

[54] **PROCESS AND APPARATUS FOR
REGENERATING A PHOTOCONDUCTIVE
LAYER**

[75] Inventor: **Willi Lanker**, Zumikon, Switzerland

[73] Assignee: **Turlabor A.G.**, Zumikon,
Switzerland

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355/15

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[58] Field of Search 355/3 R, 15, 17; 96/1 R;
134/19

[56] References Cited

UNITED STATES PATENTS

3,512,966	5/1970	Shattuck et al.	96/1 R
3,725,059	4/1973	Komp	355/15

3,770,429 11/1973 Kinoshita et al. 355/15 X

Primary Examiner—Richard L. Moses
Attorney, Agent, or Firm—Arnstein, Gluck,
Weitzenfeld & Minow

[57] ABSTRACT

A process for regenerating a photoconductive layer which has been utilized in an electrographic process wherein the layer is regenerated by removing surface particles of the layer from the remainder of the layer. Abrading the layer to remove the surface particles of the layer is the preferred embodiment of performing the process of the present invention. The regeneration can be performed prior to the formation of a latent electrostatic image in an electrophotographic duplicating process. The process of the present invention is especially useful with layers containing organic materials and also when incorporated in an electrophotographic process which includes forming a latent electrostatic image on a surface and transferring the latent electrostatic image from that surface.

6 Claims, 4 Drawing Figures

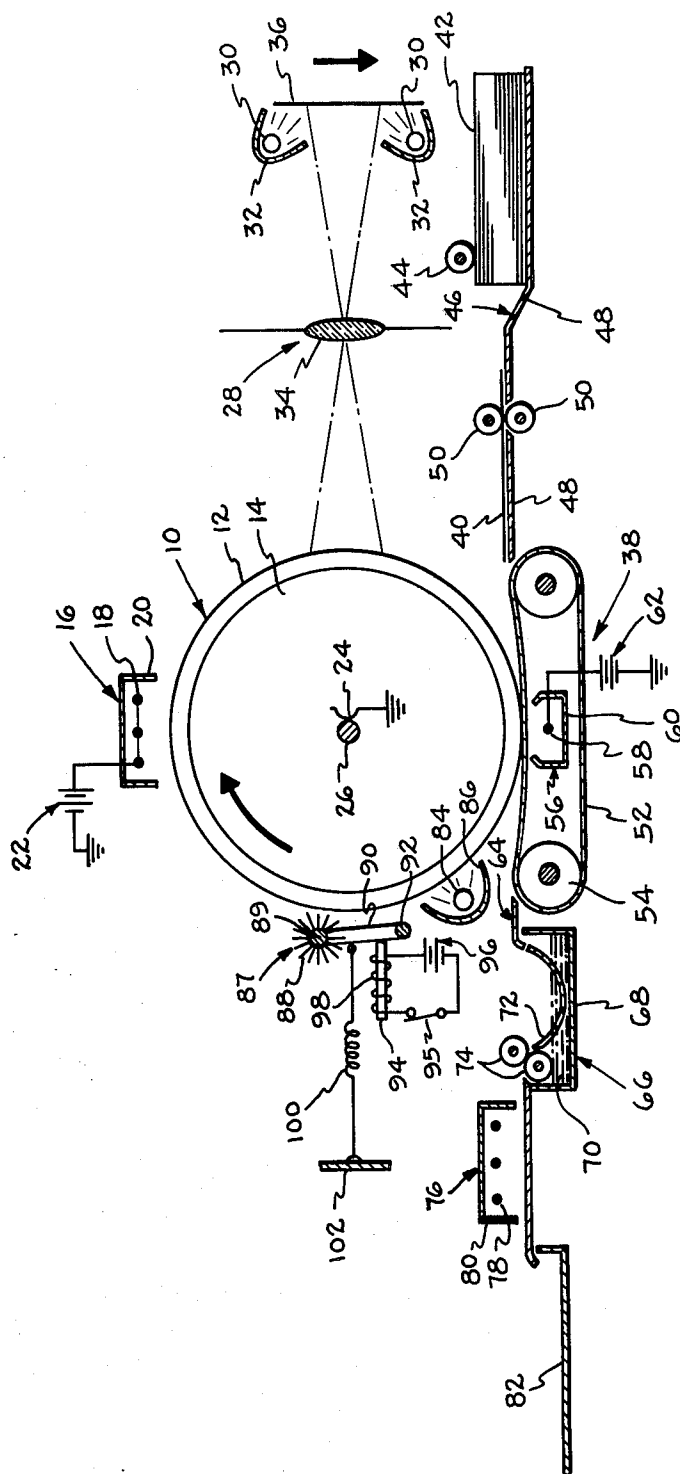
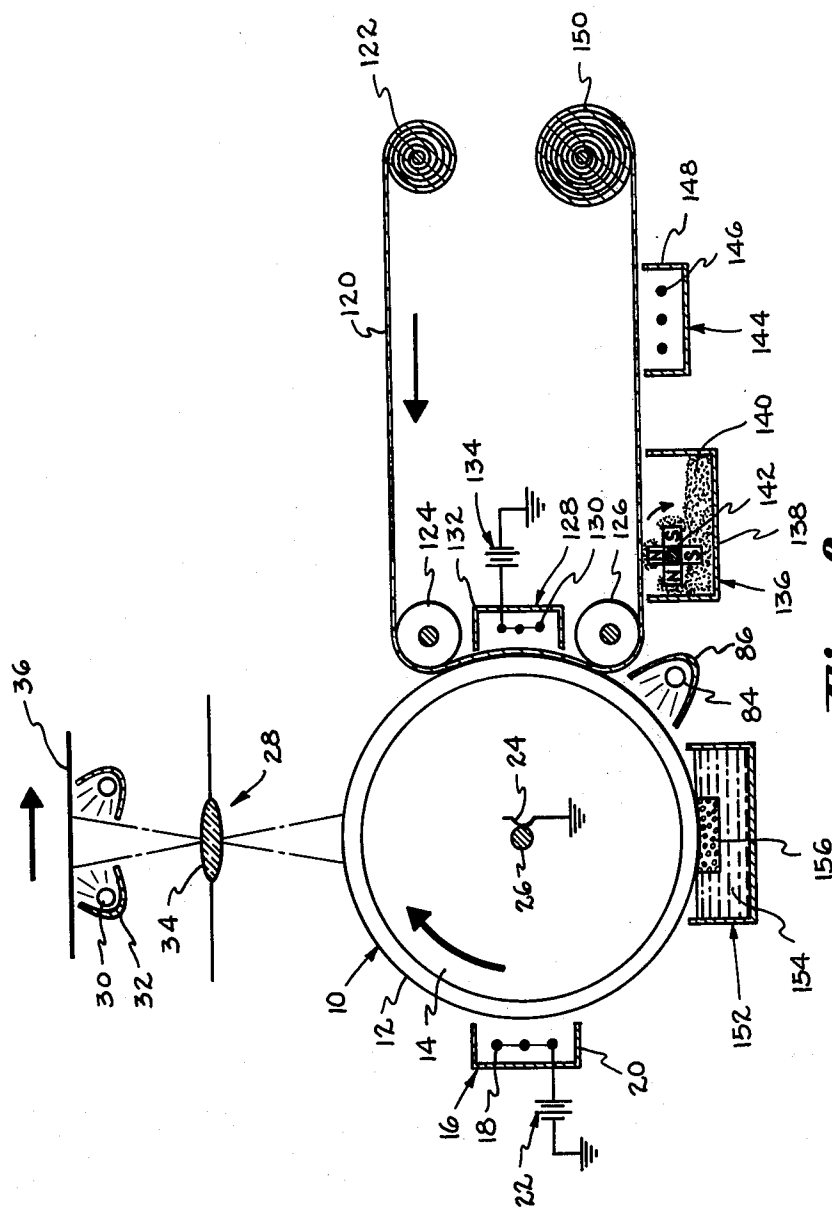


Fig. 1



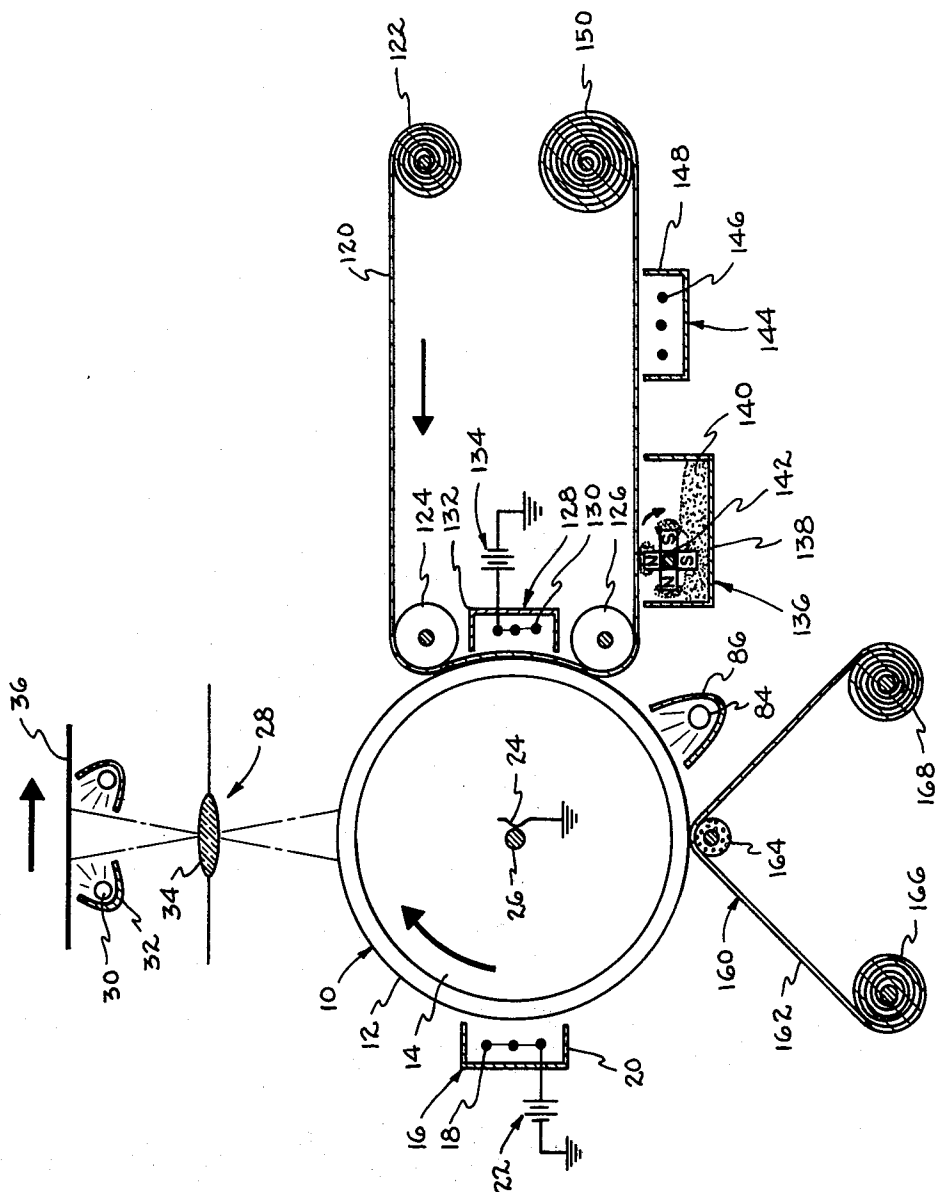


Fig. 3

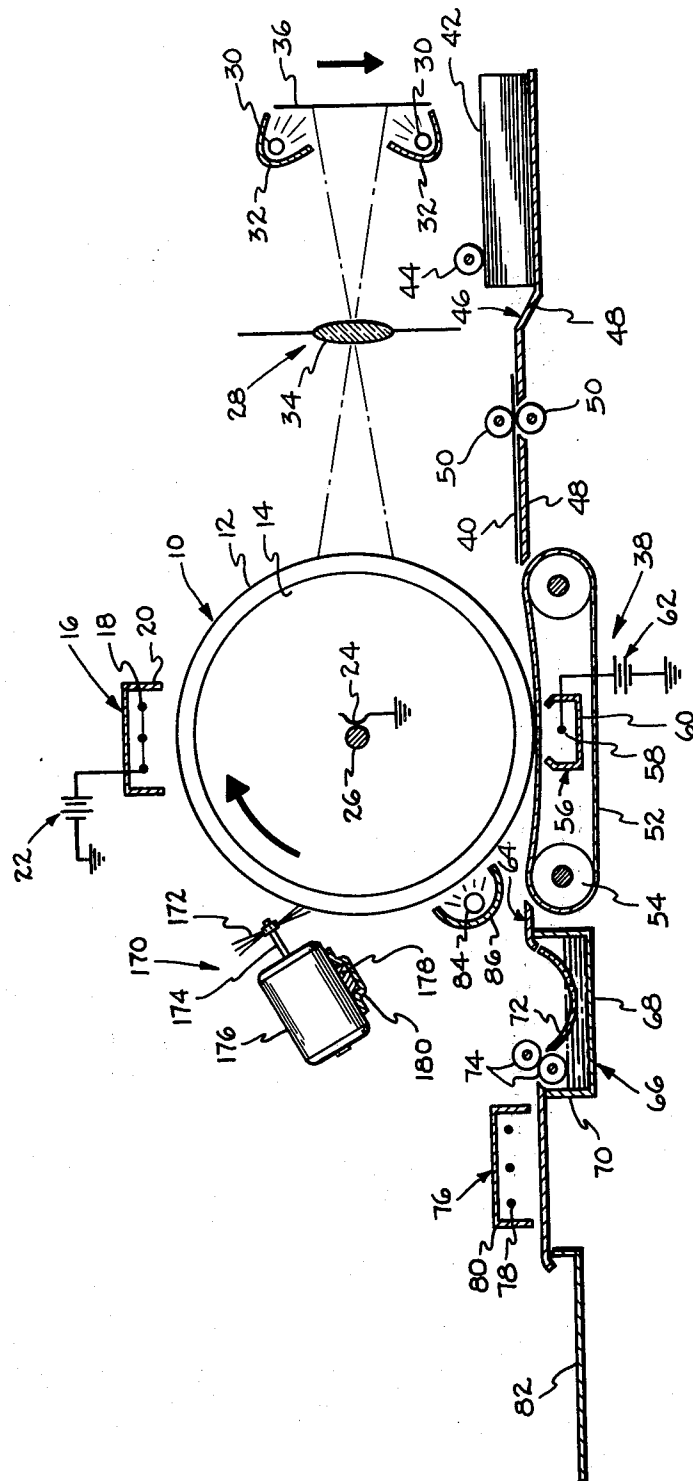


Fig. 4

PROCESS AND APPARATUS FOR REGENERATING A PHOTOCONDUCTIVE LAYER

This is a division of application Ser. No. 168,224, filed Aug. 2, 1971, now U.S. Pat. No. 3,815,295.

This invention relates to the treatment of photoconductive layers and more particularly to regenerating a used photoconductive layer for reuse in an electrophotographic duplicating process.

Electrographic processes wherein a chargeable and selectively dischargeable layer is used and electrophotographic processes utilizing photoconductive layers which are chargeable and selectively dischargeable on exposure to a light image are well known to the art. In one type of process a photoconductive layer is coated on sheets of paper which are then used as the image forming surface in the process. A latent image formed on the surface can be developed to obtain a visible copy. In a second type of process, the photoconductive layer is affixed to a cylindrical drum, a plate, or an endless belt and the layer is reused in producing successive copies. It is this second type of process to which the present invention is directed. In the past, the photoconductive material comprising the photoconductive layer which was usually affixed to a metal cylinder or plate has been a relatively hard, inorganic material such as selenium or an alloy of selenium and one or more other metals. More recently organic photoconductive materials, characterized by a softer surface, have been used either alone or in composition as the photoconductive material in the photoconductive layers, which are affixed to cylinders, plates, or endless belts.

Commercial photocopying machines utilizing the electrophotographic process of the second type described above generally include developing a latent electrostatic image on the surface of the photoconductive layer followed by transferring the developed image to a support material such as a paper sheet. This type of process will hereinafter be referred to as the "developed image transfer process." Although in transferring the developed image to the support surface, a large portion of the developer, usually in powder form, is removed from the surface of the photoconductive layer, residual developer particles remain on the surface of the layer which must be cleaned to remove the residual developer particles before the photoconductive layer can be reused in producing subsequent copies. Many methods of removing the residual toner particles have been proposed, but even with these methods, the residual developer particles build-up on the surface of the photoconductive layer and are believed to penetrate the surface of the layer, particularly where the surface contains imperfections, such as pin-holes, scratches, and the like. The preparation of the photoconductive layer for reuse after such build-up of residual developer particles required special cleaning steps usually involving temporary removal of the layer-supporting cylinder or belt from the machine.

The cleaning step required in the developed image transfer processes is eliminated in still another type of process, wherein the latent electrostatic image is formed and, without development of the latent image, the latent image is transferred from the surface of the photoconductive layer to a support surface. The transferred latent electrostatic image on the support surface can be subsequently developed on the support surface to form the visible image. In this type of process, devel-

oper particles do not contact the photoconductive layer. This latter type of process, which will hereinafter be referred to as the "latent electrostatic image transfer process," is described in several patents including L. E. Walkup, U.S. Pat. No. 2,825,814. Although the necessity of cleaning untransferred developing particles from the surface of the photoconductive layer has been eliminated by this latter method, lint removing means can be employed therewith, as disclosed by C. F. Carlson et al., in U.S. Pat. No. 3,015,304.

While it would be expected that in view of the above advantage, the latent electrostatic image transfer process would be preferable over the developed image transfer processes, the latent electrostatic image transfer process has not as yet been commercially acceptable.

The quality of the copy obtained in repeated use of the photoconductive layer in both the developed image transfer process and the latent electrostatic image transfer process deteriorates in proportion to that use. However, the deterioration in copy quality upon repeated use is especially pronounced with layers containing organic materials, particularly layers containing organic photoconductive material. Organic photoconductive materials, such as polyvinylcarbazole, have the advantages of low cost and relatively easy production as compared to inorganic photoconductive materials, such as selenium; but the deterioration as reflected in the deterioration in copy quality, upon repeated use, is greater with the former than with the latter. The deterioration in copy quality can be related to the decrease in the surface potential, or saturation surface potential, also referred to as surface acceptance voltage or charge acceptance voltage; i.e., the maximum surface potential to which a layer can be charged, and in the decrease in the dark resistivity of the photoconductive layer upon repeated use of the layer. As the use of the layer continues, the contrast of the image, as determined by the difference in potential between the unexposed and exposed areas of the image, decreases until the contrast is insufficient to obtain a usable copy. The saturation surface potential and the contrast potential, as well as the uniformity and constancy thereof, are generally referred to herein as the "electrophotographic properties." Thus, there is a continuing need for methods for regenerating photoconductive layers for reuse in electrophotographic processes, so as to produce a commercially acceptable number of copies from the layer without substantial deterioration in the quality of such copies.

It is therefore an object of this invention to provide a process wherein a photoconductive layer can be regenerated for reuse in an electrographic process.

Another object of the present invention is to provide for the regeneration of electrophotographic properties of photoconductive layers comprising material which is susceptible to deterioration of its electrophotographic properties on repeated use in an electrographic process.

Another object of the present invention is to provide a treatment system which improves the electrophotographic properties of a photoconductive layer which has been utilized in an electrographic process.

Another object of this invention is to provide for the regeneration of the electrophotographic properties of photoconductive layers comprising organic material which is susceptible to deterioration of its electro-

graphic properties upon repeated use in an electrophotographic process.

Still other objects, features and advantages of the present invention will be apparent to those skilled in the art from the following description, appended 5 claims, and annexed drawings.

The above objects and others are accomplished, generally speaking, by treating a photoconductive layer which has been utilized in an electrophotographic process, by removing surface particles of the photoconductive layer from the remainder of the layer. It has now been found that the desirable properties of used photoconductive layers, especially organic photoconductive layers, can be restored to commercially acceptable levels, for example, in the case of photoconductive layers containing organic material so as to produce at least 5,000, preferably above about 10,000, and even more preferably above about 20,000 copies of good quality per given area of the layer, by the method of the present invention. Generally, it has now been found that the deterioration of the electrophotographic properties of the photoconductive layer is primarily a surface effect and that the desirable properties of the photoconductive layer can be regenerated by removing the particles of the layer which comprise the surface of the layer. Regeneration by this method is believed to be due to the elimination or substantial reduction of the charge injecting effect the deteriorated surface particles and moisture have upon the remainder of the layer, so as to restore and stabilize the electrophotographic properties of the layer. The term "surface particles" as used herein and in the appended claims is intended to mean those particles of photoconductive material and other material, if any, which define the exposed surface of the photoconductive layer. The surface particles of a photoconductive layer which has been used repeatedly in an electrophotographic process will commonly include decomposed, chemically changed layer material and external material from the surrounding atmosphere, such as water. The surface particles may include decomposition products formed upon reaction of the exposed layer material with the surrounding atmosphere.

As a practical matter, it is realized that particles underlying the surface particles may be removed along with the surface particles. However, removal of such underlying particles, particularly in the case of organic photoconductive material, organic binder materials, and organic overcoating layers, have been found to have no substantial deleterious effect upon the desirable properties of the layer. The amount of material which can be removed in the regeneration process of the present invention is limited by the thickness of the photoconductive layer. Preferably, as little material as is necessary for regeneration is removed from the layer, but up to about one-tenth to one-third of the thickness of the photoconductive layer or 0.01 to about 1 micron, as measured from the exposed surface of the layer toward the opposite surface of the layer, can be removed in the performance of the process of the present invention. In order to be useful after regeneration, the layer should have a thickness substantially greater than the thickness of the material being removed during regeneration. Photoconductive layers, having a thickness of at least about 3 microns are preferred, and layers having a thickness above about 10 microns are even more preferred in order to provide sufficient pho-

toconductive material after regeneration for the production of copies of good quality.

The process of the present invention can be performed using a number of suitable devices. One preferred embodiment of the present invention comprises abrading the layer to remove the surface particles. The abrading can be effected in several ways. One method is to contact the layer with an abrasive material such as oxides of the various metals, such as zinc, chromium, and aluminum, and some non-metals such as silicon, or the commercially available inert polishing powders. Preferably, the abrasive material has an average diameter less than about one micron. Generally, the abrasive material is applied uniformly across the layer with a substantially constant pressure in order to substantially uniformly remove surface particles from the layer, at a small rate of abrasion, although uniform removal of the surface particles is not required to effect the regeneration. The rate of abrasion, as used herein, is the thickness of material removed from the layer per number of cycles or copies. Removal of the surface particles is intended to mean separation of the particles from the remainder of the layer, and removal of these particles therefrom. Contact of the abrasive material with the layer to obtain the separation and removal of particles can be performed by cascading the abrasive materials across the layer, by projecting the material against the layer under pressure, such as air pressure, or by similar contacting methods. The presence of small amounts of inert abrasive material, i.e., material which does not cause deterioration of the electrophotographic properties of the layer upon contact with the layer, on the surface of the photoconductive layer after regeneration is not detrimental to the use of the layer in an electrophotographic reproduction process. Moreover, the presence of such inert material on the layer may even be an advantage due to a screening effect which the abrasive particles have upon the layer. Such advantage can be noted by a reduction in overdevelopment of edges of images with less development within the edges of the images.

A particularly efficient method of contacting the layer with the abrasive material comprises supporting the abrasive material on a web and contacting, such as by rubbing, the web against the layer. In this manner, the abrasive material can be applied to the layer homogeneously and with a constant pressure, to separate surface particles of the layer from the remainder of the layer, and to remove the particles therefrom by movement of the web. Abrasive materials which are substantially spherical, such as the polishing powders, can be impregnated into the web, adhesively affixed to the web, or retained thereon by other means. Abrasive materials having diameters in the order of from about 0.1 to about 1 micron are preferred. Particularly suitable abrasive materials for use with webs as described herein are hard, inert inorganic materials, such as minerals and oxides, preferably aluminum oxide, zinc oxide, titanium dioxide, silicon dioxide or chromium oxide, and materials fibrous in shape, such as glass wool or asbestos. The web material may comprise fibrous material, such as animal fur, natural fibers, such as cotton, wool, hair, cellulose, synthetic furs, paper or cloth.

Still another efficient method of contacting the layer with abrasive materials is to contact the layer with a web which is itself abrasive. In order to lessen the occurrence of deep scratches on the remaining surface of the

layer, it is preferable to utilize abrasive materials having small diameters, in the order of about one micron or less, in or on the web. Particularly suitable abrasive materials are those having the shape of fibers or needles, which can be incorporated into the supporting web, such as by being woven therein, or can comprise the web itself. A suitable web of this type is a soft paper web which contains fine glass fibers or other abrasive fibers. These webs can be contacted with the layer by the use of tensioning rollers or a support surface as will be hereinafter described. Only slight contact pressures, in the order of from about 10 to about 100 grams per square centimeter have been found to be required when using the web materials described above, and the pressure may be decreased with increased abrasiveness of the web or the contact area. The amount of particles and the depth to which particles are removed from the layer upon performing the regeneration method of the present invention using a web as the abrasive surface or support can be controlled by adjusting the contact pressure of the web against the layer, as described above, by altering the abrasiveness of the web, e.g., by changing the nature or properties of the abrasive materials, or by altering the area of contact, as noted above, as well as by adjusting the proportion of abrasive material, the speed of the web relative to the layer, the frequency with which the web is replaced as it becomes less abrasive through use, and the interval and duration of contact of the material with the layer.

A second method of performing the abrading comprises contacting the photoconductive layer with a rotating brush. The brush preferably comprises a plurality of bristles affixed to a shaft. The shaft can be rotatably mounted adjacent the photoconductive layer with the axis of rotation either parallel, perpendicular, tangential, or at an angle to the surface of the layer, and rotated and contacted with the layer as desired. The bristles of the brush can be formed of any suitable material such as the synthetic bristles, and preferably natural bristles; for example: animal fur, such as rabbit, fox, beaver, hair of cow's ear; goat skin; horse hair; hogs bristles; mixtures thereof; and the like. The brush used in the method of the present invention for removal of the surface particles can be very soft, for example, the animal furs, such as rabbit, fox, etc., or goatskin with photoconductive layers having organic material as their top surface; whereas brushes having bristles which have greater coarseness, hardness or stiffness must be used with the inorganic layer materials. The bristles preferably have a diameter of from about 0.05 to about 0.3 millimeters, and the brush desirably has a diameter of from about 20 to about 60 centimeters. It is preferred to contact the brush with the surface of the photoconductive layer with slight pressure in the order of about 100 grams per square centimeter. Excellent result are obtained by periodically contacting the photoconductive layer with a brush as described above, whose axis of rotation is parallel to the surface of the layer, rotating at a speed of from about 1,000 to about 5,000 revolutions per minute. Although the brush can be contacted with the layer after each electrophotographic cycle, it is preferred, especially at relative humidities above about 40 per cent, to contact the layer with the brush less frequently; for example, in the order of once every 10, 100, 1000 or 10,000 cycles. Furthermore, it is also preferred to utilize a brush mounted with its axis of rotation at an angle of about 45° to about 80° to the

surface of the layer so that the bristles contact the layer at a small angle, for example, from about 10° to about 45°. The latter embodiment permits the use of brushes of greater stiffness having advantage at higher relative humidities, for example, above about 40 per cent. In general, short intervals, i.e., small numbers of latent image forming cycles, between regenerations are preferred, since the surface potential decreases with increases in the number of cycles between regeneration cycles. In addition, surface particles adhering to the bristles of the brush can be removed therefrom in a manner known to the art for removing particles from brushes, such as by contacting the brush with a blade or cleaning material, such as polishing paper.

A second embodiment of the method of the present invention for regenerating a photoconductive layer by removing surface particles, comprises washing or wetting the surface of the layer with a solvent. In one form the solvent may be applied to the layer by moving the layer through a body of the solvent or by flowing the solvent over the layer. In another method of applying the solvent to the layer, a fibrous web can be wetted with the solvent and the web then contacted with the layer in a manner similar to the application of a web supporting or containing an abrasive material to the layer. Washing the layer can also be advantageous when combined with another regeneration method, such as heretofore described, to further assist in removing, as by washing, separated particles and/or abrasive material from the surface of the layer. The photoconductive layer preferably is removed from contact with the solvent or other liquids when the layer is not being utilized for its intended function, as when electrophotographic copying using the layer has ceased.

Still another embodiment of this invention comprises the removal of surface particles using thermal means, such as radiation or heat. The performance of this embodiment can be accomplished by applying infrared radiation to the layer or by other means as hereinafter described.

The method and apparatus of the present invention will become even further apparent from the following description of the invention and from the drawings wherein:

FIG. 1 is a schematic illustration of means for regenerating a photoconductive layer according to one embodiment of this invention.

FIG. 2 is a schematic illustration of means for regenerating a photoconductive layer according to another embodiment of this invention.

FIG. 3 is also a schematic illustration of apparatus for regenerating a photoconductive layer according to still another embodiment of this invention.

FIG. 4 is a schematic illustration of a modification of the embodiment of the present invention schematically illustrated in FIG. 1.

Referring now to FIG. 1, there is shown a cylindrical drum 10 having an outer photoconductive layer 12 of photoconductive insulating material supported by a conductive inner surface 14 which may be of metal. The photoconductive layer may contain any suitable photoconductive material such as selenium, cadmium sulfide, or any of the organic photoconductors known to the art, such as polyvinylcarbazole, or any of the copolymers or derivatives thereof. The photoconductive layer may consist only of the photoconductive material or may contain organic material, for example, a binder

material such as an organic resin, or a top surface material, preferably of organic material, and preferably the top surface material is at the surface of the photoconductive layer; or other materials, and may contain one or more sensitizing dyes. For the purpose of this invention, the top surface layer in or on photoconductive layer 12 may be treated in the same manner as the photoconductive layer.

In an electrophotographic process, a latent electrostatic image is formed on the surface of the photoconductive layer 12 by means of applying a uniform charge to the photoconductive layer 12 and exposing the charged layer to a light pattern to selectively dissipate the charge on the layer 12 in accordance with the light pattern.

The uniform charge can be applied to the layer 12 by use of a charging device, such as corona unit 16. Typically, corona unit 16 includes one or more thin charging wires 18 surrounded by a conductive shield 20. A power supply such as D.C. source 22 is connected to the charging wires 18 and is also connected to the conductive inner surface 14 supporting the outer layer 12 of photoconductive insulating material by known means such as a direct connection (not shown) or through ground. The connection between the conductive inner surface 14 and the power source 22 is completed in the embodiment of FIG. 1 by means of a contact 24 electrically connected to shaft 26 of drum 10.

The step of exposing the photoconductive layer 12 bearing a uniform charge on its surface to a light pattern is performed by means of an illumination and projection system 28 comprising at least one illumination source 30 mounted in a suitable reflector 32 and a lens 34. To effect the exposure step, an original document 36 to be copied is transported by means (not shown) known to the art through the exposure station wherein light from the illumination source 30 and/or light reflected from the reflector 32 illuminates the surface of document 36 to be copied and the light rays are reflected through lens 34 onto the surface of photoconductive layer 12. The light rays from illumination source 30 and/or reflector 32 are reflected from the document 36 in varying intensity according to the absorption of the rays by the surface of document 36 bearing a visible image. The resultant reflected rays form a light pattern corresponding to the visible image on the document 36. The rays comprising the light pattern are projected by lens 34 onto the surface of the photoconductive layer 12 where they selectively discharge the uniform charge on the surface of photoconductive layer 12 in accordance with the intensity of the reflected rays. Thus, rays of relatively high intensity being reflected from white or light, usually background, areas of the visible image on document 36 cause the discharge of the uniform charge on the photoconductive layer 12; whereas rays of low intensity reflected from darker areas of the document or the absence of rays due to total absorption of the illuminated rays from source 30 and/or reflector 32, do not discharge the uniform charge or discharge the uniform charge on photoconductive layer 12 to a lesser extent in accordance with the photoconductive properties of the layer. In this manner, the uniform charge applied to the photoconductive layer 12 by corona unit 16 is selectively discharged or dissipated to form a latent elec-

trostatic image on the surface of the photoconductive layer 12.

The latent electrostatic image on the surface of photoconductive layer 12 can be utilized in several manners known to the art. As heretofor described, the latent electrostatic image on the surface of photoconductive layer 12 can be developed by various means known to the art and the developed image transferred to a receiving sheet or other suitable surface. The transferred developed image can then be fixed on the receiving surface by suitable means such as the application of infrared rays. The surface of photoconductive layer 12 after the transfer step can then be cleaned as known to the art, and reused in the next cycle of the apparatus. Cleaning of excess or residual developer remaining on the surface of the photoconductive layer after transfer of the developed image is distinct and dissimilar from the process of the present invention, as in the cleaning step the surface of the layer is merely wiped or lightly brushed to wipe or brush away the surplus developer, but care is taken not to abrade or scratch the surface of the layer; whereas in the process of the present invention the surface particles of the layer must be removed, for example by abrading, to effect regeneration of the electrophotographic properties of the layer 12. In the developed image transfer processes, such as the process described above, the process of the present invention extends the usable life of the photoconductive layer by regenerating the photoconductive properties of the photoconductive layer.

However, the process of the present invention is especially useful in the latent electrostatic image transfer process, such as the process utilized by the apparatus shown in FIG. 1. In this apparatus, the latent electrostatic image on the surface of photoconductive layer 12 is transferred by means of transfer apparatus 38 to a transfer sheet, such as sheet 40, which may be a sheet having a dielectric coating. Sheet 40 is fed from a stack of sheets 42 by a feed roller 44 into a sheet feeding path 46 consisting of guiding members 48 and rollers 50. The sheet 40 is advanced along sheet feeding path 46 onto a conveyor 52 which is normally in contact with the surface of the photoconductive layer 12, or slightly spaced therefrom. Conveyor 52 consists of one or more endless belts of material such as mylar or rubber having a resistance greater than that of the photoconductive layer 12. As the sheet 40 is conveyed into contact with the photoconductive layer 12, the latent electrostatic image on the photoconductive layer 12 is transferred to the sheet 40 by means known to the art and preferably by the application of a field.

In the apparatus shown in FIG. 1, the field is applied by means of a transfer corona unit 56 consisting of at least one corona discharge wire 58 partially surrounded by a conductive shield 60. A potential is applied to corona discharge wire 58 by means of a source of potential 62 which in turn is also connected to the conductive inner surface 14 of drum 10 by direct connection (not shown) or through ground and contact 24 and shaft 26. The potential required for transfer of the latent electrostatic image is known to the art from various patents, such as U.S. Pat. No. 2,825,814 heretofore described.

Following transfer, in the apparatus shown in FIG. 1, the receiver sheet 40 is conveyed by conveyor 52 along a second path 64 to a developing station 66. The developing station 66 shown in FIG. 1 comprises a tank or

tray 68 containing a liquid developer 70 as known to the art, such as liquid toner disclosed in Wagner U.S. Pat. No. 3,438,904. The liquid developer 70 is applied to the receiver sheet 40 by immersing the sheet in liquid developer 70 by guiding the sheet along a partially submerged guiding member 72. Sheet 40 is removed from developing station 66 by the leading edge of the sheet contacting a pair of rollers 74 which advances the sheet along second path 64. Sheet 40 next reaches drying station 76 wherein the developed image on the sheet is fixed to the sheet by evaporating liquid components of liquid developer 70 and preferably by heating and fusing developer from liquid developer on and in the surface of the sheet. The drying station 76 can consist of infrared sources 78 mounted in a reflecting shield 80. Sheet 40 is next exited from second path 64 into a receiving tray 82.

Any charges remaining on photoconductive layer 12 are discharged by means of a light source 84 mounted adjacent the surface of photoconductive layer 12 in a reflecting light shield 86 subsequent along the direction of rotation of drum 10 to the developing station 56. Naturally, to effect the discharge of the remaining charges, the spectrum of light source 84 desirably corresponds to the spectrum of the photoconductive material in photoconductive layer 12.

Referring further to FIG. 1, the apparatus of the present invention is shown therein as a brush 87 mounted to be contactable with the surface of photoconductive layer 12. Brush 87 comprises a plurality of bristles 88 mounted on a shaft 89. The brush 87 can be permanently mounted in contact with photoconductive layer 12, thus effecting regeneration of the photoconductive layer 12 upon each cycle of the layer 12 through the various steps within the electrophotographic process, or, as shown, can be spaced apart from contact with the photoconductive layer 12, but mounted so as to be selectively contactable with the layer. For example, brush 87 can be mounted on a member 90 pivoted by a shaft 92 by a solenoid plunger 94. Thus, when switch 95 is closed, an electrical circuit is completed connecting electrical source 96 to solenoid coil 98 causing solenoid plunger 94 to force member 90 to pivot about shaft 92 so that brush 87 is placed into contact with the surface of photoconductive layer 12. Upon opening switch 95, the connection of source 96 to solenoid coil 98 is broken, releasing solenoid plunger 94 from member 90. Brush 87 is withdrawn from contact with photoconductive layer 12 by means of spring 100 affixed to member 90 and on the other side to frame 102 of the apparatus, causing brush 87 to be withdrawn from contact with the photoconductive layer 12. In this manner, switch 95 can be periodically closed to cause brush 87 to be periodically contacted with the surface of photoconductive layer 12 for regenerating the photoconductive properties of the layer. Switch 87 can be replaced by suitable automatic means, such as an automatic counter, so as to complete the circuit periodically, for example after a predetermined number of cycles, e.g. revolutions of drum 10, or after a predetermined number of receiving sheets have been processed through the apparatus.

In FIG. 2, another embodiment of apparatus according to the present invention is illustrated, wherein elements similar to elements in FIG. 1 have the same reference numerals. In this embodiment, the cylindrical drum 10 provided with an outer photoconductive layer

12 is constructed and arranged in the same manner as in the case of the embodiment shown in FIG. 1. The charging unit 16 and the illumination and projection system 28 as well as the light source 84 and reflector 86 for discharging residual charges on the surface of photoconductive layer 12 correspond with the appropriate apparatus of FIG. 1 and are referenced in the same manner so that a repeated description is unnecessary.

Referring to FIGS. 1 and 2, in place of the conveyor 52 of transfer station 38, according to FIG. 2 a web 120 of receiving material is supplied from a roll of web material 122 and is applied in intimate contact with the photoconductive layer 12 by means of rollers 124 and 126. Suitable tensioning apparatus (not shown) can be included to maintain contact of the web 120 against the photoconductive layer 12. The latent electrostatic image on the surface of photoconductive layer 12 formed by means of the corona unit 16 and the illumination and projection system 28 is transferred from the surface of the photoconductive layer 12 to the receiving web 120 by the application of a field by means of corona discharge unit 128. Discharge unit 128 comprises at least one corona discharge wire 130 partially surrounded by a conductive shield 132. The corona discharge is effected by connecting a source of potential 134 to corona discharge wire 130 with the other terminal of source 134 being connected to the conductive inner surface 14 of drum 10 either by direct connection (not shown) or through ground and contact 24 and shaft 26. After the web 120 receives the transferred latent electrostatic image, it is advanced to a developing station 136 comprising, in this embodiment, a tank 138 containing solid, powdered toner 140 which is known for use in developing latent electrostatic images. The powdered toner 140 is applied to the surface of web bearing the transferred latent electrostatic image by means of a magnetic brush 142 comprising magnets mounted about a common axis and particles of material attracted by the magnet which carry the toner particles by magnetic attraction from the tank 138 to the said surface of web 120. Magnetic brushes of various types are known and can be utilized in this embodiment of the present invention. Subsequent to passage through developing station 136, the web is advanced past a fixing station 144 generally similar to drying station 76 of FIG. 1. Fixing station 144 comprises one or more infrared heating elements 146 partially surrounded by a reflective shield 148. In this manner, the visible image on the web 120 resulting from the development of the transferred latent electrostatic image at developing station 136 is fused and bonded to the surface of the receiving web 120. Thereafter, the receiving web 120 is collected on a take-up roll 150. Web 120 may be advanced by driving take-up roll 150 synchronously with the rotation of drum 10.

Following the transfer of the latent electrostatic image from the surface of photoconductive layer 12 to the surface of receiving web 120, the photoconductive layer 12 is rotated on drum 10 past illumination source and reflector and light shield 86 to discharge any charges remaining on the surface of photoconductive layer 12 to washing station 152. Washing station 152 represents, schematically, the embodiment of the present invention wherein photoconductive layer 12 is regenerated by removing surface particles of the layer by washing the layer with a solvent, i.e., a liquid which is

a solvent for the surface particles, preferably selectively a solvent for decomposed material, moisture, and other contaminants, but not substantially for undeteriorated material in the layer. Thus, as shown in FIG. 2, photoconductive layer 12 is rotated through a body of a liquid 154, which can be a solvent, for the particles comprising the surface of photoconductive layer 12. For example, where the photoconductive layer consists of polyvinylcarbazole, ethanol has been found to be a suitable solvent for surface particles thereof.

The liquid 154 preferably is a poor solvent for undeteriorated material in the photoconductive layer 12. The washing action can be effectively attained by combining the washing with another method for removing surface particles of the layer, such as those described herein. For example, as shown in FIG. 2, the washing station further preferably includes a body of solid material 156 which contacts the surface of layer 12 and the liquid 154. Solid material 156 may be in the form of a sponge or folded or thick cloth (not shown) and preferably may be abrasive to layer 12 so as to remove surface particles from layer 12 by abrading the layer in the presence of liquid 154. In this manner the liquid 154 may be a very poor solvent for layer 12, but will assist the removal of surface particles, as by washing separated particles from the surface of layer 12. By rotation of drum 10 and thereby rotation of the photoconductive layer 12 through the washing station 152, the photoconductive layer 12 is contacted with both the solid material 156 and the liquid 154 to remove, by abrading and washing and/or by dissolving, the surface particles from the layer. Other surface particle removing means, such as a web of paper or cloth or a brush, may be substituted for the solid material 156 to effect the abrading and washing operations.

A further embodiment of apparatus according to the present invention is illustrated in FIG. 3, wherein elements similar to elements in FIGS. 1 and 2 likewise have the same reference numerals. In this embodiment, the washing station 152 of FIG. 2 is replaced with a web contacting station 160. Web contacting station 160 comprises a web 162 and roller 164 which maintains contact of the web with the surface of photoconductive layer 12. Web 162 is supplied from supply roll 166, is advanced by the roller 164 toward and away from the surface of photoconductive layer 12, and is gathered by suitable means (not shown) onto a take-up roll 168. By the use of the apparatus shown in FIG. 3, a latent electrostatic image is formed on the surface of photoconductive layer 12 by first applying a uniform charge to the layer by use of corona unit 16 and by selectively discharging the uniform charge on the surface of photoconductive layer 12 by means of illumination and projection system 28. The latent electrostatic image is next transferred to a receiving web 120 by means of transfer corona unit 128. Residual charges on the surface of photoconductive layer 12 are discharged by illumination source 84 and reflector light shield 86. Surface particles of the photoconductive layer 12 are removed therefrom by means of web contact station 160 to regenerate the photoconductive layer 12 for use in the next cycle of the apparatus in accordance with this invention.

As heretofore stated, the web 162 desirably supports abrasive material on its surface and is contacted with the surface of photoconductive layer 12 by means of roller 164 providing support to the back of web 162,

and maintaining the web against the layer 12, thereby abrading photoconductive layer 12 to remove the surface particles therefrom. Gentle abrading action can be obtained by advancing the web 162 in the direction of, and at the peripheral speed of the rotation of photoconductive layer 12. Increased abrasive action can be obtained by advancing web 162 in the same direction as the direction of rotation of photoconductive layer 12 at a speed substantially greater than the peripheral speed of photoconductive layer 12, or by advancing the web in the same direction as the direction of rotation of photoconductive layer 12, but at a speed less than the peripheral speed of the photoconductive layer. Further increased abrasive action can be obtained by advancing the web at reduced speeds, by stopping the web during the regeneration step, or by advancing the web in a direction opposite to the direction of rotation of photoconductive layer 12. The amount of abrasion can also be controlled by adjusting the pressure that the roller 164 exerts on the back of web 162 to provide increased or decreased pressure of the web 162 against the photoconductive layer 12. Thus, the severity of abrasion can readily be controlled in accordance with the amount of material, i.e., surface particles and particles thereunder to be removed, and in accordance with the abrasiveness of the material on the surface of web 162.

As heretofore stated, web 162 can desirably be a web which is itself abrasive. A very suitable web 162 was prepared of paper containing fine glass fibers as the abrasive. The preparation of the web will be hereinafter described.

In FIG. 4, a modification of the apparatus illustrated in FIG. 1 is schematically illustrated, wherein elements similar to elements in FIG. 1 have the same reference numerals. The function of these similar elements and the formation and transfer of the image have been described heretofore.

As illustrated in FIG. 4, following the transfer of the latent electrostatic image from the surface of photoconductive layer 12 to the surface of sheet 40, the photoconductive layer 12 is rotated on drum 10 past illumination source 84 and reflector and light shield 86, to discharge any charges remaining on the surface of layer 12, to brushing unit 170. Brushing unit 170 can comprise a generally circular brush 172 formed of bristles affixed to a shaft 174, which rotatably supports brush 172 at an angle to the surface of photoconductive layer 12. Preferably, the brush is supported at a large angle, for example, from about 45 to about 80 degrees to the surface of the photoconductive layer 12 if flat, or to the tangent at the point of contact if the surface of the layer 12 is curvilinear as in FIG. 4. In this preferred manner the bristles forming the brush will contact the layer 12 at a smaller angle, for example from about 10° to about 45°. Shaft 174 supporting brush 172 can be rotated by suitable means, such as a motor 176 which in turn may be guidingly supported upon a guiding member 178, which advantageously may be a rack, by a bracket 180 which may include a pinion. Preferably, brush 172 is moved parallel to the axis of shaft 26 of drum 10 and hence the surface of layer 12 by known means (not shown) during operation so that the entire surface of photoconductive layer 12 is uniformly contacted with the brush during the process of the present invention. Movement in this manner can be accomplished by reciprocally moving motor 176 which supports shaft 174

and brush 172 along guiding member 178 which can be mounted parallel to the axis of shaft 26.

Brush 172 may be rotated at any desired speed, and preferably the brush is rotated rapidly, for example at speeds in the order of 10,000 to 20,000 revolutions per minute. Similarly, the pressure at which the brush contacts layer 12 can be varied, but small pressures, in the order of 50 to 100 grams over a small area such as 0.2 square millimeters, are preferred. The brush desirably has a diameter of from 10 to 20 millimeters comprising bristles having a diameter of from 0.1 to 0.2 millimeters, although harder or softer brushes can be used. As in the case of the embodiment illustrated in FIG. 1, the regeneration step may be performed at every cycle of the drum 10, or preferably periodically at intervals, such as at every 10, 100, 1,000, 10,000 imaging cycles of the drum.

The present invention is further described and specifically defined in the following examples. The examples are intended to illustrate the various preferred embodiments for carrying out the invention.

EXAMPLE 1

A comparative test was conducted with apparatus similar to the apparatus illustrated in FIG. 1. In this test, Photoconductive "Luvican M-170" obtained from Badische Anilin-Soda Fabrik, Germany, polyvinylcarbazole, mixed with 3 percent tetranitrofluorenone and 20 percent plasticizer, "Dowtherm A" obtained from Fluka A.G., Buchs, Switzerland, was coated to a thickness of from 5 to 6 microns on aluminum foil. The coated foil was taped onto an aluminum drum so that the underside of the foil was in electrical contact with the drum. Upon rotation of the drum in the dark, the coated foil was charged using a corona unit having an applied voltage of minus 10 kilovolts, direct current. At the exposure station, the coated foil was exposed to image-wise incandescent light at an exposure of 114 lux-seconds. The latent electrostatic image formed was transferred after a predetermined number "n" of charging and discharging cycles of the drum. In the cycling without transfer of the latent electrostatic image, the latent electrostatic images were discharged with an incandescent discharge lamp prior to formation of the subsequent image. In the cycling with transfer, transfer of the latent electrostatic image to a sheet of dielectric paper supported on a metal drum across an air-gap of about 60 microns was effected with the use of a transfer voltage of about 130 volts D.C. applied across the drums supporting the respective surfaces. The drum supporting the photoconductive surface was revolved at a speed of 20 revolutions per minute and the second drum also revolved at the same speed. The relative humidity during the test was approximately 50 percent. During the cycles in which transfer of the latent electrostatic image was effected, the transferred latent image was developed with liquid toner, commercially available from SCM Corporation, New York, U.S.A. The uniform charge on the surface of the photoconductor was measured at a point from about 1 to about 2 inches subsequent to the charging station. Regeneration of the photoconductive layer was effected by brushing the surface of the layer with a commercial bottle cleaning brush, i.e., synthetic plastic bristles having a diameter of 0.1 millimeter, the brush having a diameter of about 55 millimeters, revolving at 2,000 revolutions per minute, to remove the surface particles of

the layer. Thereafter cycles wherein the latent electrostatic image was formed and transferred were repeated and the voltage measurement as described above taken, and the dielectric sheets on which the latent electrostatic image was transferred were developed with liquid toner as described above and the copies compared with copies obtained prior to the 200 cycles which included the regeneration step.

The results of the above experiments are presented in the table below:

Cycle No. (n)	No. of the Cycles Including the Regeneration Step	Surface Voltage, as a Percentage of the Surface Voltage at the First Cycle
0	—	100
10,000	0	0
10,200	200	60
18,000	8,000	55-60
24,000	14,000	approx. 50

Comparison of identically developed latent electrostatic images on the dielectric paper before and after the cycles which included the regeneration step, showed an improvement of the copy quality after the said cycles. Specifically, large white spots on the otherwise dark areas, corresponding to the dark areas in the original, were present in the sheets made prior to the cycles containing the regeneration step, whereas such areas were not present in the dark areas in the sheets obtained after the said cycles. In addition, test areas of sheets obtained after the said cycles had greater contrast as compared to the background thereof, as compared to the sheets obtained prior to the said cycles.

EXAMPLE 2

Example 1 was repeated, except that a brush of goat-skin having a diameter of about 60 millimeters rotating at about 1,200 revolutions per minute was utilized at 70 percent relative humidity in place of the synthetic bristle brush. Copies of relatively good quality were obtained after 2,000 imaging cycles where the brush was contacted with the drum at each cycle, as compared to copies obtained without the application of the brush.

Similarly, the regeneration effect was obtained by the application of other brushes of goatskin, horse hair, and synthetic bristles rotating at from 1,000 to 5,000 revolutions per minute at cycling intervals of from every imaging cycle to once every 1,000 imaging cycles with the photoconductive layer described in Example 1.

EXAMPLE 3

Apparatus similar to that illustrated in FIG. 3 including a metal drum coated with the photoconductive layer defined in Example 1 was utilized in this example. Paper webs were prepared by disintegrating tissue paper, Linsoft, obtained commercially from Migros Co., Switzerland, into water by soaking the paper therein and adding glass wool having a fiber diameter of about 5 to 20 microns in predetermined amounts. The suspension was mixed and dried. Upon drying, soft paper webs of about 150 micron thickness containing predetermined amounts of glass wool were obtained.

The drum described above supporting the photoconductive layer was rotated with a web prepared as above containing 20% by weight glass wool and having a rela-

tively rough surface pressed against the layer by a roller having about 10 millimeters of soft sponge rubber as its surface with a pressure of 50 grams per square centimeter, over a contact area as wide as the photoconductive layer and having a length of 2 centimeters. By measurement, it was found that the use of the 20 percent glass wool web at the above described conditions of contact resulted in an abrasion rate of one micron per 1,000 cycles. The abrasion rate was found to increase about linearly from 2 to about 40 percent glass wool with increased proportions of glass wool in the web, and conversely the abrasion rate decreased as the proportion of glass wool in the web decreased. Similarly the abrasion rate increased with increasing pressure applied to the web against the drum and decreased with decreasing pressure. The electrophotographic properties of the layer, as evidenced by the saturation surface voltage, were regenerated to commercially acceptable levels in this example even at high relative humidity. For example, after 1,000 cycles at 70 percent relative humidity, with the paper web contacting the layer at every cycle, the saturation surface voltage measured as in Example 1, was 70 percent of the voltage measured at the first cycle; whereas without the use of the paper web, the voltage measured zero percent of the voltage at the first cycle. Copies produced using latent electrostatic image transfer apparatus, similar to that described in Example 1, to transfer the image to a dielectric coated sheet and develop the latent image, after 1000 imaging cycles of the layer at 70 percent relative humidity with the paper web contacting the layer at each cycle, were of good copy quality; whereas sheets obtained from the identical number of cycles under the same conditions, but without contact of the web with the layer, did not have any visible image on the sheet after development.

EXAMPLE 4

The abrasion rate of one micron per 1000 cycles obtained in Example 3 was found to be a limiting factor if regeneration of the photoconductive layer is to take place at each photocopy cycle or at some small number of photocopy cycles. Therefore, an abrasion rate of from about 0.01 to about 0.1 micron per 1,000 cycles is obtained by preparing, in the manner described above, paper webs having a thickness of about 50 to about 100 microns (about 15-30 grams per square meter) containing from about 1 to about 10 percent, and preferably 5 percent, glass wool having a fiber diameter of less than 5 microns preferably less than about 2 microns. These webs are contacted with the surface of the photoconductive layer at a pressure of from about 10 to about 30 grams per square centimeter to obtain the desired abrasion rate upon continuous contact. Regeneration of the photoconductive layer upon use in an electrophotographic process accomplished by applying the web to the surface of the layer periodically, for example, once every 10 to 100 cycles of the electrophotographic process, also reduces the abrasion rate. In this manner, the photoconductive layer can be utilized in from 10,000 to 100,000 electrophotographic cycles per 1 micron in thickness of the photoconductive layer until the layer becomes too thin to provide an electrostatic image which is acceptable upon development and preferably upon transfer and development. In addition, the paper web can be advanced past the area of contact with the photoconductive layer at a speed in the order of 0.1 to 1 meter per 1,000 regeneration cycles.

EXAMPLE 5

A web of tissue paper, prepared from Linsoft, obtained from the Migros Co., Switzerland, whose surface was covered with approximately 0.1-0.2 milligrams per square centimeter of aluminum oxide powder, having a diameter of approximately 0.05 micron was used in this example with apparatus similar to that illustrated in FIG. 3. Upon contact of the powder covered paper web to the surface of the photoconductive layer, controlled removal of surface particles of the photoconductive layer was obtained. The contact of the web to the layer was made with a presence of approximately 50-100 grams per square centimeter applied to the web. After 1,200 imaging cycles at 60 percent relative humidity, which included 100 imaging cycles wherein the web was applied to the layer as described above, the saturation surface voltage measured as described in Example 1, was 60 percent of the voltage at the first cycle. Where the web was not used, i.e., no regeneration step after 1,200 imaging cycles, the voltage measured was 20 percent of the voltage at the first cycle.

EXAMPLE 6

Example 5 was repeated using paper webs as described in Example 4, covered with similar amounts of polycrystalline zinc oxide. These webs, when applied to the surface of the photoconductive drum under the same conditions of applied pressure and relative humidity, abraded the surface of the photoconductive layer to remove surface particles and thereby provide regeneration of the photoconductive layer. For example, after 10,000 imaging cycles including 200 cycles where the web was applied, the saturation surface voltage, measured as in Example 1, was 50 percent of the voltage at the first cycle. Where the web was not utilized, after 10,000 imaging cycles the voltage was zero percent of the voltage at the first cycle.

EXAMPLE 7

The photoconductive layer described in Example 1 was placed on a metal drum in the manner described therein surrounded with the charging, voltage measuring, imaging and discharging apparatus described in that example. The brush apparatus in Example 1 was replaced with a tubular infrared lamp of about 150 watts mounted in a cylindrical mirrored reflector mounted adjacent the surface of the photoconductive layer so as to heat the said surface to a temperature of from about 120° to about 180° centigrade. After 10,000 imaging cycles at a relative humidity of 50 percent with the infrared lamp heating the layer at each cycle, the saturation surface voltage was measured as in Example 1 and found to be 70 percent of the voltage at the first cycle. However, after 10,000 imaging cycles under the same conditions without the use of the infrared lamp, the saturation surface voltage was zero percent of the voltage at the first cycle.

EXAMPLE 8

A photoconductive layer on a metal drum as described in the previous example was similarly surrounded with the charging, measuring, imaging and discharging apparatus described in Example 1. The regeneration step of the present invention, when used, was effected by contacting the layer lightly with facial tissue paper, Linsoft commercially obtained from the Migros

Co., Switzerland, wetted with ethanol. After 10,000 imaging cycles at 50 percent relative humidity, with the application of the ethanol-wetted tissue paper for 100 cycles, the saturation surface voltage was 50 percent of the voltage at the first cycle; whereas after the same number of imaging cycles without the use of the wetted tissue, the saturation surface voltage was zero percent of the voltage at the first cycle.

EXAMPLE 9

Apparatus similar to the apparatus described in FIG. 4 was utilized in this example. Various photoconductive layers were coated on aluminum foil and the foil affixed to a metal drum. The charging, voltage measuring, imaging and discharging apparatus described in the previous examples was utilized with the drum under the conditions hereinafter described. The regeneration step was performed using the following motor driven brush: "Moto-tool," model no. 2, kit 1, brush no. A-3, obtained from Dremel Manufacturing Co., Wisconsin, U.S.A., the brush having a diameter of 18 millimeters and a bristle thickness of 0.2 millimeters, mounted as shown in FIG. 4, with the bristles being at an angle of between about 30° and about 40° to the tangent of the layer at the point of contact. The apparatus applied the bristles of the brush to the layer with a pressure of approximately 80 grams over the limited area of contact while at rest. In operation, the brush was rotated at about 10,000 to about 20,000 revolutions per minute for about 0.01 to about 0.02 second at each portion of the layer per cycle of the drum.

Using the photoconductive layer described in Example 1, after 6,000 imaging cycles at 70 percent relative humidity, without the application of the brush the saturation surface voltage was 2 percent of the voltage at the first cycle. After one additional cycle with the application of the brush as described above, the saturation surface voltage was 70 percent of the voltage at the first cycle. Copies were obtained in another identical experiment using the latent electrostatic image transfer apparatus and procedure described in Example 1. Without the use of the brush, copies having very poor copy quality were obtained after 500 imaging cycles; whereas where the brush was applied as described above at each 100th cycle, copies having good copy quality were obtained after more than 3000 imaging cycles. In similar experiments utilizing the same photoconductive layer, at thicknesses varying from 3 to 20 microns, under conditions of from 30 to 80 percent relative humidity, distinct increases in the saturation surface voltage were obtained after from 1,000 to 40,000 imaging cycles by the use of the brush described above as compared to operation without the use of the brush.

Similarly, using the photoconductive layer described in Example 1 at an initial thickness of 15 microns in the apparatus described above, at 40 percent relative humidity the saturation surface voltage was measured at every 6000 imaging cycles up to a total of 36,000 cycles. Before the application of the brush described above at each 6000th cycle, the saturation surface voltage was from 40 to 50 percent of the voltage at the first cycle; while after the application of the brush at each 6000th cycle, the saturation surface voltage was from 65 to 80 percent of the voltage at the first cycle. At the 36,000th cycle, copies were obtained of the image using the latent electrostatic image transfer apparatus and procedure described in Example 1 immediately be-

fore and after regeneration of the properties of the layer by the application of the brush. The copier obtained after the regeneration step were found to have increased contrast and resolution with less defects including spots and developed background, as compared to the copies obtained before the regeneration step.

Other photoconductive layers without sensitizers or with other sensitizers, such as trinitrofluorenone or trinitrofluorenonemalonitrile, and without plasticizers, or with other plasticizers, such as Arochlor 1221, obtained from Monsanto Co., U.S.A., as well as other photoconductors, for example, brominated polyvinylcarbazole, provided similar regeneration of the electrophotographic properties of the layer upon application of the brush described above.

It has been found that humidity has a strong influence on the operational lifetime of photoconductive layers and in particular, on organic electrophotographic layers. It has been further found that the influence of humidity is related and appears to accelerate the deterioration in the quality of copies as heretofore described, upon repeated use of the photoconductive layer in an electrophotographic process which includes charging the layer with corona discharge means and/or transferring an image therefrom utilizing corona discharge means or an electric field. The deterioration effect, i.e., the decrease of the charge acceptance of the layer and, hence, the contrast voltage of the latent electrostatic image, with increasing humidity, was found, particularly with organic photoconductors, such as polyvinylcarbazole, to depend primarily upon the relative humidity and only slightly, if at all, upon the absolute humidity.

The method of the present invention, particularly using soft brushes, often at every operation cycle, has been found to be effective in regenerating the electrophotographic properties of the photoconductive layer to a considerable extent at low relative humidities, e.g. below about 40 percent relative humidity, and to a somewhat lesser extent at higher relative humidities. Good regeneration can be obtained according to this invention at higher relative humidities, such as at 50 to 80 percent or higher relative humidity, by using relatively hard brushes, e.g. the brush of Example 9 periodically at every 10th, 100th or 1000th cycle, or by using abrasive webs, such as that described in Example 3 at every cycle or at every 10th, 100th or 1000th cycle.

It has now been found that by heating the surface of the photoconductive layer, the effect of humidity is diminished. Therefore, it is advantageous to apply heat to the photoconductive layer prior to, during and/or subsequent to the regeneration method of the present invention in the presence of relative humidity above about 40 percent relative humidity to achieve the desirable regeneration of the present invention. For example, while Example 7 and 8 show excellent regeneration effects at 50 percent relative humidity, the effects almost disappeared during operation at 70 percent relative humidity. However, the application of heat to the photoconductive layer permits the regeneration effects even at high humidities, as illustrated in the following example.

EXAMPLE 10

Example 2 was repeated without producing copies with the addition of a 110 volt, 150 watt infrared lamp supplied with 60 volts of potential placed adjacent the

drum and partially surrounded by a cylindrical mirrored reflector so as to heat the surface of the photoconductive layer to a temperature in the order of about 100° C at the area of contact of the layer by the rotating brush. Upon utilizing the heating effect of the infrared lamp during the contacting of the rotating brush with the surface of the photoconductive layer, at 70 percent relative humidity, the smearing on the surface of the layer of surface particles separated from the layer, as occurs without heating, was greatly reduced.

In addition, the application of heat alone has the beneficial effect of at least partially regenerating the desirable properties of the photoconductive layer by removing surface particles therefrom by evaporation, as illustrated in Example 7 herein, as well as to decrease the relative humidity of the atmosphere adjacent the layer to permit the other embodiments of the present invention to regenerate the desirable properties of the photoconductive layer to a greater extent at the higher relative humidity.

While only a limited number of embodiments have been illustrated and described, it will be apparent to those skilled in the art that various modifications and improvements may be made without departing from the scope and spirit of the invention. Accordingly, it is to be understood that the invention is not to be limited by the illustrative embodiments, but only by the scope of the appended claims.

I claim:

1. A process for regenerating a photoconductive layer having a substantial amount of an organic material which has been utilized in an electrophotographic process comprising removing surface particles of the photoconductive layer from the remainder of the layer by applying thermal radiation to the surface of said layer for removal of said particles of decomposed material by vaporization.

2. A process for regenerating a photoconductive

layer having a substantial amount of an organic material which has been utilized in an electrophotographic process comprising removing surface particles of the photoconductive layer from the remainder of the layer, wherein the removing includes washing said layer with a solvent to remove surface particles of decomposed material from said layer.

3. A process for regenerating a photoconductive layer having a substantial amount of an organic material which has been utilized in an electrophotographic process comprising removing surface particles of the photoconductive layer from the remainder of the layer, wherein said removing includes contacting said layer with a fibrous web wetted with a solvent to remove surface particles of decomposed material from said layer.

4. An apparatus for regenerating a photoconductive layer having a substantial amount of an organic material which has been utilized in an electrophotographic process comprising means for removing surface particles of said photoconductive layer from the remainder of the layer, said means being mounted relative to the said layer for contact therewith.

5. The apparatus of claim 4 wherein said photoconductive layer being on the periphery of a drum and said means for removing surface particles of said layer being positioned adjacent said drum and contactable with the surface of said layer opposite the surface thereof affixed to the said drum.

6. An electrophotographic duplicating process comprising forming a latent electrostatic image on a photoconductive layer having a substantial amount of an organic material, transferring the latent electrostatic image on said layer to a receiving material and periodically regenerating said photoconductive layer for reuse by removing surface particles of said photoconductive layer from the remainder of said layer before forming a latent electrostatic image.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,910,697
DATED : October 7, 1975
INVENTOR(S) : Willi Lanker

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

IN THE SPECIFICATION:

Column 14, line 31, "test" should read --text--
Column 16, line 13, "presence" should read --pressure--
Column 17, line 28, "rotated at" should read --rotated at
from--
Column 18, line 18, "or" should read --of--

Signed and Sealed this

eleventh **Day of** *May* 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

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