United States Patent

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[73] Assignee **International Business Machines Corporation**
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[54] **ELECTROPHOTOGRAPHIC LAYER CLEANING PROCESS AND APPARATUS**
8 Claims, 4 Drawing Figs.

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[51] Int. Cl. **G03g 13/00,** G03g 15/00
[50] Field of Search ..... 134/1, 6, 9, 37; 15/1.5, 306, 306 A, 307, 308, 309; 313/63; 317/2 A, 2 C, 4; 250/49.5 GC, 49.5 ZC, 49.5 TC; 355/15

[56] **References Cited**

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ABSTRACT: An electrophotographic element is cleaned of residual toner by providing a cleaning means such as a rotating brush in contact with the element or an airblast to remove residual toner particles from the element while also providing means such as a fluorescent lamp to concurrently illuminate the portion of the element being cleaned.

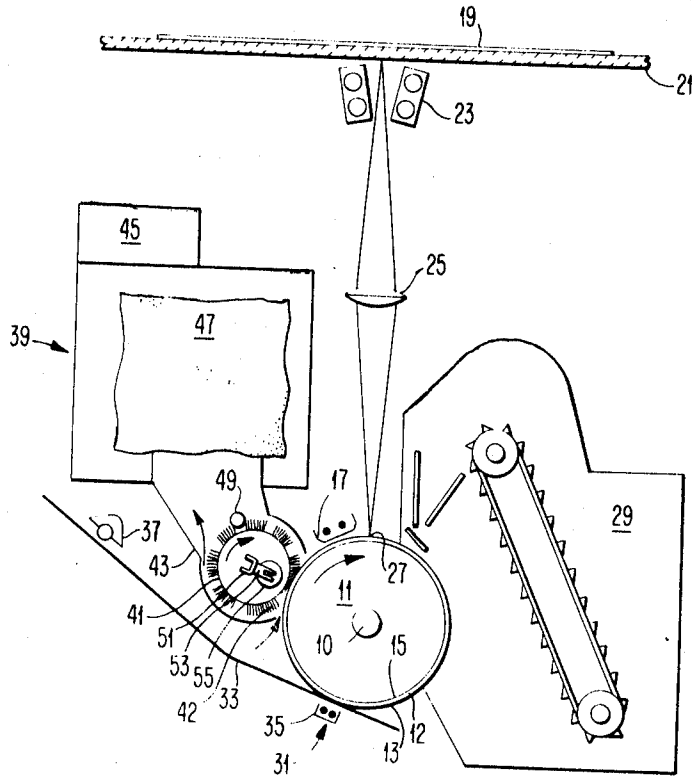


FIG. 1

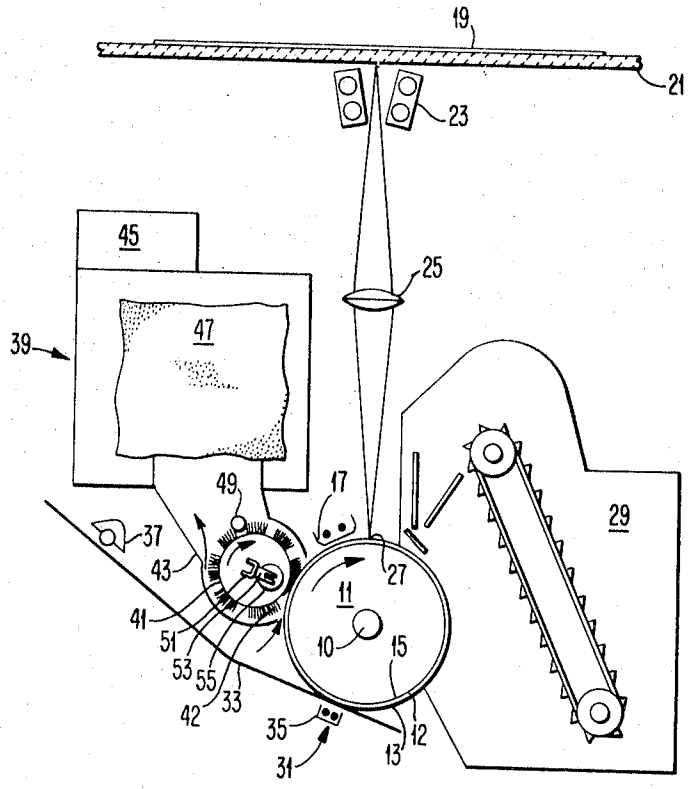
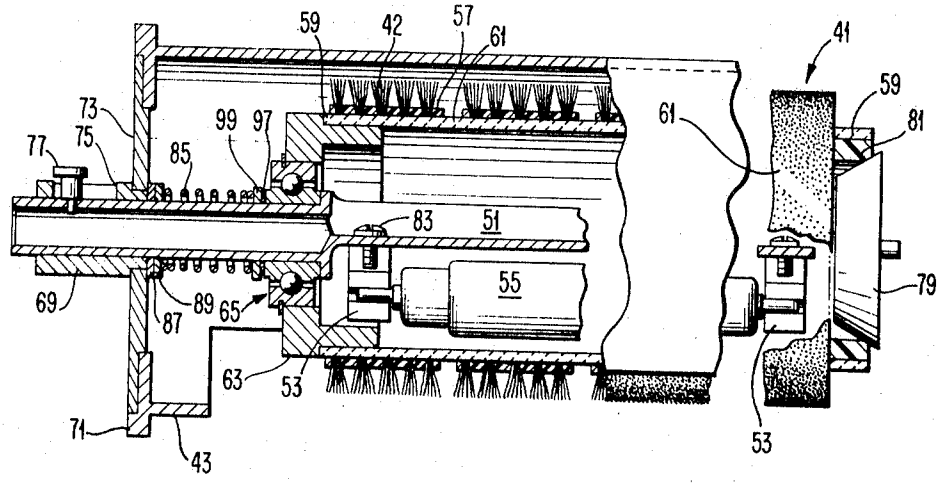


FIG. 2



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FIG. 3

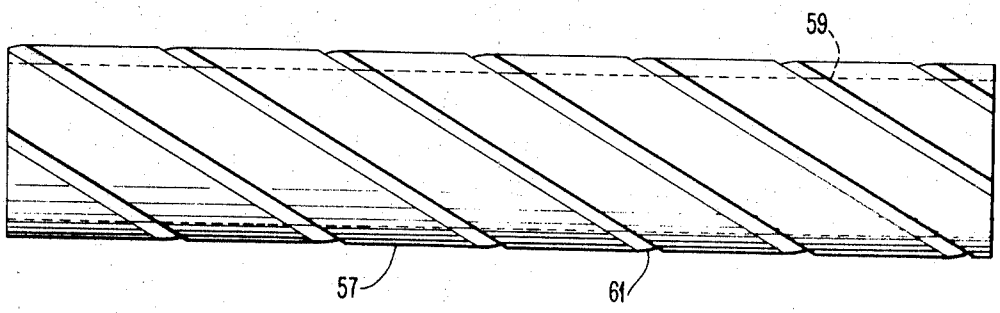
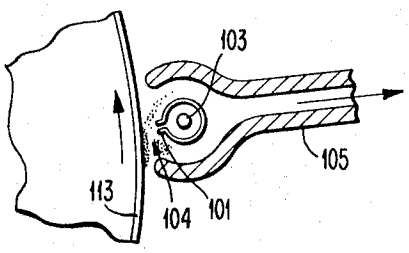


FIG. 4



ELECTROPHOTOGRAPHIC LAYER CLEANING PROCESS AND APPARATUS

BACKGROUND OF THE INVENTION

Electrophotography using photoconductive insulating layers upon which an electrostatic image is formed, for example, as is described in U.S. Pat. No. 2,297,691, has become embodied in a number of high speed copying processes. The photoconductive insulating layer is backed by a conductive layer and can be formed in the shape of a cylinder which is then rotated to bring the electrophotographic element to a number of stations involved in carrying out the electrophotographic process. The photoconductive insulating layer is first charged by applying an electrical potential across it. The charged photoconductive layer is then exposed imagewise to light and the electrical potential decays in the surface areas which are struck by light. The dark areas of the projected image retain their electrostatic charge and the image is then developed by exposing the surface of the photoconductive layer to small charged marking particles known as toner particles. The charged toner particles are attracted to the charged image areas of the photoconductive layer and thereby develop the electrostatic image. The image can then be transferred from the photoconductive layer to a copy sheet.

A number of ways are conventionally employed to develop the electrostatic image as is well known in the art. These include cascade development described, for example, in U.S. Pat. No. 2,618,552; powder cloud development described, for example, in U.S. Pat. No. 2,221,776; and magnetic brush development described, for example, in U.S. Pat. No. 2,874,063, fur brush development, donor belt development, impression development and liquid spray development. Commonly used processes in commercial copying machines are cascade and magnetic brush development. These methods employ toner particles usually comprising a heat softenable resin binder material, for example, a natural or synthetic organic compound or polymer such as styrene polymers and copolymers, epoxy resins, rosin, rosin esters, polymers of acrylic and methacrylic acid esters such as those prepared by polymerizing such monomers as methyl methacrylate, butyl methacrylate, ethyl acrylate and mixtures thereof. Various physical and chemical combinations of such polymers can also be employed. The resins are mixed with coloring matter, for example, carbon black so that a colored image can be easily heat fused onto a copy sheet. Other additives, such as plasticizers and anticaking agents can also be employed in the toner composition.

After development, the image is transferred from the photoconductive layer to the copy sheet, such as plain paper, so that the photoconductor can be reused repeatedly to produce additional copies. Conventionally, the paper is placed in contact with the developed image on the element and the toner is transferred by an electrical charge and/or mechanical pressure applied to the paper. The paper carrying the toner image is then stripped from the photoconductor.

Because it has not been found possible to make a complete transfer of toner to the copy sheet, a portion of the toner image remains on the photoconductor surface and small amounts of finely divided toner particles also cling to the nonimage areas. If not removed, this residual image and background toner will appear on the following copies. Therefore, it is necessary to provide a cleaning station for cleaning the surface of the photoconductor prior to the next copying cycle.

A number of ways of removing residual toner particles have been employed such as, for example, by physically contacting the surface of the photoconductor with either a renewable web of fiber material or with the bristles of a rotating cylindrical brush, and also by contacting the photoconductor surface with high velocity air. The removed particles are carried away from the cleaning station to a suitable receptacle by providing an air pressure differential. Light and/or corona discharges can be employed to neutralize a portion of the charge on the photoconductor prior to the time that it reaches the cleaning station so that the particles are more easily removed.

Problems have been associated with the foregoing cleaning methods because the photoconductor still retains some charge particularly in the image areas which are shielded by residual toner from the corona or light. Therefore, in certain modes of operation, it is found that the photoconductor is not completely cleaned and discharged. This is particularly the case where the apparatus provides a choice of different size copy sheets and the user selects a short copy sheet while exposing a larger size original. In this situation, there will be a portion of the image area which is not transferred to a copy sheet and which must be cleaned from the surface of the electrophotographic element. This heavily toned image sometimes taxes the cleaning apparatus to the extent that a portion of the image remains on the surface of the plate and appears on subsequent copies. This phenomena may be caused either by normal variations in the efficiency of the cleaning action resulting in some of the residual toner not being removed from the charged image areas or, even if all the toner is initially removed, then loose toner particles remaining at the cleaning station may redeposit on the charged image downstream from the point at which the toner is originally removed from the electrophotographic element.

A method and apparatus have now been found which eliminate the problem of residual image and which also provide for a general improvement in the cleaning of the photoconductor surface.

BRIEF SUMMARY OF THE INVENTION

In accordance with this invention, a method is provided for cleaning an electrophotographic element comprising removing residual toner particles from the element and illuminating the element as it is being cleaned.

An apparatus is also provided for cleaning an electrophotographic element comprising means to remove residual toner particles from the layer and means to illuminate the element as it is being cleaned.

In one embodiment of the invention, there is provided a cylindrical cleaning brush comprising strips of brush material secured to a transparent core with a source of illumination mounted within the core.

In another embodiment, a means is provided for impinging a high velocity stream of gas on the surface of the electrophotographic element along with means to illuminate the portion of the plate being contacted with the gas.

DRAWINGS

The foregoing and other objects, features, and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention as illustrated in the accompanying drawings.

FIG. 1 is a schematic side view of an electrostatic copying machine in which an embodiment of the apparatus and method of the invention is employed.

FIG. 2 is an elevational view partially in section with parts broken away of an embodiment of the apparatus of the invention shown in FIG. 1 employing a lamp mounted inside of a cleaning brush which has a transparent core.

FIG. 3 is an elevational view of the cleaning brush illustrated in FIG. 2. FIG. 4 is a schematic side view, partially in section, of another embodiment of the apparatus of the invention employing an air knife cleaning device.

DETAILED DESCRIPTION

Turning now to FIG. 1, a typical electrophotographic copying device is schematically shown in conjunction with an embodiment of the invention. A cylindrical drum 11 is mounted for rotation on a shaft 10 and a photoconductive element 12 comprising photoconductive insulating layer 13 and a conductive backing layer is mounted on the outer periphery 15 of drum 11.

A variety of photoconductive materials are conventionally employed in the photoconductive insulating layer **13**, for example, amorphous or vitreous selenium, selenium alloys with tellurium and arsenic, cadmium selenide, cadmium sulfide, and zinc oxide in a resin binder. A preferred material is an organic photoconductor comprising a 1 to 1 molar ratio of polymerized vinylcarbazole and 2,4,7-trinitro-9-fluorenone which is disclosed and claimed in an application of Shattock and Vahtra, Ser. No. 556,982, filed June 13, 1966 which issued as U.S. Pat. No. 3,484,237 on Dec. 15, 1969, and assigned to the assignee of this invention.

Preexposure corona unit **17** deposits an electrical charge of the desired polarity on the photoconductive material while it is maintained in the dark. Document **19** is held in place on a transparent plane **21** and an image of the document is projected onto the surface of the photoconductive insulating layer **13** by means of an illuminated scanning station **23** and optics **25**. The photoconductor is discharged at **27** in the portion struck by the light to form a charged image corresponding to document **19**. The drum **11** is rotated to bring the image to developer station **29** where finely divided charged toner particles are brought into contact with the charged image on the surface of photoconductive layer **13**. The developer station can employ a variety of different developer means, as previously mentioned, for example, a cascade developer unit, powder cloud developer unit or magnetic brush developer unit. The developer station illustrated at **29** is a cascade developer unit wherein a two component developer composition is caused to move across the surface of the charged image on the photoconductive layer **13**. The developer composition comprises relatively large carrier particles and relatively small heat fixable marking particles of toner as described, for example, in U.S. Pat. No. 2,618,552. The toner particles are attracted to and cling to the charged areas of the photoconductive layer **13**.

At station **31** the toned image on the surface of photoconductive layer **13** is transferred to a plain paper sheet or web **33** with the assistance of a transfer corona unit **35** which charges the paper to a polarity opposite to that of the toner particles so that it will attract the toner away from the surface of the photoconductive layer **13**. The paper is then stripped from the photoconductive layer and passed to a heating unit **37** which acts to fuse and fix the toner image onto the paper.

A certain proportion of the toner particles remain on the photoconductive layer as a result of the fact that transfer efficiency to the paper is less than 100 percent and sometimes, because the length of paper copy sheet chosen is shorter than the length of the toned image on the drum, none of the toner is transferred from some image areas.

The rotating photoconductive layer is then passed into cleaning station **39** where it is contacted by a driven cylindrical cleaning and treatment brush **41** whose length corresponds approximately to the width of photoconductive layer **13** on the drum. Brush **41** is mounted in a housing **43** and an air flow in the direction shown by the arrows is provided by a vacuum means **45** to carry off the removed toner to a filter bag **47**. A knockoff bar **49** aids in removing toner particles from the brush so that the brush remains relatively free from toner particles upon extended use. Mounted inside the brush **41** on lamp support **51** and mounting bracket **53** is a cylindrical fluorescent lamp **55** (usually about 1 watt per inch) connected to a conventional electrical power source which is not shown.

It should be understood any suitable means can be used to provide radiation of the proper wave lengths to discharge the residual charge on photoconductive layer **13** as brush fibers **42** remove the toner particles. The brush and illuminated brush-holding assembly are shown in more detail in FIGS. **2** and **3**. Brush **41** comprises strips **57** of fabric pile material of polytetrafluoroethylene such as is described in a copending U.S. application of Ray L. Dueltgen and Carl A. Queener, Ser. No. 762,952, filed Sept. 26, 1968, and assigned to the assignee of this invention. Other materials can be used for the nap of the cleaning brush such as various types of furs, for example, beaver fur, gray fox fur, rabbit fur and fiberlike synthetic materials such as nylon, rayon or Dynel and the like. The synthetic fibers **42** are woven or knit into conventional backing layers, such as, for example, cotton or polypropylene and cemented in place at the backing layer by a coating of latex. The strips **57** may be wound and secured to a transparent core **59** of acrylic plastic. In the embodiment shown, strips **57** are wound in a helical manner so as to leave about 10 percent of the core area of transparent portions **61** between adjacent strips to permit the passage of light. Other light transmitting plastics or glass can also be employed for the core material. Other methods of winding and securing to a core can also be employed. The total amount of light reaching the photoconductor can be controlled to a useful degree by the percentage of core area left uncovered, between strips.

Brush **41** is mounted for rotation at one end by locator ring **63** and bearing **65**. Lamp support **51** is mounted to frame **71** by slide **69** and clamp plate **73**. Brush **41** is mounted at the other end for rotation by chuck **79** acting on plastic insert **81**. Chuck **79** is driven by a drive means which is not shown. Lamp **55** is mounted to lamp holder **51** by mounting brackets **53** secured to lamp holder **51** by binding screws **83**. Lamp **55** is powered by a conventional electrical power source which is not shown. Spring **85**, washers **87**, **89**, **99** and retaining ring **97** provide means to assure that brush **41** is adjustably and tightly held for rotation between locator ring **63** and chuck **79**. Horizontal adjustment of lamp holder **51** is provided by a slot **75** in slide **69** and shoulder screw **77**. Housing **43** provides the proper air flow to retain the toner, which is lifted from the surface of the photoconductive layer **13** by the brush **41** from layer **13**, so that the toner is removed to filter bag **47**.

The construction of the brush is shown in more detail in FIG. **3** wherein strips **57** of brush material are affixed to transparent core **59** so as to leave uncovered portions **61** to permit the light to shine through onto the photoconductor as it is being cleaned by the brush material. It should be understood that alternate ways of accomplishing the cleaning and discharge of photoconductive layer **13** can be employed and are within the scope of the invention, for example, the use of other core materials which will permit the passage of light such as opaque materials which have apertures or which are of a screenlike construction or which have slots, for example, in the area **61** between strips of brush material. The brush backing and fibers can also be made of transparent material so that the light shines through the brush material which eliminates the need to provide discontinuties in the brush fibers to permit the passage of light.

In operation, brush fibers **42** engage the photoconductive layer **13** and flick the majority of the residual toner particles from the surface of the photoconductor. Substantially concurrently, the light impinges upon the portion of the photoconductive layer **13** which is being contacted by brush **41**. Layer **13** is sufficiently cleaned of residual toner by the initial contact with the brush fibers **42** so that the light reaches and discharges the photoconductive layer **13**. The speed of rotation of brush **41** and the width of the area of contact or "foot print" of brush **41** on the surface of photoconductive layer **13** is such that the brush will make several rotations over each portion of layer **13**. In the absence of surface charge loose toner particles are not again electrically attracted to the photoconductor prior to their being removed to the filter bag and any residual toner particles remaining on the layer **13** after initial contact with the fiber **42** are easily removed by subsequent portions of the brush from the now discharged photoconductor.

Turning now to Figure **4**, another embodiment of the invention is shown wherein an air knife **101** is employed. A high velocity stream of air is caused to impinge upon the surface of the photoconductive layer **113** and dislodge the toner particles **104**. Lamp **103** is mounted such that the area of the photoconductor contacted with the airstream is illuminated and discharged so that toner particles are not again attracted electrostatically to the surface of the photoconductive layer

113 and the particles are easily removed by a suitable air pressure differential through housing **105** to a collecting container (not shown).

It is been found that by utilizing the method and apparatus of the invention in which the photoconductor is concurrently discharged as the toner is being removed, an additional means to loosen the toner, for example, a preclean corona unit is unnecessary. The apparatus has the additional advantage of substantially completely neutralizing of the charge on the photoconductive layer between cycles without requiring the additional coronas or lights which are employed in the prior art. If the charge is not so neutralized then it may build up during the subsequent corona charging to a point where electrostatic breakdown of the photoconductive layer will occur.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and detail may be made therein without departing from the spirit and scope of the invention.

We claim:

1. An apparatus for cleaning an electrophotographic element comprising means to remove residual toner particles from a portion of said element and means to illuminate said portion of said element as it is being cleaned.

2. A process for cleaning an electrophotographic element comprising removing residual toner particles from a portion of said element and illuminating said portion of said element as it is being cleaned.

3. An apparatus for cleaning an electrophotographic element comprising means for supporting a driven brush in contact with the surface of said element, said brush comprising brush material mounted on a core which is adapted to transmit light and said brush having mounted therein a source of illumination.

4. An apparatus for cleaning an electrophotographic element comprising a housing, an air filter, means to maintain an air pressure differential between said housing and said filter, a cylindrical cleaning brush comprising strips of brush material secured to a transparent core, means to mount said brush for rotation within said housing, drive means for said brush, a lamp, a power source for said lamp, and means to mount said lamp within said core.

5. An apparatus for cleaning an electrophotographic element comprising fibrous material means said material means being adapted to transmit light, means for moving said material means over and relative to said electrophotographic element, and a source of illumination mounted behind the portion of said material means moving over said electrophotographic element.

6. The apparatus of claim **5**, wherein said material means is a driven cylindrical brush, said brush comprising brush material mounted on a core which is adapted to transmit light and said source of illumination being a lamp mounted within said core.

7. An apparatus for cleaning an electrophotographic element comprising means to impinge a high velocity stream of air onto the surface of said element and means to provide visible illumination of the proper wavelengths to electrically discharge the portion of said plate being contacted by said stream of air.

8. A process for cleaning an electrophotographic element of residual toner particles comprising removing said toner particles from said element while substantially simultaneously exposing the portion of said element being cleaned to visible illumination of the proper wave lengths to electrically discharge said element as said toner particles are removed.

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