

[54] **APPARATUS FOR INDUCTIVE IMAGING
WITH SIMULTANEOUS POLAR INK
DEVELOPMENT**

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118/DIG. 23; 355/3 R; 427/15

[51] Int. Cl.² G03G 15/10

[58] Field of Search 355/10, 17, 3 R;
118/DIG. 23; 96/1 LY, 1.3, 1 R; 427/15, 17

[56] **References Cited**

UNITED STATES PATENTS

2,968,552 1/1961 Gundlach 96/1 R

3,712,728	1/1973	Whittaker	355/10
3,806,355	4/1974	Kaufman	355/17 X
3,817,748	6/1974	Whittaker	96/1 LY
3,820,985	6/1974	Gaynor et al.	96/1 R

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[57]

ABSTRACT

An electrostatographic imaging apparatus for induction imaging of a dielectric material with simultaneous polar ink development, using a patterned polar ink applicator electrically biased with respect to a transparent conductive support base, bearing a photoconductor, with which the dielectric is in contact, in response to an image pattern projected onto the photoconductor through the support base.

3 Claims, 3 Drawing Figures

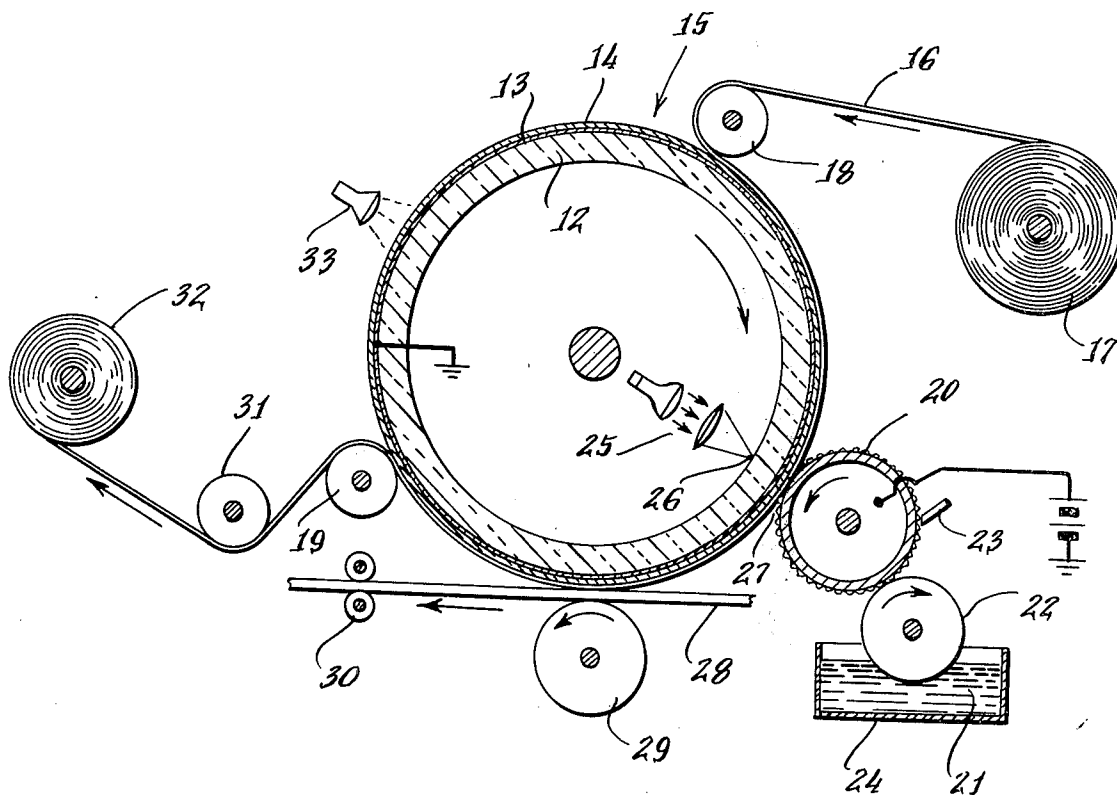


Fig. 1.

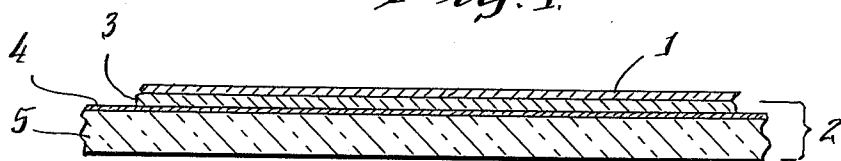


Fig. 2.

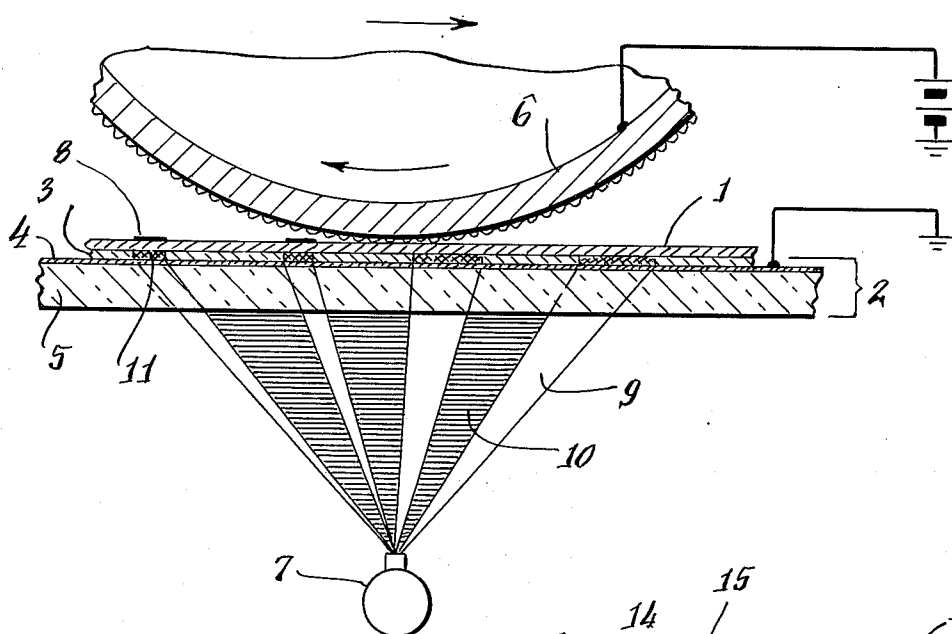
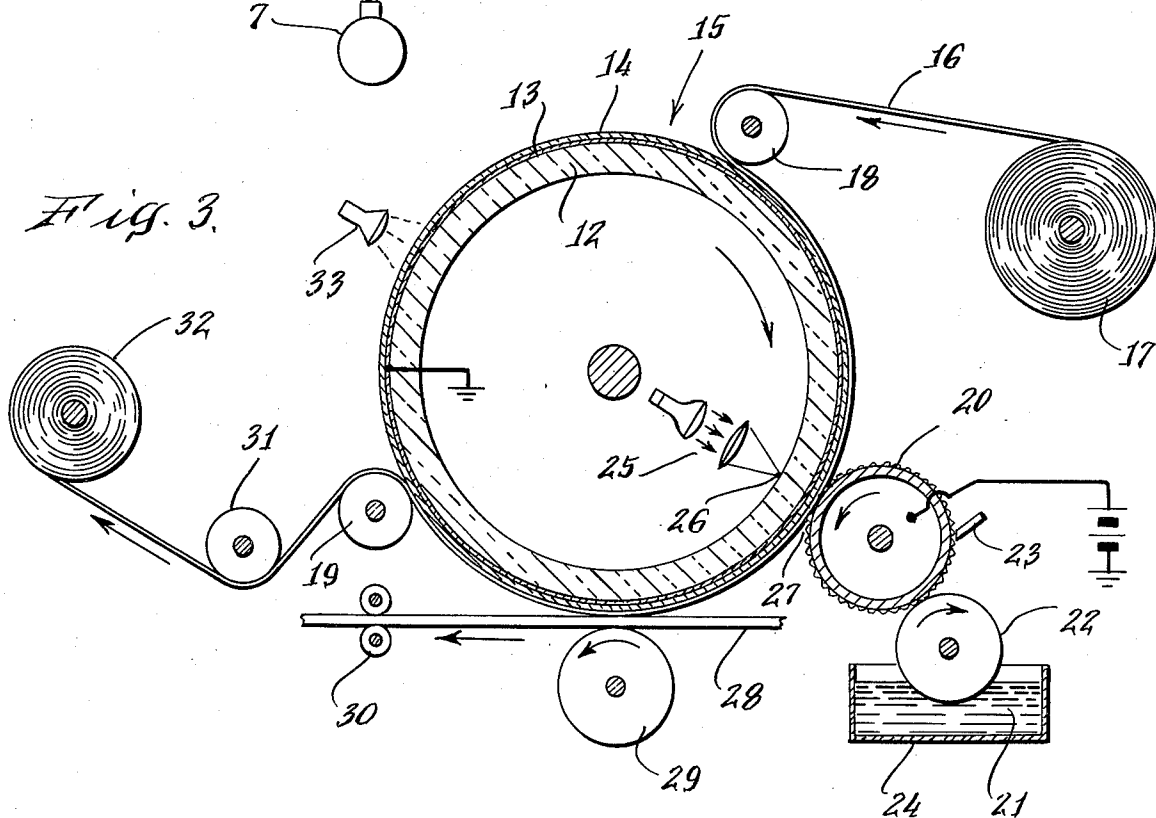


Fig. 3.



APPARATUS FOR INDUCTIVE IMAGING WITH SIMULTANEOUS POLAR INK DEVELOPMENT

BACKGROUND OF THE INVENTION

This invention relates to xerographic imaging and developing methods which employ liquid developers, particularly inductive imaging and developing methods and, more particularly, to reversal imaging and developing methods, and apparatus suitable to carry out same.

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, e.g., as by heat or pressure. 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.

Similar methods are known for applying the electroscopic particles to the electrostatic latent image to be disclosed. 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. Electrophoretic development of an electrostatic latent image may, for example, be obtained by flowing the developer over the image bearing surface, by immersing the imaging surface in a pool of the developer or by presenting the liquid developer on a smooth surfaced roller and moving the roller against the imaging surface.

A further technique for developing electrostatic latent images is the liquid development process disclosed by R. W. Gunlaach in U.S. Pat. No. 3,084,043 herein-after 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 selectively attracted from the depressed portions of the applicator surface in areas where an electrostatic field exists. With the use of a conventional electrophotographic plate which has been uniformly charged and exposed to a light and shadow pattern, the charged or image areas are developed. 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 areas of an electrostatic latent image 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 and physically moves during development in response to the electrostatic field. The liquid phase in electrophoretic developers functions only as a carrier medium for developer particles.

It is frequently desirable to provide dark hard copy corresponding to bright image input, i.e., to represent light traces or the bright portions of a projected image as dark areas on a film or paper. Typical applications include the recording of cathode ray tube traces and the projection of negative microfilm to positive output. This is not readily accomplished by conventional xerography. A technique for achieving a reverse image using polar liquid developer is disclosed in Gundlach, et al., U.S. Pat. No. 3,372,027. A photoconductive assembly comprising a photoconductor layer, a transparent electrode layer, and a transparent support layer. During exposure, a polar liquid doctor blade applicator, electrically biased with respect to the electrode layer, containing polar liquid developer, is drawn across the photoconductor layer. The developer liquid wets the layer in the illuminated areas, simultaneously producing the reversal image of the original and developing it.

While capable of producing satisfactory images, these liquid development systems in general, suffer deficiencies in certain areas and are in need of further development and improvement. Particularly troublesome difficulties are encountered in liquid development systems employing reusable or cycling electrostatographic imaging surfaces which are generally preferred imaging surfaces in automatic copying machines because of the increased speed of copying, the reduced cost per copy and the ability to produce a final print of consistent

high quality on ordinary paper. In these systems, an imaging surface such as for example, a selenium drum type photoconductor is charged, exposed to a light and shadow pattern and developed by bringing the image bearing surface into developing engagement with an applicator containing the liquid developer. The developer is transferred from the applicator to the imaging surface according to the appropriate development technique and thereafter, the developer pattern is transferred from the imaging surface to a receiving surface such as paper. During the transfer step, not all the liquid developer is transferred from the imaging surface. In order to recycle the imaging surface, the residual developer remaining on the surface following transfer must be either removed or its effects immobilized. Otherwise, it will tend to be present as background in subsequent cycles and tend to degrade subsequent charging and exposing steps in subsequent cycles. In addition, with a liquid developer which 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 applied. Furthermore, lateral conductivity of the liquid developer on the imaging surface may become excessive and the resolution of the resulting image will be poor. In addition, on repeated cycling, there is progressive accumulation of liquid developer on the imaging surface since in each cycle, not all the developer is transferred to the receiving sheet. This progressive accumulation of developer residue will quickly result in an overall loss of density, deterioration of fine detail and increased background deposits on the final copy since accurate imaging on the imaging surface is inhibited.

Additional difficulties are present in electrophoretic development systems employing cycling or reusable imaging surfaces in that the charged marking particles separate from the carrier liquid and migrate to the charged or image portions of the imaging surface. These particles strongly adhere to the imaging surface by means of Van der Waals forces since they frequently come within about 500 angstroms of the imaging surface. The Van der Waals forces are so strong that in the subsequent transfer step, a considerable portion of the particles remain on the imaging surface, thus producing prints of relatively low density and contributing to background depositions in subsequent cycles.

Procedures to remove liquid developer from the surface of reusable imaging surfaces have been proposed. However, to provide the necessary removal of the developer film, the cleaning step must be so severe and complete that there may be a progressive degradation of the imaging surface lessening its useful lifespan. The severity of the cleaning step is dictated by the fact that in most presently used methods of cleaning a liquid from a surface, the film is progressively split so that on each separate cleaning, a significant portion of the liquid remains on the photoconductor surface. The cleaning solvents generally necessary to provide adequate cleaning frequently are major contributors to the chemical attack on the imaging surface and are frequently hazardous due to their volatility and toxicity. In some instances, and with complete removal of the ink film, the electrical properties of a photoconductor, for example, are virtually destroyed by the cleaning operation after only a small number of cycles. In other instances, the cleaning solvents employed may act as solvents for the resin in a binder plate or may induce crys-

tallization of the thin layer of selenium. Thus, electrostatographic imaging systems employing reusable imaging members require a compromise between the presence of residual liquid developer on the imaging surface and the force necessary to remove sufficient developer without degradation of the imaging surface. Furthermore, in many of the previously proposed imaging systems employing reusable imaging surfaces, the cleaning mechanism becomes very sophisticated requiring close adjustments and tolerances between moving members and the application of cleaning materials in rather specified quantities. The close control necessary increases the complexity of the entire imaging system and contributes to an additional maintenance burden. In addition, some imaging surfaces may be excessively rough or porous resulting in nonuniformity of contact with the developer applicator during development. It is therefore clear that there is a continuing need for an improved electrostatographic imaging system employing a reusable or cycling imaging surface.

SUMMARY OF THE INVENTION

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

It is another object of this invention to provide a surface to be developed which does not have the undesirable properties of the image bearing surface.

It is another object of this invention to provide a smooth uniform surface upon which to develop an electrostatic charge pattern.

It is another object of this invention to provide a surface to be developed having improved liquid developer receptivity and release properties.

It is another object of this invention to provide an imaging system employing liquid development of an electrostatic latent image on a recycling or reusable electrostatographic imaging surface.

It is another object of the present invention to provide an electrostatographic imaging system employing liquid development wherein a reusable or cycling electrostatographic imaging surface does not have to be cleaned on each imaging cycle.

It is another object of this invention to provide an electrostatographic imaging system employing liquid development wherein a plurality of final copies may be obtained without the necessity of separately forming the electrostatic latent image on the reusable imaging surface for each copy.

It is an overall object of this invention to provide a system having the above advantages wherein the reproduced image is the reverse of the original light image.

The above objects are achieved by providing a system wherein a thin dielectric film or sheet is interposed between a photoconductor assembly having a transparent backing layer, and a polar liquid developer dispensing member, said dispenser being electrically biased with respect to the photoconductor assembly. The assembly is imagewise exposed through the backing layer while the developer dispensing member is moved across the interposed dielectric film, which is in contact with the photoconductive assembly. An electrostatic reversal image is thereby indirectly formed and simultaneously developed on the dielectric film. Following development, the film liquid image is contacted with a developer receiving surface to accomplish image transfer. It will thus be seen that an additional advantage of the system of this invention is the elimination of the

conventional need to pre-charge the photoconductor prior to development of the image.

More specifically, final reversal prints of high resolution and image density may be obtained on ordinary paper, for example, in a polar liquid development system wherein formation and development of an electrostatic charge pattern induced from a reusable photoconductive imaging assembly is achieved on the side of a single use film or reusable belt of dielectric material opposite that side which is in substantially uniform contact with the photoconductor. To achieve this recycling capability with a liquid development technique which provides high quality prints, the film may be interposed at any time prior to exposure and should remain in contact with the photoconductor assembly until the developer dispenser has moved across the area of the film corresponding to the photoconductor region exposed to the projected original image. The developed film may be removed from the photoconductor assembly and the developed images present on the film may be carried to a remote transfer station and there transferred to a receiving surface in image configuration; or transfer may occur with the film still in contact with the assembly. The film is preferably interposed or placed in substantially uniform line contact with the photoconductor assembly maintained thus during imaging and development.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a simplified illustration of the dielectric film contacting the photoconductor assembly in preparation for exposure and development.

FIG. 2 is a simplified illustration of an embodiment of the method of this invention, using a preferred patterned roll-type developer applicator.

FIG. 3 is a schematic illustration of an electrostatic imaging apparatus employing the method of this invention in an automatic copy mode, i.e., with a reusable photoconductor assembly and dielectric film.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to FIG. 1, a photoconductor assembly, 2, is shown in close contact with an interposed film or sheet of dielectric material, 1, as it must be before the method of this invention can be used. The assembly, 2, as used in this invention, is generally comprised of a substantially transparent support layer, 5, an intermediate, substantially transparent conductive electrode layer, 4, and a layer of photoconductive material, 3.

Although the photoconductor assembly, 2, is shown in horizontal alignment with the dielectric film, 1, it may be of any shape or geometrical configuration which permits rear imagewise exposure and close contact with the film, 1. The film is preferably kept in substantially uniform contact with the assembly such that ripples or air bubbles therebetween are eliminated.

Any suitable dielectric material may be employed as the interposed film or web in the practice of this invention. Typically, the interposed film should have sufficient tensile strength and dimensional stability to enable it to be readily interposed and maintained in uniform contact with the imaging surface and adequate resistivity and dielectric strength to enable development on one side of the interposed film in response to an electrostatic charge pattern present on the surface contacting the opposite side of the film. To provide the necessary mechanical properties and to maintain the film in contact with the imaging surface without distortion

of the film, it is generally preferred that the film have a tensile strength greater than about 4000 pounds per square inch and that the percent elongation of the film be very small. Typically, the films are nonporous and from about 6 microns to about 75 microns in thickness. Six microns is generally the lower limit due to the general inability to mechanically handle thinner films. The upper limit of about 75 microns is generally the thickness through which development may take place without significant loss of resolution. At a film thickness of about 75 microns, the resolution may be limited to about 5 to 6 line pair per millimeter. In addition, the voltage applied to the developer dispenser to induce developer transfer generally increases with the thickness of the interposed film. For film thickness greater than about 75 microns, for example, voltages greater than about 1000 volts may be necessary. On the other hand, with increasing dielectric film thickness the handling of the film during the interposition, development, transfer and separating operations is more readily facilitated. Optimum balance between mechanical handling of the film and deterioration of image resolution is generally achieved with films having a thickness of from about 12 to about 50 microns. Preferably we employ films having a thickness of from about 12 to 25 microns. The interposed films typically have volume resistivities greater than about 10^{10} ohm-cm to insure that when placed in contact with the charged imaging surface, the charge is not dissipated by lateral conduction through the interposed film. Typically the interposed films have dielectric constants greater than about 2.2.

The dielectric film may comprise a single layer or multiple layers of one material on top of another. Typical specific unitary film material include extruded or drawn polyolefin films such as polyethylene, polypropylene, and polybutene; elastomers including oil resistant neoprene, silicone elastomers and fluoroelastomers such as the copolymer of vinylidene fluoride and hexafluoropropylene available from E. I. duPont de Nemours and Company under the tradename Viton. In addition, cast films of cellulose acetate, polycarbonate, or polystyrene; extruded films of polyethylene terephthalate as well as films of polyvinyl fluoride, polytetrafluoroethylene and cellophane may be employed. Composite dielectric materials may also be employed and are particularly useful when the film is to be reused. For this purpose, barium titanate dielectric composites in which the barium titanate serves to greatly enhance the dielectric constant values of 25 to 30 are particularly useful. In addition, double layer laminated or coated films in which one component provides one property and the other component provides a second property may be employed. For example, a double layer film comprising a polyethylene terephthalate base to provide good tensile strength and a surface coating of polyvinyl fluoride providing good cleanability may be employed. While all of the above mentioned materials may be employed as the interposed film, for single use of disposable films, it is generally preferred to employ polyolefins since these materials are readily and economically available and can provide superior anti-static and strength properties. Particularly superior imaging results are obtained with the use of biaxially oriented polypropylene since it has a high dielectric constant compared to the unoriented materials and superior tensile strength when compared to other polyolefins. The interposed dielectric film may be opaque unless exposure of the imaging surface is to be through

the film in which case it should be transparent. When employing a reusable interposed web or film, it is generally preferred to provide one with sufficient thickness to withstand the necessary continuous mechanical handling of the film since the thicker materials produce the greater rigidity, durability, stiffness and ease in handling. Accordingly when employing the film as a reusable web film of the order of from about 12 to about 50 microns are preferred. A particularly superior film of this thickness when employed as a reusable interposed web is a film made of polyvinyl fluoride such as Tedlar which has high dielectric constant of from about 8.5 to 9.2, allows quick charge dissipation because of its relatively low bulk resistivity, is relatively easy to clean and is stable under long term use.

The photoconductive materials which may be used to comprise the photoconductor layer, 3, include but are not limited to, selenium and selenium alloys, with or without a thin protective overlayer of insulating material; cadmium sulfide, cadmium sulfoselenide, phthalocyanine binder coatings and polyvinyl carbazole sensitized with 2, 4, 7-trinitrofluoronone.

The photosensitive layer, 3, is bonded to transparent conductive support structure which is shown in FIG. 1 as a conductive layer, 4, and base member, 5. Typically the support structure can be a metallized, plastic or tin-oxide coated glass; e.g., NESA - coated glass. Any conductive material can be used as the electrode, 4, so long as the material, as applied to the base, 5, is transparent. The photosensitive layer, 3, is preferably comparable in thickness to the dielectric film or sheet. Depending on the dielectric constant of the photoconductive material, thickness of 25 to 100 microns or more are preferred. For a thickness of, e.g., 150 to 200 microns, the dielectric constant should be about 4 or greater.

FIG. 2 illustrates a simplified operation of the simultaneous imaging and development method of this invention. The dielectric film, 1, is again shown contacting the photoconductor assembly, 2, as in FIG. 1. A polar ink developer applicator, 6, is moved across the dielectric film, 1. The applicator, 6, and developer are electrically biased with respect to the conductive electrode, 4. The photoconductor assembly, 2, is exposed to an original light image containing light patterns, 9, and shadow patterns, 10, using light image source, 7. As the applicator moves across an area of the film corresponding to a section, 11, of the photoconductor exposed to a highlight pattern, an electrostatic field is established between the applicator and the electrode, 4, due to the photoconductive property of layer 3. This field simultaneously causes polar ink developer to be drawn from the applicator to the film thus producing a developed image, 8, of the highlight pattern. The electrostatic field in areas corresponding to the shadow patterns of the original image is much less intense, thereby not drawing developer to the film. The resultant image is the reverse of the original, i.e., the developed areas correspond to the light patterns of the projected original image.

In this particular example, the applicator, 6, is shown moving across the film and photoconductor assembly. This invention contemplates any procedure or apparatus whereby the developer applicator is brought into contact with the dielectric film while the photoconductor is being imagewise exposed. The mechanism of development employed may be substantially the same as that in the polar liquid development technique described by R. W. Gundlach in U.S. Pat. No. 3,084,043.

In this technique the liquid developer is applied to a patterned applicator such that the raised portions of the applicator surface are substantially free of developer and the level of the liquid in the recessed portions of the applicator is slightly below the level of the lands. Surface tension retains the developer in cohesive configuration in the depressed portions of the applicator surface and as the raised portions of the applicator surface are placed in light or gentle contact with the interposed layer, the liquid developer in response to electrostatic field of force generated by the potential difference on the photoconductor is guided up the sides of the depressed portions of the applicator surface and then an attached bead of developer deposits on the film substantially only in accordance with the pattern of high-light exposure. The developer remains in the depressed portions of the applicator surface except in those portions which are under the influence of the attracting electrostatic force. A principal advantage of this development technique is the ability to develop both positive and negative charge patterns with the same developer since the polar liquid developers have the ability of having charge of both polarities induced in them with substantially equal ability.

Any suitable developer dispensing member may be employed. It may take the form of a roller for example, having a patterned surface or may be in the form of an endless web or belt having a patterned surface. Porous ceramic materials and metallic sponge may also be used as the applicator device. The principal characteristics in the patterned surface form include preferably that the structure should be substantially uniform or regular in configuration having raised portions or lands and depressed portions or valleys and that it be capable of holding developer material in the depressed portions of the pattern. A particularly effective applicator device providing uniform development is a cylindrical roll having a patterned surface which may be of a trihelix, pyramidal, single thread or quadrigravure grooved pattern.

Any suitable liquid developer may be employed in the practice of this invention. Typically, the developers which are effective have a conductivity of from about 10^{-4} ohm-cm⁻¹ to about 10^{-14} ohm-cm⁻¹ and comprise colorants dispersed or dissolved in liquid vehicles. Typical vehicles within this group providing these properties include water, methanol, ethanol, propanol, glycerol, ethylene glycol, propylene glycol, 2, 5-hexanediol, mineral oil, the vegetable oils including castor oil, peanut oil, sunflower seed oil, corn oil and rapeseed oil. Also included are silicone oil, mineral spirits, halogenated hydrocarbons such as Dupont's Freon solvents and Krytox oils; esters such as fatty acid esters, kerosene and oleic acid. Any suitable colorant may be employed including both dyes and pigments. Typical pigments include carbon black and other forms of finely divided carbon, quinacridones, iron oxides, zinc oxides, titanium dioxide, and benzidine yellow. In addition, as is well known in the art, the developers may contain one or more secondary vehicles, dispersants, viscosity controlling additives, or additives which contribute to fixing the developer on the copy paper.

Depending upon the thickness of assembly, 2, the applicator, 6, is biased at a potential difference with respect to electrode, 4, sufficient to draw developer from applicator to the film in the exposed, high electric field regions of the photoconductor, however, without such development occurring in the non-exposed regions.

Typically, voltages of between about 300 to 1500 volts are preferred.

The polarity of the backing electrode, 4, should correspond to the polarity of the majority carrier appropriate to the photoconductor used; e.g., negative for cadmium sulfide or zinc oxide-binder photoconductors, etc; and positive for phthalocyanine-binder photoconductors and for selenium.

FIG. 3 is an illustration of an electrostatographic copying system employing the method and apparatus of this invention. The photoconductor assembly, 15, comprising transparent support layer, 12, electrode 13, and photosensitive element, 14, is in the form of a rotatably-mounted cylindrical drum. Electrode, 13, is connected by any suitable means to ground electrical potential, for the sake of illustration.

A thin film of dielectric material 16, such as biaxially oriented polypropylene is fed from supply roll 17 past positioning and tensioning roll 18 to provide a substantially uniform area contact of the dielectric film 16 with the surface of the photoconductor 15 substantially completely along the path from tensioning roll 18 to tensioning and separating roll 19. The dielectric film 16 should be present on the surface of the photoconductor as a smooth film as completely free of air bubbles and ripples as possible. Development and imaging is accomplished with a rotating patterned applicator roller 20 loaded with a liquid developer 21 by means of feed roller 22 and doctored by doctor blade 23 to provide liquid developer in the depressed portions of the applicator surface while the raised portions are substantially free of developer. The liquid developer may be replenished through the developer reservoir 24 by any suitable means such as gravity from a developer bath which is not depicted. Applicator, 20, is connected by any suitable means to an electrical potential supply to provide an electrical bias with respect to electrode 13. The photoconductor assembly 15 is imagewise exposed to a light and shadow pattern through the support layer 12 by any suitable image projection means, exemplified here schematically by image projection means 25 which focuses the image upon an area 26 of the assembly 15 corresponding to the area 27 on film 16 whereupon the developer applicator makes contact, thus depositing polar ink developer on the film in the light regions as described before. Exposure means 25 is synchronized with applicator 20 to assure that the applicator contacts the film 16 as the corresponding area of the photoconductor 15 is exposed to the original image. The method and apparatus of this invention is not restricted or limited to any specific image projection means so long as the developer dispenser contacts the interposition film are super-adjacent the area of the photoconductor being exposed. The developer on the interposed layer in image configuration is transferred to a receiver sheet such as ordinary paper 28, held in pressure contact with the dielectric film by means of transfer roller 29. The receiver sheet is moved through the transfer zone in contact with the interposed film at the same rate and in the same direction as the periphery of the drum. If desired, transfer may be electrostatically assisted. The receiver sheet bearing the developer in image configuration is thereafter fed through copy feed out rolls 30. The dielectric film remains in contact with the photoconductor to a point following the transfer station and is finally separated from the photoconductor by conductive separation roller 19 and passes around roller 31 with the used film being wound up on

takeup roller 32. Any charged image pattern on the photoconductor may be dissipated by blanket illumination from lamp 33 to render the photoconductor ready for the next imaging cycle.

The interposed dielectric film may be kept in substantially uniform contact without the formation of ripples of air bubbles by any suitable means. It may, for example, be fed at precisely the same rate as the periphery of the photoconductor through the development transfer and separating operations. Typically, the speed of the dielectric film may be maintained equal to that of the photoconductor surface merely by wrapping the film around the periphery of the photoconductor and maintaining the film in light pressure contact with the photoconductor. It is preferred that the dielectric film be brought into virtually complete uniform contact with the photoreceptor so that there are no ripples or air bubbles between the film and the photoreceptor in order to inhibit the distortion of developer on the dielectric film during development and to insure development of all the image areas. Instead of the dielectric film being provided from an exhaustible supply which must be replaced, as in FIG. 3, a reusable, cycling dielectric belt may be employed. A cleaning station need only be provided to remove any residual developer from the film or belt after image transfer, before the next exposure-imaging-development step. It is not necessary that image transfer from the dielectric to the copy member be accomplished before the dielectric bearing the image is separated from the photoconductor assembly. Transfer may occur at a point remote from the photoconductor by any suitable arrangement, since the imaged dielectric will retain image consistency without contacting the photoconductor.

Polar liquid development as described herein is capable of very high speed development of the order of up to 200 inches per second. The speed of development in the improved systems of this invention is limited only by the rate of developer flow in response to the applied field and the ability to mechanically handle the thin dielectric web.

EXAMPLE

An electrostatographic imaging system employing a preferred embodiment of the method and apparatus of this invention is now described using the arrangement of FIG. 3.

The photoconductor drum 15 possesses a diameter of four and three-fourths inches and comprises a 150 micron thick assembly of cadmium sulfide/plastic, 14, on NESA-coated glass, 13 and 12 respectively. The dielectric constant of the assembly is about 6.

A transparent biaxially oriented polypropylene film about 15 microns in thickness and with a dielectric constant of 3 is wrapped around about half the drum. The liquid developer employed has a volume resistivity of about 5×10^{10} ohm-cm and is of the following composition by weight:

Light paraffin oil	60 parts by weight
Ganex V-216	10 parts by weight
Microlith CT Black	30 parts by weight

Ganex V-216 is an alkylated polyvinyl pyrrolidone compound available from GAF. Microlith CT Black is a resinated predispersed carbon black pigment composed of about 33% by weight carbon black pigment and about 67% by weight ester gum available from

CIBA. The developer is loaded onto a conductive rubber cylindrical applicator roll 20 having a trihelical pattern of about 180 lines per inch and doctored to provide ridges on the applicator surface which are substantially free of liquid while the grooves are filled with liquid to a level slightly below the level of the ridges. The applicator is charged positively to about 800 volts; the photoconductor is exposed to a light and shadow pattern while contacted with the polypropylene film. The trihelical roller loaded with liquid developer is brought into very light contact, about one pound per lineal inch, with the film as it passes the point of exposure and the liquid developer is deposited on the dielectric film in a pattern corresponding to the light image areas on the photoconductor. Thereafter, while maintaining the polypropylene film in uniform contact with the photoconductor, the developer on the polypropylene film is transferred to bond paper by moving the paper through a nip formed between the polypropylene film and a rubber roller under a pressure of about one pound per lineal inch. The print on the bond paper has a resolution of about 7 line pairs per millimeter, image density of 1.0 and 0.02 background. The interposed polypropylene film is discarded by winding it up on a cylindrical roll. This imaging system is run for over 100 cycles with substantially no change in print quality.

What is claimed is:

1. An electrostatographic imaging apparatus, comprising: a photoconductor assembly comprising a photoconductive material having a conductive, essentially transparent support base; means for uniformly frontally contacting said photoconductor assembly with a dielectric sheet; means for projecting a light and shadow image pattern through said support base of said photoconductor assembly to expose said photoconductive material; means for applying concurrently with exposure, a polar liquid developer to the surface of the region of the dielectric sheet which is in uniform contact with the exposed photoconductor assembly, said means being electrically biased with respect to said photoconductive assembly conductive support base, and having a patterned surface of raised and depressed portions such that the polar liquid developer is carried in the depressed portions with the raised portions being substantially free of the developer; and means for transferring said developer from said dielectric sheet to an image copy member.

2. The apparatus of claim 1 wherein said photoconductive assembly conductive support base is comprised of an essentially transparent conductive material, adjacent the photoconductive material, and an essentially transparent insulative support material, adjacent said conductive material.

3. The apparatus of claim 1 wherein said photoconductive assembly is in the form of a rotatable, cylindrical drum.

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