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Description

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates to an electrophotographic process for recording and preserving an electrostatic latent image developed by wet development.

Description of the Related Art

In the field of image formation, a system in which a uniformly charged photoconductor is selectively irradiated with light as a function of image signals and an electrostatic latent image thus formed is developed is generally termed an electrophotographic process. This process may be roughly classified into either a dry developing method or a wet developing method.

The dry developing method has an advantage in that it is superior in the ease of handling and the stability of the toners used for development, since it is based on the principle that colorant particles are simply spread and affixed to an electrostatic latent image. However, dry developing is second to the wet development method in meeting the recent demand for high quality images, as exemplified by a video printer for taking an electronic still photograph.

On the other hand, the wet developing method makes use of a liquid developer which is produced by dispersing the dyestuff or pigment as the colorant in an insulating medium. According to the wet developing method, a resolution and gradation comparable to those of a silver halide photograph may be obtained, while the image exhibits superior weatherability when a pigment is used as the colorant.

The developer used in the conventional wet developing method contains an insulating medium which is liquid at room temperature, such as "Isopar G", a saturated hydrocarbon produced by Esso Inc., so that it is naturally liquid at room temperature (see Fig. 20).

However, the developing method employing a developer 5′ which is liquid at room temperature is inconvenient to use since the developer can be handled only with difficulty and frequent maintenance is required for maintaining stable image formation.

In the preservation and supply of the wet developer, disadvantages are presented in connection with changes in the concentration thereof caused by cohesion or precipitation of the colorant particles and disposal of waste liquids.

The Japanese Kokai (Published Application) No. 63-25670 discloses a method of developing an electrostatic latent image formed on the surface of a sensitized material wherein a toner is solidified and applied under pressure to the peripheral surface of a developing roll and the thus coated toner is dissolved by a developer and caused to flow into a space between the sensitized material and the developing roll.

In this reference, a developer such as "Isopar" is required for dissolving the solid toner, while a stable image cannot be obtained unless the supply of the developer is adjusted constantly.

For recording and preserving the electrostatic latent image in the visible form, it is preferably transferred to a suitable substrate. However, the conventional wet developing method is not necessarily suited to the purpose of forming a high quality image since the adsorption between the colorant particles and the sensitized material is so strong that the transfer efficiency is thereby lowered.

US-A-3 776 723 discloses an electrophotographic process according to the preamble of claim 1 wherein the developer may comprise a dispersion of toner particles in an electrically insulating carrier which is normally solid at room temperature, said developer being liquefied prior to entering the exposure zone. In this process, a photoconductor comprising a photoconductive insulating layer overlaying a conductive substrate is contacted with a developer-laden web. An electrostatic charge of the same or of an opposite polarity as that of the toner in the liquid developer is applied by a corona discharge electrode on the liquid developer-laden web previously deposited on the photoconductor. This charged member is then exposed to a pattern of light and shadow through the conductive transparent backing substrate. After completing these steps, a copy may be made by bringing an image receiving web in pressure contact with the liquid developer-laden web.

US-A-3 254 997 relates to an electrophotographic process comprising the use of a developer consisting of a meltable plastic or resin and a pigment dispersed therein. Said process includes the steps of forming an electrostatic image on a substrate, melting said developer and contacting the molten developer with the substrate.

Summary of the Invention

It is therefore an object of the present invention to overcome the above described deficiencies of the prior art and to provide an electrophotographic process for developing an electrostatic latent image which is superior in ease of handling and is capable of producing stable images at all times.

In view thereof, a method of the present invention comprises the use of a developer in which the colorant is dispersed and which is an electrically insulating organic material that is solid at room temperature and is liquefied by heating. The electrostatic latent image is wet developed by the thus liquefied developer.

The present invention provides an electrophotographic process for image formation wherein an electrostatic latent image is formed on the surface of a film laminated on a sensitized material using the light of a wavelength capable of being transmitted through the film, the image thus formed is developed and the film is then peeled off from the sensitized material for forming a high quality image quickly at low cost and at high transfer efficiency.

Accordingly, the subject-matter of the present invention is an electrophotographic process as defined in claim 1.

Brief Description of the Drawings

Fig. 1 is a diagrammatic view for illustrating the principle of the developing method used in the present invention.

Fig. 2 is an enlarged cross-sectional view showing essential parts of an embodiment of a developing material comprised of a base material having its overall surface coated with a developer.

Fig. 3 is an enlarged cross-sectional view showing essential parts of an embodiment of a developing material comprised of a porous base material impregnated with a developer and solidified.

Fig. 4 is an enlarged cross-sectional view showing essential parts of an embodiment of a porous base material impregnated with a developer, solidified and backed with a sheet-like base material.

Fig. 5 is an enlarged cross-sectional view showing essential parts of an embodiment of a developing material comprised of a base material having an electrically conductive layer and coated on its overall surface with a developer.

Fig. 6 is an enlarged cross-sectional view showing essential parts of an embodiment of a porous base material impregnated with a developer, solidified and coated on its reverse side with an electrically conductive layer.

Fig. 7 is an enlarged cross-sectional view showing essential parts of an embodiment of a porous base material impregnated with a developer, solidified and backed with an electrically conductive base material.

Fig. 8 is an enlarged cross-sectional view showing essential parts of an embodiment of a porous base material impregnated with a developer, solidified and backed with a base material having an electrically conductive layer.

Fig. 9 is an enlarged cross-sectional view showing essential parts of an embodiment of a developing material having plural developer regions formed thereon.

Fig. 10 is an enlarged cross-sectional view showing an embodiment of a porous base material backed with a sheet-like substrate and having plural developer regions formed thereon.

Fig. 11 is an enlarged cross-sectional view showing essential parts in which a porous base material having plural developer regions formed therein is used directly as the developing material.

Fig. 12 is an enlarged cross-sectional view showing an embodiment of a developing material having plural developer regions with a color mixing inhibit layer.

Fig. 13 is a diagrammatic view for illustrating the principle of the developing method for an electrostatic latent image forming the pre-stage of image formation.

Figs. 14(A) and 14(B) show diagrammatically the formation and elimination of electrical charges on a sensitized material on which is laminated an electrically conductive film having a dark decay time shorter than that of a sensitized material, wherein Fig. 14(A) corresponds to the charging step of Fig. 14(B) corresponds to the light exposure step. Figs. 15(A) and 15(B) show diagrammatically the formation and elimination of the electrical charges on a sensitized material on which is laminated an electrically insulating film having a dark decay time longer than that of the sensitized material, wherein Fig. 15(A) corresponds to the charging step of Fig. 15(B) corresponds to the light exposure step.

Fig. 16 is an enlarged view showing diagrammatically the state of affixture of methylene iodide on the film surface.

Fig. 17 is an enlarged cross-sectional view showing a developing apparatus employed in the examples of the present invention.

Fig. 18 shows diagrammatically the method for developing an electrostatic latent image by a developing material comprised of a base material and a developer held thereon.

Fig. 19 shows diagrammatically the method for developing an electrostatic latent image with a developing material in which a developer is held on an electrically conductive substrate.

Fig. 20 shows a prior art system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The principle of the developing method as used in the present invention will be explained by referring to Fig. 1, in which the respective process steps are preferably successively applied to one long sensitized base material 1 for convenience.

In an electrical charging step, the sensitized base material 1 is electrically charged to a minus polarity by suitable charging means, such as a corona discharge member 2. At an ensuing exposure step, selective light exposure is performed in association with the image information, using suitable exposure means, such as semiconductor infrared laser light source 3, for eliminating negative charges of the area exposed to light.

Irrespective of the method for forming an electrostatic latent image or the kind of the sensitized base material 1, any well-known organic or inorganic photoconductive materials may be used for forming the base material 1. Examples of the well-known organic photoconductive materials now in use include electrophotographic sensitized base materials consisting of poly-N-vinyl-carbazole and 2,4,7-trinitrofluorene-9-on, poly-N-vinylcarbazole sensitized with pyrylium salt type colorant, poly-N-vinylcarbazole sensitized with cyanine type colorant, an electro-photographic sensitized base material consisting mainly of organic pigments of eutectic complexes consisting of colorants and resins. Examples of inorganic photoconductive materials include zinc oxide, zinc sulfide, cadmium sulfide, selenium, selenium-tellurium alloy, selenium-arsenic alloy, selenium-tellurium-arsenic alloy and amorphous silicon type materials.

At a subsequent developing step, the sensitized base material 1, on which the electrostatic latent image has been formed as described hereinabove, is passed over a developing tank 4. A developer 7 for the electrostatic latent image, which consists of an electrically insulating organic material 5 which is solid at room temperature and contains dispersed colorant particles 6 charged to a positive polarity, is contained in the tank 4, and is heated and melted by heating means & so that it is in the liquid state.

The developer 7 supplied to the developing tank 4 consists of colorant particles 6 dispersed in an electrically insulating organic material 5 which is solid at least at room temperature and which is changed between the solid and liquid states upon heating and cooling.

The electrically insulating organic material 5 has a melting point of not lower than 30°C and preferably not lower than 40°C in view of the ordinary operating environment and for ease of handling. Although there is no specific upper limit to the melting point, practically it is about 100°C and preferably not higher than 80°C when considering that additional energy is consumed for heating an insulating material 5 with too high a melting point. Also, the upper limit of the melting point should not exceed the heat resisting temperature of the material customarily employed as the base material when the organic material is held on a base material for use.

Among the materials meeting these requirements are paraffins, waxes and mixtures thereof. The paraffins include various normal paraffins with 19 to 60 carbon atoms, such as nonadecane to hexacontane. The waxes include plant waxes such as Carnauba wax or cotton wax, animal waxes such as bees wax, ozokerite, and petroleum waxes such as paraffin waxes, crystallite waxes or petrolatum. These materials are dielectrics having dielectric constants ε in the order of 1.9 to 2.3.

In addition, crystalline high molecular materials having long alkyl groups at the side chains, such as homopolymers or copolymers of polyethylene, polyacrylamide, poly-n-stearyl acrylate or poly-n-stearyl methacrylate, such as copoly-n-stearyl acrylate ethyl methacrylate, may be employed. However, the aforementioned paraffins and waxes are preferred in view of their viscosity at the time of heating.

The colorant particles 6 dispersed into the electrically insulating organic material 5 may be organic or inorganic pigments or dyestuffs that are well-known in the art, or mixtures thereof.

The inorganic pigments include for example chromium type, iron type or cobalt type pigments, ultramarine or Prussian blue. The organic pigments or dyestuffs include Hansa Yellow (C. I. 11680), Benzidine Yellow G (C. I. 21090), Benzidine Orange (C. I. 21110), Fast Red (C. I. 37085), Brilliant Carmin 3B (C. I. 16015 - Lake), Phthalocyanin Blue (C. I. 74160), Victoria Blue (C. I. 42595 - Lake), Spirit Black (C. I. 50415), Oil Blue (C. I. 74350), Alkali Blue (C. I. 42770A), Fast Scarlet (C. I. 12315), Lodamin 6B (C. I. 45160), Lodamin Lake (C. I. 45160 - Lake), Fast Sky Blue (C. I. 74200 - Lake), Nigrocyn (C. I. 50415) or carbon black. These may be used alone or in combination. Those exhibiting desired coloration may be used selectively.

The developer may also contain resins, in addition to the electrically insulating organic materials 5 and colorant particles 6, for improving dispersibility or fixation of the colorants. These resins may be suitably selected from known materials and my include for example rubbers such as butadiene rubber, styrene-butadiene rubber, cyclized rubber or natural rubber, synthetic resins such as styrene, vinyl toluene, polyester, polycarbonate or polyvinyl acetate, rosin type resin, hydrogenated rosin type resin, alkyd resins containing modified alkyds, such as linseed oil, modified alkyd resins and natural resins such as polyterpenes. In addition, phenol resins, modified phenol resins such as phenol formalin resins, phthalic acid pentaerythritol, Kumaronindene resins, ester gum resins or vegetable oil polyamide resins may also be useful. Halogenated hydrocarbon polymers, such as polyvinyl chloride or chlorinated polypropylene, synthetic rubbers such as vinyl toluenebutadiene or butadiene-isoprene, polymers of acrylic monomers having long-chain alkyl groups, such as 2-ethylhexyl methacrylate, lauryl methacrylate, stearyl methacrylate, lauryl acrylate or octyl acrylate or copolymers thereof with other polymerizable monomers, such as styrene-lauryl methacrylate copolymer or acrylic acidlauryl methacrylate copolymer, polyolefins such as polyethylene or polyterpenes, may also be employed.

The above developer is usually admixed with electrical charge donors. This applies for the developer employed herein. The electrical charge donors employed for this purpose include, for example, metal salts of fatty acids, such as naphthenic acid, octenic acid, oleic acid, stearic acid, isostearic acid or lauric acid, metal salts of sulfosuccinates, oil-soluble metal salts of sulfonic acid, metal salts of phosphates, metal salts of abietic acid, metal salts of aromatic carboxylic acid or metal salts of aromatic sulfonic acid.

For improving the charges of the colorant particles 6, fine particles of metal oxides, such as SiO_2, Al_2O_3, TiO_2, ZnO, Ga_2O_3, In_2O_3, GeO_2, SnO_2, PbO_2 or MgO, or mixtures thereof, may be employed as charge increasing additives.

Referring to the relative contents of the above ingredients, the colorant particles 7 are employed preferably at a rate of 0.01 to 100 g, and more preferably at a rate of 0.1 to 10 g, to 1 liter of the electrically insulating organic material 5 in the melted state, while the charge donors are employed usually at a rate of 0.001 to 10 g, and preferably at a rate of 0.01 to 1 g, to 1 liter of the organic material 5. The charge increasing additive is added in an amount of not more than the same amount, as that of the colorant particles 6.

The above developer is heated by the heating means 8 into the melted state. The heating temperature may be suitably set in dependence upon, for example, the melting point, and may usually be 30 to 130°C and preferably be 40 to 110°C.

When the liquefied developer 7 is contacted with the sensitized base material 1, the colorant particles 6 migrate towards and are deposited at the negative electrical charges.

Finally, the colorant particles 6 affixed to the unnecessary portion in the course of the fixation process are eliminated and, after the process of elimination of the electrical charges, the image is formed on the sensitized base material.

Meanwhile, when the sensitized base material 1 and the developer 7 are solidified immediately after contact, the image tends to be degraded in quality. It is therefore preferred to provide heating means for heating either the sensitized base material 1 itself or a stage to which the sensitized base material 1 is secured.

The heating temperature for the sensitized base material 1 may be suitably set in dependence upon the kinds and characteristics of the sensitized material used. It is preferably not lower than the liquidus temperature of the developer 7 and is usually set in the range from room temperature to 130°C, and preferably in the range of 30 to 110°C.

The development may be monochromatic or may form a full color image using developers of various colors, such as yellow, magenta and cyan. In this case, the above described developing process may be performed repeatedly for each of the color developers, and the developing sequence is selected as a function of, for example, the kind of the light source used for sensitization. For example, when an IR laser or a UV laser is employed, the sequence is yellow-magenta-cyan or cyan-magenta-yellow, respectively. If necessary, inking may be performed with black color and, in such case, the black color may be developed at a suitable point in the course of the development of the various colors.

Although the developer 7 may be accommodated in the tank 4, as described above, it may also be carried on a suitable base in the form of a sheet- or tape-like developing material. In this case, the ease of handling of the developer is improved significantly.

Fig. 2 shows the simplest form of the development material wherein the developer 7 is coated on the overall surface of a sheet-like base material 21.

The base material 21 may be made of a high molecular film, such as polyethylene terephthalate, polypropylene, polycarbonate or polyamide, papers such as natural or synthetic paper, cloths or non-woven cloths formed of natural fibers, such as plant fibers exemplified by cotton or hemp or animal fibers exemplified by silk or wool, clothes or non-woven clothes formed of synthetic fibers including organic fibers such as polyamide, polyester, polyacetal or polyurethane and inorganic fibers such as glass, ceramics or carbon, meshes of metals or organic high molecular materials or a high molecular foam such as polyurethane foam.

Fig. 3 shows an example of a porous base material 22, wherein the developer 7 is impregnated and solidified in the porous base material 22.

The porous base material 22 in which the developer 7 is impregnated and solidified may be backed and reinforced by a sheet-like base material 21, as shown in Fig. 4.

A bias voltage may be easily applied at the time of development by affording electrical conductivity to the base material when formed into a tape or a sheet.

The base material afforded with electrical conductivity includes both a base material exhibiting electrical conductivity and a non-conductive base material on which an electrically conductive layer is formed.

In Fig. 2, the sheet-like base material 21 used is a sheet-like electrically conductive base material 21′ and the developer 7 is coated on the overall surface of the base material 21′.

The electrically conductive base material 21 may, for example be Al, Cu, stainless steel, electrically conductive ceramics, carbon, SiC, indium tin oxide (ITO), SnO_2 or electrically conductive high molecular materials.

When the base material itself is not afforded with electrical conductivity, an electrically conductive layer 24 may be formed on the surface of the base material 21 and the developer 7 may then be formed on the conductive layer 24, as shown in Fig. 5.

The conductive layer 24 is formed by evaporation, sputtering or plating of metals or by coating of a material in which electrically conductive particles are dispersed, such as a silver paste.

Fig. 6 shows an example of a porous base plate 22, in which the developer 7 is impregnated and solidified. In this example, an electrically conductive layer 24 is formed on the reverse side of the porous base plate 22 to provide for electrical conductivity.

The porous base plate 22, in which the developer 7 is impregnated and solidified in the above described manner, may be backed with a sheet-like electrically conductive base material 21′, as shown in Fig. 7, to provide for reinforcement and electrical conductivity.

Also, as shown in Fig. 8, a porous base plate 22 in which the developer 7 is impregnated and solidified in the above described manner may be laminated with the base plate 21 provided with the electrically conductive layer 24.

Also developers of plural colors may be incorporated into the base materials 21 or 21′ of the porous base material 22 when the base materials are formed into sheets or tapes and zones of the different colors may be formed by coating on one and the same base material.

In Fig. 9, for example, a yellow-color developer layer Y, a magenta color developper layer M and cyan color developer layer C are formed on the base material 21 to provide for full-color image formation. When forming the full-color image, a zone for a black developer layer B may be annexed beside the yellow, magenta and cyan colors, if so desired.

Similarly, as shown in Fig. 10, a yellow color developer Y, a magenta color developer M and a cyan color developer C may be impregnated and solidified in separate regions on the porous base material 22 laminated on the base material 21. Regions 22a of the porous material 22 between the developer regions Y, M and C are free of developer. Of course, as shown in Fig. 11, the porous base material 22 in which the yellow color developer Y, magenta color developer M and the cyan color developer C are impregnated and solidified may be directly used as the developer for developing the electrostatic latent image.

Meanwhile, when plural developer regions are formed on one and the same base material, color mixing may be caused during, above all, heating and melting.

Thus, as shown in Fig. 12, a color mixing inhibit layer 23 is provided in between the regions consisting of the developers Y, M and C.

This color mixing inhibit layer 23 may be of any type so long as it functions as a spacer. Above all, a liquid absorbing material, such as that similar to the aforementioned porous base material 22, or a liquid repellent material may be employed.

When the developers Y, M and C of the respective colors are impregnated and solidified into porous base material 22, as shown in Figs. 10 or 11, these regions of the developers of the various colors may be formed at a predetermined interval from one another so that the portions of the porous base material 22a delimited between these regions act as the color mixing inhibit layers.

For recording and preserving the developed electrostatic latent image in a state in which it can be seen readily, it is transferred to a suitable substrate. As transfer method, a method (a) consisting of providing heating means at a stage supporting a photosensitive member 1 and the developer 7 is contacted with the substrate as the developer is heated and melted, or a method (b) consisting of pressuring the substrate by means such as a roll as the developer is cooled and solidified are contemplated. In the above method (a), the heating temperature of the photosensitive member 1 may be suitably set as a function of the kinds and characteristics of the photosensitive member 1, and is preferably in the range from 30° to 110°C.

In the above method (a), when the developer 7 is contacted with the substrate as the developer 7 is heated to the melted state, and the substrate opposite to the member 1 is charged to a polarity opposite to that of the colorant particles, the transfer efficiency of the image to the substrate is improved. For applying these electrical charges of the opposite polarity, suitable means of electrification, such as a corona discharge body, may be employed.

The material used as the substrate may be selected suitably, depending on usage, as long as it can be impregnated to a more or less great degree with the electrically insulating organic material. Examples of this material include various papers materials, such as natural or synthetic paper, clothes or non-woven clothes formed of plant fibers such as cotton or hemp or animal fibers such as silk or wool, clothes or non-woven clothes formed of organic synthetic fibers such as polyamide, polyester, polyacetal or polyurethane or inorganic fibers such as ceramics or carbon, meshes such as metals or organic high molecular materials, or high molecular foams, such as polyurethane foams. For preserving the substrate in the form of a document, a paper sheet of a white ground is preferably employed as the substrate in view of higher visibility. The present invention is, however, not limited to this exemplary embodiment.

In accordance with the present invention, as an image forming method for high speed formation of a high quality image at low costs and high transfer efficiency, a method is provided consisting of laminating a film 20 which is able to transmit light from a light source 3 onto a sensitized material 1, exposing the film to light hv for forming an electrostatic latent image on the film, developing the latent image and peeling the film 20 from the sensitized material 1 (Fig. 13).

As methods for forming the image at this time, a method (a) consisting of laminating an electro-conductive film which is shorter in dark decay time than the photosensitized material, or a method (b) consisting of laminating an insulating film longer in dark decay time than the sensitized material are suitable. The dark decay time herein means the time interval during which the electrical charges on a material are reduced to one half when the material, which has been previously electrified to certain constant charges, is allowed to stand in the dark.

Possible mechanisms of charge formation and extinction in method (a) are described below referring to Figs. 14(A) and 14(B).

As shown in Fig. 14(A), the surface of an electrically conductive film 20a is electrified by corona discharge or by laser irradiation to a uniform negative charge. At this time, the positive electrical charges are induced on the sensitized material 1 opposite to the electrically conductive film 20a.

When a selective laser irradiation is then performed, as shown in Fig. 14(B), the laser light hv passes through the electrically conductive film 20a to reach the sensitized material 1. At this time, the negative charges on the surface of the electrically conductive film 20a are conducted in the direction of the film thickness towards the boundary between the film 20a and the sensitized material 1, while, on the side of the sensitized material, the positive charges or holes migrate towards the boundary only at the laser irradiated zone. The result is that, in the region in which the positive charges have migrated, the charges are neutralized and the potential is reduced to zero on the boundary, whereas, in the region in which the positive charges have not migrated, there exists a constant potential. Thus, the colorant particles 6, charged to the positive potential, are selectively affixed to the region not irradiated by the laser light hv, (as shown on the left side of Fig. 14(B)), whereas the colorant particles do not become affixed to the region where the potential has been reduced to zero by irradiation hv (as shown on the right side of Fig. 14(B)).

This becomes possible since the dark decay time of the electrically conductive film 20a is selected to be shorter than that of the sensitized material 1. If the dark decay time of the sensitized material 1 is shorter than that of the film 20a, then there is the risk that the positive charges will be dissipated before laser light irradiation and the potential distribution cannot be formed. In short, what is critical in the present invention is that the potential distribution as shown in Fig. 14(B) is formed and maintained substantially unaltered until immediately before development of the electrostatic latent image.

As may be realized from the foregoing description with reference to Fig. 13, a time t equal $t_1 + t_2 + t_3 + t_4$ is required to elapse until the electrostatic latent image is formed, wherein t_1 is the time involved in corona charging, t_2 is the time which passes from the corona charging step until the exposure step, t_3 is the time involved in exposure to light, and t_4 is the time which passes from the exposure step until the developing step. Hence, from a more practical standpoint, it suffices if the dark decay time of the electro-conductive film 20a is shorter than the above time t.

According to the present invention, as described hereinabove, the electrostatic latent image is developed on the surface of the electrically conductive film 20a and then the film 20a is peeled off from the sensitized material 1. If the film 20a is rigid enough to be used by itself for preservation and perusal, it may be used directly, as for example in the case wherein the film 20a is used directly as the sheet for an overhead projector (OHP). Alternately, the film 20a may be bonded to the substrate with the image forming surface of the film 20a in contact with the substrate, in which case the film 20a acts as the protective film so that a so-called laminate coating may be achieved simultaneously with the image transfer.

The material that may be used as the substrate may be selected suitably according to usage as long as it can be impregnated with the aforementioned insulating dispersion medium. Examples of this material include various paper materials, such as natural or synthetic paper, clothes or non-woven clothes formed of plant fibers such as cotton or hemp or animal fibers such as silk or wool, clothes or non-woven animal fibers such as silk or wool, clothes or non-woven clothes formed of organic synthetic fibers such as polyamide, polyester, polyacetal or polyurethane or inorganic fibers such as ceramics or carbon, meshes such as metals or organic high molecular materials, or high molecular foams, such as polyurethane foams. For preserving the substrate in the form of a document, a paper sheet of a white ground is preferably employed as the substrate in view of higher visibility. It is however not limiting of the present invention. By bonding the film 20a in this manner to a suitable substrate, a transfer efficiency of 100% is achieved, so that the sensitized materials 1 can be re-used.

The aforementioned organic or inorganic electrically conductive materials may be used as the sensitized material 1, as long as the material 1 is selected so that it has a dark decay time longer than that of the electrically conductive film laminated thereon. The dark decay time for the exemplary sensitized materials is about 300 seconds for polyvinyl-N-carbazole, 100 seconds for phthalocyanin, 20 to 30 seconds for amorphous selenium, and 30 to 40 minutes for the resin dispersion system of zinc oxide.

Among the properties required of the electrically conductive film is its ability to transmit the light from the exposure light source. Therefore, it is not always necessary that the film is colorless when specific effects or decorative usage are desired. On the other hand, it is necessary for the above electrically conductive film to have a shorter dark decay time than that of the sensitized material. This dark decay time depends, for example, on the film thickness. For example, a polyethylene film that is 9 μm thick having a dark decay time at 25°C of about 6.5 seconds is most preferred. In addition, polypropylene, poly-2-cyanomethyl acrylate, polybenzyl acrylate, poly-4-butylstyrene or a polyvinylidene chloride-polyvinyl chloride copolymer may be employed.

A shorter dark decay time means a correspondingly higher electrical conductivity. The aforementioned materials for the electrically conductive film are generally organic high molecular materials, such as plastics, having glass transition points Tg proper thereto. The organic high molecular materials are known to be changed drastically in their physical properties, inclusive of the electrical conductivity, on both sides of the glass transition point Tg. Polyethylene, for example, has a glass transition point Tg of -100°C which is much lower than room temperature, so that it exhibits sufficient electrical conductivity at room temperature (25°C). The dark decay time as measured with a film that is 9 μm thick is about 6.5 seconds, which is shorter than the dark decay time of the ordinary sensitized materials. Thus, polyethylene is suitable as the material of the electrically conductive material according to the present invention. However, some of the organic high molecular materials have a glass transition point Tg close to room temperature. These materials do not exhibit sufficient electrical conductivity at or near room temperature. According to the present invention, these materials having a higher glass transition point are heated to lower their dark decay time, so that these materials may also be used as the electrically conductive film. As will be apparent from the above explanation, the heating temperature at this time is selected to at least be not lower than the glass transition point Tg and preferably 20 to 30°C higher than the glass transition point Tg. At any rate, the dark decay time of the electrically conductive film is set so as to be at a desired value within the range shorter than that of the sensitized material. Examples of organic high molecular materials, and their glass transition points, that may be employed in the present invention include polypropylene (-8°C), poly-2-cyanomethyl acrylate (4°C), polybenzyl acrylate (6°C), poly-4-butylstyrene (6°C), a polyvinylidene chloride-polyvinyl chloride copolymer (10°C), poly-4-butoxycarbonyl phenyl acrylate (13°C), polyfluoro methyl acrylate (15°C), polyhexadecyl methacrylate (15°C), polycyclohexyl acrylate (17°C), polymethyl acrylate (17°C), polyneopentyl acrylate (22°C), polycyano methyl acrylate (23°C), polypropyl-2-propylene (27°C), polyisobutyl ethylene (29°C) and poly-3-ethylstyrene (30°C). The temperatures within the parenthesis denote the glass transition points Tg for each material.

The preestimated mechanism for generation and elimination of the electrical charges in the method (b) is hereinafter explained with reference to Figs. 15(A) and 15(B).

As shown in Fig. 15(A) the surface of the insulating film 20b is charged to a uniform negative polarity by corona discharge. At this time, positive charges are induced on the sensitized material opposite to the insulating film 20b.

Then, as shown in Fig. 15(B), selective laser irradiation is performed, whereby the laser light hν passes through the insulating film 20b to reach the sensitized material 1. Due to its properties, the insulating film 20b is unable to shift the negative charges existing in the vicinity of its surface along the film thickness, so that the positive charges migrate to close to the boundary between the film 20b and the sensitized material 1 in the regions irradiated with the laser light. The result is that a region of different potentials, that is, the distance of the negative and positive charges, is locally produced within the laminated material. In short, the colorant particles 6 charged to the positive polarity are selectively affixed to the non-irradiated region, but are not affixed to the region when the distance between the two charge types is reduced by irradiation and which may be deemed to be roughly neutral electrically.

This is made possible in that the dark decay time of the insulating film 20b is selected to be longer than that of the sensitized material 1. Should the dark decay time of the insulating film 20b be shorter, the negative charges are dissipated before irradiation of the laser light so that the desired potential distribution cannot possibly be achieved.

In the above summary of the mechanism for the formation and disappearance of the electrical charges, some residual potential unavoidably exists at the exposed region produced by laser light irradiation. This residual potential presents practically no disadvantage since it can be cancelled by the application of a bias voltage to, for example, the developer side.

In this manner, according to the present invention, the electrostatic latent image is developed on the surface of the insulating film 20b and the film is subsequently peeled off from the sensitized material 1. The insulating film 20b may be used directly, as in the above described electrically conductive film, or it may be bonded to another suitable substrate. The method (b) and the materials shown therein may be used for bonding.

The aforementioned organic or inorganic electrically conductive materials may be used as the sensitized material 1, as long as the material 1 is selected so that is has a dark decay time longer than that of the electrically insulating film laminated thereon.

Among the properties required of the electrically insulating film is its ability to transmit the light from the exposure light source. Therefore, it is not always necessary that the film is colorless when specific effects or decorative usage are desired. On the other hand, it is necessary for the above electrically conductive film to have a longer dark decay time than that of the sensitized material. For example, polyethylene terephthalate having a dark decay time of about

400 seconds is preferred. Other materials such as polystyrene, polyphenylene sulfide, polyimide of polyamide, may also be employed.

Since the image is formed directly on the laminated film on the sensitized material, an image of a higher quality may be obtained when the film exhibits higher wettability with respect to the developer, whether the film is the electrically conductive film or the electrically insulating film. For meeting the above requirements, it is required that the contact angle with respect to methylene iodide be of not more than 60°. In Fig. 16, the contact angle with respect to methylene iodide defines an angle θ to the surface of the film 20 as measured between a tangential line drawn at a contact edge of the methylene iodide 30 and the plane of the film 20. When this contact angle θ is of not less than 60°, a high quality image cannot be obtained because of poor wettability with respect to the developer. Among the materials satisfying these conditions are polyethylene, polyvinylidene chloride-polyvinyl chloride copolymer, polyvinyl chloride (PVC), polyimide, polyamide and polypropylene. The film employed herein needs to have a contact angle with methylene iodide of not more than 60° at the operating temperature.

Example 1

A developing apparatus used in the present example will now be explained.

The developing apparatus is formed by an electrostatic latent image forming section and a developing section, both accommodated in a single vessel 9, as shown in Fig. 17. The electrifying, exposure and the developing steps are carried out integratedly in that a stage 10 holding the sensitized material 1 is shifted along a guide rod 11.

The stage 10 holding the sensitized base material 1 is provided with heating means 12 adapted for heating the sensitize base material 1 to a predetermined temperature.

The latent image forming section is subdivided into an electrifying section and a light exposure section. In the electrifying section, the overall surface of the sensitized base material 1 is electrified to, for example, a negative charge by an electrifying unit 2.

The light exposure section is made up of an optical system including a laser diode 3a, a lens 3b and a reflective mirror 3c. The section plays the role of selectively exposing the overall electrified surface of the sensitized material 1 as a function of signals to eliminate the charges of the portions thus exposed to light.

The developing section includes three developing tanks 4a, 4b, 4c containing three kinds of developer for full color developer, these tanks 4a to 4c being provided in this order in the direction of extension of the guide rod 11 within an air tank 13 provided with a blower fan 14.

The developing tanks 4a, 4b and 4c are composed of first tanks $4a_1$, $4b_1$ and $4c_1$ fitted with stirrers $4a_3$, $4b_3$ and $4c_3$ and second tanks $4a_2$, $4b_2$ and $4c_2$ provided around the outsides of the first tanks. Heating means 8a, 8b and 8c are provided on the bottom of the tanks.

The developers 7a, 7b and 7c, accommodated in these developing tanks 4a, 4b and 4c, are heated by the above heating means 8a, 8b and 8c to the melted state, and are adapted to be ejected slightly upward during development via slits $4a_5$, $4b_5$ and $4c_5$ formed in lids $4a_5$, $4b_5$ and $4c_5$ of the first tanks $4a_1$, $4b_1$ and $4c_1$ into contact with the sensitized base material 1.

Each tank 4a, 4b, 4c is separated from the other tanks by air ejected via air nozzles 13a provided extending from the air tank 13 to prevent color mixing.

The rear portion of the developing section is provided with a unit 15 for removing unnecessary electrical charges.

In the above described developing apparatus, the overall surface of the sensitized base material 1 is electrified to negative charges by the electrifying unit 2.

The base material 1 is then selectively exposed to light by the light exposure section such that the charges in the exposed portion are released to form a predetermined electrostatic latent image.

The sensitized base material 1 is then moved along the guide bar 11 to a position facing the developer tank 4a, as it is heated, and the latent image is developed by the developer contained in the tank 4a.

The base material 1 is then moved to the unit 15 where the unnecessary charges are removed.

The sensitized base material 1 is then again moved to the latent image forming section to undergo the sequential steps of electrification - light exposure - development by the developing tank 4b - charge removal - electrification - light exposure - development in the developing tank 4c and - charge removal to form a full color image.

Using the above described developing apparatus, a full-color image has been formed with the following developers A, B and C contained in the tanks 4a, 4b and 4c.

Developer A

The present developer A is the cyan-color electrostatic latent image developer.

0.625 g of Lionol Blue KX-F1 produced by Toyo Ink Co. Ltd., as colorant, and 0.5 g of IP 2825, isoparaffin solvent produced by Idemitsu Sekiyu Co. Ltd., were comminuted by the Fouver-Maler method to produce a paste. This paste was dispersed in 50 ml of a separate isoparaffin solvent "Isopar H" produced by Esso Inc. and admixed with 0.05 g of "Aluminum Oxide C" produced by Nippon Aerosil Co. Ltd., as the charge reinforcing agent and the resulting mixture was dispersed for 12 hours in a paint shaker together with alumina beads. The resulting dispersion was admixed with 9.5 g of a 50%-solution of "FR101", acrylic resin produced by the Mitsubishi Rayon Co. Ltd. in toluene, 0.025 g of zirconium naphthenate as the charge donor and 0.025 g of calcium naphthenate to produce a concentrated developing liquid.

Then, 120 ml of paraffin melting at 42 to 44°C was previously melted at 70°C and 5 ml of the concentrated developing liquid was dispersed in the solution to produce a blue color latent image developer.

Developer B

The present developer B is a yellow-colored electrostatic latent image developer.

0.5 g of Similar Fast Yellow 8GF produced by Dai Nippon Ink Co. Ltd., as colorant, and 0.5 g IP2825, isoparaffin solvent produced by Idemitsu Sekiyu Co. Ltd., were comminuted by the Fouver-Maler method to produce a paste. This paste was dispersed in 50 ml of a separate isoparaffin solvent "Isopar H" produced by Esso Inc. and admixed with 0.01 g of "Aerosil 200" Ultra fine particles of dry silica produced by Nippon Aerosil Co. Ltd., as the charge reinforcing agent and the resulting mixture was dispersed for 18 hours in a paint shaker together with glass beads. The method for preparing the concentrated developing liquid and the electrostatic latent image developer is similar to the method described in connection with the developer A.

Developer C

The present developer C is the magenta-color electrostatic latent image developer.

0.8 g of Simular Rodamin Y toner F, produced by the Dai Nippon Ink Co. Ltd. as the colorant and 0.5 g of linseed oil were comminuted by the Fouver-Maler method to produce a paste. This paste was dispersed in 50 ml of "Isopar H", an isoparaffin solvent produced by Esso Inc. and the dispersing operation was performed for 18 hours in a paint shaker together with glass beads. The method for preparing the concentrated developing liquid and the latent image developer is the same as that described in connection with the developer A.

On the other hand, a sheet of transparent electrically conductive film (of 0.2μm thickness) and a modified vinyl acetate resin (film thickness, 2μm) were laminated on polyethylene terephthalate film (125μm thick) and a photosensitive layer (film thickness, 8μm) containing 2 mg of cyanine dye ("NK 2892" produced by Nippon Kanko Shikiso Co. Ltd.) as sensitizer was formed on the laminate to produce the sensitized base material 1. Since the image quality may be degraded when the developers solidify immediately after contact with the sensitized base material 1, the stage 10 for securing the base material 1 was heated to 55°C by the heating means 12.

As a result, a satisfactory full-color image comparable in resolution and definition with a silver halide photograph is consistently obtained.

Example 2

A developing method for an electrostatic latent image will be hereinafter explained by reference to the example shown in Fig. 18 and using the developer of Figure 2.

The sensitized base material 1 is comprised of a sheet-like base layer 1a and a photosensitive layer 1b formed on the base layer 1a. A latent image of the negative charges was formed on the layer 1b by the electrification and light exposure steps as a function of the image information.

For developing the base material 1 carrying the latent image of the negative charges by the developer of the present example, the base material is placed so that the developer 7 in the form of a layer on a backing 21 contacts with the layer 1b and is then fed under pressure applied by a roller 16 provided with heating means H. Of course, a pressure plate or other means is provided opposite the roller 16 so that pressure is exerted as the base 1 and developer 7 pass therebetween.

When the developer 7 and the photosensitive layer 1b are contacted with each other and heated by the roller 16, the developer 7 is liquefied and the colorants contained in the developer 7 migrate to and are deposited at the regions where the negative charges exist. The colorants affixed to unnecessary (uncharged) regions are then removed. The charge removing and fixing steps are then carried out to form the image on the sensitized base material 1. Since the image quality may be degraded when the developer solidifies immediately after contact with the sensitized base material 1, the sensitized base material 1 or the stage 10 for securing the base material 1 is preferably heated by heating means 12.

The present inventors tentatively produced the sheet-like developing material and developed an electrostatic latent image. It has been found that a satisfactory full-color image comparable in resolution and definition with the silver halide photograph could be obtained consistently.

Example 3

A third developing method for an electrostatic latent image will be hereinafter explained with reference to Figure 19 using the developer example shown in Fig. 5.

The sensitive base material 1 is comprised of a sheet-like base layer la and a photosensitive layer 1b formed on the base layer 1a. A latent image of the negative charges was formed on the layer 1b by the electrification and light exposure steps as a function of the image information.

For developing the base material 1 carrying the latent image of the negative charges by the developer of the present example, the base material is placed so that the developer 7 contacts with the layer 1b and pressure is applied by a roller 16 provided with heating means H as the base material 1 is fed past the roller 16.

When the developer 7 and the photosensitive layer lb are contacted with each other and heated by the roller 16, the developer 7 is liquefied and the colorant contained in the developer 7 migrates to and is deposited at the regions where the negative charges exist. The colorant affixed to the unnecessary region is then removed. The charge removing and fixing steps are then carried out to form the image on the sensitized base material 1. Since the image quality may be degraded if the developer solidified immediately after contact with the sensitized base material 1, the sensitized base material 1 or the stage 10 for securing the base material 1 is preferably heated by heating means 12.

Since the electrically conductive layer 24 is formed on the base material 21 a d.c. source 17 may be connected to the layer 24 to apply a bias voltage for development.

By application of this bias voltage, it becomes possible to control the relative potential of the latent image as well as to control the degree of fixing of the colorant 6 to the electrostatic latent image.

Both the bias voltage and an a.c. voltage may be applied to the layer 24 as shown in Fig. 19 to use the latter as the heating member to omit the heating means H for the roller 16. Since the electrically conductive layer 24 is formed of a thermally conductive material, such as metal, the heating temperature for the developer 7 may be advantageously equalized.

The present inventors tentatively produced the sheet-like developing material and developed an electrostatic latent image. It has been found that a satisfactory full-color image comparable in resolution and definition with a silver halde photograph can be obtained consistently.

Example 4

In the present example, an electrostatic image is formed, using a sensitized material comprised of a laminated polyethylene film as the electrically conductive film, the latent image is developed by a cyan-color developer, and the polyethylene film was peeled from the sensitized material and bonded to ordinary paper.

A sheet of a transparent electrically conductive film (0.2 μm thick) and a modified vinyl acetate resin (film thickness, 2 μm) were laminated on polyethylene terephthalate film (125 μm thick) and a photosensitive layer (film thickness, 8 μm) containing 2 mg of cyanine coloring matter ("NK 2892" produced by Nippon Kanko Shikiso Co. Ltd.) as a sensitizer was formed on the laminate to produce the sensitized base material. The dark decay time of the sensitized material is 300 seconds. A polyethylene film 9 μm thick was laminated as an electrically conductive film on this sensitized material.

The developer used in this example is the aforementioned electrostatic latent image developer previously proposed by the present Applicant. This developer was prepared in the following manner.

First, 0.625 g of Lionol Blue KX-F1 produced by Toyo Ink Co. Ltd., as a colorant, and 0.5 g of IP 2825, isoparaffin solvent produced by Idemitus Sekiyu Co. Ltd., were comminuted by the Fouver-Maler method to produce a past. This paste was dispersed in 50 ml of a separate isoparaffin solvent "Isopar H" produced by Esso Inc. and the resulting mixture was dispersed for 12 hours in a paint shaker together with alumina beads. The resulting dispersion was admixed with 0.5 g of a 50%-solution of "FR101", acrylic resin produced by the Mitsubishi Rayon Co. Ltd. in toluene, 0.025 g of zirconium naphthenate and 0.025 g of calcium naphthenate as the charge donor to produce a concentrated developing liquid. Then, 120 ml of paraffin melting at 42 to 44°C was previously melted at 70°C and 5 ml of the concentrated developing liquid was dispersed in the solution to produce a cyan color latent image developer.

In forming an image, a sensitized material comprised of a laminated polyethylene film 20 as shown in Fig. 13 is subjected to corona discharge 2 at -6 kV so as to be charged to -700 V in its entirety. The sensitized material is then subjected to selective light exposure by a semiconductor laser 3 of a wavelength of 780 nm to form an electrostatic latent image. Then, as the developer 7 is heated by suitable heating means, not shown, provided on the developer tank 4, for example, for maintaining the developer 7 in the melted state, the electrostatic latent image was developed for forming an image on the polyethylene film.

With the time t_1 involved in corona charging of 3 seconds, the time t_2 from corona charging until exposure being 2 seconds, the time t_3 for exposure of 3 seconds and the time t_4 from exposure until development being 2 seconds, the total time amounts to 10 seconds. The 9μm thick polyethylene film used as the electrically conductive film in the present example has the dark decay time at 25°C of about 6.5 seconds, thus satisfying the requirement that the dark decay time be shorter than the total time t.

After the fixation and charge removal steps, the polyethylene film is peeled from the sensitized material 1 and bonded to an ordinary paper sheet to transfer the image thereto.

The image, thus, transferred to the ordinary paper sheet showed high resolution of 500 lines/mm or 1000 dots/mm and excellent gradation. Since the electrically conductive film in its entirety is bonded to the substrate, the transfer efficiency is 100%, while the sensitized material can be used repeatedly.

Although the case of forming a cyan-color monochromatic image has been explained in the present example, it is to be noted that the present invention can be applied to formation of a full-color image as well. For forming the full-color image, the steps of electrification, light exposure and charge removal are repeated for each of the three primary colors for the same sensitized material and the transfer operation is then performed collectively. The sensitized material may used repeatedly after the transfer operation.

Example 5

In the present example, a sensitized material comprised of a film of a polyvinylidene chloride-vinyl chloride copolymer, referred to hereinafter as Saran film, as the electrically conductive film is used. The Saran film is heated to about 50°C to form an electrostatic latent image, and this latent image was developed by using a cyan color developer and the Saran film was then peeled off from the sensitized material and bonded on the ordinary paper sheet.

The developer and the sensitized material used herein are the same as those used in Example 4.

For forming the image, a 10μm thick Saran film was laminated on the sensitized material and heating was then performed by heating means provided on a stage, not shown, adapted for supporting the sensitized material, so that the temperature of the Saran film was about 50°C. This Saran film has a glass transition point Tg of 10°C and a longer dark decay time at room temperature (25°C) of not shorter than 300 seconds, so that it can be applied only with difficulty to the present invention. This dark decay time could be reduced to 6.6 second by heating to about 50°C as described above. This is shorter than the dark decay time of the sensitized material employed in the present example, which is 300 seconds, or the time t from corona charging until development, which is 10 seconds.

The corona discharge is then performed at -6 kV to electrify the overall surface of the Saran film to about -700 V. Then, selective light exposure is performed with a semiconductor laser with the wavelength of 780 nm to form an electrostatic latent image. Then, as the developer 7 is heated by suitable heating means, not shown, provided on the developer tank 4, for example, for maintaining the developer in the melted state, the electrostatic latent image is developed for forming an image on the Saran film.

After the fixation and charge removal steps, the Saran film is peeled from the sensitized material and bonded to an ordinary paper sheet to transfer the image thereto.

The image thus transferred to the ordinary paper sheet showed high resolution of 500 lines/mm or 1000 dots/mm and excellent gradation. Since the electrically conductive film in its entirety is bonded to the substrate, the transfer efficiency is 100%, while the sensitized material can be used repeatedly.

For comparison, a similar image was tentatively formed at room temperature, but a satisfactory image quality could not be obtained.

Although the case of forming a cyan-color monochromatic image has been explained in the present example, it is to be noted that the present invention can be applied to formation of a full-color image as well. For forming the full-color image, the steps of electrification, light exposure and charge removal are repeated for each of the three primary colors for the same sensitized material and the transfer operation may then be performed collectively. The sensitize material may be used repeatedly after the transfer operation.

Example 6

In the present example, an electrostatic latent image is formed by using a sensitized material comprised of a laminated PET film as an insulating film, this latent image is developed with a cyan-color developer and the PET film is peeled off from the sensitized material and bonded to an ordinary paper sheet.

The developer and the sensitized material employed herein are the same as those used in Example 4.

In forming an image, a sensitized material comprised of a 9 μm thick laminated polyethylene film (dark decay time, 300 seconds) is subjected to corona discharge at -6 kV so as to be charged to -700 V in its entirety. The sensitized material is then subjected to selective light exposure by a semiconductor laser of a wavelength of 780 nm to form an electrostatic latent image. Then, as the developer is heated by suitable heating means, not shown, provided on the developer tank, for maintaining the developer in the melted state, and as the bias voltage of -400 V is applied to the developer to prevent wasteful deposition of colorant particles due to the residual potential at the light exposure section, the electrostatic latent image is developed to form an image on the PET film.

After the fixation and charge removal steps, the polyethylene film is peeled from the sensitized material and bonded to an ordinary paper sheet to transfer the image thereto.

The image thus transferred to the ordinary paper sheet showed high resolution of 500 lines/mm or 1000 dots/mm and excellent gradation. Since the electrically conductive film in its entirety is bonded to the substrate, the transfer efficiency is 100%, while the sensitized material can be used repeatedly.

Although the case of forming a cyan-color monochromatic image has been explained in the present example, it is to be noted that the present invention can be applied to formation of a full-color image as well. For forming the full-color image, the steps of electrification, light exposure and charge removal are repeated for each of the three primary colors for the same sensitized material and the transfer operation may then be performed collectively. The sensitized material may be used repeatedly after the transfer operation.

Example 7

In the present example, an electrostatic latent image is formed by using a sensitized material comprised of a laminated polyethylene film, this latent image is developed with a cyan-color developer and the polyethylene film is peeled off from the sensitized material bonded to an ordinary paper sheet.

The developer and the sensitized material employed herein are the same as those used in example 4.

In forming the image, a sensitized material comprised of a laminated 9µm thick polyethylene film having a contact angle of 45° with respect to methylene iodide is subjected to corona discharge and thereby charged in its entirety to negative polarity. Then, selective light exposure is performed by a semiconductor laser to form an electrostatic latent image on the polyethylene film. Then, as the developer is heated by heating means, not shown, provided for a developing tank for maintaining the developer in the melted state, and as the bias voltage of -400 V is applied to the developer to prevent wasteful deposition of colorant particles due to the residual potential at the light exposure section, the electrostatic latent image is developed to form an image on the polyethylene film. The developing time is about three seconds. After the subsequent fixation and charge removal steps, the polyethylene film is peeled off from the sensitized material and bonded to the ordinary paper sheet to transfer the image thereto.

The image thus transferred to the ordinary paper exhibited high resolution and gradation.

Then, by way of a comparative example, a film having a contact angle of not less than 60° with respect to methylene iodide was used as the film laminated on the sensitized material, and the image was formed on the film under the same conditions as in Example 7 and transferred to an ordinary paper sheet. As the film having the contact angle of not less than 60° with respect to methylene iodide, polyvinylidene fluoride (contact angle, 63°) and polytrifluoroethylene (contact angle, 71°) were used.

The image obtained with the use of these films having the contact angle with respect to methylene iodide not less than 60° was inferior in resolution or gradation to that obtained with the use of a film having the contact angle with respect to methylene iodide of not more than 60°.

Since these images are bonded along with the films onto the ordinary paper sheet, the transfer efficiency is 100% and the sensitized material can be used repeatedly.

Although the case of forming the cyan color monochromatic image has been explained in the present example, it is to be noted that the present invention may be applied to formation of full-color images.

Claims

1. An electrophotographic process comprising the use of a developer (7) consisting essentially of colorant particles (6) dispersed in an electrically insulating organic material (5) which is solid at ambient temperature and capable of transforming between the solid state and the liquid state when heated and cooled, said process being **characterized by** the following steps:

   laminating a film (20) capable of transmitting light from an exposure light source (3) onto a photoconductor (1),

   forming an electrostatic latent image on said film (20) by selective exposure of said film (20) corresponding to image information and by elimination of electrical charges on an exposed portion of said film (20),

   developing said electrostatic latent image by contacting said developer (7) melted by heating means (8, 12) with said film (20) carrying said electrostatic latent image, said colorant particles (6) being charged to a polarity opposite to that of said film (20) and being affixed on and developing said electrostatic latent image, and

   peeling said film (20) from said photoconductor (1).

2. The electrophotographic process according to claim 1, further comprising the step of electrifying said photoconductor (1) prior to the lamination of film (20).

3. The electrophotographic process according to claim 1, further comprising the step of electrifying a surface of said film (20) after the lamination of said film (20).

4. The process according to claim 3, wherein the film (20) is an electrically insulating film (20b) having a dark decay time longer than that of the photoconductor (1).

5. The process according to claim 3, wherein the film (20), is an electrically conductive film (20a) having a dark decay time shorter than that of the photoconductor (1).

6. The process according to claim 5, wherein the electrically conductive film (20a) is heated.

7. The process according to claim 3, wherein the film (20) has a contact angle with respect to methylene iodide of not more than 60°.

Patentansprüche

1. Elektrophotographisches Verfahren, umfassend die Verwendung eines Entwicklers (7), welcher im wesentlichen aus Farbmittelteilchen (6), die in einem elektrisch isolierenden organischen Material (5) dispergiert sind, welches bei Umgebungstemperatur fest ist und in der Lage ist, beim Erwärmen und Kühlen zwischen dem festen Zustand und dem flüssigen Zustand zu transformieren, besteht, wobei das Verfahren durch die folgenden Schritte **gekennzeichnet** ist:
   Laminieren eines Films (20), welcher in der Lage ist, Licht von einer Belichtungsquelle (3) auf einen Photoleiter (1) durchzulassen bzw. zu übertragen,
   Bilden eines elektrostatischen latenten Bildes auf dem Film (20) durch selektive Belichtung des Films (20) entsprechend einer Bildinformation und durch Eliminieren elektrischer Ladungen auf einem belichteten Bereich des Films (20),
   Entwickeln des elektrostatischen latenten Bildes durch Kontaktieren des durch Erwärmungseinrichtungen (8, 12) geschmolzenen Entwicklers (7) mit dem das elektrostatische latente Bild tragenden Film (20), wobei die Farbmittelteilchen (6) auf eine Polarität geladen werden, die derjenigen des Films (20) entgegegesetzt ist und darauf fixiert werden und Entwickeln des elektrostatischen latenten Bildes, und
   Ablösen des Films (20) von dem Photoleiter (1).

2. Elektrophotographisches Verfahren nach Anspruch 1, umfassend weiterhin den Schritt des Elektrifizierens des Photoleiters (1) vor der Laminlerung des Films (20).

3. Elektrophotographisches Verfahren nach Anspruch 1, umfassend weiterhin den Schritt des Elektrifizierens einer Oberfläche des Films (20) nach der Laminierung des Films (20).

4. Verfahren nach Anspruch 3, wobei der Film (20) ein elektrisch isolierender Film (20b) ist, welcher eine Dunkel-Abfallzeit aufweist, welche länger ist als diejenige des Photoleiters (1).

5. Verfahren nach Anspruch 3, wobei der Film (20) ein elektrisch leitfähiger Film (20a) ist, welcher eine Dunkel-Abfallzeit aufweist, die kürzer ist als diejenige des Photoleiters (1).

6. Verfahren nach Anspruch 5, wobei der elektrisch leitfähige Film (20a) erwärmt wird.

7. Verfahren nach Anspruch 3, wobei der Film (20) einen Kontaktwinkel in bezug auf Methyleniodid von nicht mehr als 60° aufweist.

Revendications

1. Procédé électrophotographique comprenant l'utilisation d'un révélateur (7) se composant essentiellement de particules de colorant (6) dispersées dans un matériau organique isolant électriquement (5) qui est solide à la température ambiante et capable de se transformer de l'état solide à l'état liquide lorsqu'il est chauffé et refroidi, ledit procédé étant caractérisé par les étapes suivantes :
   lamination d'une couche (20) capable de transmettre de la lumière à partir d'une source de lumière d'exposition (3) sur un photoconducteur (1),
   formation d'une image latente électrostatique sur ladite couche (20) par exposition sélective de ladite couche (20) correspondant à des informations d'image et par élimination des charges électriques sur une partie exposée de ladite couche (20),
   développement de ladite image latente électrostatique en mettant en contact ledit révélateur (7) fondu par des dispositifs de chauffage (8, 12) avec ladite couche (20) portant ladite image latente électrostatique, lesdites particules de colorant (6) étant chargée à une polarité opposée à celle de ladite couche (20) et étant attachées à celle-ci et développement de ladite image latente électrostatique, et
   exfoliation de ladite couche (20) dudit photoconducteur (1).

2. Procédé électrophotographique selon la revendication 1, comprenant en outre l'étape d'électrification dudit photoconducteur (1) antérieurement à la lamination de la couche (20).

3. Procédé électrophotographique selon la revendication 1, comprenant en outre l'étape d'électrification d'une surface de ladite couche (20) après la lamination de ladite couche (20).

4. Procédé selon la revendication 3, dans lequel la couche (20) est une couche isolante électriquement (20b) ayant un temps de détérioration du noir plus long que celui du photoconducteur (1).

5. Procédé selon la revendication 3, dans lequel la couche (20) est une couche conductrice électriquement (20a) ayant un temps de détérioration du noir plus court que celui du photoconducteur (1).

6. Procédé selon la revendication 5, dans lequel la couche conductrice électriquement (20a) est chauffée.

7. Procédé selon la revendication 3, dans lequel la couche (20) a un angle de contact par rapport à l'iodure de méthylène de pas plus de 60°.

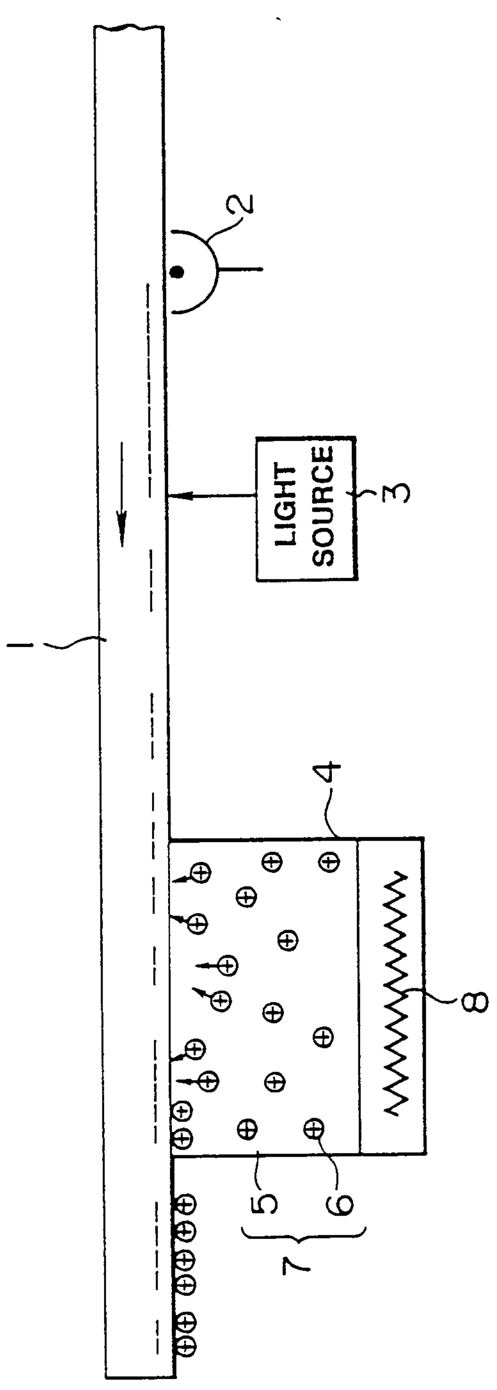


FIG.1

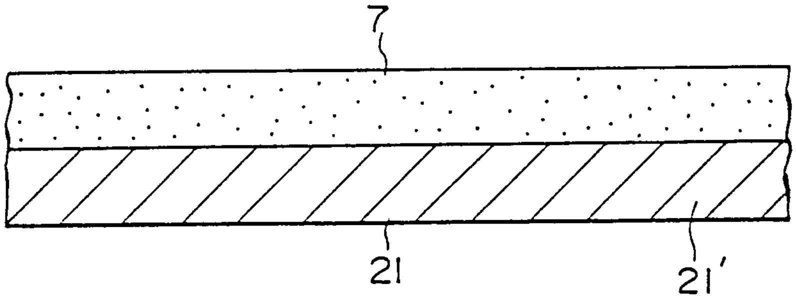


FIG.2

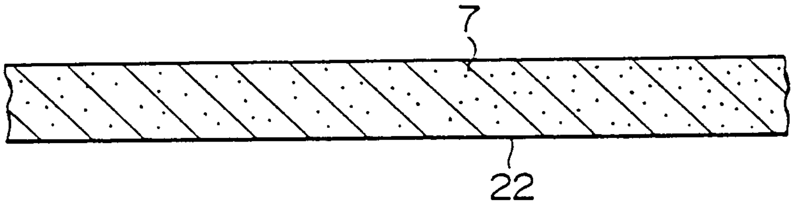


FIG.3

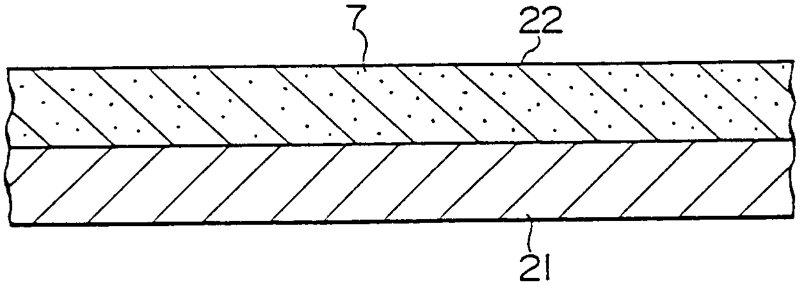


FIG.4

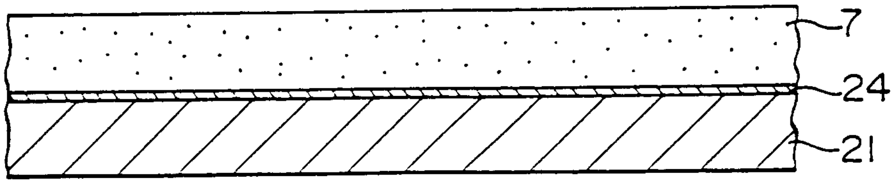


FIG.5

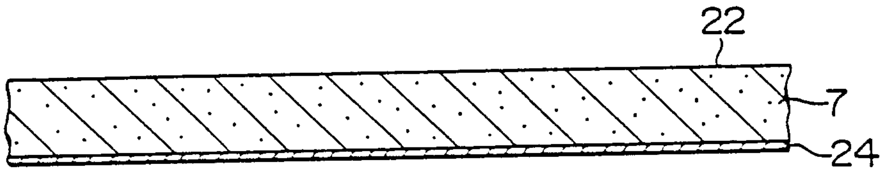


FIG.6

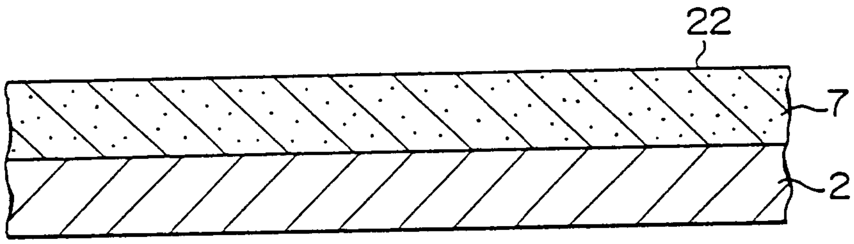


FIG.7

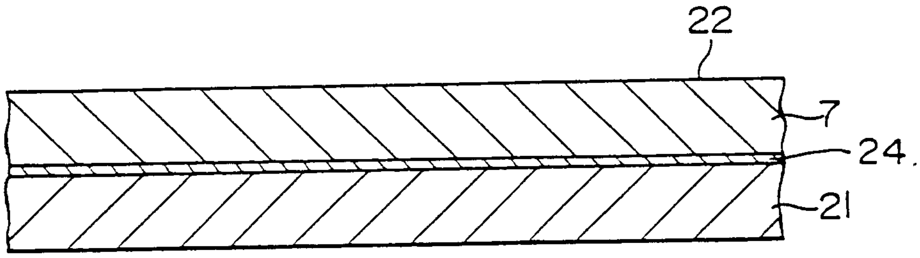


FIG.8

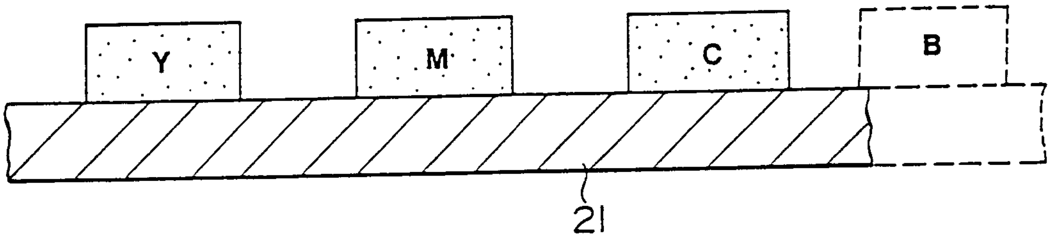


FIG.9

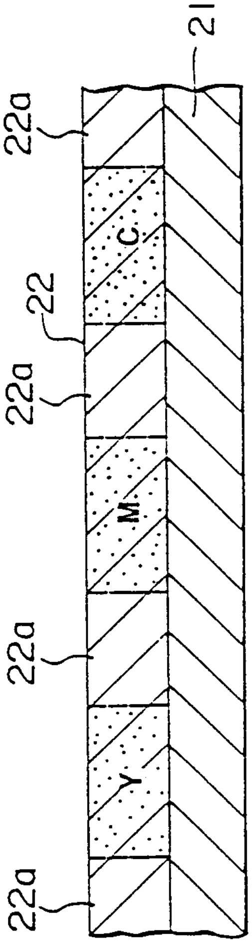


FIG.10

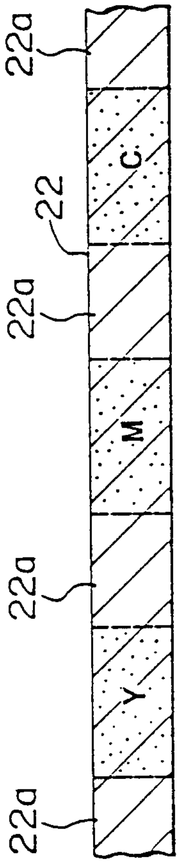


FIG.11

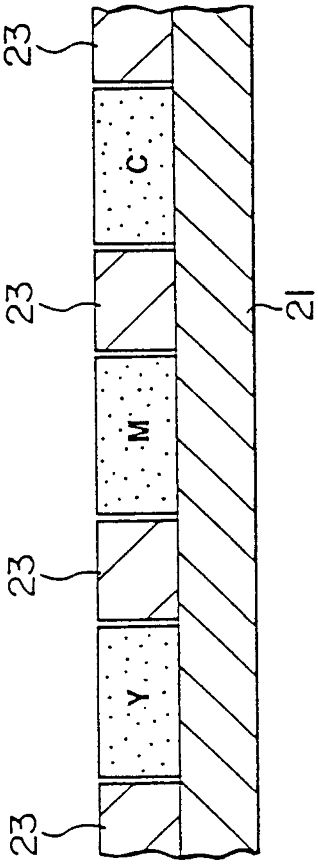


FIG.12

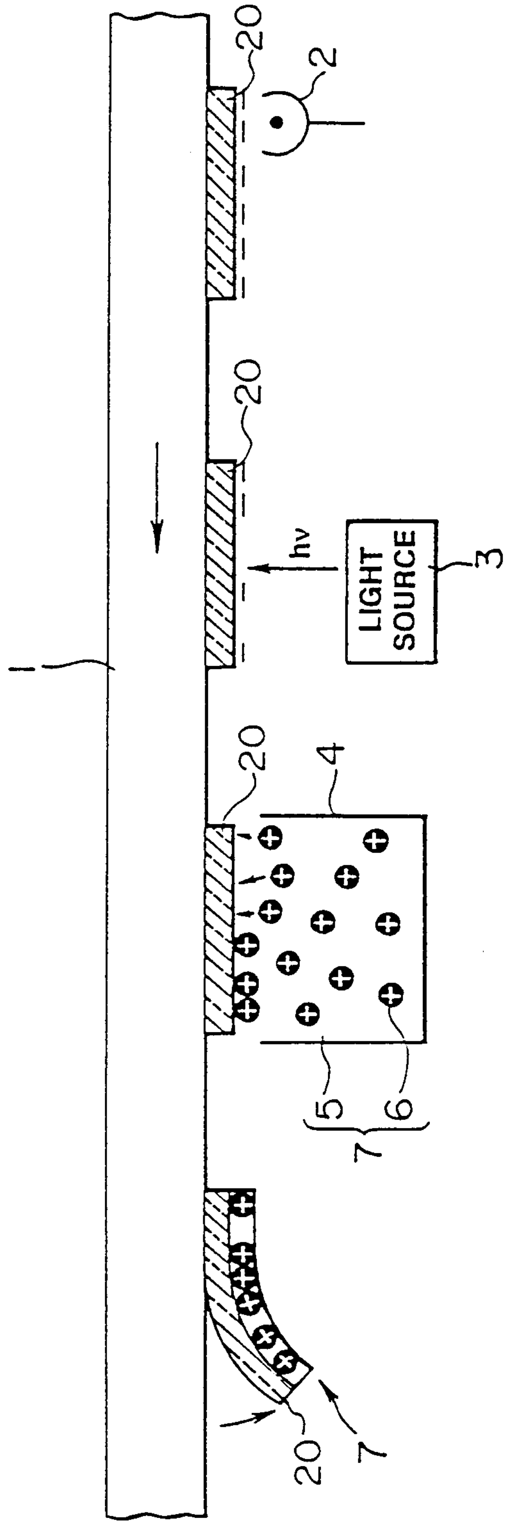


FIG.13

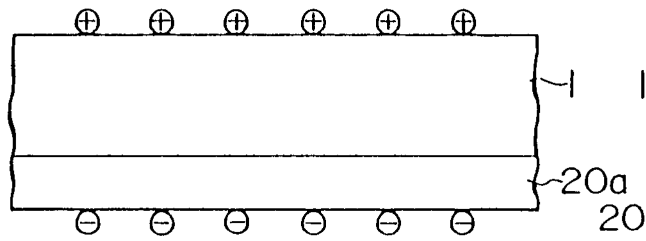


FIG.14(A)

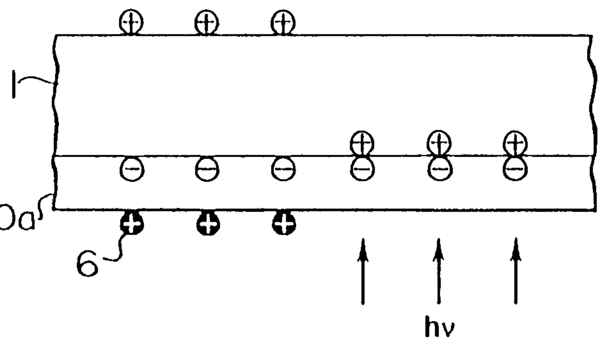


FIG.14(B)

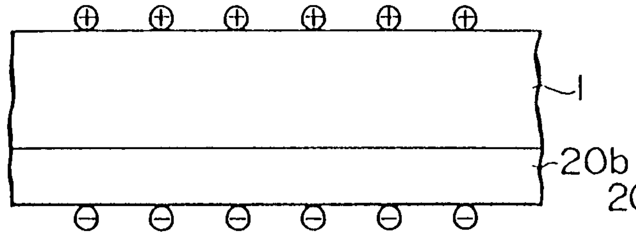


FIG.15(A)

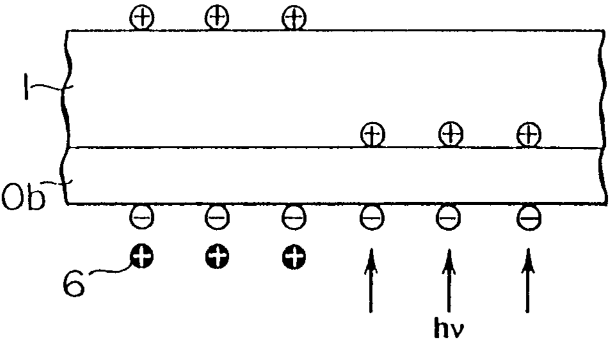


FIG.15(B)

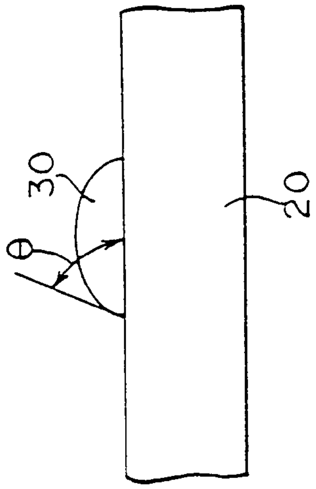
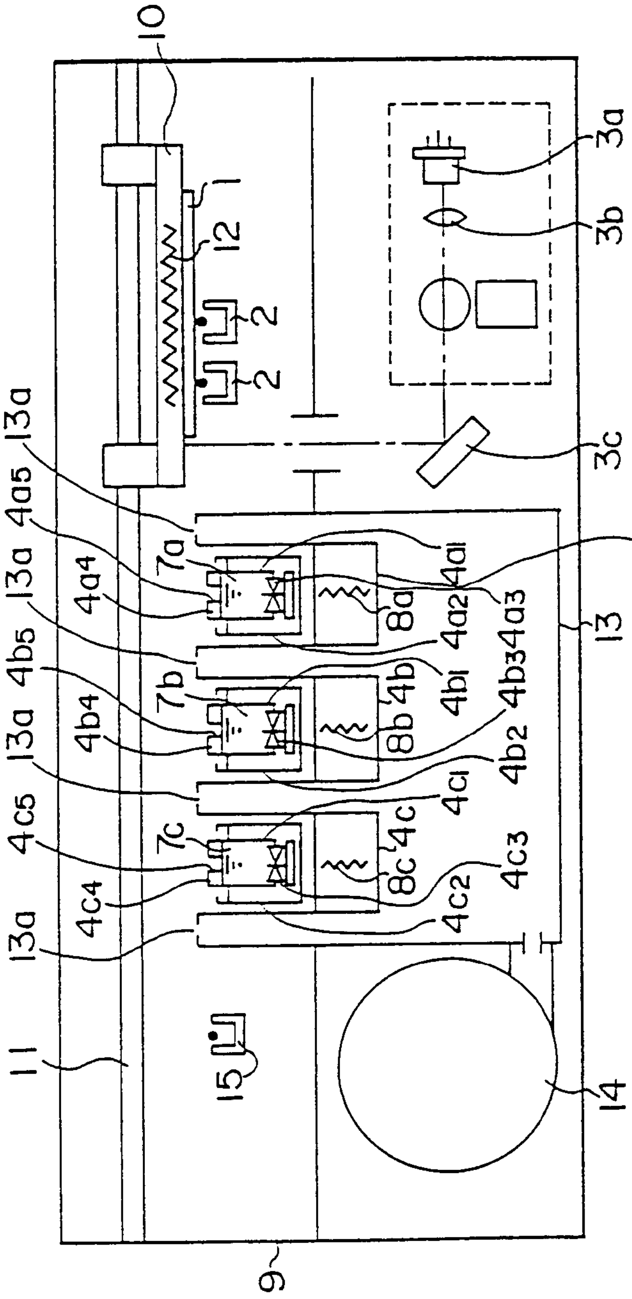

θ
30
20

FIG.16


10
1
12
2
2
3a
3b
3c
13a
4a5
4a4
7a
4a1
4a
8a
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4a3
13a
4b5
4b4
7b
4b1
4b
8b
4b3
4b2
13a
4c5
4c4
7c
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8c
4c3
4c2
13a
13
11
15
14
9

FIG.17

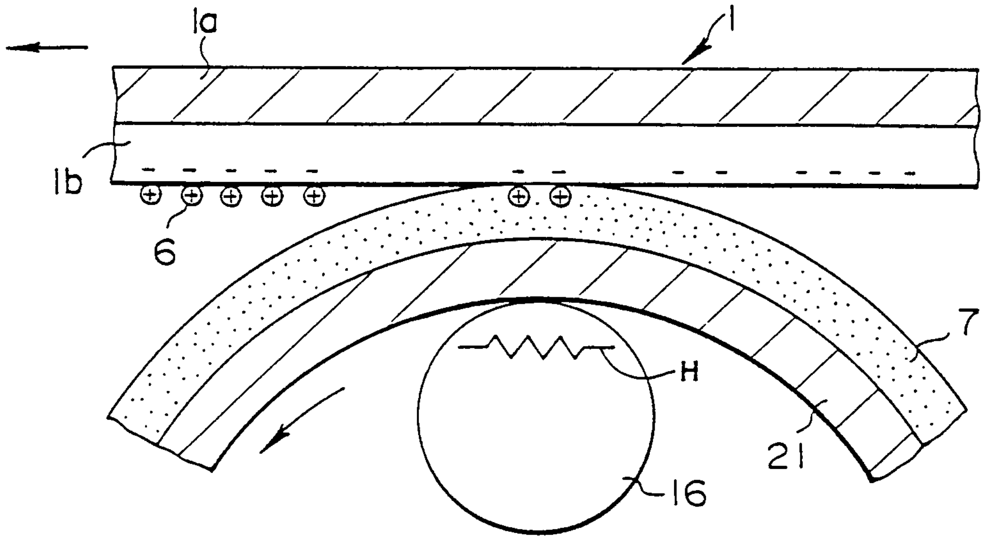

FIG.18

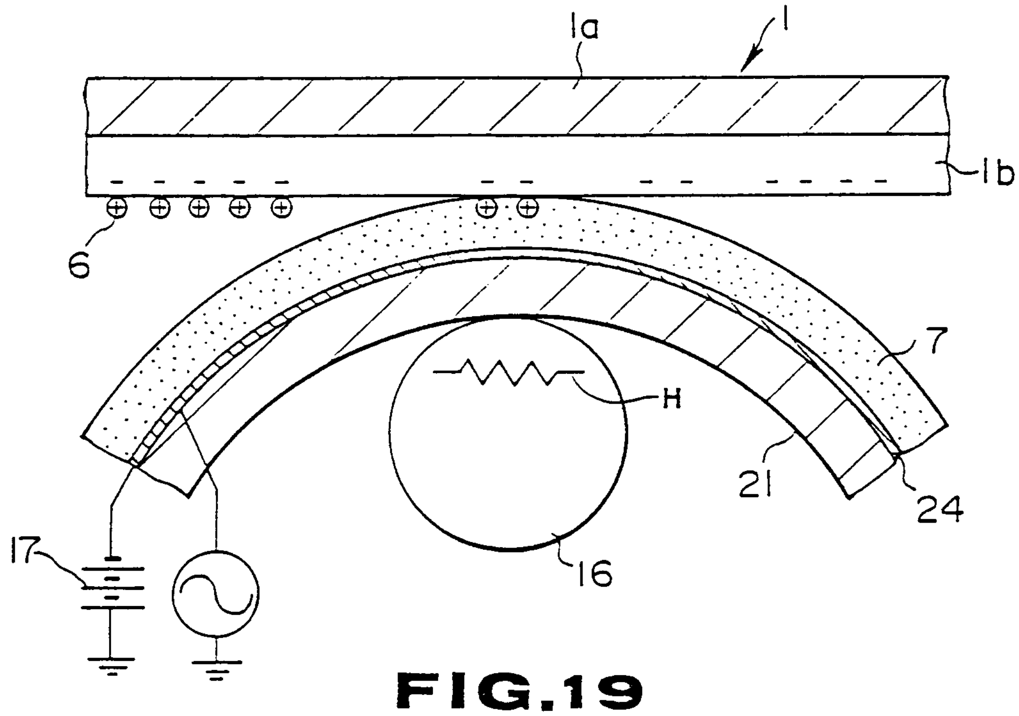

FIG.19

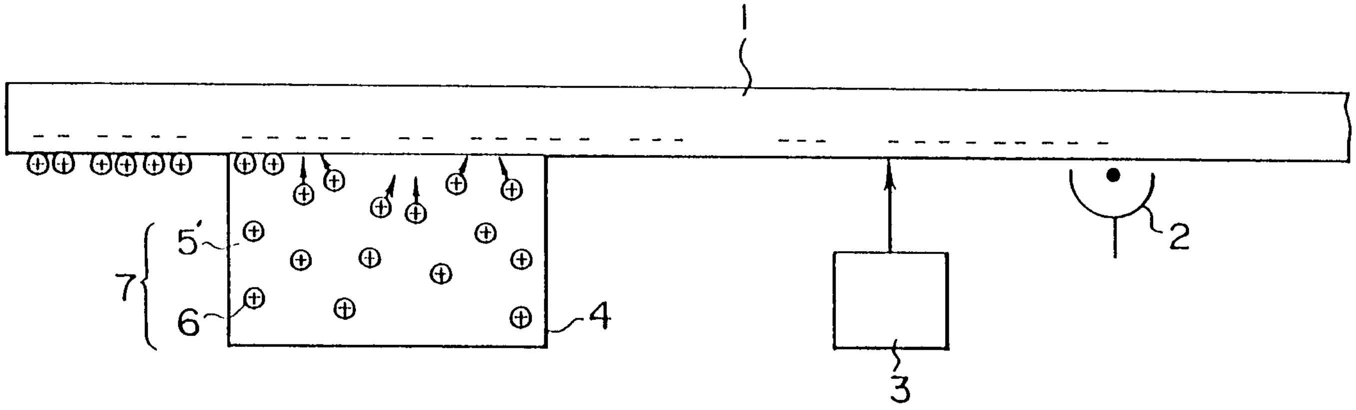

FIG. 20

(PRIOR ART)