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[11] **3,862,801**

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[54] **METHOD OF CLEANING AN ELECTROSTATOGRAPHIC IMAGING SURFACE**

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Related U.S. Application Data

[62] Division of Ser. No. 886,634, Dec. 19, 1969, Pat. No. 3,725,059.

[52] **U.S. Cl.** ..... **355/15,** 15/103.5, 96/1 LY, 117/37 LE, 118/637 LX, 134/6

[51] **Int. Cl.** **G03g 13/14,** G03g 13/22

[58] **Field of Search** ..... 134/6, 9; 117/37 LE; 118/DIG. 23, 637; 355/15; 15/100, 103.5; 96/1 LY, 1.4

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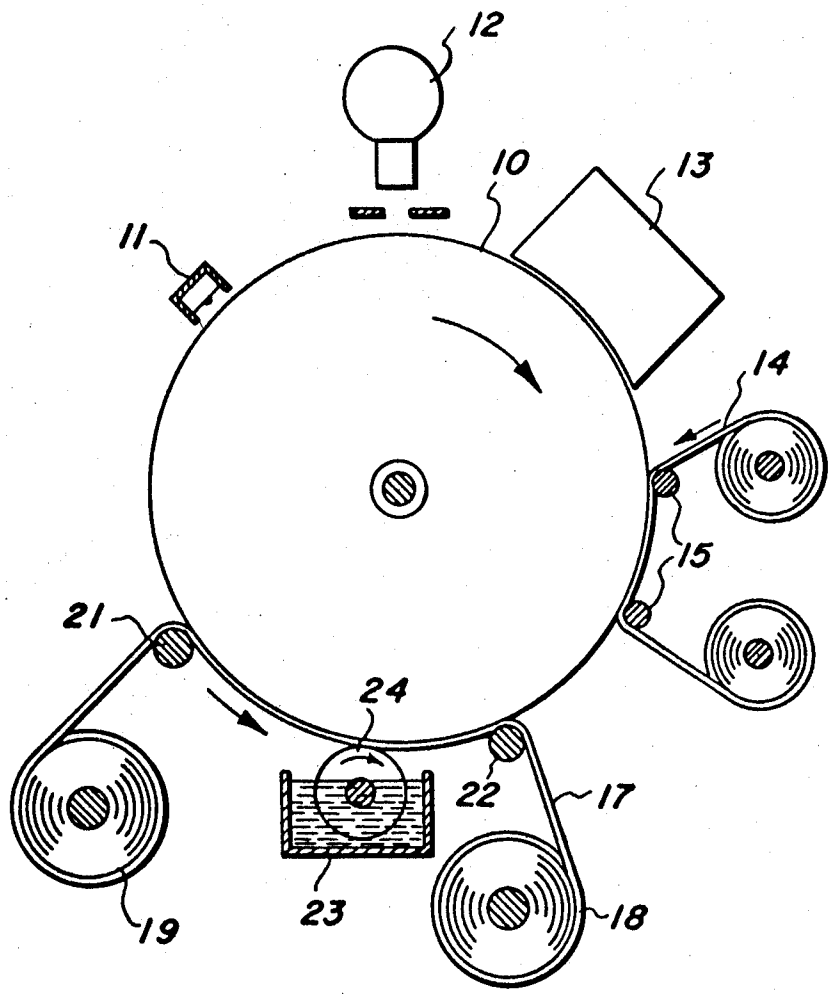
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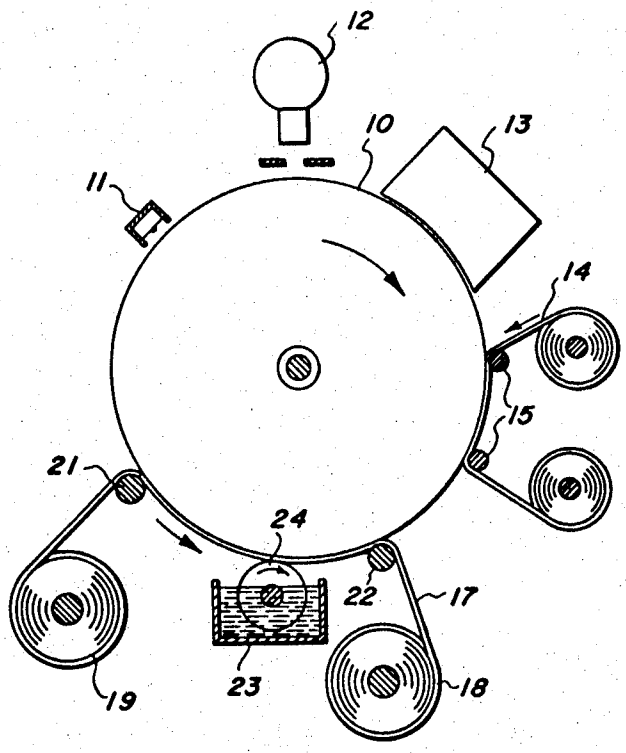
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[57] **ABSTRACT**

An electrostatographic imaging system wherein the imaging surface is cyclically cleaned of residual nonaqueous liquid developer by contacting the imaging surface with a cleaning liquid which is miscible with the nonaqueous liquid developer to dissolve substantially all residual liquid developer. Removal of the miscible cleaning liquid and dissolved liquid developer from the imaging surface may be accomplished with a thin film of liquid being permitted to remain on the imaging surface for every cycle.

8 Claims, 1 Drawing Figure




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METHOD OF CLEANING AN ELECTROSTATOGRAPHIC IMAGING SURFACE

This is a division of application Ser. No. 886,634, filed Dec. 19, 1969, now U.s. Pat. No. 3,725,059.

BACKGROUND OF THE INVENTION

This invention relates to imaging systems, and more particularly, to improved cleaning systems and techniques.

The formation and development of images on the surface of photoconductive materials by electrostatic means is well known. The basic electrostatographic process, as taught by C. F. Carlson in U.S. Pat. No. 2,297,691 involves placing a uniform electrostatic charge on a photoconductive insulating layer, exposing the layer to a light-and-shadow image to dissipate the charge on the areas of the layer exposed to the light and developing the resulting electrostatic latent image by depositing on the image a finely divided electroscopic material referred to in the art as "toner." The toner will normally be attracted to those areas of the layer which retain a charge, thereby forming a toner image corresponding to the electrostatic latent image. This powder image may then be transferred to a support surface such as paper. The transferred image may subsequently be permanently affixed to a support surface as by heat. Instead of latent image formation by uniformly charging the photoconductive layer and then exposing the layer to a light-and-shadow image, one may form the latent image directly by charging the layer in image configuration. The powder image may be fixed to the photoconductive layer if elimination of the powder image transfer step is desired. Other suitable fixing means such as solvent or overcoating treatment may be substituted for the foregoing heat fixing step.

Similar methods are known for applying the electroscopic particles to the electrostatic latent image to be developed. Included within this group are the "cascade" development technique disclosed by E. N. Wise in U.S. Pat. No. 2,618,552; the "powder cloud" technique disclosed by C. F. Carlson in U.S. Pat. No. 2,221,776 and the "magnetic brush" process disclosed, for example, in U.S. Pat. No. 2,874,063.

Development of an electrostatic latent image may also be achieved with liquid rather than dry developer materials. In conventional liquid development, more commonly referred to as electrophoretic development, an insulating liquid vehicle having finely divided solid material dispersed therein contacts the imaging surface in both charged and uncharged areas. Under the influence of the electric field associated with the charged image pattern, the suspended particles migrate toward the charged portions of the imaging surface separating out of the insulating liquid. This electrophoretic migration of charged particles results in the deposition of the charged particles on the imaging surface in image configuration.

A further technique for developing electrostatic latent images is the liquid development process disclosed by R. W. Gundlach in U.S. Pat. No. 3,084,043 hereinafter referred to as polar liquid development. In this method, an electrostatic latent image is developed or made visible by presenting to the imaging surface a liquid developer on the surface of a developer dispensing member having a plurality of raised portions or "lands" defining a substantially regular patterned surface and a plurality of portions depressed below the raised portions or "valleys." The depressed portions of the developer dispensing member contain a layer of conductive liquid developer which is maintained out of contact with the electrostatographic imaging surface. Development is achieved by moving the developer dispensing member loaded with liquid developer in the depressed portions into developing configuration with the imaging surface. The liquid developer is believed to be attracted from the depressed portions of the applicator surface in the charged field or image areas only. The developer liquid may be pigmented or dyed. The development system disclosed in U.S. Pat. No. 3,084,043 differs from electrophoretic development systems where substantial contact between the liquid developer and both the charged and uncharged area of an electrostatic latent image bearing surface occurs. Unlike electrophoretic development systems, substantial contact between the polar liquid and the areas of the electrostatic latent image bearing surface not to be developed is prevented in the polar liquid development technique. Reduced contact between a liquid developer and the nonimage areas of the surface to be developed is desirable because the formation of background deposits is thereby inhibited. Another characteristic which distinguishes the polar liquid development technique from electrophoretic development is the fact that the liquid phase of a polar developer actually takes part in the development of a surface. The liquid phase in electrophoretic developers functions only as a carrier medium for developer particles.

In copending application of Alan B. Amidon, Joseph Mammino, and Robert M. Ferguson, Ser. No. 839,801 filed July 1, 1969, now abandoned, entitled Imaging Systems an imaging technique is disclosed wherein an electrostatic latent image is developed by placing the imaging surface adjacent a patterned applicator surface having a substantially uniform distribution of raised portions or "lands" and depressed portions or "valleys" and containing a relatively nonconductive liquid developer in the depressed portions of the applicator. Liquid developers having a conductivity of from about 10^{-10} to about 10^{-14} (ohms-cm)$^{-1}$ are surprisingly attracted to the image portions without any substantial electrophoretic particle separation of particles from the liquid.

While capable of producing satisfactory images this development system can be improved upon in certain areas. Particular areas of improvement include development systems employing a reusable or cycling imaging surface. In these systems, for example, a photoconductor such as a selenium or a selenium alloy drum as the photoconductor surface is charged, exposed to a light and shadow image and developed by bringing the image bearing surface into developing configuration with an applicator containing developing quantities of liquid developer thereon. The liquid developer is transferred to the imaging surface in image configuration. Thereafter the developer pattern on the imaging surface is transferred to copy paper where the liquid developer may be absorbed by the paper to form a permanent print. During the transfer operation not all of the liquid developer is transferred to the copy paper and a substantial quantity may remain on the imaging surface. In order to recycle the imaging surface this developer must be either removed or immobilized, otherwise it will tend to be present as background in subsequent cycles. If the liquid developer is relatively conductive

having a resistivity less than about 10^{10} ohm-cm any residue remaining on the imaging surface may damage charge acceptance of the imaging surface by laterally dissipating electrostatic charge subsequently put on it. This lateral conductivity of residual liquid developer may lead to degradation of image resolution. While lateral conductivity is of secondary importance in development systems employing the more resistive liquid developers the problem of progressive accumulation of liquid developer on the imaging surface in each cycle still persists. This progressive accumulation of developer residue results in an overall loss of density, deterioration of fine detail and contributes to increased background deposits on the final copy, particularly since accurate imaging on the imaging surface may be inhibited.

Procedures to remove the residual developer liquid from the imaging surface after each cycle have been employed. However, to provide the necessary removal of residual liquid developer the cleaning step must be so severe and complete that there may be a progressive degradation of the imaging surface lessening the useful life span. The severity of the cleaning step is dictated by the fact that in cleaning a liquid film from a surface the film is progressively split so that on each separate cleaning about one half the liquid remains on the imaging surface. In some instances and with complete removal of the residual developer the electrical properties of a photoconductor, for example, may be virtually destroyed by the cleaning operation after only a small number of cycles.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a developing system which overcomes the above noted deficiencies.

It is another object of this invention to provide a novel cleaning system.

It is another object of this invention to provide a cleaning system which makes more efficient use of cleaning materials.

It is another object of this invention to provide a simple cleaning system capable of cyclical use.

It is another object of this invention to provide a liquid development system superior to known systems.

It is another object of this invention to provide a cleaning system superior to known systems.

The above objects and others are accomplished generally speaking by providing a cycling electrostatographic imaging system having a cleaning system which enables cleaning of residual liquid developer without degradation of the imaging surface. More specifically, residual nonaqueous liquid developer remaining on an electrostatographic imaging surface after the developer has been transferred to a receiver sheet in image configuration is cyclically cleaned by contacting the nonaqueous residual developer on the imaging surface with a cleaning liquid which is miscible with the nonaqueous liquid developer. The cleaning liquid is employed in an amount sufficient to dilute and disperse within it substantially all of the residual liquid developer. In a liquid development system employing a cycling or reusable electrostatographic imaging surface and also employing a fairly resistive nonaqueous, non-water compatible liquid developer, the residual developer remaining on the imaging surface in any one cycle is cleaned from the surface by directly contacting the imaging surface with a fibrous material moistened with a cleaning liquid and then removing the excess liquid including dispersed pigment by contacting the imaging surface with a dry fibrous material. By so applying the cleaning liquid to the imaging surface the residual liquid developer is effectively dissolved and particulate material, such as pigment, is suspended within the cleaning liquid and removed from the imaging surface. While it is highly desirable to provide an electrostatographic imaging surface which is completely free of residual liquid developer in a development system employing an aqueous liquid developer it is surprisingly found that in the development technique of this invention employing a nonaqueous, fairly resistive liquid developer that a thin film principally of cleaning liquid and containing minor quantities of liquid developer may be permitted to remain on the imaging surface for each cycle.

The invention may be further illustrated by reference to the FIGURE of the accompanying drawing in which an electrostatic latent image is placed on the imaging surface illustrated as a rotating cylindrical drum photoconductor **10** such as a selenium drum by uniformly placing a positive charge on the drum by charging means **11** and then exposing the charged surface to a light-and-shadow image through exposure means **12.** The electrostatic latent image is developed at developing station **13** and the developer on the imaging surface in image configuration is transferred to a receiver sheet such as ordinary paper **14** which is moved through the transfer zone in contact with the drum at the same rate and in the same direction as the periphery of the drum. The paper to which the developed image is transferred is held in transfer position by idlers **15.** The residual developer present on the electrostatographic imaging member is cleaned from the imaging member at a cleaning station. At the cleaning station a porous absorbent roll **24** is rotating in a bath **23** of a cleaning liquid and is in contact with one side of an absorbent fibrous cleaning web **17.** The cleaning web **17** is slowly advanced from supply reel **19** through idlers **21** and **22** into wiping contact with the imaging surface and finally into takeup reel **18.** The cleaning web is preferably moved slowly in the direction countercurrent to the direction of the advancing imaging surface so that the cleanest portion of the web contacts the cleanest portion of the imaging surface. In any imaging cycle, during the initial stages of contact between the cleaning web and imaging surface the cleaning liquid and the residual liquid developer are intimately mixed together with large or gross quantities of liquid being absorbed by the cleaning web. As a result of the counter current motion of the imaging surface and the cleaning web the residual liquid developer and the cleaning liquid are removed from the imaging surface by the cleanest portion of the cleaning web. The cleaning liquid applicator roller **24** supplies cleaning liquid to the absorbent cleaning web **17** and the cleaning liquid passes through the cleaning web and contacts the imaging surface and there dilutes and disperses the liquid developer in the cleaning liquid. This countercurrent movement of imaging surface and cleaning web provides in the order of sequence in which they take place on the imaging surface the removal of gross quantities of cleaning liquid and liquid developer together with the loosening of residual developer on the imaging surface; the uniform distribution of cleaning liquid over the imaging surface to provide dissolution of liquid developer vehicle and

suspension of particulate material in the cleaning liquid; and the absorbent removal of residual mixture of cleaning liquid, liquid developer and substantially all particulate material in web **17**. The cleaning liquid applicator roller **24** may be independently driven or driven by contact with the absorbent fibrous material and may be retractable from the web surface to provide cleaning liquid only on demand. It may also be desirable in certain machine configurations to provide a cleaning system which is retractably engagable with the imaging surface.

It is also contemplated that additional configurations of cleaning liquid applicator, absorbent fibrous material, or web configurations may be employed. For example, the configurations disclosed in copending application of R. Komp and R. M. Ferguson, Ser. No. 886,633 entitled Imaging System and filed concurrently herewith, now abandoned, may be employed.

The cleaning technique according to the instant invention has been found to be particularly effective in cleaning nonaqueous liquid developers from electrostatographic imaging surfaces. By nonaqueous development or nonaqueous developers it is intended to define that group of liquid developers which are not water compatible and can therefore be described generally as oil based materials having dielectric constants less than about 3.5 and surface tensions less than about 40 dynes/cm. These liquid developers are relatively electrically nonconductive and are based on vehicles having a bulk resistivity greater than about 10^{10} ohm-cm. Any suitable developer from this class may be employed. Typical vehicles within this group that may be employed singly or in combination include mineral oil, vegetable oils such as castor oil, peanut oil, coconut oil, sunflower seed oil, corn oil, rapeseed oil, and sesame seed oil. Also included are hydrocarbon oils, fluorocarbon oils such as DuPont's Freon solvents and Krytox oils, silicone oils, kerosene, carbon tetrachloride, octane, toluene, oleic acid, and drying oils such as linseed and tung oil. In addition, as is well known in the art, the developers may contain one or more secondary vehicles, dispersants, pigments or dyes, viscosity controlling agents, drying oils or additives which contribute to fixing the pigment on the copy paper. In the development techniques described in U.S. Pat. application Ser. No. 839,801, the preferred and most practical operating range of resistivity providing balance between conductivity, time constant for lateral discharge and development speed is from about 2×10^{10} to about 10^{12} ohm/cm.

Any suitable cleaning liquid which is miscible with the liquid developer may be employed. Typical cleaning liquids include the nonaqueous, non-water compatible liquids discussed above and any additional liquids which are miscible with a particular developer employed and have a bulk resistivity greater than about 10^{10} ohm/cm. Typically, the cleaning liquids have dielectric constants and surface tensions in the ranges stated with respect to the liquid developers. Typical materials include hydrocarbon oils, coconut oil, vegetable oils, such as peanut oil, sunflower seed oil, rapeseed oil, corn oil, fluorocarbon oils, silicone oils, carbon tetrachloride, toluene and oleic acid. The cleaning liquid should be so selected that they do not have a deleterious effect on either the imaging surface which they are to clean or on any of the materials or machine components with which they come in contact and particularly should not chemically attack the absorbent fibrous material which applies the cleaning liquid to the imaging surface. Additionally, the cleaning liquids are preferably nonodorous and nontoxic and have flash points in excess of 110°F.

A particular advantage of the development system according to this invention is that the residual liquid developer and cleaning liquid need not be completely removed from the imaging surface on each imaging cycle. Instead the wiping contact or cleaning of residual liquid developer and cleaning liquid on the imaging surface may be sufficient only to leave a thin film on the imaging surface. With incomplete cleaning, however, it is preferred to provide a substantially continuous thin film of residual liquid developer and cleaning liquid on the imaging surface in order to provide uniformity on the imaging surface. The thickness of any film remaining on the imaging surface must, however, be closely controlled in order to avoid any problems of imaging through a thick layer of liquid or dissipation of charge on the imaging surface. In order to provide adequate imaging capability it is preferred to provide a thin layer which is substantially transparent so that imaging may take place through this layer of liquid. Typically, the film of residual liquid developer and cleaning liquid on the imaging surface may be present in the layer up to a thickness of about 1 micron. If a layer much in excess of 1 micron in thickness is provided it will be too thick to provide adequate definition and resolution of image characters and may contribute to undesirable background. The latitude in mechanical operation which permits the presence of a thin layer of residual liquid developer and cleaning liquid on the imaging surface according to the technique of this invention is highly desirable from the automated machine point of view since rigorous cleaning operations, materials and techniques are not required.

Where optimum image resolution and contrast are desired it is generally perferred to provide an imaging surface which has been cleaned of substantially all residual developer and cleaning liquid. To facilitate complete removal of the imaging surface it is preferred to provide a cleaning liquid which is readily evaporated or removed from the imaging surface. Preferably a cleaning liquid which has a medium range volatility or will evaporate at a temperature below a temperature which may thermally degrade any of the other materials and in particular the imaging surface is employed. When employing a material of medium or high range volatility a simple heating lamp may be employed to provide adequate vaporization of the cleaning liquid. Any residual cleaning liquid containing non-aqueous developer dissolved therein remaining on the imaging surface may, however, be removed with the use of a highly absorbent porous material.

The cleaning liquid may be applied to the imaging surface in any suitable manner. Typically, an absorbent porous material containing absorbed cleaning liquid may be employed. Particularly effective application of cleaning liquid is obtained with highly absorbent fibrous and porous materials. The porous materials may be employed in the configuration of a sponge. The absorbent fibrous materials may be employed in the configuration of felt tips, brushes or wicks. They preferably are in the form of continuous webs to facilitate the rapid, continuing resupply of new cleaning and applicating surfaces and to provide both applicating and re-

moval surfaces. Since the fibrous material may function as a liquid cleaning applicator to the imaging surface and may also function as an absorbent sheet, the fibrous material should have sufficient wet strength that it does not rip or part when it is wet by the cleaning liquid. The fibrous material is preferably softer than the imaging member so as to not abrade it, is lint free so as not to offset lint or other particulate matter to the imaging surface and is not chemically reactive with either the liquid developer or the imaging surface. The fibrous material preferably does not contain any deleterious solubles which may be dissolved in the cleaning liquid or the cleaning system. It has adequate absorbing capacity to absorb the liquid residue resulting from the smearing of the residual liquid developer and the cleaning liquid on the imaging surface. The most important characteristics of the fibrous material, however, are the good transmission of cleaning liquid from a cleaning liquid supply to the imaging surface and a good absorption and retention of cleaning material after cleaning has been accomplished. Any suitable fibrous material may be used. Typical fibrous cleaning materials include those made from rayon, nylon, cotton, cheese cloth, flannel, Dacron, polyester fibers, polypropylene fibers, paper and cellulose fibers, combinations of rayon and cotton and mixtures thereof. Particularly satisfactory cleaning is obtained with those fibrous webs which are substantially homogeneous and thick and have a high absorbent capacity.

The liquid cleaning material may be supplied to the absorbent fibrous material in any suitable manner. Typical means of supplying the cleaning liquid from a liquid reservoir to the absorbent fibers is by means of an absorbent, porous wet sponge roll rotating in contact with one side of the absorbent web which delivers the cleaning liquid to the imaging surface on the other side of the absorbent web. Additional means to supply the cleaning liquid to the absorbent web include dipping the absorbent web in the cleaning liquid to virtually saturate the absorbent web. Typical sponge rollers include polyurethane foams and rubber sponges which may be rotating in a bath of cleaning liquid or which may be fed internally from some cleaning liquid reservoir at a remote site. The cleaning liquid may also be applied to the absorbent fibrous material by means of a porous belt applicator or by means of brushes, capillary tubes, gravure rollers, metallic sponge, unglazed porcelain, or felt tips.

The liquid cleaning material may be supplied to the imaging surface in any suitable amount. Preferably sufficient cleaning liquid is added to assist in loosening residual developer from the imaging surface, in uniformly distributing it over the imaging surface and in removing the particulate and dissolved colorant. Typically to achieve these results, the cleaning liquid is applied to the imaging surface in an amount of from about 0.02 to about 1 cubic centimeter per 100 square inches.

In operation an electrostatic latent image is placed on an electrostatographic imaging surface in conventional manner. The latent image is thereafter developed with a liquid developer according to any of the techniques previously discussed. Development preferably is obtained with the use of a patterned surface applicator roller wherein a liquid developer is present in the depressed portions of the applicator while the raised portions are substantially free of developer and the developer is pulled from the developer applicator to the imaging surface in image configuration. After transfer of the developer from the imaging surface to a receiver sheet in image configuration the residual developer is removed from the imaging surface.

The cleaning liquid and residual liquid developer may be removed from the imaging surface in any suitable manner. Typically, the imaging surface may be wiped with an absorbent material such as a porous sponge or absorbent web. A particularly preferred embodiment in providing effective cleaning with minimum effort and materials is that illustrated in the FIGURE wherein a cleaning liquid is applied to an absorbent fibrous web material on one side from a rotating porous sponge roll rotating in a bath of cleaning liquid in an amount sufficient to provide a cleaning amount on the opposite side of the absorbent fibrous web. While the cleaning web and the imaging surface may be moved in the same direction, greatest cleaning efficiency and minimum contact length have been found to occur when the web and the plate are moved in substantially opposite directions. By applying the cleaning liquid to the absorbent fibrous web at a point during the cleaning contact between the web and the imaging surface intermediate the beginning and terminating cleaning portions, a three section cleaning station is provided. The imaging surface first encounters a wet section of the web saturated with relatively dirty or developer contaminated cleaning liquid containing dissolved residual liquid developer vehicle and dispersed residual developer solids. The residual liquid developer on the imaging surface is smeared or distributed over the surface with excessive quantities of liquid developer being removed. The imaging surface then passes against progressively cleaner, but still wet sections of the web up to the point of application of initial cleaning liquid and initial formation of cleaning liquid and developer mixture, and finally encounters a dry web which absorbs remaining liquid developer or cleaning liquid. It should be emphasized that the contact between the cleaning web when wet and the imaging surface provides the necessary smearing of cleaning liquid and residual developer to remove residual developer and cleaning liquid from the imaging surface including any particles which may have adhered rather tightly to the imaging surface. If necessary or desired, any residual liquid cleaner or developer may be removed by the application of heat.

Typically, the absorbent fibrous material is in the form of a web positioned along a portion of the imaging surface. The length of contact between the imaging surface and the absorbent fibrous web is dependent upon many factors including, but not limited to, the amount of cleaning liquid necessary to apply, the amount of residual developer necessary to remove the absorbent capacity of the particular fibrous cleaning web the solvent action of the cleaning fluid and the speed of operation. Typically, with an electrostatographic imaging surface in the configuration of a drum the area of contact with the cleaning web may comprise from about 5% to about 50% of the imaging surface during any portion of the cleaning cycle. To provide adequate spacing of additional imaging stations while providing satisfactory cleaning, the cleaning web may preferably comprise from about 30% to about 40% of the imaging surface area. While the cleaning and imaging surface may be moved in the same direction, minimum contact length has been found to occur when the web and plate are

moved in substantially opposite directions. The contact length may also be varied to some extent by the application of pressure between the cleaning web and the imaging surface. However, the pressure must be so regulated so as not to provide any unnecessary abrading function on the imaging surface. Typically, the pressure applied between the cleaning web and the imaging surface in both dry and wet portions is between 0.25 and 10 pounds per linear inch of contact between the cleaning web and imaging surface. A satisfactory balance between minimizing abrasion effects on the imaging surface and absorbing capacity of the cleaning web is observed with a pressure of from about 0.5 to about 10 pounds per linear inch at the line of contact between the cleaning web and the imaging surface. The rate at which a web of cleaning material is consumed is a function of the rate of plate movement and the relative rate of the web required to yield satisfactory cleaning has been found to vary to some degree depending upon the particular cleaning material employed. Typically the cleaning web is found to have a speed on the order of 1/40 to 1/1,500 of the imaging surface speed. To reduce drag on the cycling imaging surface and reduce the tendency for the web to rip not allowing sufficient time for adequate absorption of residual developer and cleaning liquid the cleaning web preferably has a speed on the order of from about 1/100 to about 1/500 of the imaging surface speed.

Any suitable electrostatographic imaging surface may be cleaned with the technique of this invention. Basically any surface upon which an electrostatic charge pattern may be cyclically formed or developed may be employed. Typical electrostatographic imaging surfaces include dielectric materials, dielectrics coated on conductive surfaces such as plastic coated papers or metal belts, xeroprinting masters, electrographic recording surfaces, photoconductors and overcoated photoconductors. Typical photoconductors that may be employed include selenium and selenium alloys, cadmium sulfide, cadmium sulfo selenide, phthalocyanine binder coatings and polyvinyl carbazole sensitized with 2,4,7 trinitrofluorenone. The electrostatographic imaging surface may be employed in any suitable structure including plates, belts or drums and may be employed in the form of a binder layer. For more effective cleaning, it is preferred to provide a surface to be cleaned which has a very smooth surface and generally the more smooth and uniform the surface the better will be the cleaning.

When a recycling or reusable photoconductor is employed as the electrostatographic imaging surface in the development systems according to this invention, it may be desirable to add a small amount of an appropriate Lewis acid or base to the cleaning liquid. Unless an appropriate Lewis acid or base has been provided as a constituent of the liquid developer according to the technique described by J. Mammino and A. Amidon in application Ser. No. 838,328 entitled Imaging Systems and filed July 1, 1969, it is preferred to provide a small amount of this additive in the cleaning liquid. The addition of an appropriate Lewis acid or base enables the photoconductors to maintain their ability to accept and hold charge for every imaging cycle. The mechanism by which this is accomplished, however, is not fully understood at the current time. However, by providing a small amount of an appropriate Lewis acid and Lewis base, the electrical properties of reusable photoconductors may be cyclically rejuvenated and imaging quality through successive imaging steps maintained. For any particular photoconductor, the additive to the cleaning liquid is specially selected between the two groups of materials, Lewis acids and Lewis bases. Generally, for photoconductors which are positively charged, Lewis bases are employed and for photoconductors which are negatively charged, Lewis acids are employed. Typical examples of Lewis bases include among others, the triarylmethane dyes such as crystal violet, malachite green, pararosaniline, basic fuchsin; xanthane dyes such as rhodamine B, eosin, erythrosine and fluorescein; aniline dyes such as nigrosine and aniline black, solid soluble porphyrin derivatives such as tetraphenyl porphine and copper chlorophyllin; thionine dyes, such as methylene blue and thionine; amines such as triphenylamine, polycyclic aromatic and heterocyclic compounds such as anthracene, pyrene, fluorene, acridene, carbazole and their basic derivatives, aromatic hydroquinones, diamino phenyl oxazoles and triazin. Typical Lewis acids include among others, indanthrone dyes, such as anthrazol blue IBC, azo dyes such as napthol blue black, B, benzoazurin G; aromatic compounds such as 2,4,7 trinitrofluorenone, tetrachlorophthalic anhydride, chloranil, fluoranil, anthraquinone, and 2-dicyanomethylene-1,3-indanedione. The Lewis base nigrosine is a particularly preferred material in obtaining optimum rejuvenation of electrical properties for positively charged selenium or selenium alloy photoconductor.

The appropriate Lewis acid or base should be present at least in an amount necessary to maintain the electrical properties of a cycling photoconductor. They may be insoluble or soluble in the cleaning liquid. For better cycling characteristics it is preferred that they at least be molecularly dispersed in the liquid in order to insure complete availability to the entire photoconductor surface and to insure maximum rejuvenation and stabilization of the photoconductor. To provide maximum stabilization of the photoconductor, the Lewis acid or base preferably is at least partially soluble in the cleaning liquid. Typically the Lewis acid or base is present in an amount of from about 0.1% to about 0.5% by weight of the cleaning liquid.

DESCRIPTION OF PREFERRED EMBODIMENTS

The following preferred examples further define and describe the preferred materials, methods and techniques of the present invention. Example II is presented for comparison purposes. In the examples all parts and percentages are by weight unless otherwise specified.

EXAMPLE I

An imaging system similar in configuration to that depicted in the FIGURE is assembled. A photoconductor in the form of a drum having a diameter of about 8 inches comprising a surface layer of selenium of about 20 microns thick on a conductive aluminum substrate is positively charged to about 450 volts and exposed to a light-and-shadow image in conventional manner. The electrostatic latent image is developed by moving a patterned surface applicator roll having developing quantities of developer in depressed portions thereof past the image bearing surface so that liquid developer is pulled out of the depressed portions to the image bearing surface in image configuration. The development speed is about 12 inches per second. The

developer employed is of the following composition by weight:

Drakeol 9	48 parts
Microlith CT Black	33 parts
Ganex V216	19 parts

Drakeol 9 is a mineral oil with a kinematic viscosity of about 17 centistokes at 38° C. and a specific gravity of about 0.839 to 0.854 at 25° C. available from Pennsylvania Refining Company. Microlith CT Black is a resinated predispersed carbon black pigment available from CIBA: Ganex V216 is an alkylated polyvinyl pyrrolidone available from GAF. The developer on the photoconductor is transferred to bond paper in image configuration. A cleaning liquid applicator comprising a polyurethane foam wrapped on a steel core to provide a roll about 1 ½ inches in diameter is independently driven in contact with a bath of Sohiovolt 35, a hydrocarbon liquid sold by Standard Oil of Ohio, on the one side and in contact with a fibrous absorbent web on the other side. The web is made of cotton fibers dispersed in a Nylon binder sold by Chicopee Mills, Incorporated as type 3427. The cleaning liquid applicator sponge is positioned at the 6 o'clock position with respect to the drum and about midway between two idler rollers which position the cleaning web in contact with the selenium drum along about 30% of its area. The cleaning web is advanced in the direction opposite to the selenium drum at a speed of about 1/450th that of the drum's speed. The first print obtained with this apparatus is free of background, has image density of 0.95, a background of 0.01 and resolution of about 5 line pairs per millimeter. The selenium drum has a substantially continuous film of cleaning liquid on its surface in a thickness of about 0.5 microns. After repeated cycling of 40 prints, no significant change of print quality is observed.

EXAMPLE II

The procedure of Example I is repeated except that the cleaning liquid applicator roller is disengaged from the cleaning web so that a substantially dry cleaning of the selenium drum is obtained. The first print has a resolution of about 5 line pairs per millimeter with clear background. Subsequent prints lose detail and resolution dropping to about 2 lp/mm after about 6 cycles while the background increases.

EXAMPLE III

An overcoated photoconductor about 9 inches by 14 inches in dimension comprising a one quarter mill film of polyethylene terephthalate obtained from E. I. duPont de Nemours and Company under the trade name Mylar overcoated on a 20 micron thick layer of selenium on a flat aluminum substrate prepared according to the procedure of Example I in U.S. Pat. No. 3,251,686 is charged and exposed to a light-and-shadow image in conventional manner. The electrostatic latent image is developed in the manner described in Example I with a developer of the following composition by weight:

Flexricin P6	50 parts
Ganex V216	20 parts
Microlith CT Black	30 parts

Flexricin P6 is a butyl acetyl ricinoleate available from Baker Castor Oil Company. The developer on the overcoated photoconductor is transferred to bond paper in image configuration. Thereafter, the overcoated photoconductor is cleaned by first contacting it with a web saturated with a cleaning liquid of the following composition by weight:

Isopar H	95 parts
Cottonseed oil	5 parts

Isopar H is a synthetically prepared paraffinic hydrocarbon liquid having a specific gravity of 0.76 and a viscosity at 25° of 1.30 centipoises available from Humble Oil and Refining Company. The wet web is advanced against the overcoated photoconductor under a pressure of about 0.3 pounds per linear inch. Thereafter, the overcoated photoconductor is contacted with a substantially dry cleaning web of a nonwoven rayon fabric sold by Chicopee Mills, Incorporated under the name of Masslinn Fabric type S-1000. The first print obtained with this technique has a clean background and image density of 1.0 and a resolution of about 9 line pairs per millimeter. On repeated cycling after 55 prints, the quality is observed to remain the same.

EXAMPLE IV

Five parts of the liquid developer of Example I are diluted with 95 parts of mineral spirits to provide an electrophoretic liquid developer. An electrostatic latent image is formed on a clean selenium xerographic plate comprising a surface layer of selenium about 50 microns thick on a conductive aluminum plate in conventional manner. The selenium plate is uniformly contacted with the liquid developer by immersing the plate in a bath of developer. The pigment particles in the developer migrate to form an image on the selenium plate. The developer adhering to the photoconductor is transferred to bond paper in image configuration. A cleaning fabric as described in Example I saturated with mineral oil (Drakeol 9) is moved across the plate under a pressure of about 0.5 pound per linear inch. The first print obtained is free of background and has an image density of 1.2 and a resolution of about 35 line pairs per millimeter. The cleaned selenium plate has a residual film of less than 1 micron of substantially clear mineral oil on its surface. The above procedure is repeated for an additional 50 cycles. No significant change in print quality is observed.

The technique of this invention provides a sufficient cleaning of an electrostatographic imaging surface such that imaging may be cyclically accomplished in the presence of a thin film of liquid developer or cleaning liquid on the imaging surface. The cleaning technique has the advantage of providing a very fast and efficient manner of cyclically providing an imaging surface without any significant abrasion or degradation of the imaging surface and in a manner that requires very few mechanically moving parts. It further provides a cleaning system which minimizes contamination of mechanical movements or the excessive use of liquids and conserves expendable material by applying only sufficient cleaning materials, cleaning liquid, and cleaning web to the area to be cleaned.

Although specific materials and operational techniques are set forth in the above exemplary embodiment using the cleaning technique of this invention,

these are merely intended as illustrations of the present invention. There are other materials and techniques than those listed above which may be substituted with similar results. Other modifications of the present invention will occur to those skilled in the art upon a reading of the present disclosure which modifications are intended to be included within the scope of this invention.

What is claimed is:

1. A method of cleaning nonaqueous liquid developer from an electrostatographic imaging surface comprising contacting said surface with a cleaning liquid miscible with said liquid developer by

1. placing said imaging surface in wiping contact with an absorbent fibrous material which makes continuous contact across the width of said imaging surface of from 5–50 percent of the area of said imaging surface,
2. applying said cleaning liquid across the full width of said fibrous material at a point intermediate the limit of contact of fibrous material and said imaging surface, and
3. providing counter movement between said imaging surface and said fibrous material, so as to provide a cleaning progression ranging from a first region of fibrous material saturated with a comparatively high concentration of residual liquid developer in said cleaning liquid, an intermediate region of fibrous material saturated with a comparatively lower concentration of residual liquid developer in said cleaning liquid and a last region of dry fibrous material adapted to leave, after cleaning, a substantially continuous transparent film of cleaning liquid diluted-residual developer on said imaging surface.

2. The method of claim **1** wherein said film is less than about 1 micron in thickness.

3. The method of claim **1** wherein said fibrous material comprises a web in contact with the imaging surface and wherein the miscible cleaning liquid is supplied to the opposite side of said cleaning web by contact with a liquid reservoir.

4. The method of claim **1** wherein said imaging member is a reusable photoconductor.

5. The method of claim **4** wherein the photoconductor is selected from the group consisting of selenium and selenium alloys.

6. The method of claim **4** wherein said cleaning liquid contains a small amount of a material selected from the group consisting of Lewis acids and Lewis bases.

7. The method of claim **1** wherein said contact is contact under pressure of from about 0.25 to about 10 pounds/linear inch.

8. The method of claim **1** wherein the liquid vehicle of said nonaqueous liquid developer has a conductivity less than 10^{-10} ohm/cm^{-1}.

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