United States Patent Office 3,795,530 Patented Mar. 5, 1974

3,795,530

ELECTROSTATIC LATENT IMAGE DEVELOPMENT

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No Drawing. Original application Apr. 26, 1968, Ser. No. 724,596, now Patent No. 3,676,215. Divided and this application Dec. 7, 1971, Ser. No. 205,746

Int. Cl. G03g *13/08*

U.S. Cl. 117—17.5 12 Claims

ABSTRACT OF THE DISCLOSURE

A simple electrostatographic imaging system including an electrostatographic imaging surface, a donor member having a liquifiable polar developer layer on a surface thereof and developer repellent spacer particles sandwiched between the electrostatographic imaging surface and the liquifiable polar developer layer. Imaging is accomplished in this system by forming an electrostatic latent image on the surface of the electrostatographic imaging surface, liquifiying the liquifiable polar developer on the surface of the donor member and allowing the resulting liquified polar developer to migrate to the surface of the electrostatographic imaging surface in image configuration.

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a division of application Ser. No. 724,596, filed Apr. 26, 1968, now U.S. Pat. No. 3,676,215.

BACKGROUND OF THE INVENTION

This invention relates to imaging systems, and more particularly, to improved developer applicators, their manufacture and use.

The formation and development of images on the surface of photoconductor materials by electrostatic means is well known. The basic xerographic process, as taught by C. F. Carlson in U.S. Pat. 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-hand-shadow image, one may form the latent image by directly 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 means such as solvent or overcoating treatment may be substituted for the foregoing heat fixing steps.

Several methods are known for applying a developer to an electrostatic latent image to be developed. One development method, as disclosed by E. N. Wise in U.S. Pat. 2,618,552, is known as "cascade" development. In this method, a developer material comprising relatively larger carrier particles having fine toner particles electrostatically coated thereon is conveyed and rolled or cascaded across the electrostatic image bearing surface. The composition of the carrier particles is so chosen as to triboelectrically charge the toner particles to the desired polarity. As the mixture cascades or rolls across the image-bearing surface, the toner particles are electrostatically deposited and secured to the charged portion of the latent image and are not deposited on the uncharged or background portions of the image. Most of the toner particles accidentally deposited in the background areas are removed by the rolling carrier, due apparently, to the greater electrostatic attraction between the toner and the carrier than between the toner and the discharged background. The carrier and excess toner are then recycled. This technique is extremely good for the development of line copy images.

Another method of developing electrostatic images is the "magnetic brush" process as disclosed, for example, in U.S. Pat. 2,874,063. In this method, a developer material containing toner and magnetic carrier particles is carried by a magnet. The magnetic field of the magnet causes alignment of magnetic carriers into a brush-like configuration. This "magnetic brush" is engaged with the electrostatic image-bearing surface and the toner particles are drawn from the brush to the latent image by electrostatic attraction.

Still another technique for developing electrostatic latent images is the "powder cloud" process as disclosed by C. F. Carlson in U.S. Pat. 2,221,776. In this method, a developer material comprising electrically charged toner particles in a gaseous fluid is passed adjacent the surface bearing the electrostatic latent image. The toner particles are drawn by electrostatic attraction from the gas to the latent image. This process is particularly useful in continuous tone development.

A further technique for developing electrostatic latent images is the liquid development process disclosed by R. W. Gundlach in U.S. Pat. 3,084,043. 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 defining a substantially regular patterned surface and a plurality of portions depressed below the raised portions. The depressed portions contain a layer of conductive liquid developer which is maintained out of contact with the electrostatographic imaging surface. When the raised areas of the developer applicator is brought into contact with an electrostatic latent image bearing surface, the developer creeps up the sides of the raised areas and deposits in the charged areas.

In automatic xerographic equipment employing the development techniques described above, particularly the cascade development technique, it is conventional to employ a xerographic plate in the form of a cylindrical drum which is continuously rotated through a cycle of sequential operations including charging, exposing, developing, transfer and cleaning steps. The plate is usually charged with corona to a positive polarity by means of a corona generating device of the type disclosed by L. E. Walkup in U.S. Pat. 2,777,957 which is connected to a suitable source of high potential. After forming a developed image on the electrostatic latent image during the development step, the developed image is transferred to a support surface by various means such as a corona generating device or by contacting the developed image with a receiving surface having an affinity for the developer. After the transfer step, the imaging surface is normally cleaned by abrasive contact with a suitable wiping device such as the web disclosed by W. P. Graff, Jr. et al. in U.S. Pat. 3,186,838 or the brush disclosed by M. I. Turner et al in U.S. Pat. 3,751,616.

While ordinarily capable of forming satisfactory images, conventional xerographic imaging systems suffer serious deficiencies in certain areas. Normally, large, complex and expensive apparatus are required to effectuate

most of the known electrostatographic imaging techniques, including the principal systems described above. Further, the numerous precision components of these imaging machines require the manufacturer to maintain a large staff of skilled maintenance personnel who must be readily available on short notice for apparatus repairs or adjustment. The most commonly used xerographic system today employs the cascade development technique. However, because of the space consuming toner transport and recycling equipment necessary to carry out the cascade process, the degree of machine size reduction is somewhat limited. The problem of equipment complexity is also an undesirable feature of the liquid development system described by R. W. Gundlach in U.S. Pat. 3,084,043, hereinafter referred to as "polar liquid development." Unlike conventional liquid development systems, substantial contact between the polar liquid and the areas of the latent electrostatic image bearing surface not to be developed is prevented in the polar liquid development technique. Reduced contact between a liquid developer and the non-image areas of a 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 conventional liquid development processes is the fact that the liquid phase of a polar developer actively takes part in the development of a surface. The liquid phase in conventional liquid developers functions only as a carrier medium for developer particles. Thus, undesirable features such as developer instability during storage and change in particle concentration during the course of development are major obstacles to be overcome in perfecting conventional liquid development systems. Further, the insulating hydrocarbon liquids normally employed as the carrier liquid in conventional liquid development systems are occasionally volatile, toxic, inflammable or malodorous. Further, because the carrier liquid of conventional liquid development systems makes "wetting" contact with all areas of the image-bearing surface (i.e., image and background areas), large quantities of the toxic, flammable and malodorous material are consumed and ultimately released to the ambient atmosphere. In addition, the pigments or other solid particles in conventional liquid development systems often cause applicator clogging and require additional image fixing steps such as imaging overcoating. Although the polar development technique possesses some advantages over the conventional liquid development systems, such as greater developer stability, it too is not entirely free of objectionable features. Since the polar liquid developer applicator should be doctored to prevent the liquid from covering the applicator peaks in order to assure clean background, the spacing and pressure between the doctor blade and the applicator is often critical particularly when high quality copies are desired. Since the applicator and doctor blade are not immune to wear, proper spacing is often difficult to maintain for prolonged periods of time in automatic machines. In addition, accumulation of dust and scratches on the applicator and nicks on the doctor blade tend to promote the formation of background deposits on the final copy. Thus, there is a continuing need for a better system for developing latent electrostatic images.

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 simple compact development system.

It is another object of this invention to provide a development system employing stable developer materials.

It is another object of this invention to provide a development system having reduced maintenance requirements.

It is another object of this invention to provide a development system employing a self-fixing developer.

It is another object of this invention to provide a development system requiring equipment of reduced size and complexity.

It is another object of this invention to provide a system employing developers having physical and chemical properties superior to those of known developing materials.

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

The above objects and others are accomplished, generally speaking, by providing an electrostatographic imaging system wherein an electrostatic image bearing surface is brought substantially parallel and adjacent to, but out of contact with the surface of a normally solid liquifiable polar developer layer. Uniform spacing is achieved between the surface to be developed and the polar developer layer by spacing particles having ink repellent surfaces and an average diameter sufficient to maintain the developer substantially out of contact with the imaging surface in the background areas. Upon liquification of the developing layer, as by heat or solvent treatment, the conductive polar developer material is attracted to and deposits on the charged areas. Although it is not entirely clear, it is postulated that the liquified developer creeps up the sides of the spacing particles and/or forms wrinkles between the spacing particles and is attracted to and wets the charged areas of the imaging surface, while being held out of contact from the discharged areas. The liquifiable polar ink layer may be liquified prior to, simultaneously with or subsequent to contact with the latent image bearing surface. The developer layer is preferably carried on a donor web or sheet. After development has occurred, the donor sheet is separated from the imaging surface. Separation may be effected before or after resolidification of the developer material.

Any suitable ink repellant coated or uncoated particulate material which remains substantially undeformed during the development process may be employed as the spacing particle of this invention. Typical particle or particle core materials which remain substantially undeformed during the development process include organic materials such as thermosetting resins and thermoplastic resins which melt at temperatures above the liquifying temperature of the developer as well as inorganic materials such as glass, sand, calcium carbonate, steel, copper and the like.

The spacing particle may possess a spherical, granular, cubical, cylindrical, smooth, irregular or other suitable shape and surface characteristics. A spherical shape is preferred because the average spacing between the imaging surface and developer layer is predictable with greater accuracy. Further, optimum image definition and quality are achieved with spherical spacers because the contact area between the photoreceptor surface and the spacing particles is at a minimum. The spacing particles should have an average diameter between about 2 to about 60 microns. The largest dimension of a spacing particle need not, in every case, be considered in determining the average particle diameter. For example, the length of fibrous spacing particles can normally be ignored. However, if the fibrous spacing particles comprise short right cylinders having a length approaching that of the fiber diameter, it would be appropriate to consider the length of the cylinder when one determines the average spacing diameter because of the possibility that some of the spacing particles may be positioned with the axis perpendicular to rather than parallel to the surface of the donor web or sheet. Thus, the criteria for determining whether a spacing particle dimension should be included in calculating the spacing distance is whether that dimension will directly affect the spacing distance. The dimension of a spacing particle which directly affects the spacing distance will hereafter be referred to as the "spacing diameter." The optimum

spacing diameter is between about 6 to about 20 microns as determined by minimizing background and maximizing image density.

Although a spacing particle may have a smooth or irregular outer surface, the outer surface should repel or be adhesive to the polar inks of this invention. The surface of a spacing particle is sufficiently developer repellent that the liquified polar developer employed tends to form "balls" or "beads" rather than a film or coating on a surface formed from the spacing particle material. Optimum results are achieved when the liquified developer tends to form "balls" on a surface formed of the spacing particle material in a manner similar to the formation of balls of mercury on a slate surface. Typical particulate materials which tend to repel polar liquids include anthracene, naphthalene, copped powder, zinc stearate powder, waxes such as carnauba, microcrystalline and hydrocarbon waxes, and hydrophobic resins such as Teflon, polyethylene, polypropylene, Kel F (Minnesota Mining and Manufacturing), silicone resins such as General Electric SR 82, and polystyrene powders and two-phase materials such as titanium dioxide powder treated with silicone wax, glass beads coated with fluorocarbon polymers, particles coated with solid metal salts of fatty acids, such as calcium carbonate coated with zinc stearate, and mixtures thereof. The preferred class of materials consist of a hydrophilic pigment which has been substantially completely coated with a preoriented layer of a surface treating agent, such as for example a linear compound having one developer repellent end and one hydrophilic end. Typical examples of such compounds include the long chain fatty acids and their metal salts, for example, the stearates, amine salts of long chain fatty acids, long chain aliphatic alcohols, and long chain fatty acid amides. Typical hydrophilic pigments which may be coated with such compounds include chalk, titania, zinc oxide, powdered glass, chromium, aluminum, copper phthalocyanine, starch, carbon and mixtures thereof. Composite particles having substantially analogous properties may be formed in certain cases by reacting a surface reactive pigment with a suitable surface covering agent. Typical examples include silica treated with esters or chlorosilane derivatives, rosin reacted carbon powder, and the like. It has been found that composites of pigments with such surface treating agents are externally polar developer repellent to a remarkable degree. It is believed that the surface films are preferentially oriented with their hydrophilic side adjacent the film pigment interface, thus presenting a uniformly developer repellent side to the developer. This renders such particles particularly suitable for the use intended in this invention. Where the spacing particles comprise an ink repellent material coating on a core, the coating may be applied to the core by any suitable technique. Typical coating processes include dipping, spraying, vapor coating, brushing and the like. Since the surface area of the ends of fibrous spacing particles such as glass fibers usually constitute a minor portion of the total surface area of the particles, long fibers may be coated with an ink repellent material prior to comminution into short spacing particles.

Preferably, the spacing particles should be transparent or have a color which matches the color of the surface of the ultimate copy sheet. However, the spacing particles may, for special effects, comprise particles having one or more colors which contrast with the color of the surface of the ultimate copy substrate.

Any suitable liquifiable polar material which is conductive in the fluid state may be employed in the developer of this invention. Polar developers of this invention are distinguished from fusible electrophoretic developers by the fact that polar developers respond to the electrostatic fields as a homogeneous unit without significant separation of any of its components. The polar developer in the molten or dissolved state should be sufficiently conductive to collapse electric field lines within the developer. Satisfactory results are achieved with developers having a volume resistivity of less than about 10^{13} ohm-cms. A liquified developer having a volume resistivity of less than about 10^{10} ohm-cms. is preferred for optimum speed and image quality, particularly when electrically non-conductive donor substrates are employed. The thermoplastic developing layer should become fluid in the range above about 120° F. to about the charring point of paper. Developer material which melts below about 120° F. tends to promote blocking of donor sheets during storage. An adhesive interleaf or back coating used in packaging renders a lower melting developer feasible. The liquification temperature should be kept below the degradation temperature of the donor substrate and photoconductive surface. For optimum efficiency, speed and machine simplicity, a fluid range between about 135° F. to about 310° F. is preferred. Optimum results are obtained with developers containing polar thermoplastic polymeric and non-polymeric crystalline materials. These materials melt rapidly and are characterized by a narrow liquification temperature range. Thus, crystalline developers are particularly desirable in high speed machines which require developer materials having highly predictable and close tolerance liquification properties. Since developement time and developer viscosity are linearly related, higher development speeds are achieved with lower viscosity fluidized developers. A satisfactory development speed of about 3 seconds is achieved with a developer having a viscosity of about 10^4 poises. Optimum development speeds are attained with liquified polar developers having a viscosity of less than about 10^2 poises at a temperature between about 135° F. and about 210° F. Typical thermoplastic materials which have a resistivity less than about 10^{13} ohm-cms. in the molten state include polyethylene glycols, cetyl alcohol, stearyl alcohol, stearic acid, palmitic acid, or thermoplastic materials which are normally too insulating, but are rendered sufficiently conductive by such additives as ionic dyes, quaternary ammonium salts, organic and inorganic humectants, semiconductive pigments or other well known conductive additives. The addition of polar solvents will provide the same effect as in the case of vapor softening discussed below.

If desired, softening of the developer may be effected with the aid of a developer solvent or solvent mixture rather than heat. Selection of a particular solvent depends upon the specific developer material employed and the ultimate resistivity of the liquified mixture of solvent and developer materials. Care should be taken to select a solvent which will provide a liquified developer mixture having a volume resistivity less than about 10^{13} ohm-cms. Relatively volatile solvents are preferred for high speed development to promote rapid removal of the solvent from the ultimate developer images after development. If the developed image is to be transferred to an absorbent receiving sheet, a nonvolatile solvent may be employed. Typical combinations of developer material and solvent include: Polyethylene glycol and water; polypropylene glycol and methyl alcohol; n-butyl stearate and alcohol; oleamide and glycerine; elaidamide and ethylene glycol; and polyethylene glycol and isopropyl alcohol.

Various additives may be added to the polar developer material to alter the color, melting characteristics, wetting characteristics or other property of the developer. Any suitable dye or pigment may be employed as a colorant. The colorant may be present in the liquified developer as a dissolved component or as suspended or dispersed particles. Since the polar developer migrates as a homogeneous unit, the performance of the developer is substantially unaffected by the presence or absence of pigment particles. The effect of the zeta potential of the suspended or dispersed pigment, if pigments are employed, upon the performance of the polar developer is insignificant because the pigment particles are carried along by the liquid developer medium as it transfers under the influence of the external field rather than being selectively drawn out of the liquid developer medium by the electric field. More

specifically, the mechanism of development is unaffected by the zeta potential of any pigment particles in the polar developer because the liquified developer is sufficiently conductive to cause collapse of electric field lines within the developer thereby preventing the pigment particles from being acted upon by a field. If an insulating rather than conductive polar developer matrix is employed with conductive pigment particles, electrophoretic development with selective migration of the particles will occur rather than polar development in which developer transfers as a homogeneous unit. Although pigment colorants are incidental to the mechanism of development, they are preferred over dye colorants because the deposited developer images are more permanent and less subject to fading than deposited images containing dyes. Unlike conventional liquid development systems the expendible solid developer of this invention avoids the problem of accumulation of pigment material on applicator surfaces followed by eventual clogging. Typical colorants include azo dyes such as Congo red (C.I. 370), Chrysamine (C.I. 400), Benzopurpurin 4B (C.I. 448), Benzazurin (C.I. 502), Congo Corinth (C.I. 375), Brilliant Yellow (C.I. 364), Diamine Violet (C.I. 394), Developed Black BH (C.I. 401), and Eire Direct Black EW (C.I. 481), acridine dyes such as acridine yellow (C.I. 785) and Rhenonine Al (C.I. 795); quinoline dyes such as Supra Light Yellow GGL; azine dyes such as Safranine T (C.I. 841); triarylmethane dyes such as Pararosaniline (C.I. and Melachite Green (C.I. 657); xanthene dyes such as Rhodamine B (C.I. 749); sulphur dyes such as Sulfur Navy Blue (C.I. 959) and pigments such as Hydron Blue R (C.I. 969); ultramarine blue, aluminum powder, carbon black, cadmium sulfide, iron oxide and the like. The colorant may, if desired, be a material which can be converted into a colored material during or after development by reaction with another compound, by exposure to light, by oxidation, by heating or by any other suitable technique.

Lower or higher melting materials may be added to the developer material to alter the developer melting temperature. For example, p-dibromobenzene can be added to a polystyrene-methyl polymethacrylate containing a conductive additive to lower the melting temperature. The liquification rate of the developer can be accelerated or retarded by combining the higher or lower melting additive with the developer in any suitable manner such as by blending, emulsifying, or coating. A preferred configuration comprises a low melting solid solvent layer sandwiched between the donor substrate and developer layer. For example, the donor sheet can comprise a paper substrate coated with a first layer of acetylortho-toluidine and a second layer of methyl polymethacrylate containing a conductive additive. When heat is applied to the layered structure, particularly from the uncoated side, the low melting solid solvent rapidly melts and dissolves the developer layer at a temperature lower than the normal melting temperature of the developer layer itself. Crystalline solid solvents are preferred because they melt more sharply and rapidly, thereby permitting precise control over the development process. Typical crystalline solid solvents include p-dibromobenzene, acetyl-ortho-toluidine, n-phenylacetamide and beta-naphthol. Materials which reduce the surface tension of the developer may also be added to the developer layer. The surface tension modifier may be added in any suitable manner such as the techniques described above with reference to other developer additives. Reduction of liquified developer layer surface tension is desirable because greater development speed at reduced electrostatic image potentials are achieved. Additives for reducing the surface tension of a liquid are well known. Typical surface tension reducing materials include sodium glyceryl monolaurate, sulfate, triethanolamine salts of fatty acids, dioctyl sodium sulfosuccinate, and mixtures thereof.

The donor substrate or backing sheet may comprise any suitable material or materials sufficient to support the developer layer. The donor support may be conductive or insulating. The donor support surface in contact with the developer or developer solid solvent layer is preferrably selected from materials which are wetted by the developer or developer solid solvent material. A wettable donor substrate surface promotes the formation of a uniform developer layer during donor sheet manufacture. A wettable donor substrate surface also prevents the liquified developer layer from forming undesirable balls, beads or droplets which exceed the maximum spacing tolerence established by the spacing particles, thereby contacting the background areas of the imaging surface. Futher, balls or beads on repellant donor developer support surfaces tend to run, particularly on surfaces which are not perfectly horizontal. The surface of materials which are not wettable by the developer layer may be treated with any suitable material which promotes wetting. Typical developer receptive materials include calendered papers, finely-grained aluminum foils, Mylar, non-woven calendered fabrics of rayon, polyolefin and polester resins, cast film bases such as cellulose acetate, and the like. Donor sheet substrates having smooth surfaces are preferred. However, porous surfaces are satisfactory if the number or size of the pores do not adversely affect the desired spacing distance between the outer surface of the developer layer and the latent image bearing surface. Since the ink layer thickness tends to be variable when deposited on donor substrates having uneven surfaces, the ink available for development also varies from point to point over the donor sheet surface. A relatively flexible donor substrate is desirable where the donor sheet is supplied in roll form or where the donor sheet must travel a tortuous path through a copying or duplicating machine. Preferably, the rigidity and deformation resistance of the donor substrate should be sufficient to prevent substantial sagging of the donor substrate between the spacing particles and to prevent undue penetration of the spacing particle into the donor sheet substrate during the development process. Typical materials which exhibit sufficient strength to support a developer layer include paper, polyethylene terephthalate, aluminum, Tedlar, cellulose acetate, calendered papers, aluminum foil, polyolefin webs and the like.

The developer layer may be applied to the donor substrate by any suitable process such as spraying, cast coating, dip coating, extrusion coating, draw bar coating, calender coating, hot melt coating, solution coating, gravure coating, and the like. Satisfactory results are obtained when the developer layer including the solid solvent layer, if employed, is from about 2 to about 30 microns thick. A layer or layers 5 to about 10 microns thick is preferred because high density images and rapid development rates are achieved.

The donor devices of this invention may be employed to develop latent electrostatic images on any suitable surface including the surface of photoconductive layers. The photoconductive layers may comprise homogeneous layers, organic or inorganic photoconductors embedded in a non-photoconductive matrix, organic or inorganic photoocnductors embedded in a photoconductive matrix or the like. Typical photosensitive materials include vitreous selenium, vitreous selenium alloyed with arsenic, cadmium sulfide, zinc oxide, cadmium sulfoselenide, Watchung Red B, the alpha form of metal-free phthalocyanine (C.I. 74100), the X form of metal-free phthalocyanine, Algol G.C. (C.I. 67300) and the like. Representative patents or applications in which photoconductive materials are disclosed include U.S. Pat. 2,803,542 to Ullrich, U.S. Pat. 2,970,906 to Bixby U.S. Pat. 3,121,006 to Middleton, U.S. Pat. 3,121,007 to Middleton, U.S. Pat. 3,151,982 to Corrsin and U.S. Pat. 3,357,989 to Byrne and Kurz. The above listing of organic and inorganic materials is illustrative of typical materials and should not be taken as a complete listing of photosensitive materials. Where the photosensitive material is mixed with a binder, the resulting un-

charged layer should preferably be ink repellent for maximum image definition under extended periods of donor layer-imaging layer contact time. As defined above, a surface is deemed ink repellent, when the liquified polar developer or ink employed tends to form "balls," "beads" or "droplets" rather than a film or coating on the ink repellent surface. Imaging surfaces which are not developer repellent may be employed where optimum image definition under extended donor layer-imaging layer contact is of secondary importance. Typical binders for photoconductive materials include polyvinyl chloride, polystyrene, polymethylmethacrylate, polyvinyl acetate, silicone resins and the like. As is well known in the art, photoconductive layers are usually employed with a backing or support layer which are more conductive than the photoconductive insulating layer. Typical examples of electrostatic imaging surfaces are described in the patents cited above and in the examples set forth below.

The spacing particles of this invention are positioned between the donor and imaging surfaces during development. The spacing particles may be carried on the donor surface, the imaging surface or on both the donor or imaging surface prior to bringing the donor and imaging surfaces together in a spaced face-to-face relationship with the spacing particles therebetween. If desired, the spacing particles may be introduced between the donor and imaging surfaces as the two surfaces are brought together. Preferably, the spacing particles are loosely scattered over the donor or imaging surface. The particles may be applied by any suitable technique including sprinkling by hand or by means of an automatic hopper. Uniform distribution of the particles as a monolayer over the donor or imaging surface is enhanced by the application of high frequency vibratory energy to the surface to be covered. Alternatively, instead of depositing loosely held particles on the surface of the donor sheet, the spacing particles may be physically fixed to the donor sheet surface in any suitable manner such as by heating the developer layer to allow the spacing particles to sink into the layer or by pressing the particles into the layer with a smooth roller. Generally, the specific average diameter of the spacing particle selected depends upon the thickness of the developer layer and solid solvent layer, if any. Satisfactory results are achieved with spacing particles having an average diameter between about 5 to about 50 percent greater than the thickness of the developer layer and the solid solvent layer, if any. However, spacing particles having an average spacing particle diameter of between about 10 percent to about 20 percent greater than the thickness of the developer and solid solvent layers are preferred because dense images are obtained with a minimum of background deposits at higher development rates. When the spacing particles are randomly deposited on a donor or imaging surface, the distance between neighboring particles should be sufficiently small to adequately maintain the desired spacing distance between the donor surface and the imaging surface and to prevent undue sagging or deflection of either the donor or photoconductor. Deflection or sagging of the donor and/or imaging sheet between neighboring spacing particles should be slight in comparison to the spacing particle size. Donor or photoconductor layers backed by highly flexible backings usually require the presence of a greater number of spacing particles for adequate support than rigid donor or photoconductive layers. Obviously, the degree of support provided by the spacing particles also varies with other factors such as the porosity of the donor backing, the diameter of the spacing particle and the thickness of the developer layer. Good dense images are obtained with a spacing particle monolayer in which most of the particles touch each other. Satisfactory images are achieved with an average spacing between neighboring particles as high as about 2,000 microns.

When photoconductive imaging sheets are employed with the donor sheet and spacing particles of this invention, the imaging sheets may be charged and exposed in the conventional manner prior to development. Where the photoconductive layer is supported on a conductive substrate such as metal foil plates or polymeric films having a conductive coating, uniform electrostatic charging may be effected, for example, by corona discharge as described by Carlson in U.S. Pat. 2,588,699. The imaging surface of self supporting photoconductive layers may be provided with a uniform electrostatic charge by any well known method such as the double corona charging technique disclosed by R. W. Gundlach in U.S. Pat. 2,885,556. The charged photoconductive imaging surface may then be discharged in image configuration by exposure by any conventional means. Where desired, an electrostatic latent image may be formed on the imaging surface by other techniques well known in the art such as by TESI imaging as disclosed in U.S. Pat. 2,833,648 or by interposition imaging as disclosed in U.S. Pat. 3,013,878.

Liquification of thermoplastic developer layers or thermoplastic developer layers combined with solid solvent material may be effected by any suitable heating technique including conduction, radiation, convection or combinations thereof. For example, a heated roller, a heated platen, an oven or infrared lamp may be employed to fluidize the developer. Application of infrared heat energy through a transparent imaging surface and/or transparent donor substrate is particularly effective for liquifying intensely colored developer layers. If a liquid solvent is employed with or without the aid of heat energy to effect fluidization of the developer layer, it is preferably applied as a mist or vapor because; greater control over the ultimate thickness of the developer layer is achieved. Further, when the spacing particles are applied to the surface of the developer layer prior to liquification, the likelihood of removal of the particles is reduced if a solvent mist or vapor rather than solvent liquid in bulk form is applied. However, if the developer layer is liquified subsequent to the application of spacing particles, a solvent in liquid bulk form may be employed. The solvent liquid in bulk form may be applied by any suitable means such as by flow coating, roll coating, dip coating and the like.

The imaging surface bearing the electrostatic latent image may be brought substantially parallel and adjacent to but out of contact with the polar developer layer in any suitable manner. The step of developing the imaging surface may be accomplished by placing the entire latent image bearing surface adjacent to the developer layer, for example, by sandwiching spacing particles between a flat imaging sheet and a flat developer layer supported by a flat donor sheet or by progressively positioning incremental portions of an imaging surface adjacent to a portion of a developer layer. In either case, sufficient pressure should be employed to permit the spacing particles to effectively maintain the imaging surface and donor substrate in a parallel relationship with a spacing distance substantially equal to the average spacing diameter of the spacing particles. Excessive pressure should be avoided because substantial deformation of the spacing particles or penetration of the spacing particles below the imaging surface and/or donor sheet surface may occur.

Satisfactory imaging is obtained with a latent image-to-background area contrast potential of about 300 volts. Generally, an increase in contrast potential improves image density and definition. To further effectuate development through electrostatic attraction of the polar developer on the donor substrate to the image bearing surface in image configuration, may be biased to any desired potential including that of ground, through a connection to a potential source. When so electrically connected, the image charges on the imaging surface induce, due to conductivity through the conductive developer and donor substrate, if conductive, charges opposite in polarity to the charges on the imaging surface. Thus, when the conductive developer or donor substrate, if conductive, is grounded and areas of the imaging surface carry positive

charges, a corresponding negative charge is induced through the donor substrate into the conductive developer in those areas positioned adjacent to the positive charges, thereby causing a field to be established between the developer and the charge on the imaging surface. In areas of the developer layer corresponding to areas of the imaging surface bearing substantially no charge, no electric field of attraction exists to cause fluidized developer to migrate to the imaging bearing surface. Therefore, development occurs only in the charged areas when the conductive developer or conductive donor substrate is connected to ground or connected to a low potential generally about the level of the uncharged or substantially uncharged areas of the imaging surface. Since the mechanism of development in accordance with this invention is not polarity sensitive, development will take place in the charged areas as described above regardless of whether the charged areas are negative or positive in polarity. Thus, positive charges are induced into the developer in areas corresponding to the negative charges on the imaging surface and the resulting field causes the developer to migrate to and deposit on the imaging surface in image configuration. If desired, uncharged areas may be developed by applying to the conductive developer or conductive donor substrate a potential of the same polarity and of about the same level as the charged areas on the imaging surface. In this embodiment, a field will exist between uncharged areas on the imaging surface and the developer layer and no field will exist between the charged areas on the imaging surface and the corresponding areas in the developer layer. Thus, the developer will not be attracted to the charged areas on the imaging surface. However, in areas having substantially no charge, charges will be induced into the developer layer and the conductive substrate of the latent image film, resulting in electric fields of force which cause developer to deposit on the imaging surface in the uncharged areas. For example, a potential of about 200 volts may be applied to the conductive developer layer where uncharged or substantially discharged areas having a potential in the order of 10 volts are to be developed. In practice, it is generally desirable to apply a slight bias to overcome the adhesion of the developer material to the donor member and to assure high quality and background-free developer deposition. Thus, when applying a raised potential to the conductive developer layer or to the conductive donor substrate, it is desirable to provide a difference of potential of about 30 to about 50 volts. For example, for development of discharged areas of an imaging surface bearing charged areas having a potential of about 450 volts, a potential of about 500 volts is applied to the conductive developer or conductive donor substrate. This additional potential applied to the developer layer or donor substrate, if conductive, creates a stronger field for fluidized developer movement and deposition. Similarly, when developing charged areas having background areas bearing a residual charge, for example, of about 5 volts positive, it is desirable to apply a potential of about 30 to 50 volts negative to the conductive developer or conductive donor substrate. Where highly conductive fluidized developer materials are to be employed, no external source of potential need be applied to bias the developer layer. Thus, the conductive developer layer may be considered to be electrically floating. However, developer deposition in the background areas of the ultimate print and the dependence on the ratio of charged-to-uncharged areas in the latent image renders the use of an unbiased developer layer less desirable than the embodiment in which a controlled potential is applied to the conductive developer layer or conductive donor substrate.

Generally, the length of time required to develop an electrostatic latent image bearing surface increases with an increase in viscosity and surface tension of the fluidized developer. Where liquified developers exhibiting relatively high surface tension are employed and a reduction of development time is desirable, the reduction of development time may be effected by decreasing the average spacing particle diameter and/or decreasing the liquified developer viscosity, and/or by increasing the bias on the developer layer or conductive donor substrate to aid developer migration to the imaging surface. Considerable latitude in liquified developer surface tension is permissible. Satisfactory results are achieved with developers having a surface tension in the range of less than about 80 dynes/cm.

As described above, developers for conventional liquid development systems comprise marking particles suspended in an insulating carrier liquid or insulating fusible carrier medium. An insulating carrier matrix is required to prevent destruction of the electrostatic latent image and to permit persistence of the field through the developer in order to exert forces on the marking particles. Development occurs by migration of the suspended marking particles through the liquid carrier to the electrostatic latent image. The ultimate developed image consists essentially of migrated marking particles. Unlike conventional liquid development systems, the normally solid developer of this invention is electrically conductive in the fluidized state and the ultimate developed image contains the liquified portion as well as marking particles, if marking particles are employed. In addition, the customary prior art process requirement of an additional image fixing step is obviated with the self-fixing developer of the invention. Thus, the many disadvantages inherent in the prior art systems such as developer spilling, settling of suspended marking particles, marking particle depletion, applicator clogging, removal of insulating carrier liquids from an imaging surface and the like are substantially eliminated with the development system of this invention. Further, the complex precision applicators required in the prior art liquid development systems are rendered unnecessary by the use of the spacing particles of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following examples further define, describe and compare exemplary methods of preparing the development system components of the present invention and of utilizing them in a development process. Parts and percentages are by weight unless otherwise indicated. The examples, other than the control examples, are also intended to illustrate the various preferred embodiments of the present invention.

In the following, Examples I through XIII, are carried out with donor substrates carrying a liquifiable developer layer applied by means of wire-wound rod to coat a solvent diluted and/or heated developer material. The electrophotographic binder plates employed in the examples are either paper sheets or webs coated with a zinc oxide-melamine formaldehyde or zinc oxide-silicone resin photoconductive insulating layer or brass sheets coated with amorphous selenium. All of the liquifiable polar developers described in the following examples have a viscosity of less than about 10^4 poises, a surface tension of less than about 80 dynes/cm., and a conductivity of less than about 10^{13} ohm-cms.

EXAMPLE I

A calendered donor substrate sheet comprising 0.004 inch aluminum foil is coated with a conductive developer layer having a thickness of about 8 microns and comprising polyethylene glycol (3 parts Carbowax 1500 with 6 parts Carbowax 6000, available from Union Carbide Corporation) colored with about 0.25 part by weight based on the total weight of the developer layer, of crystal violet diluted with 25 parts methyl alcohol. Spacing particles comprising zinc stearate coated calcium carbonate and having an average spacing diameter of about 10 microns are applied to the surface of the developer layer to pro-

vide an average spacing distance between neighboring spacing particles of about 25 microns. The imaging surface of a zinc oxide binder plate is then corona charged to a potential of about 350 to 400 volts negative and exposed to a light and shadow image to form an electrostatic latent image. The imaging surface bearing the electrostatic latent image is then placed adjacent and parallel to the spacing particle covered surface of the coated donor substrate. The resulting sandwich is then placed under slight pressure between metal platens heated to about 150° F. After about 5 seconds, the sandwich is removed and the donor substrate is immediately separated from the imaging surface. Upon cooling, a fixed, dense image having good definition is obtained without an additional fixing step.

EXAMPLE II

A control run is made with substantially the same material and steps employed in Example I except that the use of spacing particles is omitted. After separation, the imaging surface is found to carry an image which is discernible with great difficulty because of the existence of substantial background deposits of developer.

EXAMPLE III

A donor substrate sheet comprising 0.003 inch calendered paper is coated with a conductive developer layer having a thickness of about 18 microns and comprising carnauba wax colored with about 0.35 part by weight, based on the total weight of the developer layer of methyl violet. Spacing particles comprising silica powder and having an average spacing diameter of about 20 microns are applied to the surface of the developer layer to provide an average spacing distance between neighboring spacing particles of about 35 microns. The imaging surface of a zinc oxide binder plate is then corona charged to a potential of about 400 volts negative and exposed to light and shadow image to form an electrostatic latent image. The imaging surface bearing the electrostatic latent image is then placed adjacent and parallel to the spacing particle covered surface of the coated donor substrate. The resulting sandwich is then placed under slight pressure between metal platens heated to about 190° F. After about 1 second, the sandwich is removed and the donor substrate is immediately separated from the imaging surface. Upon cooling, a fixed, dense image of good quality is obtained without an additional fixing step.

EXAMPLE IV

A control run is made with substantially the same materials and steps employed in Example III except that the use of spacing particles is omitted. After separation, the imaging surface is found to carry an image which is discernible with great difficulty because of the existence of substantial background deposits of developer.

EXAMPLE V

A donor substrate sheet comprising Riegl conductive paper having a thickness of about 0.003 inch is coated with a conductive developer layer having a thickness of about 15 microns and comprising paraffin wax (Sunoco 5460 available from Sun Oil Company) colored with about 0.05 part by weight, based on the total weight of the developer layer, of phthalocyanine. Spacing particles comprising silica powder and having an average spacing diameter of about 20 microns are applied to the surface of the developer layer to provide an average spacing distance between neighboring spacing particles of about 50 microns. The imaging surface of a photoconductive binder plate is then corona charged to a potential of about 350 to 400 volts, negative and exposed to a light and shadow image to form an electrostatic latent image. The imaging surface bearing the electrostatic latent image is then placed adjacent and parallel to the spacing particle covered surface of the coated donor sheet. The resulting sandwich is then placed under slight pressure between metal platens heated to about 170° F. After about 2 seconds, the sandwich is removed and the donor substrate is immediately separated from the imaging surface. Upon cooling, a fixed, dense image having good definition is obtained without an additional fixing step.

EXAMPLE VI

The process described in Example V is repeated with substantially identical materials except that the spacing particles are calendered into the developer layer, but not into the donor substrate sheet. The calendering operation is employed to eliminate the presence of loose spacing particles during shipment, storage and subsequent use in the development process. The images obtained when the above described donor layer is employed, are substantially identical to the images obtained with the system described in Example V.

EXAMPLE VII

A donor substrate sheet comprising aluminum foil having a thickness of about 4 mils is coated with a conductive developer layer having a thickness of about 10 microns and comprising polyethylene glycol (Carbowax 1500, available from Union Carbide Corporation) colored with about 0.02 part by weight, based on the total weight of the developer layer, of nigrosene. Spacing particles comprising polyethylene spheres and having an average spacing diameter of about 18 microns are applied to the surface of the developer layer to provide an average spacing distance between neighboring spacing particles of about 30 microns. The developer repellent imaging surface of a zinc oxide photoconductive binder plate in which the binder is silicone resin is then corona charged to a potential of about 400 volts negative and exposed to a light and shadow image to form an electrostatic latent image. The imaging surface bearing the electrostatic latent image is then placed adjacent and parallel to the spacing particle covered surface of the coated donor sheet. The resulting sandwich is then placed between metal platens heated to about 160° F. and an electrical bias of about 40 volts is applied to the developer layer. After about 2 seconds, the sandwich is removed and the donor substrate is immediately separated from the imaging sheet. Upon cooling, a fixed, dense image is obtained without an additional fixing step.

EXAMPLE VIII

A donor substrate sheet comprising aluminum foil having a thickness of 0.005 inch is coated with a conductive developer layer having a thickness of about 10 microns and comprising polyethylene glycol (Gafabol, available from General Aniline and Film Corporation) colored with about 0.25 part by weight, based on the total weight of the developer layer of methyl violet. Spacing particles comprising sand particles coated with dimethylpolysiloxane oil and having an average spacing diameter after the coating operation of about 123 microns are applied to the surface of the developer layer to provide an average spacing distance between neighboring spacing particles of about 40 microns. The developer repellent surface of a zinc oxide photoconductive binder plate in which the binder is silicone resin is then corona chrged to a potential of about 450 volts negative and exposed to a light and shadow image to form an electrostatic latent image. The imaging surface bearing the electrostatic latent image is then placed adjacent and parallel to the spacing particle covered surface of the donor sheet. The resulting sandwich is then placed between metal platens heated to about 170° F. After about 1 second, the sandwich is removed and allowed to cool. The donor substrate is then separated from the imaging sheet to provide a fixed, dense image without an additional fixing step.

EXAMPLE IX

A donor substrate sheet comprising aluminum foil having a thickness of 0.005 inch is coated with a first layer having a thickness of about 3 microns and comprising n-eicosane and a colored second layer having a thickness of about 15 microns and comprising paraffin wax (Sunoco 5512 available from Sun Oil Company) colored with about 0.05 part by weight, based on the total weight of the solid solvent and colored conductive second layers, of phthalocyanine. Spacing particles comprising silica powder and having an average spacing diameter of about 20 microns are applied to the surface of a developer repellent imaging surface bearing an electrostatic latent image to provide an average spacing distance between neighboring spacing particles of about 50 microns. The surface of the developer layer is then placed adjacent and parallel to the spacing particle covered imaging surface. The resulting sandwich is then placed between metal platens. The metal platen adjacent the donor substrate is heated to about 150° F. After about 5 seconds, the sandwich is removed and the donor substrate is immediately separated from the imaging surface. Upon cooling, a fixed image relatively free of background deposits is obtained without an additional fixing step.

EXAMPLE X

A control run is made with substantially the same materials and steps employed in Example IX except that the use of spacing particles is omitted. After separation, the imaging surface is found to carry an image which is discernible with great difficulty because of the existence of substantial background deposits of developer.

EXAMPLE XI

An electrically conductive donor substrate web comprising 0.004 inch aluminum foil is coated with a conductive developer layer having a thickness of about 8 microns and comprising polyethylene glycol colored with about 0.25 part by weight, based on the total weight of the developer layer of crystal violet. Spacing particles comprising zinc stearate coated calcium carbonate and having an average spacing diameter of about 10 microns are applied to the surface of the developer layer to provide an average spacing distance between neighboring spacing particles of about 25 microns. The imaging surface of a zinc oxide binder layer containing melamine formaldehyde binder resin supported by a conductive web is corona charged to a negative potential of about 400 volts and exposed to a light and shadow image to form an electrostaic latent image. The imaging surface bearing the electrostatic latent image is then placed adjacent and parallel to the spacing particle covered surface of the coated donor substrate. The resulting sandwich is then fed between a pair of pinch rollers heated to about 150° F. Sufficient pressure is applied to the sandwich by the rollers to bring the inside surfaces of both the donor substrate and conductive web substantially parallel and adjacent to, but spaced from, each other by a distance approximately equal to the average spacing particle diameter. An electrical bias of about 500 volts negative is applied to the pinch roller in contact with the conductive donor substrate web during passage of the sandwich between the rollers. After development, the donor substrate is peeled from the sandwich. Upon cooling to room temperature, a fixed, dense reversal image of good quality is obtained.

EXAMPLE XII

An insulating donor substrate web comprising calendered paper is coated with a conductive developer layer having a thickness of about 18 microns and comprising carnauba wax colored with about 0.35 part by weight, based on the total weight of the developer layer of methyl violet. Spacing particles comprising silica powder particles having an average spacing diameter of about 20 microns are applied to the surface of the developer layer to provide an average spacing distance between neighboring spacing particles of about 35 microns. The developer repellent imaging surface of a zinc oxide photoconductive binder web in which the binder material is silicone resin and the supporting web in conductive paper is then corona charged to a potential of about 400 volts negative and exposed to a light and shadow image to form an electrostatic latent image. The imaging surface bearing the electrostatic latent image is then placed adjacent and parallel to the spacing particle covered surface of the coated donor substrate. The resulting sandwich is then fed between a pair of pinch rollers heated to about 190° F. Since some non-uniformity of particle size is present in the particular batch of spacing particles employed, sufficient pressure is applied to the sandwich by the rollers to force the larger spacing particles beneath the inside surfaces of both the donor substrate and conductive web to provide a spacing distance between the inside surfaces of both the donor substrate and conductive web approximately equal to a desired spacing distance of about 20 microns. The conductive supporting web for the photoconductive binder and the conductive developer are electrically grounded during passage of the sandwich between the rollers. After development, the sandwich is rapidly cooled by contact with a roller which is internally cooled with cold circulating water. The donor substrate is then peeled from the sandwich. A fixed image of good quality is obtained.

EXAMPLE XIII

A conductive donor substrate web comprising 0.004 inch aluminum foil is coated with a conductive developer layer having a thickness of about 8 microns and comprising polyethylene glycol colored with about 0.25 part by weight, based on the total weight of the developer layer of crystal violet. Spacing particles comprising zinc stearate coated calcium carbonate particles having an average spacing diameter of about 10 microns are applied to the surface of the developer layer to provide an average spacing distance between neighboring spacing particles of about 25 microns. The developer layer is then fluidized by contacting the uncoated side of the donor substrate with a heated platen to permit the spacing particles to penetrate into the fluidized developer layer. After penetration of the particles into the developer layer, the developer layer is allowed to cool and harden. The purpose of the heating operation is to prevent the loss of loose spacing particles during shipment, storage, and subsequent handling of the developing element in a development process. A developer repellent imaging layer of amorphous selenium supported on a brass sheet is then corona charged to a potential of about 700 volts positive. The charged imaging surface is then placed adjacent and parallel to the face of a cathode ray tube and is exposed to a light and shadow image from the cathode ray tube face to form an electrostatic latent image. The electrostatic latent image bearing surface is then placed adjacent and parallel to the developer layer and the resulting sandwich is fed between a pair of pinch rollers heated to about 150° F. Sufficient pressure is applied to the sandwich by the rollers to bring the inside surface of both the door substrate and binder web substantially parallel and adjacent to, but spaced from, each other by a distance approximately equal to the average spacing particle diameter. The pinch roller in contact with the conductive donor substrate web is connected through a potentiometer across a battery to the conductive web supporting the imaging layer to provide a positive bias of about 700 volts. This electrical bias is maintained during passage of the sandwich between the rollers. After cooling to room temperature, a fixed image of good quality is obtained on the discharged areas of the photoreceptor.

Although specific materials and conditions are set forth in the above exemplary processes of making and using the developer material and spacing particles of this invention,

these are merely intended as illustrations of the present invention. There are other developer materials, coated and uncoated spacing particles, substituents and processes such as those listed above which may be substituted for those in the examples with similar results.

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 developing an electrostatic latent image on an imaging surface comprising the steps of initially positioning adjacent said imaging surface at least a portion of the free surface of a substantially uniform normally solid liquifiable polar developer layer supported on a donor substrate, said polar developer layer being electrically conductive in the liquified state, and having a thickness from about 2 to about 30 microns, a melting temperature in the range greater than about 120° F., a viscosity of less than about 10^4 poises in its liquified state and a volume resistivity in the liquified state of less than about 10^{13} ohm-cm., providing a sufficient number of developer repellent spacing particles between said imaging surface and said donor substrate to maintain said imaging surface less than about 30 microns from but substantially out of contact with said free surface of said polar developer layer, and liquifying said polar developer layer adjacent said imaging surface whereby at least a portion of said polar developer layer migrates to and deposits on said imaging surface in image configuration.

2. A method of developing according to claim **1** comprising exposing said polar developer layer to heat energy at a temperature of at least the melting point of said polar developer to liquify said layer.

3. A method of developing according to claim **1** comprising adding a solvent to said polar developer layer to liquify said layer.

4. A method of developing according to claim **1** including applying an electrical bias potential to said developer layer to promote migration of at least a portion of said developer layer to said imaging surface.

5. A method of developing according to claim **1** wherein said spacing particles have an average spacing diameter of from about 2 to about 60 microns and the averge spcing distance between neighboring particles is less than about 2,000 microns.

6. A method of developing according to claim **5** comprising liquifying said developer layer to wet said donor substrate and providing an imaging surface, the background area of which is repellent to said developer in the liquified state.

7. The method of claim **1** comprising positioning a uniform solid solvent layer for dissolving polar developer when said solid solvent liquifies, between said donor substrate and said polar developer layer, said solid solvent having a lower melting point than said polar developer.

8. The method of claim **7** wherein said solid solvent is a crystalline material and the combined thickness of said solid solvent layer and said polar developer layer is between about 2 and about 30 microns.

9. A method of developing an electrostatic latent image on an imaging surface comprising the steps of liquifying at least a portion of a uniform normally solid liquifiable polar developer layer supported on a donor substrate, said polar developer layer being electrically conductive in the liquified state, and having a thickness from about 2 to about 30 microns, a melting temperature in the range greater than about 120° F., a viscosity of less than about 10^4 poises in its liquified state and a volume resistivity in the liquified state of less than about 10^{13} ohm-cm., positioning the free surface of the resulting liquified portion of said developer layer adjacent said imaging surface, providing a sufficient number of developer repellent spacing particles between said imaging surface and said donor substrate to maintain said imaging surface less than about 30 microns from but substantially out of contact with said free surface of said liquified portion of said developer layer whereby at least a portion of said polar developer layer migrates to and deposits on said imaging surface in image configuration.

10. A method of developing according to claim **9** including allowing said developer layer to reharden and separating said donor substrate from said imaging surface whereby a fixed developer deposit in image configuration on said imaging surface is formed.

11. The method of claim **9** comprising placing a uniform solid solvent layer in which polar developer is soluble when the solid solvent liquifies, between said donor substrate and said polar developer layer, prior to liquifying said polar developer layer, said solid solvent having a lower melting point than said polar developer.

12. The method of claim **11** wherein said solid solvent is a crystalline material and the combined thickness of said solid solvent layer and said polar developer layer is between bout 2 and about 30 microns.

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U.S. Cl. X.R.

96—1 LY, 1 R; 117—27, 33, 37 LE

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,795,530 Dated March 15, 1974

Inventor(s) Robert W. Gundlach

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5, line 15, correct the spelling of "copper".

Column 7, line 20, delete "400" and substitute therefor --410--.

Column 7, line 28, after "(C.I." first occurrence, insert --676)--.

Column 8, line 58, correct the spelling of "photocon-".

Column 10, line 67, after "configuration," insert --the conductive ink or the donor substrate, if conductive,--.

Column 14, line 58, delete "123" and substitute therefor --12--.

Column 14, line 63, correct the spelling of "charged".

Column 15, line 50, correct the spelling of "electrostatic".

Column 18, last line, correct the spelling of "about."

Signed and sealed this 15th day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.