutralize the particles and the neutralized particles removed by another convenient removal method such as a brush or vacuum nozzle.

Although not intended to be so limited, for convenience of illustration the cleaning device and method of this invention are described for use in an automatic xerographic reproducing machine. In the process of xerography, a xerographic plate comprising a layer of photoconductive material on a conductive backing is given an uniform electric charge over its surface and is then exposed to the subject matter to be reproduced by various projection techniques. This exposure discharges the plate in accordance with the light intensity reaching it, thereby, creating a latent electrostatic image on or in the plate.

Development of the image is effected by developers which comprise, in general, a mixture of suitable pigmented or dyed resin base powder, hereinafter referred to as toner, and a granular carrier material which functions to generate triboelectric charges on and to carry the toner. More specifically, the function of the carrier material is to provide a mechanical control of the toner or to carry the toner to an image surface and simultaneously provide almost complete homogeneity of charge polarity.

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In the development of the image, the toner powder is brought into surface contact with the photoconductive surface and held there electrostatically in a pattern corresponding to the latent electrostatic image. Thereafter, the developed toner powder image may be transferred to a support material to which it may be fixed by any suitable means such as heat fusing.

In high speed xerographic equipment, the photoconductive plate is often in the form of a drum or belt which allows the surface to sequentially pass through a plurality of xerographic processing stations. Such a moving photoconductive surface can thereupon be readily reused and another duplication cycle effected. However, in practice, transfer of the toner image to the support material is incomplete leaving a residual toner powder image on the photoreceptor surface. Such residual toner images are detrimental to the reuse of the surface and have an adverse effect on reproductions produced in subsequent operations of the xerographic device. One cause of the incomplete transfer of the toner is that toner generally comprises a range of sizes, and the larger particles tend to readily transfer while the smaller particles are apt to remain attached to the photoconductor because of the electrostatic attraction of these charged particles to the charged plate. The smaller particles are more difficult to transfer to the support material, since they usually carry less electrostatic charge than larger toner particles and, therefore, require a greater electric field for removal from the photoreceptor than do the larger toner particles which result in less efficient transfer. The residual toner is electrostatically attached to the photoconductor by the charge that exist on the surface of the toner layer as well as at the interface between the toner powder and the photoreceptor surface. Generally, after transfer the residual toner powder has an electrical charge that varies in magnitude and even polarity depending on conditions, for example, such as relative humidity, temperature, the transfer current used to effect transfer of the toner powder to the support material, paper moisture content, and the composition of the developer material.

One known technique of removing residual images from a photoconductive surface after transfer has been by the use of a rotating brush. The brush cleaner is generally made of a soft material which rotates against the residual toner powder bearing surface to remove the residual particles. An example of such a cleaning system is disclosed in Walkup et al., U.S. Pat. 2,832,977, issued May 6, 1958 wherein a brush, having an electrical charge applied to its bristles, contacts the particles and attracts them from the drum. A vacuum system is operatively connected to the brush to remove the toner collected on the bristles to prevent inefficient cleaning or abrasion of the photoreceptive surface resulting from the accumulation of toner on the brush bristles.

Several problems are associated with the brush technique of cleaning the xerographic surface. One difficulty lies in the selection of the material of the brush itself since the brush must be soft enough not to damage or scratch the photoconductive surface and yet abrasive enough to remove the particles firmly fixed to the photoconductor by electrostatic attraction. Also, the brush material must be capable of retaining a sufficient charge to attract the toner particles in the manner intended. However, even after a careful selection of the brush material, damage can occur to the photoreceptor surface after repeated cleaning due to the abrasion of the brush fibers contacting the surface to remove residual toner firmly retained by electrostatic forces. Further, repeated cleaning causes the brush bristles to become weakened resulting in ineffective cleaning of the surface making it necessary to frequently replace these components. Such changing of the brush is

inconvenient and uneconomical in continued use of the xerographic equipment.

Another difficulty that arises in conjunction with brush cleaning is the accumulation of toner powder on the brush which results in toner being reapplied to the photoconductor surface as the brush becomes clogged. The accumulation requires the use of a vacuuming system to clean the brush which increases the machine size and expense as well as being ineffective in maintaining a completely clean brush. Also, brush cleaners do not sufficiently neutralize the charge on the toner particles even when the bristles are electrically biased and neutralization by a brush is particularly difficult when the toner charge varies in magnitude and polarity.

One technique devised as an attempt to overcome some of the problems presented by brush cleaning was the use of a web cleaner. An example of a web cleaner is disclosed in Eichorn, U.S. Pat. No. 3,190,198, issued June 22, 1965, wherein a cleaning web is brought into rubbing contact with a photoreceptor to remove the residual toner powder image. In practice, the web moves relative to the photoconductive layer at a slower speed than the photoreceptive surface and scrapes off the residual toner. However, as is the case with the brushes, the web is in frictional contact with the drum and it becomes difficult to apply sufficient pressure to remove the particles and yet not abrade the photoconductive layer. Further, the material used as a web must have such properties as to sufficiently clean the surface and yet again not to damage the photoreceptor. Often the web is coated with a toner collecting substance which leaves a residual coating on the surface and is detrimental in further use of the photoreceptor. Another difficulty of web cleaning is that a thin layer of toner can remain on the photoreceptor since it is usually not possible to apply the necessary pressure for adequate cleaning of electrostatically adhering particles. Generally, the particles that are not removed are the smaller particles which are electrostatically bonded to the photoreceptor after image transfer. It has been attempted in the prior art to place a charge on the cleaning web to facilitate removal of the toner through neutralization of the charge on the particles, but even in such a system the problem of abrasion on the drum and insufficient removal of the toner powder film still remains because such a charged web has proven relatively ineffective in neutralizing the varying magnitude and polarity of the charged toner. It, therefore, becomes desirable to utilize a cleaning technique which overcomes many of the aforementioned problems associated with prior art cleaning methods.

A copending application, Ser. No. 830,314, filed concurrently with the present application and entitled "Surface Cleaning By Ionized Flow," by Frederick W. Hudson, discloses a method and apparatus which overcomes many of the aforementioned problems presented by the prior art cleaning techniques. The copending application accomplishes this improved cleaning by directing a flow of air which has been ionized into negative and positive charges by corona wires against a surface bearing residual image particles to thereby neutralize the charge thereon and effect ready removal of the particles from the surface. Even though the copending application produces improved cleaning over prior art methods, it has been found that the technique utilizing corona wires to ionize the flow suffers from the drawback of creating ions in the flow at a location too remote from the surface. Thus, some of the positive and negative ions formed in the flow have an opportunity to recombine to lessen the amount and number of charged ions reaching the surface to be cleaned. Therefore, it is advantageous in ionized air flow cleaning to create the ionization of the air flow at a point as closely adjacent to the residual particles as possible to insure that a greater amount of charge is carried to the photoreceptive surface.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to improve the cleaning of charged particles from a surface.

Another object of this invention is to improve the method and apparatus for neutralizing residual toner powder images remaining on a photoreceptor surface after transfer of a toner image to a support member.

A further object of this invention is to improve the method and apparatus for ionizing air being impinged on a surface for the cleaning thereof.

These and other objects are attained in accordance with the present invention wherein there is provided a method apparatus for cleaning residual electroscopic toner particles from a surface by utilizing a flow of ionized air to neutralize the charge on the particles electrostatically affixed thereon. The air flow is created by any well known means such as a fan and is directed through a fluid conduit having a nozzle at its end confronting the surface to be cleaned. The flow in the method and apparatus of the present invention is ionized immediately adjacent the surface by utilizing the nozzle as an ion generator. The nozzle is formed of two adjacent conductive surfaces electrically insulated from each other and having an electrical potential applied between the two surfaces to create a corona discharge therebetween. The corona discharge ionizes the air flow passing through the nozzle into positive and negative charges. By utilizing the nozzle as the ion generator, recombination of the negative and positive charge is eliminated since the nozzle is in close proximity to the surface. A short transit time between ionization and contact with the residual particles prevents this recombination. It has been found that the ion generating nozzle of this invention greatly improves the neutralization of charged residual particles, since a greater amount of ions impinges thereon because of the prevention of the recombination of the charged particles in the flow. Therefore, since the charge on the particles is more effectively neutralized, the bond of the materials to the surface bearing them is reduced to allow ready removal of the neutralized particles.

DESCRIPTION OF THE DRAWINGS

Further objects of the invention together with additional features contributing thereto and advantages accruing therefrom will be apparent from the following description of several embodiments of the invention when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic illustration of a xerographic device utilizing the cleaning device of the present invention,

FIG. 2 is a frontal perspective illustration of one embodiment of the cleaning device of the present invention,

FIG. 3 is an enlarged perspective illustration of an embodiment of the ionizing nozzle utilized in the cleaning device of FIG. 2 according to the present invention; and,

FIG. 4 is an enlarged schematic illustration of a second embodiment of ionizing nozzle utilized in the cleaning device of FIG. 2.

FIG. 5 is an enlarged schematic illustration of still another embodiment of the ionizing nozzle utilized in the cleaning device of FIG. 2.

FIG. 6 is a schematic end view of the embodiment of the nozzle illustrated in FIG. 6.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown a schematic view of a drum type automatic xerographic reproducing machine utilizing the present invention. The central element of the apparatus is a drum 1 mounted for rotation and drivable in a conventional direction by a motor not shown. The drum 1 comprises an outer surface with a layer of photoconductive insulating material such as vitreous selenium or other suitable surface. A uniform electrostatic charge is placed on the photoconductive surface of the drum by means of a conventional corona charging

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device 2. The uniformly charged surface on the drum is then moved to an exposure means 3 which may be any well known device which will expose the charged surface of copy to be reproduced, thereby, forming a latent electrostatic image of the copy on the photoconductor drum surface in a manner well known in the art.

Following the formation of a latent electrostatic image of the copy to be reproduced, the image on the drum will move to a development device 4 to bring the charged image into contact with developer material comprising toner and carrier. The electric field of the charged image causes toner to affix thereto and form a visible image. After development, the visible image moves to a transfer means 5 and is transferred from the drum to a web of paper 6 or other suitable support medium which is positioned in contact with the drum by rollers 7 and 8. A second corona charging device 9 applies a charge to the side of the web opposite the image to facilitate transfer of the toner powder in image configuration. The toner image on the web moves past the heating element 10 which permanently affixes the toner to the paper web to form a duplicate of the original copy. A cleaning device 100 according to the present invention (to be hereinafter described in detail) contacts the photoreceptor surface after it moves past the transfer device to remove any residual image material from the surface prior to a subsequent reproduction cycle. It should be clear that other modes of charging, exposing, transfer, and fusing may be utilized in connection with the present invention.

Referring now to FIG. 2, there is illustrated one embodiment of the cleaning device 100 according to the present invention. The cleaning device 100 includes a casing 21 which is mounted in brackets 22 to be in close proximity to the drum surface and is of sufficient width to extend across the drum. The casing 21 forms a duct 23 wherein a flow of air is created by means of an air flow generating means 24 such as, for example, a suitable fan. The flow of air created in the duct is directed onto the surface 1 bearing residual image and background material to be removed. An adjustment member 25 is provided to allow the housing to be rotatably moved so as to selectively adjust the angle that the flow of air strikes the surface to be cleaned.

A nozzle 26 is mounted at the end of the duct directly adjacent the photoconductor drum to increase the velocity of the air flow impinging on the surface and to ionize the air into positive and negative charges for neutralizing the charge on the residual image and background particles. The nozzle 26 extends the width of the drum to insure air flow striking all areas of the surface and includes two side walls 27 and 28 of a conductive material which on their inner surfaces 29 and 30 are in a parallel relationship to each other. The nozzle also includes two end walls 31 and 32 on each side of the nozzle formed also of a conductive material wherein the end walls are separated from the two parallel side walls by two strips 33 and 34 of insulating material on both sides of the nozzle such as, for example, "Teflon," to electrically insulate the two side walls from each other.

The electrically isolated side walls 27 and 28 of the nozzle (spacer members 35 and 36 including electrically insulating materials) are connected to an electrical potential to create a corona discharge between the two parallel surfaces 29 and 30 of the walls. The corona emission created by the application of an electrical potential to the nozzle side walls results in ionization of the air flow into positive and negative charges prior to the air flow reaching the surface to be cleaned. The ionized air flow of both polarities thereupon impinges upon the photoconductive surface and neutralizes any charge remaining on the electroscopic toner after transfer of the image. It should be clear that the negative charges created in the ionized air will tend to neutralize the positively charged particles and the positive charges in the flow will tend to neutralize the negative charged particles. The enlarged

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perspective view of the nozzle 26 in FIG. 3 more clearly illustrates the structure of the nozzle. It has been found that by utilizing the nozzle in the present invention as the ionization means, the recombination of positive and negative charges which occurs rapidly in a flow of air is prevented, since the nozzle is in close vicinity of the photoconductor surface. Therefore, the present invention greatly improves the neutralization of the charge on particles bonded to the surface to be cleaned.

Referring now to FIG. 4, there is illustrated an embodiment of the nozzle which improves the corona breakdown of the air flowing between the two parallel walls 29 and 30. The structure of FIG. 4 is identical to that illustrated in FIG. 2 except that the knife edge 37 of the nozzle is formed with a series of serrations 38 shown, in FIG. 4, as a plurality of slots. The utilization of slots at the nozzle openings has been found to greatly improve the corona breakdown between the surfaces thereby creating a significantly improved ionization of the air and provide better neutralization of the charged particles lying on the drum surface. The form of the serrations could be in other shapes and forms such as a sawtooth pattern and the like. Also, the particular number of serrations utilized depends on the desired degree of ionization of the air flow.

Referring now to FIGS. 5 and 6, there is illustrated another embodiment of the nozzle which improves the corona breakdown of the air flowing through the two parallel walls 29 and 30. Such an improved ionization of the air flowing through the nozzle is effected by a plurality of fine tubes 39 extending along the direction of the flow of the air to form a series of multiple jets. The plurality of tubes 39 are secured in any suitable manner (not shown) within the flow passage of the nozzle contained between the two end walls and the two side walls. The ends of the tubes extend from within the nozzles to slightly beyond the end thereof immediately adjacent the surface to be cleaned. Ionization of the air created in the form of this embodiment is produced by a series of corona wires 40 wherein a single corona wire is mounted in any suitable means (not shown) to extend longitudinally within the tube member and the corona wire is connected to a suitable bias potential. Therefore, the flow created by the fan is directed between the surfaces of the side and end walls of the nozzle and through the plurality of tubes to impinge upon the surface to be cleaned. Negative and positive charges are created in the air flow through the tubes by means of the corona wires ionizing the air. An insulating material 41 concentrically surrounds each of the corona wires substantially the entire length thereof except near the end adjacent the surface to be cleaned where ionization occurs because of corona emission. Therefore, it should be apparent that the flow of air is ionized by the plurality of tubes in the immediate vicinity of the photoconductor surface. Since the embodiment of FIG. 5 ionizes the air by the passage of the plurality of corona wires, the necessity of a bias potential being connected to the parallel side walls as in the embodiments of FIGS. 3 and 4 of the nozzle is obviously eliminated with the electrical bias for ionization in this embodiment being applied between the conductive tubes 39 and the non-insulated ends of the corona wires 40. Also, any number or arrangement of the thin tubes may be utilized in the present invention depending on the desired degree of ionization of air.

The embodiments disclosed in this application effectively neutralize the charge remaining on the particles of the surface to allow the particles to be readily removed. The velocity of the flow of the ionized air can be selected to physically remove neutralized particles to be carried to any suitable collection means such as a vacuum system or the like. Alternatively, the particles may remain on the surface after neutralization by the flow of the ionized air according to the present invention,

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and be physically removed from the surface by some convenient removal device such as a vacuum system, a lightly stroking brush, or the like. Therefore, the surface may be cleaned by the impact of the ionized flow striking the surface to neutralize the charge on the particles thereon and to physically remove them from the surface, or the particles may be neutralized by the flow of ionized air and then removed by some other convenient method.

In the above description there has been disclosed an improved device and method for effectively cleaning a residual image from the xerographic photoconductive surface after transfer of substantially all the image to a support material. The surface to be cleaned was described for convenience of illustration as being that on a xerographic drum, but the invention may be used to clean other well-known photoconductive members in the form of plates, belts, webs or the like. It is further within the scope of the present invention to utilize the charged particle neutralizing and cleaning method and apparatus as described herein to remove charged particles from surfaces other than photoreceptors.

While the invention is described with reference to preferred embodiments, it will be understood by those skilled in the arts that various changes may be made and equivalents may be substituted for elements thereof without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its essential teachings.

What is claimed is:

1. Apparatus for removing electrically charged electroscopic particles from a support member comprising duct means for coupling to an energy source for producing fluid flow,

a nozzle coupled to said duct means, said nozzle being mounted close to and extending over said support member, said nozzle having an exit orifice for directing fluid onto said support member to remove the particles with impacting fluid,

said nozzle including at the exit orifice two electrically conductive electrodes electrically insulated from one another, said electrodes facing each other forming a fluid conduit for passing fluid through the nozzle and said electrodes being arranged such that ions flow generally parallel to said support member when an electrical energy source is coupled to the electrodes, and

an electrical energy source coupled to said electrodes for ionizing fluid between them causing an ion flow generally parallel to said support member to enable positive and negative ions to be diverted by the fluid flow toward the support member.

2. The apparatus of claim 1 wherein said particles include toner particles and said support member comprises a photosensitive member on which latent electrostatic images are created and developed with said toner particles.

3. The apparatus of claim 1 wherein said electrodes include elongated walls generally parallel to one another and extending across substantially the width of the support member.

4. The apparatus of claim 3 including means to selectively adjust said nozzle to vary the angle of the flow of fluid directed to the support member.

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5. Apparatus for removing electrically charged electroscopic particles from a support comprising

duct means for coupling to an energy source for producing fluid flow,

a nozzle coupled to said duct means supported close to and extending over the support having an exit orifice for directing fluid onto the support to remove the particles with impacting fluid,

said nozzle including at the exit orifice spaced electrically conductive members electrically insulated from one another positioned within the path of fluid flow, and

an electrical energy source coupled to said spaced members for ionizing fluid between them causing an ion flow generally perpendicular to the direction of fluid flow to enable ions to be diverted by the fluid flow toward the support, wherein said spaced electrically conductive members include a plurality of conductive tubes each having a corona wire positioned therein such that fluid flows through the tubes to the support and ionization occurs between a wire and the inner wall of a tube.

6. A method of removing electrically charged electroscopic particles from a support member comprising directing a flow of fluid through a nozzle onto the support member to remove the particles with the impacting fluid and applying an electrical potential between two electrodes electrically insulated from each other, the electrodes being positioned near the exit orifice of said nozzle, the electrodes forming a fluid conduit within said nozzle, the applying of the said electrical potential ionizing fluid between the electrodes and generating an ion flow generally parallel to the support member, enabling positive and negative ions to be diverted by the fluid flow toward the support member.

7. A method of removing electrically charged electroscopic particles from a support comprising directing a flow of fluid through a nozzle onto the support to remove the particles with the impacting fluid and applying an electrical potential between spaced members positioned near the exit orifice of said nozzle to ionize fluid between the members generating an ion flow generally perpendicular to the fluid flow enabling ions to be diverted by the fluid flow toward the support, wherein said spaced members have edges that are serrated.

8. The method of claim 7 wherein said serrations are rectangular.

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MORRIS O. WOLK, Primary Examiner

D. G. MILLMAN, Assistant Examiner

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15—1.5, 306; 134—37; 317—2 R, 4; 355—15