

[54] **SURFACE CLEANING BY IONIZED FLOW**

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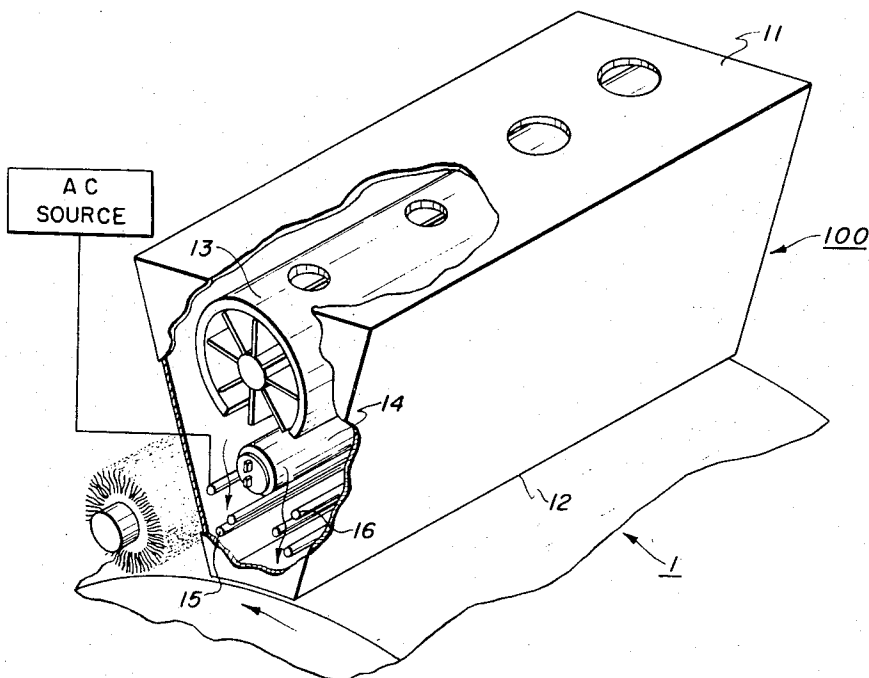
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[57]

ABSTRACT

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 member. Fans or air pumps are utilized to direct a flow of ionized air to the surface to be cleaned. The 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. The ionization is produced by corona discharge, and illuminating means may also be included.

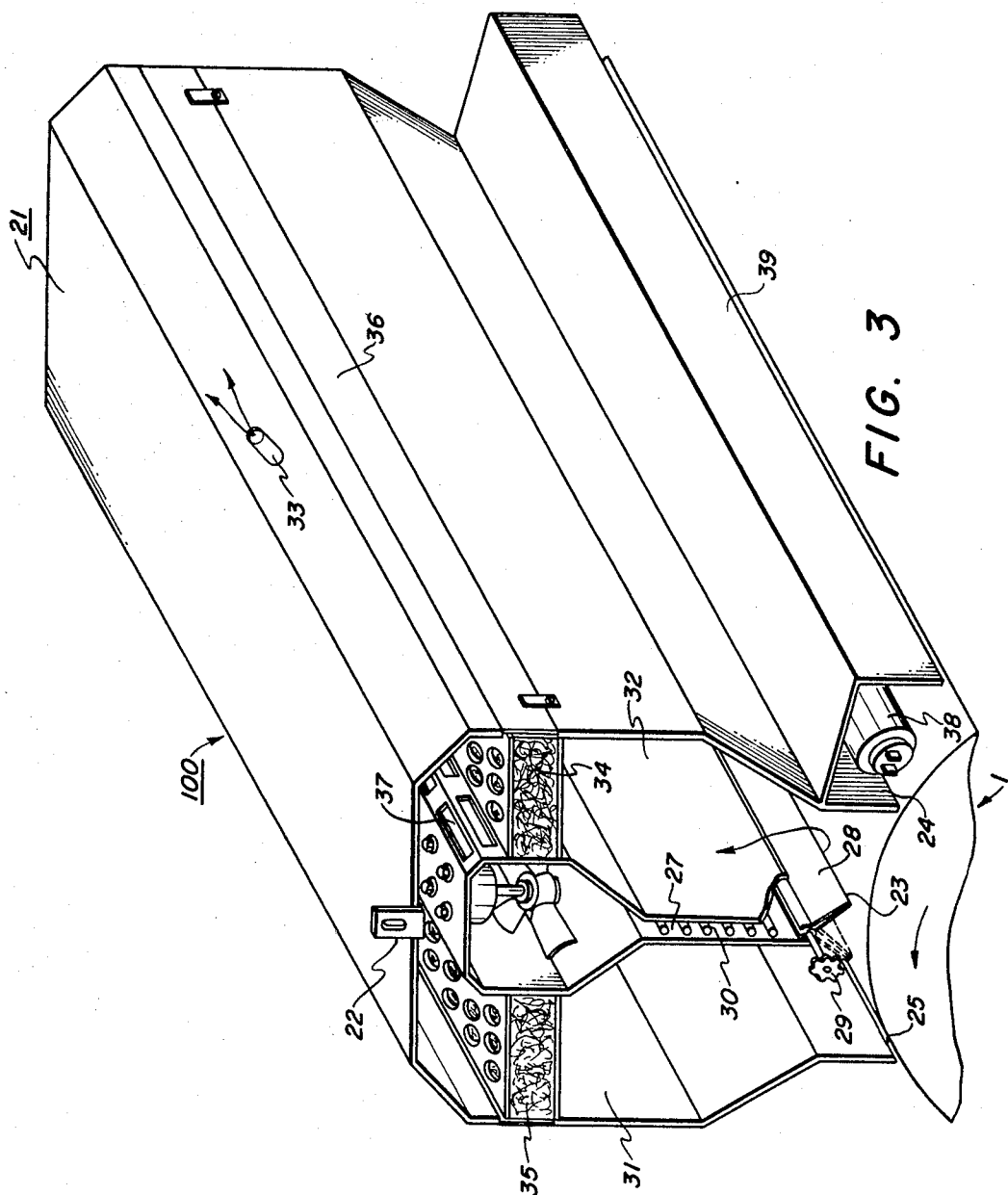
9 Claims, 3 Drawing Figures



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SHEET 2 OF 2



SURFACE CLEANING BY IONIZED FLOW

This is a continuation of application Ser. No. 830,314, filed June 4, 1969, now abandoned.

BACKGROUND OF THE INVENTION

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

More specifically, the invention relates to a cleaning process and apparatus adapted to clean residual toner powder 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. Removal of the particles is accomplished through the use of fans which direct air in contact with corona wires causing ionization of the air stream. The ionized air thereupon flows onto the residual image bearing photoconductive surface to contact the charged residual image particles and neutralizes the charge thereon. In one embodiment of the invention the flow of the air carries the particles away from the surface after neutralization or, alternatively, the neutralized particles may be removed by any other technique such as a vacuum source.

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 a 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 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. 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 lies in the fact 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 the 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 thereby require a greater electric field for removal from the photoreceptor than do the larger tone particles which results in less efficient transfer. The residual toner is electrostatically attached to the photoconductor by the charges 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. No. 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 resulting from the accumulation of the toner on the 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.

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Another difficulty that arises in conjunction with brush cleaning is the accumulation of toner powder on the brush which actually can result in toner being reapplied to the photoconductor surface as the brush becomes clogged with toner. 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 if the toner charge varies in magnitude and polarity.

One technique of cleaning devised as an attempt to overcome some of the problems presented by brush cleaning was by use of a web cleaner. An example of a web cleaner is disclosed in the 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 the prior art cleaning methods.

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 prevent abrasion of a photoconductive surface during removal of residual toner powder images thereon.

Still another object of this invention is to effectively remove electrostatically neutralized toner particles from a photoconductive surface.

A still further object of this invention is to improve the method and apparatus for neutralizing an electrostatic charge left on a photoconductive surface.

These and other objects are attained in accordance with the present invention wherein there is provided a method and apparatus for cleaning a residual electroscopic toner powder from a surface by utilizing a flow of ionized air onto the surface to neutralize the charge on the particles electrostatically affixed thereon. Such a flow of ionized air is effected by fans or an air pump which causes the air to move in contact with a series of corona wires which ionizes the air into positive and negative charged particles. The flow of the charged air is directed onto the photoconductive layer according to present invention and will neutralize the charge existing on the electrostatically affixed residual toner powder image to allow the residue to be easily removed and carried away. By removing the charge on the toner film or layer with an ionized air flow, the particles can be easily carried away from the surface by the flow of air itself or by some other convenient technique of removal. The present invention is particularly effective in neutralizing varying magnitude and polarity of charges on the residual image since the air is ionized into two polarities of charges. As a further aid to removing the toner powder a light may be directed onto the photoconductive surface during cleaning to dissipate the surface charge and further weaken the electrostatic attraction of the toner thereby facilitating the removal of residual material.

The invention effectively cleans the xerographic surface without imposing any abrasive force to the drum as encountered by use of the aforementioned prior art cleaning devices. Also, the necessity of frequent changing the brush or web after extended use is eliminated. Further, the invention does not suffer from the inefficient removal of small particles as in a web cleaner or the accumulation of toner on the cleaning element as experienced in the conventional brush cleaning technique. Accumulation of toner on the brush element utilized in one embodiment of the present invention is minimized since the brush element only dusts off a layer of particles having been neutralized in the novel manner described herein. Accordingly, the uncharged particles are readily removed from the brush after being picked up from the surface, whereas in the prior art brush systems the removed particles are in a charged state thereby causing them to cling more securely to the brush and accumulate thereon. Therefore, the novel cleaning process and devices described in the application overcomes many of the aforementioned problems of the prior art cleaning methods as well as other numerous difficulties and renders effective and efficient cleaning of residual toner powder from a photoconductive surface.

DESCRIPTION OF THE DRAWINGS

Further objects of the invention together with additional features contributing thereto and advantages ac-

cruing 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; and,

FIG. 3 is a frontal perspective illustration of a second embodiment of the cleaning device according to the present invention.

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 M. 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 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 to copy to be reproduced to thereby form 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 carrier and toner whereby 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 material 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 form. 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 according to the present invention. A drum 1 having a photoconductive surface to be cleaned moves past the residual image cleaning device 100. The toner cleaning device 100 comprises a hollow casing or housing 11 mounted by suitable brackets (not shown) in close proximity to the drum surface. The casing is substantially closed except at end 12 which is spaced a slight distance from contact with the photoconductive surface to allow air flow

thereto. A fan or air pump 13 creates a low velocity flow of air through the casing and out the open end 12 onto the residual toner image.

A florescent lamp 14 is mounted within the casing 11 in parallel relationship to the drum surface and is connected to a suitable power supply to illuminate the photoconductor through the opening at end 12. By illuminating the photoconductor surface, charges of both polarities that remain on the surface after transfer are dissipated through the conductive backing. To ionize the air discharged from the casing, two series of corona wires 15 and 16 are supported parallel to the lamp in the air flow created by the air pump or fan. The corona wires are positioned in this embodiment of the invention between the photoreceptor and the lamp and extend the length of the casing. A voltage source supplies an AC potential to each wire to effect a corona discharge therefrom ionizing the air flow from the fan or air pump. Since the corona wire ionizes the air into both negative and positive charges, all charges that exist on the residual toner particles are neutralized by the ionized air flow to minimize the electrostatic bond between the particles and the photoconductor. The neutralized toner is removed by a collection device 17 which is shown as a light stroking brush, but may also be any other suitable device that will remove the particles from the surface, as for example, by a vacuum system or an air jet.

The number of corona wires appearing in each of the two series 15 and 16 is shown to be three although any other number could be utilized depending on the desired degree of ionization of the air. Further, it should be apparent that the ionized air flow in the embodiment of FIG. 2 could be adjusted to be a velocity sufficient to physically separate the toner from the surface as the ionized air flow neutralizes the toner charge. Such a combined neutralization and removal of the residual toner would eliminate the need of collection means 17.

Referring now to FIG. 3, there is illustrated a second embodiment of the cleaning device 100 constructed in accordance to the present invention. Shown in FIG. 3 is a casing or housing 21 suitably mounted on brackets 22 to be positioned in close relationship to the residual image bearing photoconductive surface 1. The casing is substantially closed except at the opening 23 confronting the photoconductor. The opening or end 23 of the casing is spaced a slight distance from the drum to form air ports 24 and 25 to draw air into the casing from the atmosphere as will be discussed later. Supported in the casing parallel to the photoreceptor is a multiple blade air fan 26 which forces air through duct 27 onto the entire width of the photoreceptor. The duct has an opening at its end which extends the entire width of the photoreceptive surface to insure flow to all areas thereof.

A nozzle or port 28 is adjustably supported at the open end of the duct in a hinge manner which allows the nozzle to direct air flow to the photoconductor at various angles of flow. The dotted lines in FIG. 3 show an example of an adjusted position of the nozzle, although any angular position of the nozzle may be selected. Nozzle 23 is adjustable because it has been found that neutralization of the charge on the toner will sometimes occur more efficiently in certain encountered conditions if the ionized air reaches the surface at some selected direction other than normal to the photoreceptive surface. A suitable knob 29 is located

externally of the casing to facilitate adjustment of the angle of the nozzle although other convenient adjustment effecting means may be utilized within the scope of the present invention.

Extending within the air duct are a series of corona wires 30 which are connected to an AC voltage source and act to ionize the air forced thereover by the fan and subsequently directed onto the photoreceptor. Six such corona wires are shown, but any number of corona wires may be utilized according to the present invention depending on the desired degree of ionization of the air. The ionization of the air forms both negative and positive charges which move to the surface and neutralize any charge existing on the toner and thus eliminate or greatly reduce the electrostatic charges existing on the particles. The toner, through neutralization, thereby becomes similar to a dust layer which can be readily lifted and carried away. The ionized air flow from the fan in this embodiment simultaneously neutralizes the charge on the toner and aids in physically separating and carrying away the unbonded particles.

To facilitate the collection of toner particles removed from the surface, the air flow is recirculated in the casing through two return ducts 31 and 32. The circulation through the outlet ducts is effected by reducing the pressure in the casing below atmospheric by means of an exhaust opening 33 which is connected to a suitable exhausting device such as a fan (not shown). By reducing the pressure in the casing, the input flow caused by fan 26 is drawn back into the casing through the return ducts. Further, because of the reduced pressure in the casing and the air flow created by the fan 26, air also is drawn into the casing through the openings or ports 24 and 25. This added flow through the provided ports aids in removal of the neutralized toner and prevents toner from being passed outside of the casing. The externally derived flow through the openings 24 and 25 also circulates through the return ducts 31 and 32 and, therefore, the combined flow from the fan and from the openings 24 and 25 carries neutralized toner through the return duct.

Two filters 34 and 35 which, for example, can be made of a fiber glass material, are mounted in the return ducts and collect toner carried by the return air flow. An access plate 36, located on one side of the casing 21, can be removed to allow easy accessibility to one of the filters in order to replace it as it becomes clogged through continual cleaning. A similar access plate (not shown) is provided on the opposite side of casing to replace the other filter as needed. In operation, after the toner is collected by the filter the flow through the filter is recirculated in the casing through intake ports 37 of the fan 26. As a control to insure complete removal of the neutralized particles and to minimize toner loss to the outside of the casing, brackets 22 are adjustable to position the casing 21 relative to the drum 1 and thereby vary the size of the openings 24 and 25 and the amount of flow entering the casing therethrough.

It should be apparent that the form of the device of the present invention shown in FIG. 3 operates as the photoreceptive surface moves relative thereto and provides effective cleaning of the residual toner from the entire photoconductor. Furthermore, the embodiment may be used without the toner collection means described herein so that the angularly adjustable nozzle 28 can direct ionized air against the surface to be

cleaned to neutralize the charged toner and simultaneously carry it off the drum surface by force of the air flow itself. A florescent lamp 38 connected to a suitable power supply is mounted in a housing 39 to illuminate the photoreceptor surface before it moves in confrontation with the cleaning device through the conductive backing to dissipate any charge left on the photoreceptor after transfer.

In the above description there has been disclosed an improved device and method for effectively cleaning a residual image from a xerographic photoconductive surface after transfer of substantially all of 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 devices and processes described herein to remove charged particles from surfaces other than photoreceptors.

While the invention has been described with reference to preferred embodiments, it will be understood by those skilled in the art 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 teaching of the invention without departing from its essential teachings.

What is claimed is:

1. Apparatus for removing electrically charged particles from a photosensitive support surface comprising an ion generator including a corona electrode having associated therewith means for generating a quantity of positive and negative ions, a duct for directing an airflow generated separately from the ion generator passed in contact with the ion generator onto the support surface to convey ions to the support surface and the particles thereon and

illuminating means for directing light on areas of the photosensitive support surface onto which the airflow is directed.

2. The apparatus of claim 1 further including airflow generating means for generating a flow of fluid of a sufficient velocity to remove from the surface particles neutralized by ions carried thereto.

3. The apparatus of claim 1 including means to convey particles from the support surface.

4. The apparatus of claim 1 wherein said duct is supported within a casing for retaining and recirculating said separately generated airflow within said casing.

5. The apparatus of claim 4 wherein said casing includes filter means for collecting airborne electroscopic particles circulated therethrough.

6. The apparatus of claim 4 wherein said casing includes ports to create a predetermined airflow thereto.

7. The apparatus of claim 1 including nozzle means supported from said duct to direct said separately generated airflow onto the surface at a predetermined angle.

8. The apparatus of claim 4 wherein said casing includes means adapted to reduce the pressure therein below atmospheric.

9. The method of removing electrically charged particles from a photosensitive support surface comprising

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generating a quantity of positive and negative ions with means including a corona electrode, directing airflow generated separately from the corona electrode past said corona electrode and through a duct onto the support surface to convey 5

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ions to the support surface and to the particles thereon and illuminating with light the areas of the photosensitive support surface onto which the airflow is directed.
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