# United States Patent [19]

**Ferguson et al.**

[11] **3,867,170**

[45] **Feb. 18, 1975**


[54] **METHOD FOR CLEANING LIQUID DEVELOPERS**


[75] Inventors: **Robert M. Ferguson**, Penfield, N.Y.; **Richard J. Komp**, Bowling Green, Ky.

[73] Assignee: **Xerox Corporation**, Rochester, N.Y.



[22] Filed: **Aug. 14, 1972**

[21] Appl. No.: **280,289**

**Related U.S. Application Data**

[62] Division of Ser. No. 886,633, Dec. 19, 1969, abandoned.

[52] **U.S. Cl.** ..... **117/37 LE**, 96/1 L Y, 134/6, 355/15

[51] **Int. Cl.** ..... **G03g 13/22**, B08b 3/08

[58] **Field of Search** ..... 134/6, 9; 117/37 LE; 96/1 LY; 355/10, 15



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 144,544 | 11/1873 | Ives | 134/6 |
| 795,216 | 7/1905 | Forster | 134/6 |
| 2,889,758 | 6/1959 | Bolton | 355/15 |
| 3,084,043 | 4/1963 | Gundlach | 96/1 LY |
| 3,368,526 | 2/1968 | Matsumoto et al. | 117/37 LE |
| 3,559,570 | 2/1971 | Martel et al. | 96/1 LY |
| 3,615,397 | 10/1971 | Dimond et al. | 96/1.4 |
| 3,656,948 | 4/1972 | Mammino | 355/15 |
| 3,725,059 | 4/1973 | Komp | 117/37 LE |



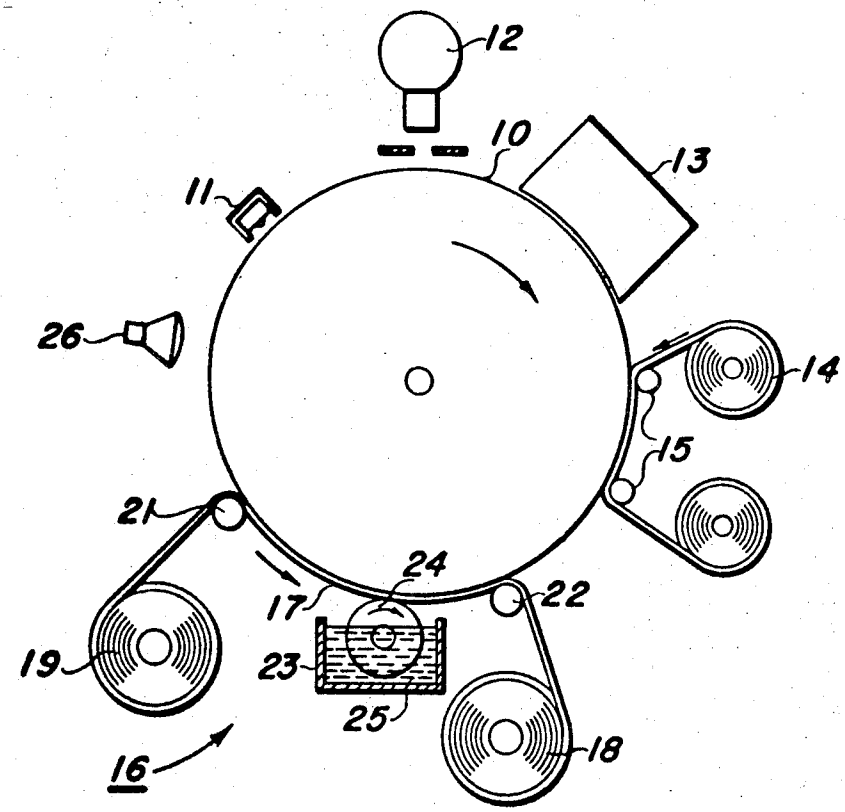
*Primary Examiner*—Michael Sofocleous



[57] **ABSTRACT**

An electrostatographic imaging system wherein the imaging surface is cyclically cleaned of residual aqueous liquid developer by contacting the imaging surface with a cleaning liquid which is miscible with the liquid developer to disperse substantially all the residual liquid developer. The cleaning liquid is preferably applied to the imaging surface by contacting the imaging surface with an absorbent fibrous material moistened with the cleaning liquid. The cleaning liquid with any dispersed aqueous developer may be removed from the imaging surface by means of an absorbent fibrous material.


**10 Claims, 3 Drawing Figures**



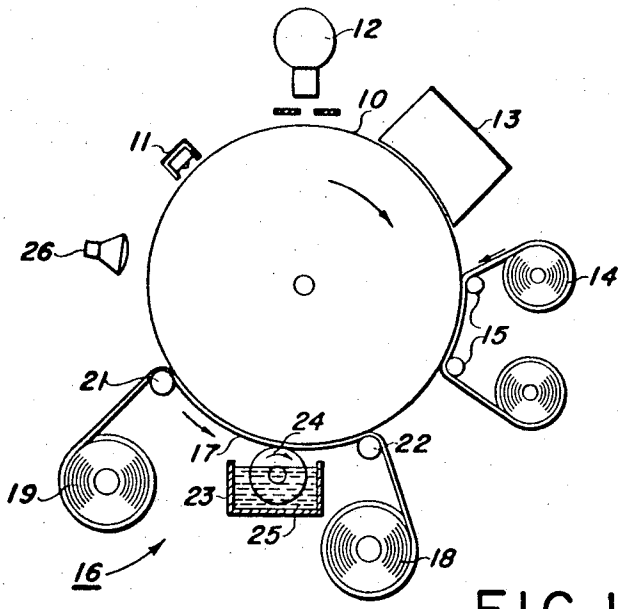



FIG. 1

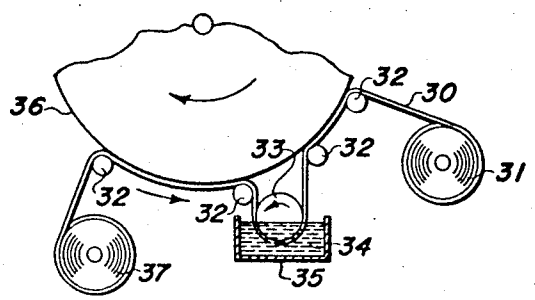



FIG. 2

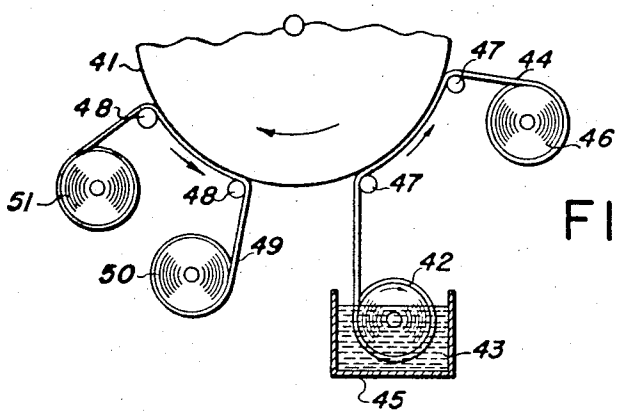



FIG. 3

# METHOD FOR CLEANING LIQUID DEVELOPERS

This is a division of application Ser. No. 886,633, filed Dec. 19, 1969, and now abandoned.

## 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 contains 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 developer 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.



An additional liquid development technique is that referred to as "wetting development" or selective wetting as described in U.S. Pat. No. 3,285,741. In this technique, an aqueous developer uniformly contacts the entire imaging surface and due to the selected wetting and electrical properties of the developer, substantially only the charged areas of the imaging surface are wetted by the developer. The developer should be relatively conductive having a resistivity generally from about $10^6$ to $10^{10}$ ohm-cm and having wetting properties such that the wetting angle measured when placed on the imaging surface is smaller than 90° at the charged area and greater than 90° at the uncharged areas.

While capable of producing satisfactory images, these liquid development systems can be improved upon in certain areas. Particular areas of improvement include those liquid development systems employing reusable or cycling electrostatographic imaging surfaces. In these systems, for example, a photoconductor such as a selenium or 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 according to the appropriate technique from the developer applicator onto the image bearing surface in image configuration. Thereafter, the developer pattern on the electrostatographic imaging surface is transferred to copy paper and the liquid developer may be absorbed by the paper to form a permanent print. During the transfer operation, not all the liquid developer is transferred to the copy paper and a considerable quantity remains on the photoconductor surface. In order to recycle the imaging surface, this residual developer must be either removed or its effects counter-

acted, otherwise it will tend to be present as background in subsequent cycles. When the liquid developer is relatively conductive having, for instance, a resistivity less than about $10^{10}$ ohm-cm, any residue remaining on the imaging surface may dissipate any charge subsequently put on it. That is, lateral conductivity of the liquid developer on the imaging surface may become excessive and the resolution of the resulting image will be poor. On repeated cycling there is also a progressive accumulation of liquid developer on the imaging surface since in each cycle not all the developer is transferred to the copy paper. 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 liquid developer from the imaging surface have been employed. A simple wiping technique with a cloth, brush or weblike material has been proposed. However, to provide adequate cleaning of the electrostatographic imaging surface, the contact between the imaging surface and the cleaning member must be so extensive and severe that there is a degradation of the imaging surface. Otherwise, a film of residual developer will remain on the imaging surface and interfere with any subsequent imaging cycle. An additional proposed method of cleaning has been the use of a wiper blade held in contact with the imaging surface which may be moved over the imaging surface. Difficulties have been encountered with this technique in that the entire residual developer is not removed. Many of the difficulties described with respect to the cleaning systems proposed are due to the fact that on cleaning a film from a surface the film is progressively split so that on each separate cleaning only about one half the film is removed.

## 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 simple cleaning system capable of cyclical use.

It is another object of this invention to provide a simple mechanical means for cyclically cleaning a reusable imaging surface.

It is another object of this invention to provide a cleaning means for cleaning residual liquid developer from a reusable electrostatographic imaging surface.

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 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. The cycling electrostatographic imaging system is cyclically cleaned by contacting the residual developer on the electrostatographic imaging surface with a cleaning liquid which is miscible with the liquid developer. The cleaning liquid is employed in an amount sufficient to dilute and disperse within it substantially all of the residual liquid developer. More specifically, in a liquid development system employing a cycling or reusable electrostatographic imaging surface, 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 the cleaning liquid and then removing the excess liquid 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 dispersed within the miscible cleaning liquid and substantially completely removed from the imaging surface. After contact with the dry fibrous material, any cleaning fluid remaining on the imaging surface following removal of the residual liquid developer may be removed by means of a stream of warm air.

The invention may be further illustrated by reference to the accompanying drawings in which:

FIG. 1 is a schematic view of an embodiment of an electrostatographic imaging system employing the cleaning system of this invention.

FIG. 2 is a schematic view of a portion of an electrostatographic imaging system employing an alternative cleaning system.

FIG. 3 is a schematic view of an alternative cleaning system.

In the electrostatographic imaging system depicted in FIG. 1, an electrostatic latent image is placed on the imaging surface here 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**, 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 liquid developer present on the electrostatographic imaging member is then cleaned from the imaging member at cleaning station **16**. At cleaning station **16**, a porous absorbent roll **24**, is rotating in a bath **23**, of cleaning liquid **25**, 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, in 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 countercurrent 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 absor-

bent cleaning web **17,** which passes through the cleaning web and contacts the imaging surface, and there dilutes and dissolves the liquid developer. 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, dilution and solution of the liquid vehicle of the developer in the cleaning liquid together with dispersion of any solid developer materials such as pigments in the cleaning liquid, and removal of residual mixture of cleaning liquid and liquid developer. While it is anticipated that the absorbing cleaning web will be adequate to remove substantially all the liquid developer, a heat source such as lamp **26,** may be provided to dry or volatilize any residual liquid remaining on the imaging surface. 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.

FIG. **2** depicts the cleaning portion of a schematic view of the technique according to this invention in which an electrostatographic imaging surface **36,** is in contact with cleaning web **30,** advanced in countercurrent direction to the imaging surface. In this embodiment, the liquid cleaning material **34,** in bath **35,** is applied to the cleaning web **30,** held in the cleaning bath by roller **33,** but out of contact with the imaging surface. The cleaning web is advanced from a supply roll **37,** through idler rollers **32** in contact with the imaging surface and thereafter advanced through the cleaning liquid bath **35,** and again advanced past the imaging surface by idler **32,** on to takeup roll **31.**

The embodiment shown in FIG. **3** is an alternative to the cleaning system of this invention in which two web cleaning stations are provided. In the direction of movement of the electrostatographic imaging surface, after transfer of the developed image in image configuration to a receiver sheet, the imaging surface **41,** first comes in contact with fibrous web **44,** having absorbed therein cleaning liquid. The cleaning liquid **43,** is supplied from bath **45,** by immersing the fibrous web supply roll **42,** in the bath. The fibrous web is supported in contact with the imaging surface by means of idler **47,** and is stored when dirty on takeup roll **46.** Following cleaning with the cleaning liquid, the imaging surface may be in moving contact with dry absorbent fibrous web **49,** supplied from supply roll **51,** and held in wiping contact with the imaging surface by means of idlers **48,** and stored after use by means of takeup roll **50.** This embodiment provides an initial cleaning of the imaging surface by cleaning web **44,** with cleaning liquid **43,** followed by a cleaning with a dry fibrous web.

The cleaning technique and apparatus according to the instant invention has been found to be particularly effective in the cleaning of aqueous liquid developers from electrostatographic imaging surfaces. By aqueous development or aqueous developers, it is intended to define that group of liquid developers which are water compatible and which therefore include liquid compositions based upon water, glycerin and suitable water compatible alcohols, glycols, polyols and other well known polar liquids. Any suitable developer from this class may be employed. Typically, the developers for which this cleaning system is effective have a conductivity of from about $10^{-4}$ $(ohm\text{-}cm)^{-1}$ to about $10^{-10}$ $(ohm\text{-}cm)^{-1}$. Typical developer vehicles within this group providing these properties include: glycerol; polypropylene glycol; 2,5 hexanediol; methanol; ethanol; propanol; isopropanol; 1,4 dioxane; acetic anhydride; formic acid; glyoxal; mono, di and tri ethanol amine; butyl formate; eugenol; acetyl acetone; and diethylene glycol mono ethyl ether and glycerin. 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 or additives which contribute to fixing the pigment on the copy paper.

As stated above, the liquid cleaning material is miscible with the liquid developer. Any suitable cleaning liquid which is miscible with the developer may be employed. Typical cleaning liquids include the water compatible or aqueous liquids discussed above and any additional liquid which is miscible with the particular developer employed in any development system. Typical materials include: water; methanol; ethanol; propanol; isopropanol; ethylene glycol; 2,5, hexanediol; and glycerin. The cleaning liquids 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 preferably are nonodorous and nontoxic.

To facilitate complete removal of the cleaning liquid from the imaging surface, it is preferred to provide a cleaning liquid which is readily evaporated or removed from the imaging surface. To this end, it is preferred to provide 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. In a particularly preferred embodiment using a vitreous selenium photoconductor, it is preferred to provide a cleaning liquid which has a boiling point below about 130° C. To minimize waste due to evaporation during idle machine periods, it is preferred to provide a cleaning liquid with a boiling point of between about 45° C. to about 100° C. Optimum conservation of cleaning liquid while maintaining adequate removal ability without degradation of imaging materials is obtained with the cleaning liquids having boiling points from between about 60° C. to about 80° C. When employing a material of medium to high range volatility, a simple heating lamp such as depicted in FIG. **1** may be employed to provide adequate removal of the cleaning liquid. Any residual cleaning liquid containing aqueous developer dispersed therein remaining on the imaging surface may be removed, however, 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 such as porous sponges and fibrous materials may be employed. Particularly effective application of cleaning liquid is obtained with highly absorbent fibrous materials. While the absorbent fibrous materials may be employed in the configuration of felt tips 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 removal 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 not to 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. Also the fibrous material preferably does not contain any solubles which may be dissolved in the cleaning liquid or cleaning system and has adequate absorbent 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 ability to transmit cleaning liquid from a cleaning liquid supply to the imaging surface and a good absorption and retention of cleaned material after the cleaning has been accomplished. Any suitable fibrous material may be used. Typical fibrous cleaning materials include those made from cheesecloth, flannel, rayon, cotton, Dacron, polyester fibers, polypropylene fibers, paper and cellulosic fibers, Nylon, combinations of rayon and cotton and mixtures thereof. Particularly satisfactory cleaning is obtained with those fibrous webs which are substantially homogenous 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 roller, 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 all particulate and dissolved colorant. Typically, to achieve these results, the cleaning liquid is applied to the imaging surface in an amount of from about 0.2 to about 3 cubic centimeters per one hundred 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 remaining on the imaging surface is removed from the imaging surface according to the technique of this invention. According to this technique and particularly according to the preferred embodiment illustrated in FIG. 1, 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, minimum contact length and greater cleaning efficiency 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 any 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 substantially all residual developer from the imaging surface including any particles which may have adhered rather tightly to the imaging surface. As also depicted in FIG. 1, 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 compise 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 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 about 0.25 and about 10 pounds per lineal 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 3 pounds per lineal 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 1/1500 of the imaging surface speed. To reduce drag on the cycling imaging surface and reduce the tendency for the web to rip, but 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 trinitrofluorononone. 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.

## 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 FIG. I but without the heat lamp is assembled. A photoconductor in the form of a drum comprising a surface layer of selenium 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 the 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 speed of development is about 12 inches per second. The developer employed is of the following composition by weight:

| | |
|---|---|
| Glycerol | 76 parts by weight |
| Nigrosine J | 4 parts by weight |
| Sorbitol | 19 parts by weight |
| Santicizer 160 | 2 parts by weight |

Nigrosine J is a dye available from American Cyanamid Company. Santicizer 160 is a butyl benzyl phthalate plasticizer available from Monsanto Company. The developer on the photoconductor is transferred to bond paper in image configuration. A cleaning liquid applicator comprising polyurethane foam, wrapped on a steel core to provide a roll about 1 to 1½ inches in diameter is independently driven partially submerged in a cleaning liquid bath of two parts by weight n-propyl alcohol and one part by weight water on the one side and in contact with a fibrous absorbent web on the other side. The web is made of rayon and is available from the Kendall Company under the designation Webrils T3529. The cleaning liquid applicator sponge roll is positioned 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 1/150 $^{th}$ that of the drum speed and in contact under a pressure of about 2 pounds/lineal inch. The first print obtained with this apparatus is free of background and has a resolution of about 10 line pairs per millimeter. After repeated cycling of 50 prints no significant change in print quality is observed. Furthermore, the machine components are substantially dry and free from liquid developer and cleaning fluid.

## EXAMPLE II

The procedure of Example I is repeated except that the polyurethane cleaning liquid applicator roll is disengaged from the cleaning web so that only a substantially dry web cleaning is provided. The first print obtained has a resolution of about 10 line pairs per millimeter. No further images are obtained on further cycling because the residual conductive ink film dissipates the electrical charge on the photoreceptor.

## 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 & Company under the trade name Mylar) overcoated on a 20 micron thick layer of selenium or an aluminum substrate prepared according to the procedure of Example I in U.S. Patent No. 3,251,686 is charged and exposed to a light-and-shadow image in conventional manner. The electrostatic latent image is developed with a developer of the following composition by weight:

| | |
|---|---|
| 2,5-Hexanediol | 98 parts by weight |
| Butvar B-78 | 1 part by weight |
| Irgacet Black RL | 1 part by weight |

Butvar B–78 is polyvinyl butyrol sold by Shawinigan Resins Corporation. Irgacet Black RL is a dye sold by Geigy Chemical Corporation. The developer on the overcoated photoconductor is transferred to bond

paper in image configuration. The overcoated photoconductor is contacted with a 120 line per linear inch patterned gravure roll carrying a cleaning liquid comprising by weight about 90 parts water and about 10 parts acetylacetone. Thereafter, the overcoated photoconductor is contacted with a web of Miracloth Type 9243, a nonwoven Rayon fabric sold by Chico pee Mills Incorporated under a pressure of about 0.75 pound per lineal inch and moving at a rate of 1/500 $^{th}$ of the photoreceptor. The first print has a resolution of about 7 line pairs per millimeter. After repeated cycling of 35 prints no significant change in print quality is observed and no residual developer film is present on the overcoating.

## EXAMPLE IV

A xeroprinting master 9 by 14 inches is prepared by placing a thin insulating coating of epoxy resin about 0.0005 inches thick in image configuration on a conductive plate of aluminum by means of a silk screen stencil, and then hardening the resin in known manner. The plate is charged to +450 volts by passing it under a corona charging unit. The image is developed in the manner described in Example I with a liquid developer having the following composition by weight:

| | |
|---|---|
| Polypropylene glycol | 67 parts by weight |
| Staybelite Ester 5 | 7 parts by weight |
| Microlith CT Black | 20 parts by weight |
| Ganex V516 | 7 parts by weight |

Staybelite Ester 5 is an esterified wood rosin sold by Hercules Powder Company. Microlith CT Black is a predispersed carbon black pigment and ester gum composition in the approximate ratio of 40% pigment to 60% resin. Ganex V516 is an alkylated polyvinyl pyrrolidone sold by GAF Corporation. The developer is transferred to bond paper and the resulting print has an image density of about 0.7, background density of less than 0.01, and resolution of about 6 line pairs per millimeter. The plate is cleaned by contacting it with a nitrile sponge rubber roll saturated with a cleaning liquid of 2 parts ethanol and one part water by weight. Thereafter, the xeroprinting master is wiped with a web of Webrils type T3707, a nonwoven rayon fiber fabric sold by the Kendall Company to provide a substantially dry imaging surface. The master is cycled 75 times without any loss in image quality. Between cycles, the surface of the master is substantially dry.

## EXAMPLE V

The procedure of Example I is repeated with a developer liquid of the following composition by weight:

| | |
|---|---|
| Diethylene glycol monoethyl ether | 69 parts by weight |
| Microlith CT Black | 31 parts by weight |

The polyurethane roll is rotating in contact with a bath of cleaning liquid comprising 4 parts by weight water and 1 part diacetone alcohol. The cleaning web is made of nonwoven polyester fabric sold by the Kendall Company under the name Webrils 1445 and is advanced in the direction opposite to that of the selenium drum at a speed of about 1/375 $^{th}$ that of the drum speed and is in contact with the drum under a pressure of about 1.5 pounds per linear inch. Results comparable to those obtained in Example I are obtained.

## EXAMPLE VI

The procedure of Example I is repeated with a developer liquid of the following composition by weight:

| | |
|---|---|
| Glycerol | 70 parts by weight |
| Sorbitol | 14 parts by weight |
| Nigrosine J | 2 parts by weight |
| Methylene Blue | 0.3 parts by weight |
| Triethanolamine | 14 parts by weight |

The first print obtained has a resolution of about 6 line pairs/millimeter and is free of background. The residual ink remaining on the photoreceptor is cleaned by first contacting the photoreceptor with a cleaning web saturated with a cleaning liquid comprising by weight 3 parts water and one part ethylene glycol monomethyl ether. The cleaning web is made of a nonwoven Dynel fabric sold by the Kendall Company under the name of Wibrils M 1410. (Dynel is the trademark for a modacrylic fiber sold by Union Carbide Chemicals Company.) The cleaning web is submerged in the bath of cleaning liquid as shown in FIG. III and applies cleaning liquid to the photoreceptor along about 15% of its area. The cleaning liquid on the photoreceptor is next contacted by a dry web of the same materials as described above covering about 25% of the photoreceptor area and effectively absorbing all of the cleaning liquid diluted residual developer film. Both cleaning webs are driven counter to the photoreceptor direction at a speed of about 1/450 $^{th}$ that of the photoreceptor and in contact with the photoreceptor under a pressure of about 0.75 pounds per linear inch of contact. After repeated cycling of 50 prints, no significant change in print quality is observed. Furthermore, the machine components are substantially dry and free from liquid developer and cleaning liquid.

The technique provided by the instant invention provides a substantially complete cleaning of all residual aqueous developer from an imaging surface without any significant abrasion of the imaging surface in a very fast and efficient manner and employs very few mechanical moving parts. It further provides a cleaning system which minimizes contamination of mechanical movements by the excessive use of liquids and conserves expendible 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. The method of cyclically developing electrostatic latent images on a reusable electrostatographic imaging surface comprising the steps of forming an electrostatic latent image on the imaging surface, developing the image with an aqueous liquid developer, transferring the developer from the imaging surface to a receiving surface in image configuration, contacting said imaging surface with a cleaning liquid which is miscible with

said aqueous liquid developer, distributing said cleaning liquid over said imaging surface to dissolve residual developer liquid and disperse residual developer solids in said cleaning liquid and substantially completely removing the cleaning liquid and residual developer from said imaging surface by moving contact with a dry absorbent fibrous material.

**2.** The method of cyclically developing electrostatic latent images on a reusable electrostatographic imaging surface comprising the steps of forming an electrostatic latent image on the imaging surface, developing the image with an aqueous liquid developer, transferring the developer from the imaging surface to the receiving surface in image configuration, contacting the imaging surface with an absorbent fibrous material moistened with a cleaning liquid which is miscible with the aqueous liquid developer, distributing said cleaning liquid over a portion of said imaging surface to dissolve residual developer liquid and disperse residual developer solids in said cleaning liquid, and substantially completely removing said cleaning liquid containing said dissolved liquid developer therein from said imaging surface to prepare the imaging surface for the next imaging cycle.

**3.** The method of claim **2** wherein said absorbent fibrous material comprises a web in continuous contact with a portion of said imaging surface.

**4.** The method of claim **2** wherein said absorbent fibrous material is a web in contact with said imaging surface and said step of contacting includes supplying said miscible cleaning liquid to the opposite side of said cleaning web by contact with a liquid reservoir.

**5.** The method of claim **2** wherein said step of removing comprises contacting the imaging surface with a dry, absorbent fibrous material.

**6.** The method of claim **2** wherein said miscible cleaning liquid has a boiling point of below 130° C.

**7.** The method of claim **2** wherein said imaging member is a reusable photoconductor.

**8.** The method of claim **7** wherein the photoconductor is selected from the group consisting of selenium and selenium alloys.

**9.** The method of claim **2** wherein said contact is contact under a pressure of from about 0.25 to about 10 pounds per lineal inch.

**10.** The method of claim **2** wherein said liquid developer has a conductivity of from about $10^{-4}$ $(ohm\text{-}cm)^{-1}$ to $10^{-10}$ $(ohm\text{-}cm)^{-1}$.

* * * * *