

[54] **REVERSAL LIQUID DEVELOPING USING A DEVELOPMENT ELECTRODE AND CORONA CHARGING**

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Related U.S. Application Data

[63] Continuation of Ser. No. 322,599, Jan. 10, 1973, abandoned, which is a continuation of Ser. No. 111,065, Jan. 29, 1971, abandoned.

[52] U.S. Cl. **96/1 LY; 427/17; 204/181**

[51] Int. Cl. ... **B41m 5/20; G03g 13/10; G03g 13/22**

[58] Field of Search **96/1 R, 1 LY, 1.3; 117/37 LE**

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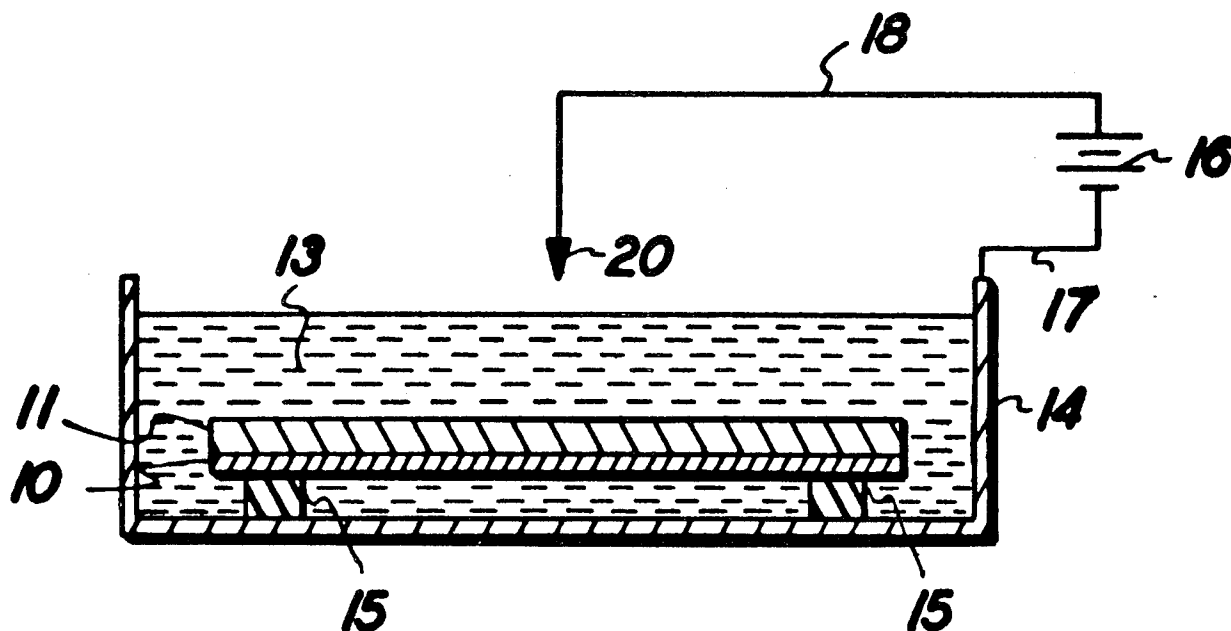
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[57] ABSTRACT

Toner images are formed by providing an electrostatic recording member having an imaging surface and a rear surface, forming an electrostatic latent image on the imaging surface, positioning a development electrode parallel and spaced from the imaging surface, applying corona ions to the rear surface of the recording member, the corona ions having a polarity opposite to the polarity of the electrostatic latent image, and contacting the imaging surface with toner particles to deposit at least a portion of the toner particles on the imaging surface in image configuration.

3 Claims, 6 Drawing Figures



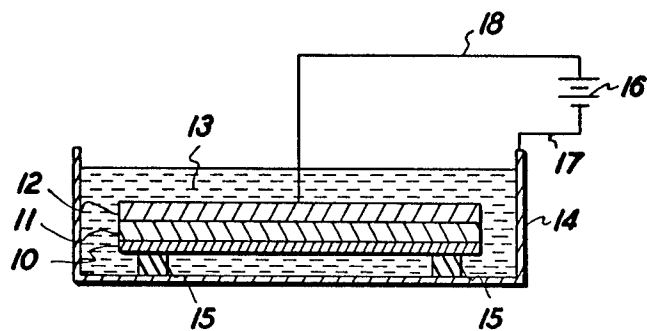


FIG. 1

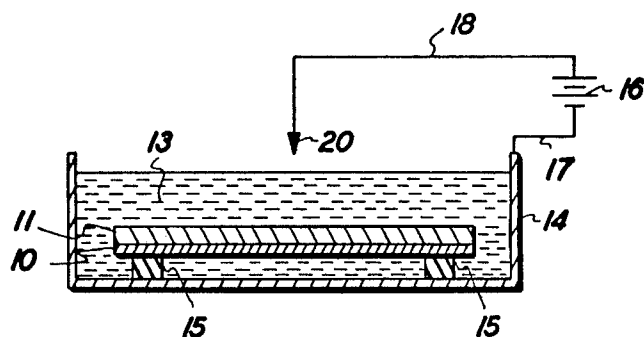


FIG. 2

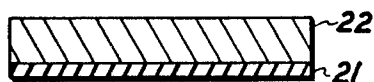


FIG. 3

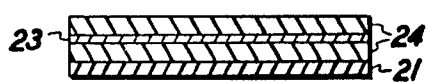


FIG. 4

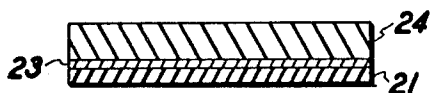


FIG. 5

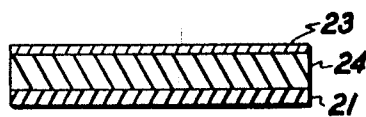


FIG. 6

REVERSAL LIQUID DEVELOPING USING A DEVELOPMENT ELECTRODE AND CORONA CHARGING

This is a continuation of application Ser. No. 322,599 filed Jan. 10, 1973, now abandoned, which is a continuation of application Ser. No. 111,065 filed Jan. 29, 1971, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to imaging systems, and more particularly, to a reversal imaging process.

The formation and development of images on the surface of photoconductive materials by electrostatic means is well known. One conventional process involves placing a uniform electrostatic charge on a photoconductive insulating layer comprising zinc oxide powder and a resin 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 the resulting electrostatic latent image by depositing on the image a charged toner which is usually 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.

Generally, when the toner particles have a charge identical to that of the latent image, deposition of the toner particles on the discharged areas on the photoconductive insulating layer occurs. This is referred to in the art as reversal development. For optimum reversal development, a development electrode is positioned opposite the photoconductive layer and is electrically biased to a polarity approximating that of the charged image. A backing electrode is employed in conjunction with the development electrode during reversal development. This backing electrode is positioned on the rear surface of the photoconductive insulating layer. The backing electrode may comprise a separate conductive electrode or if the substrate supporting the photoconductive insulating layer is sufficiently electrically conductive, the substrate itself may be employed as the backing electrode. Normally, the electrical bias mentioned above is applied by connecting the development electrode and the backing electrode to an external source of potential. All of the foregoing elements other than the external source of potential are usually immersed in a liquid developer during liquid development.

Since many supporting substrates for photoconductive insulating layers are insufficiently electrically conductive to be employed as the backing electrode, a separate electrode is usually employed as the backing electrode. This separate electrode should normally be in close physical contact with the supporting substrate of the photoconductive layer. This type of close contact is frequently difficult to achieve with many supporting substrates for photoconductive insulating layers. Since the development electrode is normally submerged in the liquid developer during development, the electrode accumulates a deposited coating of toner particles which must be periodically cleaned from the development electrode. Both the development electrode and the backing electrode also require electrical conductors connecting the electrodes to an external power source. Obviously, these conductors must also be immersed in the developing liquid. Because of the fact that an external bias is applied to the development elec-

trode and backing electrode through appropriate electrical conductors to an external power source, sparks may occur as a result of an electrical short between the development electrode and the backing electrode. Sparking near liquid developers is undesirable because many liquid developers contain flammable liquid components. Since most reversal development systems are deficient in one or more of the above areas, there is a continuing need for an improved reversal imaging system.

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 a more simplified imaging technique.

It is a further object of this invention to provide an imaging technique having fewer cleaning requirements.

It is still another object of this invention to provide an imaging technique which reduces the danger of fire hazards.

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

The above objects and others are accomplished, generally speaking, by providing an electrostatographic recording member having an imaging surface and a rear surface, forming an electrostatic latent image on the imaging surface, positioning a development electrode parallel and spaced from the imaging surface, applying corona ions to the rear surface of the recording member, the corona ions having a polarity opposite to the polarity of the electrostatic latent image, and contacting the imaging surface with toner particles until at least a portion of the toner particles deposit on the imaging surface in image configuration.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a longitudinal sectional side view of a conventional device for forming reversal images.

FIG. 2 is a sectional side view of a device for carrying out a reversal development embodiment of this invention.

FIG. 3a, 3b, 3c and 3d are cross-sectional views of various recording members which may be employed in the present invention.

As described above, positive development is accomplished in conventional electrophotography by depositing colored electrically charged particles referred to as "toner" on electrically charged areas of an imaging surface and reversal development is effected by depositing the toner particles on the discharged areas of an imaging surface. In positive development, a development electrode is placed parallel to and spaced from the imaging surface to achieve a faithful reproduction of the original. In reversal development, it is necessary to apply a bias potential between the development electrode and the backing electrode positioned behind the imaging surface to cause the toner particles to move toward the imaging surface.

Conventional reversal development is illustrated in FIG. 1. Reference character 10 designates a recording

layer upon which an electrostatic latent image is formed. Recording layer 10 is normally a photoconductive insulating layer. In FIG. 1, the electrostatic latent image is located on the lower surface of recording layer 10. Recording layer 10 is secured to a supporting layer 11. Where supporting layer 11 is a poor conductor of electricity, a backing electrode is normally positioned in contact with the supporting layer. Where the supporting layer 11 is highly electrically conductive, the backing electrode may be omitted because the supporting layer 11 serves as an electrode. Where supporting layer 11 comprises paper or paper treated to render it slightly conductive, the use of the backing electrode 12 is usually required. Reference character 13 designates a conventional liquid developer which is usually confined within electrically conductive container 14.

As is well known in the art, conventional liquid developers comprise finely-divided electrically charged toner particles suspended in a highly insulating liquid. In the system illustrated in FIG. 1, the latent image and toner particles are electrostatically charged with a charge having a negative polarity. Insulating spacing bars 15 are provided to maintain a narrow spacing between the bottom of electroconductive container 14 and recording layer 10. Satisfactory results are achieved with a spacing between about $\frac{1}{8}$ millimeter and about 3 millimeters. An external potential approximating the value necessary for neutralizing the electric field due to the highest charge density of the electrostatic latent image on recording layer 10 is provided by a power source 16 through electrical conductors 17 and 18. As shown in FIG. 1, the external potential is applied between backing electrode 12 and the bottom of electrically conductive container 14. As a result of the applied potential, the toner particles in developer liquid 13 are deposited in the areas of the recording layer 10 having the smallest charge density. Application of the external potential is maintained until sufficient quantity of toner particles is deposited. With conventional reversal development techniques as that illustrated in FIG. 1, the portions of the backing electrode 12 and the electrical conductor 18 immersed in developer liquid 13 become smeared with toner particles which deposit thereon. This deposit is undesirable because it must be periodically cleaned from backing electrode 12 and conductor 18. If the supporting layer 11 comprises materials having high electrical resistance, a cumbersome separate backing electrode 12 is required. The separate backing electrode 12 also requires an electrical conductor 18 which must be immersed in the developer liquid.

FIG. 2 illustrates a schematic cross-section of a preferred embodiment of this invention. The corona discharge electrode 20 is secured to one end of electrical conductor 18 disposed above developer liquid 13. The backing electrode 12 which is indispensable for the device illustrated in FIG. 1 is not required in the embodiment in FIG. 2. Any suitable well known corona discharge electrode may be employed. The corona discharge electrode illustrated in the drawings is a needle-shaped electrode. When a distance between the corona discharge electrode 20 and the surface of developer liquid 13 is 50 millimeters and the distance between the surface of liquid developer 13 and supporting layer 11 is 30 millimeters, satisfactory development is achieved by maintaining the supply voltage from power source 16 at 4,500 volts to provide an electric discharge be-

tween about 30 seconds and about 60 seconds. The specific volume resistivity of the developer liquid 13 under these conditions is about 10 ohm-cm and the spacing between the recording layer 10 and electrically conductive container 14 is about 2 millimeters.

When employing a technique of this invention, the supporting layer 11 may be electrically conductive or electrically insulating. For example, supporting layer 11 may comprise such highly electrically insulating materials such as polyesters. Generally, the developing time and the potential applied to the corona discharge electrode 20 can be reduced in proportion to an increase in electroconductivity of supporting layer 11. The desired electrical potential applied to corona discharge electrode 20 will depend upon numerous factors such as the spacing between the corona discharge electrode and supporting layer 11, the spacing between recording layer 10 and electrically conductive container 14, the resistivity of the liquid developer and the like. Since the electrostatic charge is applied to the exposed surface of supporting layer 11 by means of corona discharge, no electrical connection is required between the power source and supporting layer 11. Moreover the exposed surface of supporting layer 11 remains free from unsightly deposits of toner particles. Since ions produced as a result of corona discharge tend to spread out in a wide area, corona discharge electrode 20 produces essentially the same effect as that of a backing electrode 12 covering and in intimate contact with the entire exposed surface of supporting layer 11.

Unlike the configuration illustrated in FIG. 1 wherein a separate backing electrode 12 is utilized, the device of this invention deposits an electrostatic charge directly on the exposed surface of supporting layer 11 thereby eliminating the problems associated with maintaining intimate contact between backing electrode 12 and supporting layer 11. The ions produced by corona discharge electrode 20 can be deposited on supporting layer 11 more uniformly by utilizing a plurality of corona discharge electrodes suitably disposed above supporting layer 11. Development may be conducted while the discharge electrodes and supporting layer 11 are moved relative to each other.

As described above, the development time and applied potential may be proportionately reduced as the electroconductivity of the supporting layer 11 is increased. It should be noted, however, that the electroconductivity need not be increased throughout the entire thickness of supporting layer 11 in order to achieve reduced developing time or a lower applied potential requirement. Both the developing time and the applied potential may be reduced when only a fraction of the entire thickness of supporting layer 11 is highly electroconductive. In other words, all that is necessary to reduce developing time or applied potential is a layer in supporting layer 11 sufficient to provide electrical polarization upon exposure to corona discharge.

FIG. 3 illustrates one example of electrophotographic imaging member useful in the present invention. In this figure, a dielectric recording layer 21 is carried on the surface of a metal plate 22.

FIG. 4 illustrates another embodiment of an electrophotographic recording member which may be employed in this invention. In this figure, the dielectric recording layer 21 is supported on a sandwich comprising a thin metal layer 23 between two insulating layers 24.

Another embodiment which may be utilized in the process of this invention is depicted in FIG. 5. In this embodiment dielectric recording layer 21 is secured to a thin metal layer 23 which is in turn secured to an insulating layer 24.

Another embodiment of an electrophotographic material useful in the present invention is shown in FIG. 6. In this embodiment, insulating layer 24 is sandwiched between dielectric recording layer 21 and a thin metal layer 23.

The desired objects of the present invention as discussed above may be achieved with any of the electrophotographic materials illustrated in FIGS. 3 through 6. If desired, the dielectric recording layers may be employed without supporting layers. Thus, as discussed above, a backing electrode is unnecessary in the process of this invention and the problems associated with the requirement for intimate contact between a backing electrode and a supporting layer are eliminated. Further, toner deposition on electrical connections and the backing electrode along with the attendant cleaning problems are avoided because the corona discharge electrode need not be immersed in the developing liquid. In addition, ignition of inflammable developing liquid vapors resulting from sparks caused by contact between a backing electrode and electroconductive containers is prevented with the process of this invention.

The following example further defines, describes and compares preferred methods and materials of the present invention.

EXAMPLE

A conventional photoconductive binder plate comprising a photoconductive insulating layer of zinc oxide particles dispersed in an insulating resin matrix carried on a sheet of conductive paper is uniformly charged with a negative electrostatic charge, exposed to a light-and-shadow image to form a negatively charged electrostatic latent image and thereafter placed in a developing apparatus similar to that illustrated in FIG. 2. Insulating spacing bars having a thickness of about 2 millimeters are employed to separate the latent image bearing surface of the binder plate from the bottom of the electrically conductive metal container. The metal container contains a liquid developer comprising finely-divided negatively charged toner particles having an average particle size less than about 1 micron suspended in an electrically insulating organic liquid and having a volume resistivity of about 10 ohm-cm. The distance between the upper surface of the binder plate and the surface of the liquid developer in the metal

container is about 30 millimeters. A needle-shaped corona discharge electrode is positioned about 50 millimeters above the surface of the liquid developer. The corona discharge electrode and metal containers are connected to a power supply which provides an output potential of about 4,500 volts. The positive corona ions supplied by the corona discharge electrode are deposited on the binder plate for about 45 seconds. After termination of corona discharge and removal of the binder plate from the liquid developer, examination of the binder plate reveals toner particle deposits in the areas of the photoconductive insulating layer which were exposed to light during the image exposure step.

Although specific materials and conditions are set forth in the foregoing example, these are merely intended as illustrations of the present invention. Various other suitable electrophotographic layers, backing layers, and corona discharge potentials such as those listed above may be substituted for those in the examples similar results. Other materials may also be added to the photoreceptor, backing layer, and developer to sensitize, synergize or otherwise improve the imaging properties of other 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 for reversal development of electrostatic latent images in a liquid developer comprising providing an electrostatographic recording member having an imaging surface and a rear surface, forming an electrostatic latent image on said imaging surface, immersing said recording member into a liquid developer, positioning a development electrode parallel and spaced from said imaging surface, developing said image by applying corona ions to said rear surface of said recording member by a corona discharge electrode disposed outside said liquid developer, said corona ions having a polarity opposite to the polarity of said electrostatic latent image whereby said ions causes the contacting of said imaging surface with toner particles in conformance to said electrostatic latent image.

2. A method according to claim 1 including maintaining the spacing between said development electrode and said imaging surface between about 1/8 millimeter and about 3 millimeters.

3. A method according to claim 1 wherein said toner particles have the same polarity as said electrostatic latent image.

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