United States Patent

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[54] **CLEANING LIQUID DEVELOPED ELECTROSTATIC IMAGES BY CONTACT WITH VAPORIZED CLEANING FLUID**
8 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** ..... **117/37 LE,** 96/1.2, 117/8, 134/11, 134/15, 134/107, 355/15
[51] **Int. Cl.** **G03g 13/10,** B08b 3/04
[50] **Field of Search** ..... 117/37 LX, 8, 10; 96/1 LX, 1.2; 134/11, 12, 14, 15, 31, 107; 355/15; 118/637

[56] **References Cited**

UNITED STATES PATENTS

2,726,166	12/1955	Greaves	117/17.5 X
3,078,589	2/1963	Carlson	96/1.4 X
3,140,160	7/1964	Carlson	34/155
3,199,223	8/1965	Carlson	34/155
3,276,896	10/1966	Fisher	117/37
3,301,698	1/1967	Fauser et al.	96/1 X
3,356,498	12/1967	Moe et al.	117/37 X

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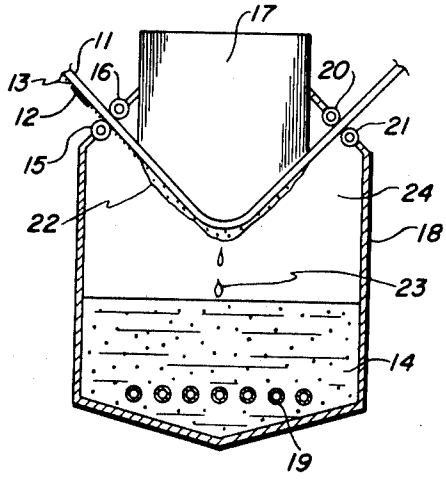
ABSTRACT: Images are improved by evaporating a cleaning liquid in a cleaning liquid reservoir, condensing the resulting cleaning liquid vapor, following the condensed cleaning liquid over the surface of a developed electrostatographic recording member to remove toner particles from the background areas as well as other contaminants and returning the spent liquid to the cleaning liquid reservoir.



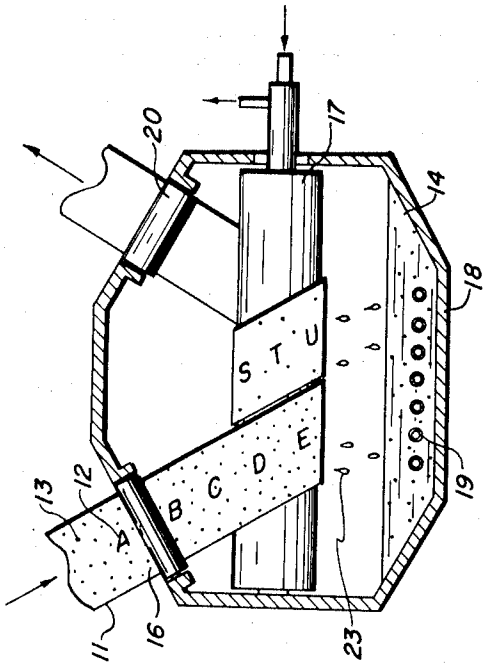


FIG. 3

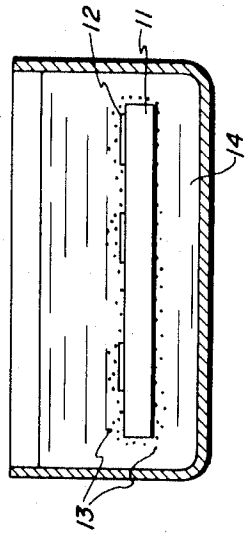


FIG. 1

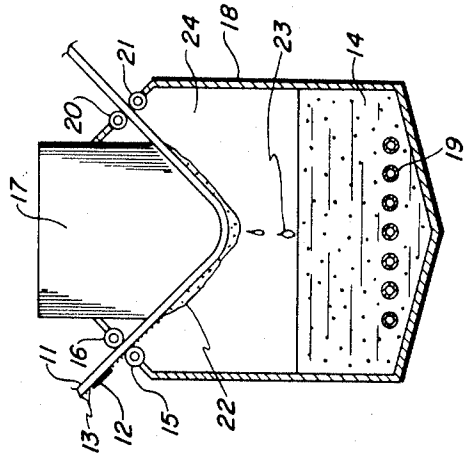


FIG. 2

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CLEANING LIQUID DEVELOPED ELECTROSTATIC IMAGES BY CONTACT WITH VAPORIZED CLEANING FLUID

BACKGROUND OF THE INVENTION

This invention relates to imaging systems, and more particularly, to an improved method and apparatus for developing electrostatic latent images with a liquid developer.

Processes for the formation and the development of images on the surface of photoconductive materials by electrostatic means is well known. These processes include dry techniques such as cascade, powder cloud and magnetic brush processes and wet techniques such as the liquid development process. One conventional liquid development process involves placing a uniform electrostatic charge on a photoconductive insulating layer comprising zinc oxide powder and a resinous binder carried on a conductive paper substrate, 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 electrostatic latent image by depositing on the image a charged toner which is dispersed in an insulating liquid. The charged toner may be suitably colored and may have a polarity of charge identical or opposite to that of the latent image to be developed. If the polarity or charge of the toner is identical to that of the latent image, reversal development will occur whereas a toner having a charge opposite to that of the latent image will be attracted to the latent image.

Although considered a highly desirable technique for the formation of images, difficulties are encountered with attempts to form high quality images with the liquid development process. Generally, liquid development is effected by either immersing the electrostatic latent image bearing surface into the liquid developer or contacting the image bearing surface with a uniform film of liquid developer carrier on an applicator surface. The liquid developer adhering to the imaging surface is thereafter dried by mere exposure to ambient air at room temperature, circulating heated air, infrared heating, pressure from squeegee rollers or the like. Unfortunately, the liquid developer adhering to the background areas of the imaging surface contain toner particles which remain on the imaging surface after drying. These undesirable background deposits are particularly acute in high speed continuous tone development systems employing a liquid developer containing high concentrations of toner particles.

In multicolor processes, where the development process is repeated with different colored developers corresponding to the primary colors to form a colored print on a single photosensitive surface, it is highly desirable that the charging and discharging properties of the photosensitive layer remain substantially unaffected by the presence of a toner image previously formed on the photosensitive layer. Generally, with conventional liquid development processes, the fixing agent, stabilizer, electric charge regulator and the like which are employed in liquid developer remain on the photosensitive layer after development and tend to deteriorate the photoreceptor properties thereby inhibiting the proper formation of subsequently developed images.

It has been found that uniform photoreceptor properties can be maintained and background toner deposits can be reduced by rinsing the imaging surface immediately after development with a liquid which contains little or no toner particles or other contaminants. However, the rinsing liquid rapidly becomes ineffective due to the accumulation of toner particles and other undesirable materials found in liquid developers. In addition, a rinsing step presents additional problems in high speed development systems because treatment time and equipment complexity is increased. In addition, as a result of increasing toner contaminants in the rinsing liquid, additional equipment is required to remove these contaminants.

In addition to mere dipping of a developed imaging surface into a toner free cleaning liquid, one could attempt to remove toner from the background areas of a developed surface by spraying the developed surface with a cleaning liquid. Unfortunately, the spray tends to disturb the deposited toner image and cause smearing. Further, the cleaning liquid employed in the spraying technique also becomes contaminated with toner particles which must eventually be removed by suitable means such as a filter. Since most liquid development techniques are deficient in one or more of the above areas, there is a continuing need for improved imaging processes.

SUMMARY OF THE INVENTION

It is therefore, an object of this invention to provide an imaging system overcoming the above noted deficiencies.

It is another object of this invention to provide an imaging technique which improves electrostatographic image quality.

It is a further object of this invention to provide images having reduced background deposits.

It is still another object of this invention to provide an imaging system which removes contaminants more effectively from imaging surfaces.

It is another object of this invention to provide an imaging system superior to those of known systems.

The above objects and others are accomplished by evaporating a cleaning liquid in a cleaning liquid reservoir, condensing the resulting cleaning liquid vapor, flowing the condensed cleaning liquid over the surface of a developed electrostatographic recording member to remove toner particles from the background areas as well as other contaminants and returning the spent liquid to the cleaning liquid reservoir.

BRIEF DESCRIPTION OF THE DRAWINGS

The advantages of the improved electrostatographic imaging systems will become further apparent upon consideration of the following disclosure of the invention, particularly when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic sectional view in which an electrostatographic image is cleaned by immersion in a cleaning liquid.

FIG. 2 is a schematic sectional view of an electrophotographic imaging apparatus employing an embodiment of the cleaning system of this invention.

FIG. 3 is a schematic sectional view of an alternative form of the apparatus shown in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The conventional technique to remove toner particles from the background areas of a developed electrostatographic recording member by immersion in a toner free cleaning liquid is illustrated in FIG. 1. Reference character 12 designates a toner image formed by conventional liquid development techniques on a photoreceptor sheet 11. Removal of excess toner particles deposited on the front and rear surfaces of the photoreceptor sheet 11 is effected by immersing the photoreceptor sheet 11 in cleaning liquid 14. During immersion, various components such as fixing agents, stabilizers and electric charge regulators originating from the liquid developer are also removed from the photoreceptor sheet 11 by cleaning liquid 14. It is apparent, that the cleaning liquid employed in this cleaning system is most efficient when fresh uncontaminated cleaning liquid is employed. Obviously, the cleaning liquid should be selected from liquid which will not destroy the toner image or dissolve and swell the photoreceptor sheet 11. It is further apparent, that the cleaning liquid is preferably a liquid which is highly insulating and has a low dielectric constant. Although the cleaning process described with reference to FIG. 1 reduces background deposits in developed images, they require the time-consuming operation and is difficult to automate. Automation of this process would require the addition of a cleaning stage as well as equipment to reclaim the cleaning liquid as the toner concentration in the cleaning liquid gradually increases with each cleaning cycle.

In FIG. 2, a developed photoreceptor sheet 11 bearing a toner image 12 and excess toner particles 13 is delivered by means of guide rollers 15 and 16 into a vessel 18. These guide rollers 15 and 16 are not held in close contact with photoreceptor sheet 11 therefore do not smudge the deposited toner image 12. The lower portion of vessel 18 contains a stored cleaning liquid 14. This cleaning liquid 14, of course, should be selected from those materials which will not swell or dissolve the photoreceptor sheet 11 or the toner image 12. For example, if ordinary electrofax paper is employed, cyclohexane, hexane, heptane, or petroleum solvents such as isoparaffin or gasoline may be used. If desired, a suitable amount of chlorinated hydrocarbon or fluorinated hydrocarbon may be added to the cleaning liquid to render the cleaning mixture less flammable. A heating unit 19 is disposed near the bottom of vessel 18 to cause evaporation of cleaning liquid 14. Heating unit 19 may comprise any suitable heating means such as an electric heating element or hot water or steam pipe. A cooling unit 17 is positioned at the top of closed vessel 18 and comprises a lower "U"-shaped cooling surface which contacts the rear surface of photoreceptor sheet 11 as it is guided into the vessel 18 by means of rollers 15 and 16 and guided out of vessel 18 by squeeze rollers 20 and 21. The cooling unit 17 may be cooled by any suitable means such as passage of chilled water or other types of coolants therethrough. Upon contact with the cooling unit 17, the photoreceptor sheet 11 is sufficiently cooled to cause vapors from the heated cleaning liquid 14 to condense on the developed surface of photoreceptor 11. The condensed cleaning liquid tends to flow toward to bottom of the "U"-shaped cooling member thereby washing the excess toner particles along with it until it eventually drops away from the bottom of the "U"-shaped cooling member. After the excess toner particles 13 are removed from photoreceptor sheet 11 by the condensed cleaning liquid, photoreceptor sheet 11 is transported between squeeze rollers 20 and 21 to remove excess cleaning liquid and adhering to the surface of photoreceptor sheet 11. Since photoreceptor sheet 11 is cleaned with a substantially uncontaminated cleaning liquid, maximum removal of excess toner particles 13 and other undesirable liquid developer components is effected. Further, it is apparent that the cleaning liquid 14 can be repeatedly employed to clean photoreceptor sheet 11 because the vapor from the cleaning liquid is not contaminated with nonvolatile components present in the condensed liquid stored at the bottom of the vessel 18.

If desired, the heating unit 19 and cooling unit 17 may comprise the hot and cold ends, respectively of a heating element utilizing the Peltier effect. The squeeze rollers 20 and 21 may optionally be heated to further dry the imaged surface. Exposure of the developed photoreceptor sheet 11 to a current of dry air may also be employed to dry the sheet.

The cleaning step of this invention should be carried out before the developed photoreceptor sheet 11 is allowed to dry. Poor results are obtained when removal of background toner deposits is attempted after the developed photoreceptor sheet 11 is permitted to dry completely.

Generally, the temperature of the cooling unit 17 should be sufficiently below the dew point of the cleaning liquid vapor to effect vapor condensation. However, the temperature of the cooling unit 17 should not be so excessively low that the condensed cleaning liquid is solidified on the surface of the photosensitive layer. The melting point of the solidified cleaning liquid on the surface of photosensitive layers caused smearing of the toner image. Thus, the temperature of the cooling unit 17 should be maintained below the dew point of the cleaning liquid vapor and above the melting point of the cleaning liquid.

Another specific embodiment of the cleaning system of this invention is illustrated in FIG. 3. In this embodiment, cleaning liquid 14 is stored in the lower portion of closed vessel 18 and heating pipes 19 are immersed in the stored liquid. A cooling roller 17 is positioned in approximately the center of the closed vessel 18 and provided with means to circulate a coolant within cooling roller 17. A developed photoreceptor web 11 is introduced into the closed vessel 18 by means of at least one guide roller 16. The developed photoreceptor web 11 is wound around the periphery of cooling roller 17 with the imaged surface facing outwardly. As the developed photoreceptor web 11 is transported around cooling roller 17, the cleaning liquid vapors condense upon and clean the imaged surface of photoreceptor web 11 in substantially the same manner as described with reference to the embodiment illustrated in FIG. 2. The cleaned photoreceptor web 11 is thereafter transported out of the closed vessel 18 by squeeze roller 20. Although the cleaning liquid droplets 23 are contaminated, it is evident that only clear uncontaminated liquid is condensed on the cooled surface of imaged photoreceptor web 11.

Thus, in the system of this invention, the background toner deposits and soluble liquid developer components which adhere to the surface of an electrostatographic imaging member are washed away by fresh clear cleaning liquid. It is apparent from the foregoing description that consumption of a cleaning liquid is reduced to a minimum and contamination of the cleaning liquid does not impede cleaning effectiveness.

In the examples described above, the cleaning liquid vapors are condensed directly on the surface of an imaging member. If desired, the developed surface of an imaging member can be cleaned with cleaning liquid condensed by a cooling unit remote from said imaging member.

Although specific materials and conditions are set forth in the foregoing examples, these are merely intended as illustrations of the present invention. Various other suitable electrostatographic imaging members, developers and cleaning system configurations including those listed above may be substituted for those in the specific examples with similar results. Other materials may also be added to the imaging member of cleaning liquid to sensitize, synergize or otherwise improve the imaging properties or desirable properties of the system.

Other modifications of the present invention will occur to those skilled in the art upon a reading of the present disclosure. These are intended to be included within the scope of this invention.

What is claimed is:

1. A method of forming images comprising providing an electrostatographic imaging member bearing an electrostatic latent image on a recording surface, developing said electrostatic latent image with a liquid developer comprising an insulating carrier liquid and suspended toner particles whereby at least a portion of said toner particles deposit on said recording surface to form an imaged recording surface having image areas and background areas, transporting said imaged recording surface into a cleaning zone, heating a cleaning insulating liquid in which said toner particles are substantially insoluble to form vapors of said cleaning liquid, condensing said vapors of said cleaning liquid on said imaged recording surface by cooling said vapors whereby condensed cleaning liquid formed by condensing said vapors flows on said imaged recording surface and washes away said toner particles deposited in said background areas of said imaged recording surface, and collecting said condensed cleaning liquid contaminated with said toner particles washed away from said background areas.

2. A method of forming images according to claim 1 including transporting said imaged recording surface in a downwardly convex path into said cleaning zone wherein said condensed cleaning liquid formed by condensing said vapors flows on said imaged recording surface and washes away said toner particles deposited in said background areas of said imaged recording surface.

3. A method of forming images according to claim 1 including transporting said imaged recording surface into said cleaning zone in a helical path wherein said condensed cleaning liquid formed by condensing said vapors flows on said imaged recording surface and washes away said toner particles

deposited in said background areas of said imaged recording surface.

4. A method of forming images according to claim 1 including drying the washed imaged recording surface as it is transported out of said cleaning zone to remove excess cleaning liquid adhering to said washed imaged recording surface.

5. A method of forming images according to claim 1 wherein said condensed cleaning liquid formed on said imaged recording surface is initially substantially uncontaminated with toner particles.

6. A method of forming images according to claim 1 including the subsequent steps of forming a new electrostatic latent image on said recording surface, developing said new electrostatic latent image with said liquid developer to form an imaged recording surface having image areas and background areas, transporting said imaged recording surface into said cleaning zone, reheating the collected condensed cleaning liquid contaminated with toner particles washed away from background areas to form vapors of said cleaning liquid, condensing said vapors of said cleaning liquid on said imaged recording surface by cooling said vapors whereby condensed cleaning liquid formed by condensing said vapors flows on said imaged recording surface and washes away toner particles deposited in background areas of said imaged recording surface, and collecting said condensed cleaning liquid.

7. A method of forming images according to claim 1 including forming a new electrostatic latent image on said electrostatographic imaging member and developing said new electrostatic latent image with another liquid developer having a different color.

8. A method of forming images according to claim 1 including condensing said vapors of said cleaning liquid on said imaged recording surface substantially immediately after developing said electrostatic latent image with said liquid developer.

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