

March 27, 1973

W. L. GOFFE

3,723,110

ELECTROPHOTOGRAPHIC PROCESS

Filed Dec. 21, 1970

2 Sheets-Sheet 1

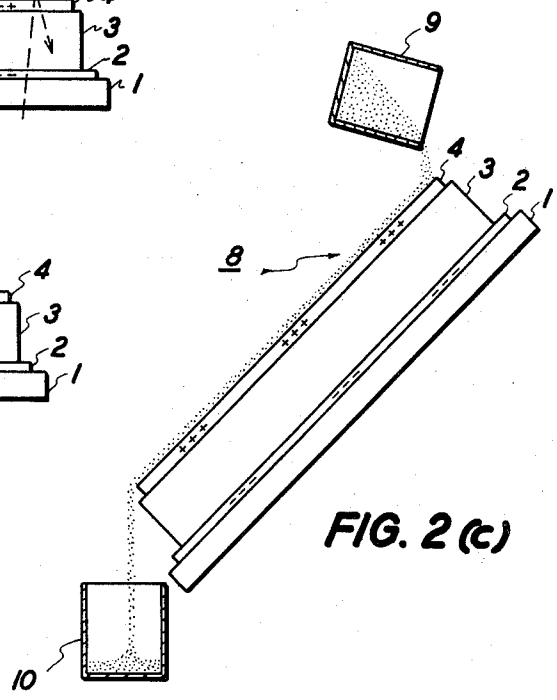
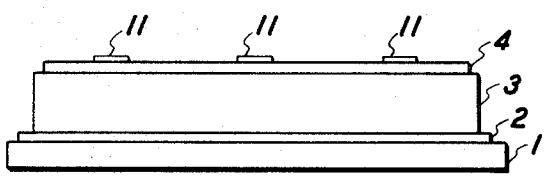
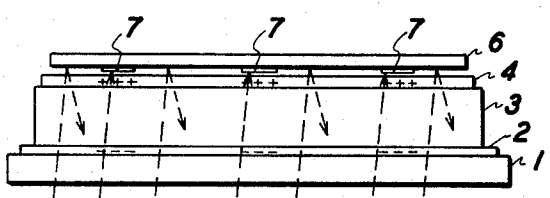
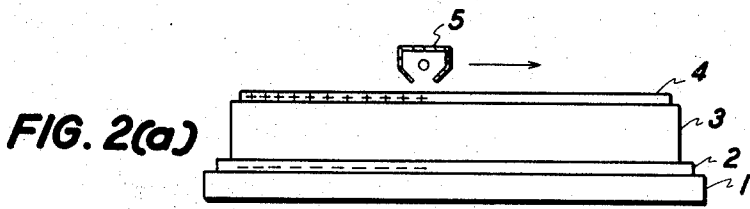
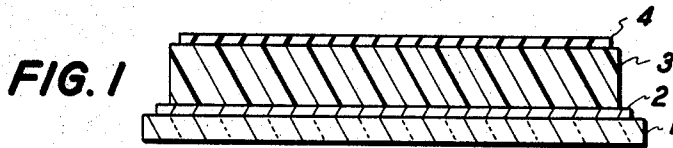


FIG. 2(d)

FIG. 2(c)

INVENTOR  
WILLIAM L. GOFFI

BY *Anthony Karambela*

ATTORNEY

March 27, 1973

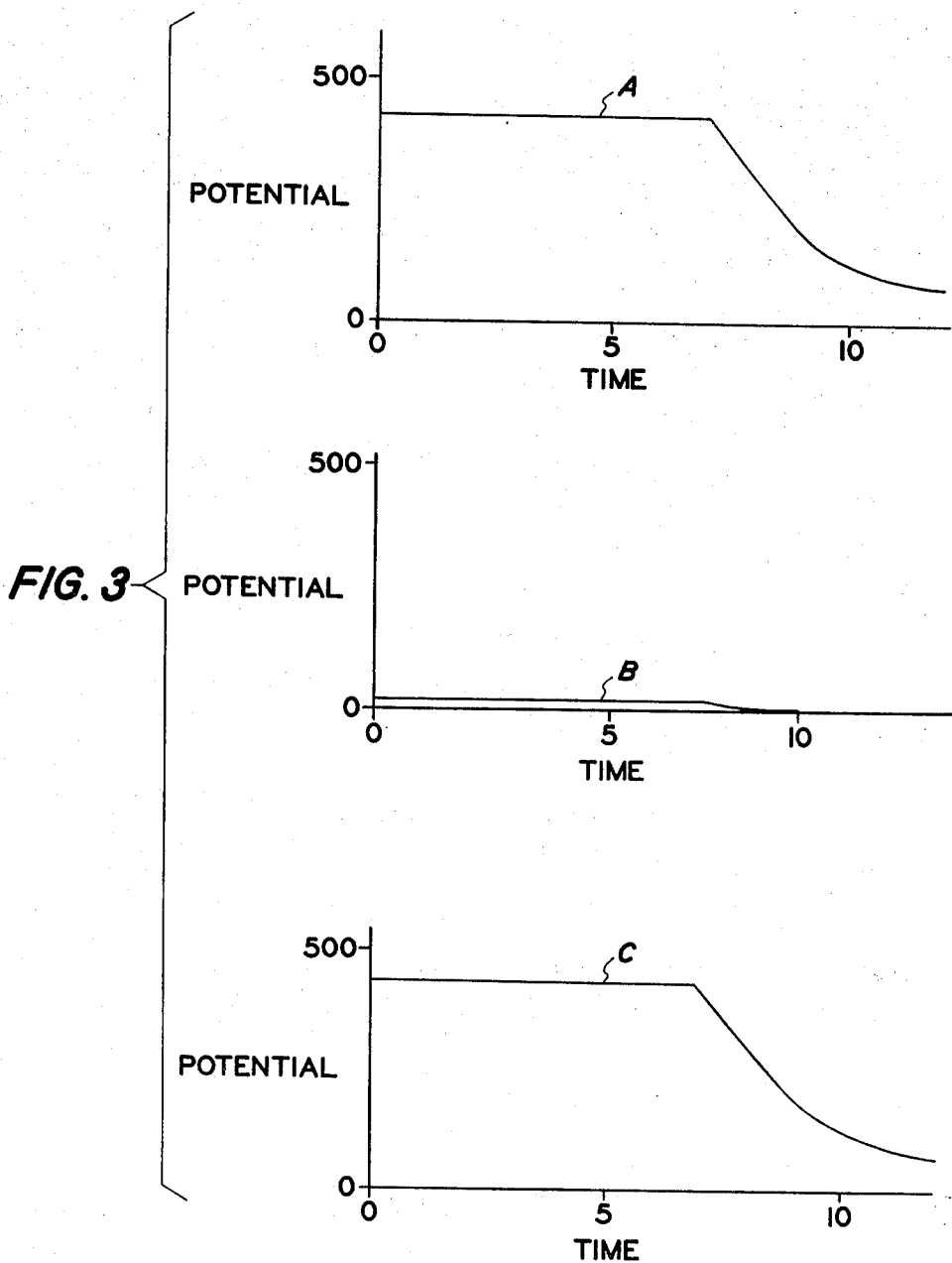
W. L. GOFFE

3,723,110

ELECTROPHOTOGRAPHIC PROCESS

Filed Dec. 21, 1970

2 Sheets-Sheet 2



1

2

3,723,110

**ELECTROPHOTOGRAPHIC PROCESS**

William L. Goffe, Webster, N.Y., assignor to Xerox Corporation, Stamford, Conn.

Continuation-in-part of application Ser. No. 608,606, Dec. 19, 1966, now Patent No. 3,573,906. This application Dec. 21, 1970, Ser. No. 99,939

The portion of the term of the patent subsequent to Apr. 4, 1988, has been disclaimed

Int. Cl. G03g 13/22

U.S. Cl. 96—1 PC

9 Claims

**ABSTRACT OF THE DISCLOSURE**

An electrophotographic plate and imaging process are disclosed. The plate comprises a conductive substrate coated with a thick organic insulating layer overcoated with a thin photoconductive layer. Images may be formed by electrostatically charging the plate, exposing it to an image and developing with electroscopic marking material.

**BACKGROUND OF THE INVENTION**

This application is a continuation-in-part of parent application, Ser. No. 608,606, filed Dec. 19, 1966 in the United States Patent Office now U.S. Patent 3,573,906.

This invention relates to electrophotography and, more particularly, to novel electrophotographic plates and their use in electrophotography.

It is known that images may be formed and developed on the surface of certain photoconductive materials by electrostatic means. The basic xerographic process, as taught by Carlson in U.S. Patent 2,297,691, involves uniformly charging a photoconductive insulating layer and then exposing the layer to a light-and-shadow image which dissipates the charge on the areas of the layer which are exposed to light. The electrostatic latent image formed on the layer corresponds to the configuration of the light-and-shadow image. This image is rendered visible by depositing on the image layer a finely divided developing material comprising an electroscopic marking material called a toner. This powder developing material will normally be attracted to those portions of the layer which retain a charge, thereby forming a powder image corresponding to the latent electrostatic image. This powder image may be transferred to paper or other receiving surfaces. The paper then will bear the powder image which may subsequently be made permanent by heating or other suitable fixing means. The above general process is also described in U.S. Pats. 2,357,809; 2,891,011 and 3,079,342.

That various photoconductive insulating materials may be used in making electrophotographic plates is known. Suitable photoconductive insulating materials such as anthracene, sulfur, selenium or mixtures thereof, have been disclosed by Carlson in U.S. Patent 2,297,691. These materials generally have sensitivity in a blue or near ultra-violet range, and all but selenium have a further limitation of being only slightly light sensitive. For this reason, selenium has been the most commercially accepted material for use in electrophotographic plates. Vitreous selenium, while desirable in many aspects, suffers from serious limitations in that it is subject to recrystallization into nonsensitive forms, has insufficient adhesion to many substrate materials during a flexing and requires costly and complex procedures, such as vacuum evaporation, for forming the photosensitive layer. Because of the economic and commercial considerations, there have been many recent efforts towards developing a photoconductive insulating material other than selenium for use in electrophotographic plates.

Photoconductive materials which have been recently

developed include various two-component materials, such as inorganic photoconductive pigments dispersed in binder materials. These materials, in general, have sensitivity lower than selenium and have a rough surface and high fatigue characteristics such as to make them unsuitable for use in processes in which a developed image is transferred to a receiving sheet and the photoconductive plate reused.

In addition, a variety of polymeric and binder-type organic photoconductor plates have been developed. These, however, have the inherent disadvantages of high cost of manufacture, brittleness, poor adhesion to supporting substrates, and low temperature distortion properties which make them undesirable in automatic electrophotographic apparatus which often include powerful lamps and thermofusing devices which tend to heat the electrophotographic plate.

Many of the above described photoconductors must either be used in one particular form, e.g., vitreous rather than crystalline selenium, or in a binder, e.g., zinc oxide in resin binders, because the photoconductor in a binder free or crystalline condition, while photosensitive, will not hold an electrostatic charge for a time sufficient to permit exposure and development.

Also, many of the photoconductive materials described above are opaque and are thus unsuitable for "reflex" exposure system in which light must pass through the photoconductor. Instead, these photoconductors require the use of elaborate and expensive optical systems to impose a light image on the charged photoconductive surface.

It is, therefore, an object of this invention to provide an electrophotographic plate and process overcoming the above noted disadvantages.

Another object of this invention is to provide an electrophotographic plate capable of using photoconductive materials which if used in a single layered plate would have prohibitive dark decay.

It is another object of this invention to provide an electrophotographic plate having improved adhesion to supporting substrates.

It is another object of this invention to provide a novel electrophotographic imaging system.

It is still another object of this invention to provide a novel reflex-type electrophotographic imaging system.

It is yet another object of this invention to provide an electrophotographic plate having a wide range of useful physical properties.

It is still another object of this invention to provide a photoconductive layer suitable for the fabrication of low cost, flexible electrophotographic plates.

The foregoing objects and others are accomplished in accordance with this invention, generally speaking, by providing an electrophotographic plate as described in copending application U.S. Ser. No. 403,002, filed Oct. 12, 1964 and now abandoned and U.S. Ser. No. 460,377 filed June 1, 1965 and now issued U.S. Patent No. 3,520,681, comprising a conductive substrate, having thereon a layer of an insulating organic material overcoated with a thin photoconductive layer. Since the photoconductive layer can be made very thin, it can be quite transparent even where formed from a material, such as selenium, which is in the usual thickness substantially opaque. Also, since this layer is very thin, materials such as metallic selenium powder which would ordinarily have prohibitively high dark decay may be used as the photoconductive layer. As is further pointed out below, this plate is useful both in conventional electrophotography and because of its relatively high transparency in a reflex-type system.

Generally, after formation of the electrostatic latent image on the xerographic plate of this invention, the

image is then typically utilized. One typical utilization mode is rendering the image visible by the xerographic development techniques of contacting the latent image areas with a finely divided marking material called toner that is brought into surface contact with the surface of the plate and is held there electrostatically in a pattern corresponding to the electrostatic latent image. However, there are many other ways of utilizing the electrostatic latent image formed on the imaging members hereof some of which are described hereinafter.

For example, the migration imaging process of copending application Ser. No. 483,675, filed Aug. 30, 1965 may be used to cause an imagewise migration of a fracturable or microscopically discontinuous thin photoconductive layer into an underlying plastic layer in image configuration, generally corresponding to the electrostatic latent image pattern.

Another mode of utilizing the electrostatic latent images formed on the imaging members hereof is to transfer the charge pattern to another layer by bringing the two layers into very close proximity and utilizing breakdown techniques as described, for example, in Carlson Patent 2,982,647 and Walkup Patents 2,825,814 and 2,937,943. For example, the layer to which the charge image is transferred may be a surface deformable material which may be caused to deform in image configuration as disclosed in Gunther et al. Patent 3,196,011.

The electrostatic latent image may also be directly read out utilizing devices such as electrometers which detect potential differences which may be translated into giving the graphic information that was represented by the original electrostatic latent image.

Insulating receiving sheets may be brought into contact with the electrostatic latent image bearing plates hereof and the receiving sheet developed with toner utilizing techniques which permit a plurality of such copies to be made from one master electrostatic latent image.

As disclosed in copending application Ser. No. 867,049, filed Oct. 16, 1969 wherein a relatively more conductive image receiving sheet including paper may be placed in contact with the electrostatic latent image bearing plates hereof inducing an image in said receiving sheet which induced image can be developed by techniques which permit 100 or more such developed receiving sheets to be made from a single master electrostatic latent image.

In general, the thickness of the insulating interlayer should be about 10 to 40 times the thickness of the photoconductive layer. For optimum flexibility and best handling characteristics, the insulating layer should have a thickness of about 2 to 4 microns. The useable range, however, extends from about 0.5 to 50 microns thickness. The photoconductor may have a thickness in the range of 0.02 to 4 microns. For optimum sensitivity and flexibility the photoconductive layer should have a thickness sufficient to absorb about 75-95% of the incident actinic light. For a selenium layer, the thickness would be from about 0.1 to about 0.2 micron. In the reflex mode, this layer may be toward the thinner end of this range, about 0.03 micron in thickness for selenium, to permit a suitable proportion of impinging light to pass through and be reflected back from the original to be reproduced, as is further described below. The layer should directly absorb from about 50% to 80% of the incident actinic light for optimum results in the reflex mode.

The substrate may comprise any suitable conductive material. Typical conductive materials include metal surfaces such as aluminum, brass, stainless steel, copper, nickel, and zinc; conductively coated glass such as tin oxide or indium oxide coated glass; similar coatings on plastic substrates; or paper rendered conductive by the inclusion of a suitable chemical therein or through conditioning in a humid atmosphere to insure the presence

therein of sufficient water content to render the materials sufficiently conductive.

Any suitable insulating material may be used for the insulating interlayer. Where a reflex-exposure system is to be used, it is preferred that this layer be at least partially transparent. Depending upon the substrate and photoconductor used, the insulating material may be chosen for good adhesion properties to these materials. Typical insulating materials include polyolefins such as polyethylene and polypropylene; vinyl and vinylidene polymers such as polystyrene, polyvinyl acetate, and polyvinyl carbazole; fluocarbons such as polytetrafluoroethylene, and polyvinyl fluoride; polyamides such as polycaprolactam; polyesters such as polyethylenetriethylate; polyurethanes; polypeptides such as caseine, polysulfides; polysulfones; polycarbonates; cellulosic polymers such as viscose, phenolic resins such as phenol formaldehyde resins; phemenol resins; polyester resins; proxy resins; silicone resins; alkyl resins; curane resins; and mixtures and copolymers thereof.

For highest sensitivity, a small amount of a sensitizing additive may be incorporated in the insulating interlayer. With many resins, merely allowing a small amount of residual solvent to remain in the insulating layer after it is coated is sufficient to impart sufficient sensitivity to the system. Also, suitable organic photoconductors or, with aromatic resins, Lewis acids may be used to enhance sensitivity. Generally, the sensitizer may make up about 30 to 70 percent by weight of the insulating layer. Typical organic photoconductors include triphenyl amine; 2,4-bis(4,4'-diethylaminophenyl) - 1,3,4 - oxadiazole; 2,5-bis(p-aminophenyl)-1,3,4-oxadiazole; triphenyl pyrrol; 4,5-diphenylimidazolidinone; 2 - mercapto - benzthiazole; 2-phenyl-4-alpha-naphthylidene-oxazolone; 3-amino carbazole; 2-phenyl-4-(4'-dimethyl aminophenyl)-7-methoxyquinazoline and mixtures thereof.

Typical aromatic resins which may be sensitized with suitable Lewis acids include epoxy resins, phenoxy resins, polycarbonates, phenolics, polystyrenes, polysulfones, polyphenylene oxide and mixtures and copolymers thereof.

Typical Lewis acids include 2,4,7-trinitro-9-fluorenone; 2,4,5,7-tetranitro-9-fluorenone; picric acid; 1,3,5-trinitrobenzene; chloranil; 4,4-bis(dimethyl amino)-benzophenone; tetrachlorophthalic anhydride; benzanthracene-7,12-dione and mixtures thereof.

The photosensitive overlayer may comprise any suitable photoconductive material. Selenium is a preferred material because of its relatively high sensitivity, good adhesion to plastic substrates and substantial transparency in very thin layers. Typical photoconductive materials include selenium (both vitreous and crystalline), sulfur, anthracene, zinc oxide, zinc sulfide, cadmium sulfide, cadmium selenide, lead iodide, lead chromate, and mixtures thereof. Typical organic photoconductive material include phthalocyanine; 1,2,5,6-di(C,C'-diphenyl)-thiazole-anthroquinone; 1-(4'-methyl-5'-chloroazobenzene-2'-sulfonic acid)-2-hydroxy-3-naphthoic acid; quinacridones; and those listed above.

The photoconductive layer may be homogeneous or may comprise the photoconductor dispersed in an insulating binder, where desired. Typical binders would include the insulating materials listed above.

It is preferred for highest resolution that the photoconductive material may be coated directly onto the surface of the intermediate layer or may be dispersed in a binder and coated over the intermediate layer. It should be noted that materials which are ordinarily thought of as too conductive to be used in a single component photoconductive layer may be used in the thin photoconductive layer of this invention where suitable.

The novel electrophotographic plate and imaging process of this invention will be further understood upon reference to the drawings wherein:

FIG. 1 shows a section through a plate according to this invention,

FIG. 2 shows a schematic representation of a reflex imaging process utilizing the electrophotographic plate of this invention, and

FIG. 3 shows comparative sensitivity curves for plates of the prior art and of this invention.

Referring now to FIG. 1 there is seen a supporting substrate 1 which, in this exemplary instance, is glass. On the surface of the supporting substrate is a layer of conductive material 2 which, in this exemplary instance, is tin oxide. Such tin oxide coated glass members are generally available from the Pittsburgh Plate Glass Company under the name "NESA glass." Alternatively, supporting substrate 1 and conductive layer 2 could be combined in the form of a homogeneous conductive material such as aluminum. On the surface of conductive layer 2 is a relatively thick layer of organic insulating material 3. On the surface of insulating layer 3 is a relatively thin photoconductive layer 4.

Insulating layer 3 may be formed on conductive substrate 2 by any conventional methods. Typical coating methods include spraying, dip-coating, Mayer bar draw down, roll coating, electrostatic deposition, and any desirable combination of these.

The photoconductive layer 4 may be coated onto insulating layer 3 by any suitable method. Vacuum evaporation is an especially desirable method for coating materials such as selenium. Powdered photoconductors may be applied to the insulating layer 3 by first coating a thin layer of oil thereover and then cascading the powder against the oiled surface. Where the photoconductor is in solution the suspension may be coated onto the surface by any suitable method.

FIG. 2 shows a schematic representation of a reflex imaging method especially suitable for use with the plate of FIG. 1. As shown in FIG. 2(a) the plate is first given a uniform electrostatic charge. Here, a corona discharge unit 5 is passed across the surface of the plate laying down a uniform positive charge on the plate surface. Typical corona discharge processes are described by Carlson in U.S. Pat. 2,588,699. Alternatively, the plate could be charged triboelectrically as described by Carlson in U.S. Pat. 2,297,691, by means of a roller held at a high potential as described by Gregay et al. in U.S. Pat. 2,980,834 or by means of a conductive liquid at a high potential as described by Walkup in U.S. Pat. 2,987,600. Any suitable charging means may be used.

The charged plate is then exposed in a reflex mode as shown in FIG. 2(b). An original 6 to be copied is placed face down on the charged surface of the plate. Dark, light absorbing original image areas 7 are in contact with the plate. Uniform light is then directed through the substrate 1 against the original 6. Light striking areas 7 is absorbed. Light striking the original sheet 6 between areas 7 is reflected back into the photoconductive layer. The quantity of light imposed is regulated so that light passing through the photoconductive layer 4 to impinge on original 6 is not quite enough to discharge the photoconductor. However, when in background areas the reflected light is added to the originally impinging light, the photoconductive layer 4 is discharged. The discharge appears to be by charge injection from photoconductive layer 4 into and through insulating layer 3. Thus, while the areas may not be discharged to the substrate, the charge is far enough below the surface of photoconductor 4 so as to not generate very strong fields in the air above the surface of layer 4. This results in an electrostatic latent image on the surface of photoconductive layer 4 corresponding to the original; surface charge remaining only in those areas corresponding to opaque areas 7.

The latent electrostatic image may then be developed by any suitable means. Typical development methods include cascade development as described by Walkup in U.S. Pat. 2,618,551; fluidized bed development as described by Mott et al. in U.S. Pat. 3,008,826; liquid development as described by Mayer et al. in U.S. Pat.

2,897,133; magnetic brush development as described by Giamo in U.S. Pat. 2,930,351; powder cloud development as described by Carlson in U.S. Pat. 2,221,776 and any desirable combination thereof. In the schematic representation shown in FIG. 2(c), electroscopic marking particles 8 are cascaded across the photoconductive layer 4 from container 9. Particles which contact the charged areas of photoconductive layer corresponding to original image areas 7 are attracted and held to the surface. Other particles pass on and are caught in container 10.

After development, the plate is heated to the melting temperature of the electroscopic marking particles 8 or the melting temperature of the insulating layer to fuse the particles to the plate. FIG. 2(d) shows the final imaged plate. The developed image at 11 consisting of particles fixed to the surface corresponds to original image 7. Alternatively, instead of fixing the powdered image to the surface to the plate, the particles could be transferred to a receiving sheet, such as paper as by the method described in Schaffert, U.S. Pat. 2,576,047. The particles would then be fused to the paper and the photoconductive plate could then be reused as in the above described process.

As can be seen from the above description of the schematically represented process, this is a simple process eliminating complex optical systems. Uniquely, this system is capable of using photoconductors, such as selenium, which in the ordinarily used thicknesses are insufficiently transparent for reflex imaging. Despite the extremely thin photoconductive layers used, these plates have surprisingly high photosensitivity as will be seen from the examples below.

FIG. 3 is indicative of the surprising sensitivity of the plate of this invention. Three plates are prepared as described in Example XIV below. Each plate is charged and exposed. Sensitivity measurements indicate that a plate having a thin photoconductive layer over a relatively thick substantially insulating layer (Curve A) is much more sensitive than the same photoconductive layer alone on a conductive substrate (Curve B) and has sensitivity comparable to a photoconductive layer as thick as the photoconductive and insulating layers of the plate of the present invention (Curve C). Also, the charge acceptance of the thin selenium layer when used alone has very low charge acceptance, as indicated by Curve B. In FIG. 3, potential on the plate is indicated on the vertical axis, while time in seconds after initial charging is indicated along the horizontal axis. As can be seen from each curve, there is a sharp drop in potential upon exposure to light which is turned on after 7 seconds. The greater and more rapid the potential dissipation, the more sensitive the plate.

The following examples will further define the invention with respect to the novel electrophotographic plate and imaging process. Parts and percentages are by weight unless otherwise indicated. Examples below should be considered to illustrate various preferred embodiments of the present invention.

#### Example I

Initially, a xerographic plate is prepared. About 10 parts of Staybelite 5, a glycerol ester of hydrogenated rosin available from the Hercules Powder Company is dissolved in about 50 parts of toluene. The solution is coated onto the conductive surface of a NESA glass sheet (tin oxide coated glass available from Pittsburgh Plate Glass Company). The resin is dried onto the plate surface and has a dry thickness of about 4 microns. A layer of vitreous selenium is then vacuum evaporated onto the resin surface to a thickness of about 0.2 micron by the process described by Bixby in U.S. Pat. 2,970,906. The thus formed plate is then uniformly electrostatically charged to a positive potential of about 450 volts by corona discharge means as described by Carlson in U.S. Pat. 2,588,699. The charged plate is exposed to an orig-

7

inal by projection using a conventional black-and-white transparency. Exposure is by means of a tungsten lamp about 10 inches from the plate. Exposure is about 10 foot candle seconds. The latent electrostatic image resulting on the plate is then developed by cascading electroscopic marking particles comprising a pigmented resin across the plate, as described by Walkup in U.S. Pat. 2,618,551. The powder image is then transferred to a paper receiving sheet and fused thereon, as described by Schaffert in U.S. Pat. 2,576,047. An excellent image corresponding to the original is observed on the paper sheet.

#### Example II

A second xerographic plate is prepared as in Example I except that here the Staybelite 5 resin layer has a dried thickness of about 2 microns and the selenium layer has a thickness of about 0.1 micron. This plate is charged to a positive potential of about 470 volts, exposed and developed as in Example I. Here, the toner image is fused directly to the plate. A good image corresponding to the original results.

#### Example III

The xerographic plate is first prepared. On the conductive surface of a NESA glass sheet, a layer of Staybelite 5 having a dried thickness of about 4 microns is formed. The surface of the resin film is moistened with a thin film of Dow No. 200 fluid, a silicone oil available from the Dow Chemical Company. Cadmium sulfide powder, available from the Radio Corporation of America under the trade name RCA 2103 is then cascaded over the plate surface. This plate is then charged by corona to a positive potential of about 400 volts. The plate is then electrometered. Dark decay is found to be negligible. Upon exposure to white light, the potential on the plate is observed to rapidly decay by about 130 volts.

#### Example IV

A xerographic plate is prepared as in Example III above except that in place of the cadmium sulfide powder the resin surface is coated with a layer of powdered Rhodamine B, a fluorescent dye chemically described as 9-(O-carboxyphenyl)-6-(diethylamino) - 3 - xanthene-3-ylidene-diethyl-chloride, available from E. I. du Pont de Nemours & Company. The plate is charged by corona to a positive potential of about 400 volts. Upon exposure to white light, the potential of the plate is observed to rapidly decay by about 200 volts.

#### Example V

A plate is prepared as in Example III above except that in place of the cadmium sulfide powder the resin surface is coated with powdered zinc oxide. (Florence Green Seal #8, available from New Jersey Zinc Company). This plate is charged to a positive potential of about 380 volts by corona discharge means. Upon exposure to white light, the plate is observed to rapidly discharge to a potential of about 150 volts.

#### Example VI

A plate is prepared as in Example III above except that in place of the cadmium sulfide powder is used a metallic selenium powder. This plate is charged by corona to a positive potential of about 550 volts. Dark decay is found to be about 15 volts per second. Upon exposure to white light, the plate is observed to discharge about 100 volts in one second.

#### Example VII

A xerographic plate is first prepared. About 10 parts polyvinyl chloride is dissolved in about 30 parts methyl ethyl ketone. This solution is dip coated onto the conductive surface of a NESA glass sheet to a dry thickness of about 2 microns. Onto the surface of the polyvinyl chloride is then evaporated a 0.2 micron layer of amor-

8

phous selenium. This plate is then charged to a positive potential of about 750 volts. The plate is then electrometered. Dark decay is found to be negligible. Upon exposure to a 4000 angstrom light the potential on the plate is observed to decay by about 120 volts in about 0.2 second.

#### Example VIII

A plate is prepared as in Example VII, except that in place of the evaporated selenium layer the surface of the polyvinyl chloride is coated with a layer of RCA 2103 cadmium sulfide powder dispersed in a gelatin binder. This plate is charged to a positive potential of about 620 volts. The plate is then electrometered. Dark decay is found to be negligible. Upon exposure to white light, the potential on the plate is found to decay to nearly zero volts.

#### Example IX

A xerographic plate is prepared as follows. About 10 parts VYNS, a vinyl chloride-vinyl acetate copolymer available from the Union Carbide Corporation, is dissolved in about 30 parts methyl ethyl ketone. To this solution is added about 2 parts 2,5-bis-(p-amino phenyl)-1,3,4-oxadiazole, available from Kalle & Company. This solution is dip coated onto the conductive surface of a NESA glass substrate to a dry thickness of about 4 microns. On the resin surface is evaporated about a 0.5 micron layer of amorphous selenium. As a control, a second plate is prepared by evaporating a 7 micron layer of amorphous selenium directly onto the conductive surface of a NESA glass substrate. Each plate is then corona charged to a positive potential of about 700 volts. Each plate is then exposed using a 4000 angstrom monochromatic light. The light decay curve starting at about 700 volts continues down to about 160 volts residual and then levels out. It is noted that the light decay slope is equal for each of the two plates. Thus, it is seen that a very thin layer of selenium over a sensitized resin layer has equal photosensitivity to a much thicker layer of amorphous selenium.

#### Example X

About 8 parts zinc oxide powder (Florence Green Seal #8) is placed in about 20 parts methanol. To this mixture is added about 0.03 part Rhodamine B. The methanol is then evaporated off, leaving the Rhodamine B adsorbed onto the surface of the zinc oxide. A sheet of 5 mil Mylar (polyethylene terephthalate available from E. I. du Pont de Nemours & Company), having a thin layer of aluminum on the surface is coated with a solution of Staybelite Ester 10 (a glycerol tri-ester of 50% hydrogenated wood resin, available from the Hercules Powder Company) in toluene to a film thickness of about 2 microns. The dyed zinc oxide particles are then cascaded across the surface to form a substantially uniform layer about 1 micron thick. The plate is then heated to about 65° C. to cause the zinc oxide particles to sink into the resin surface slightly and adhere thereto.

The thus formed electrographic plate is charged to a negative potential of about 150 volts. The plate is then exposed to white lights; total exposure being about 80 foot-candle-seconds. Electrometer measurements indicate a potential drop due to light exposure of about 80 volts continuing with further exposure beyond 80 foot-candle-seconds to zero volts.

#### Example XI

An electrophotographic plate is prepared as in Example III, except that in place of the cadmium sulfide the plate surface is coated with finely divided Monolite Fast Blue GS, a mixture of the alpha and beta forms of metal-free phthalocyanine, available from the Arnold Hoffman Company. The plate is charged to a negative potential of about 180 volts by corona discharge means. The plate is then exposed to a 4000 angstrom lamp. Electrometer

measurements indicate a loss in potential due to light exposure of about 80 volts in about 1.5 seconds continuing with more exposure to zero volts.

#### Example XII

A xerographic plate is prepared as follows. About 10 parts polyvinyl carbazole is dissolved in about 20 parts benzene. To this solution is added about 0.5 part 2,4,7-trinitro-9-fluorenone. The conductive surface of a NESA glass substrate is coated with this solution to a dry thickness of about 3 microns. About a 0.1 micron layer of amorphous selenium is then evaporated onto the resin surface. This plate is then charged to a positive potential and electrometered. Low dark decay is observed. The plate is then exposed to white light. The charge on the plate is observed to rapidly decay to a low potential.

#### Example XIII

A plate is prepared as in Example XII. The plate is then uniformly electrostatically charged to a positive potential of about 450 volts by corona discharge means. The charged plate is then placed in face-to-face contact with a sheet of paper having black images on the surface. The plate is then exposed through the NESA substrate to the light from a Number 1 Xerox camera for 10 seconds. The original is then separated from the selenium surface and electroscopic marking particles are cascaded across the selenium surface. A powder image is observed corresponding to the original. The powder image is electrostatically transferred to a paper receiving sheet and heat fused thereon. An excellent image corresponding to the original results. The plate is then reused with another original as by the above described process.

#### Example XIV

Three xerographic plates are prepared as follows. The first plate consists of about a 4 micron layer of Staybelite 5 on the conductive surface of NESA glass. A 0.1 micron layer of vitreous selenium is formed over the resin layer. The second plate consists of a 0.1 micron layer of selenium on the conductive surface of a NESA glass sheet. The third plate consists of a 4.1 micron layer of vitreous selenium on a NESA substrate. Each of these plates is uniformly charged by means of a corona discharge unit held at about 6000 volts. Dark decay of these plates is measured for a few seconds and then each is exposed to a tungsten lamp. Electrometer curves for these plates are shown in FIG. 3. As indicated by the curves, the composite plate of this invention (curve A) accepts a potential of about 420 volts and has excellent sensitivity, comparable to that of the thick selenium plate (curve C). The thin selenium layer, when used alone (curve B) has very low charge acceptance, less than 20 volts, and low sensitivity.

Although specific components and proportions have been described in the above examples, other suitable materials and conditions as listed above, may be used with similar results. In addition, other materials may be added to the photoconductive layer and to the insulating inter layer to synergize, enhance, or otherwise modify their properties. For example, the layers may have various electrical and dye sensitizers added thereto if desired.

Other modifications and ramifications 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. An imaging process comprising the steps of:

- (a) providing an electrophotographic plate comprising a layer comprising a substantially insulating organic resin having a thickness of from about 0.5 to about 50 microns and overlying said insulating layer a photoconductive layer having a thickness of less than about 1 micron;

(b) substantially uniformly electrostatically charging said photoconductive layer;

(c) exposing said electrophotographic plate to an image wise pattern of activating electromagnetic radiation to form an electrostatic latent image on the free surface of said photoconductive layer according to said electromagnetic radiation.

2. An imaging process comprising the steps of:

(a) providing an electrophotographic plate comprising a layer comprising a substantially insulating organic resin having a thickness of from about 0.5 to about 50 microns and overlying said insulating layer a photoconductive layer having a thickness of about .2 micron;

(b) substantially uniformly electrostatically charging said photoconductive layer;

(c) exposing said electrophotographic plate to an image wise pattern of activating electromagnetic radiation to form an electrostatic latent image on the free surface of said photoconductive layer according to said electromagnetic radiation.

3. The process as defined in claim 1 wherein said insulating resin layer has a thickness of from about 2 to 4 microns and said photoconductive layer has a thickness of from about 0.1 to 0.2 micron.

4. An imaging process comprising the steps of:

(a) providing an electrophotographic plate comprising a conductive substrate, a layer comprising a substantially insulating organic resin overlying said substrate, said layer having a thickness of from about 2 to 4 microns and a photoconductive layer overlying said insulating layer, said photoconductive layer having a thickness of from about 0.1 to less than about 1 micron, said plate being at least partially transparent;

(b) substantially uniformly electrostatically charging said photoconductive layer;

(c) bring said charged photoconductive layer into face-to-face contact with an original to be reproduced;

(d) exposing said photoconductive layer and original to activating electromagnetic radiation through said plate; and

(e) separating said original from said photoconductive layer.

5. An imaging process comprising the steps of:

(a) providing an electrophotographic plate comprising a conductive substrate, a layer comprising a substantially insulating organic resin overlying said substrate, said layer having a thickness of from about 2 to 4 microns and a photoconductive layer overlying said insulating layer, said photoconductive layer having a thickness of from 0.1 to about .2 micron, said plate being at least partially transparent;

(b) substantially uniformly electrostatically charging said photoconductive layer;

(c) bring said charged photoconductive layer into face-to-face contact with an original to be reproduced;

(d) exposing said photoconductive layer and original to activating electromagnetic radiation through said plate; and

(e) separating said original from said photoconductive layer.

6. An imaging process comprising the steps of:

(a) comprising a first layer comprising a substantially insulating organic resin having a thickness of from about 0.5 to 50 microns, said first layer comprising polyvinyl carbazole and overlying said insulating layer a photoconductive layer having a thickness of from about 2 to 4 microns;

(b) substantially uniformly electrostatically charging said photoconductive layer;

## 11

- (c) exposing said electrophotographic plate to an image wise pattern of activating electromagnetic radiation to form an electrostatic latent image on the free surface of said photoconductive layer according to said electromagnetic radiation. 5
7. An imaging process comprising the steps of:
- (a) providing an electrophotographic plate comprising a conductive substrate, a first layer having a thickness of from about 0.5 to about 50 microns comprising a substantially insulating organic resin overlying said substrate and a photoconductive layer having a thickness of less than about 1 micron overlying said insulating layer said first layer comprising polyvinyl carbazole, said plate being at least partially transparent; 10
- (b) substantially uniformly electrostatically charging said photoconductive layer; 15
- (c) bringing said charged photoconductive layer into face-to-face contact with an original to be reproduced; 20
- (d) exposing said photoconductive layer and original to activating electromagnetic radiation through said plate; and
- (e) separating said original from said photoconductive layer. 25
8. An imaging process comprising the steps of:
- (a) providing an electrophotographic plate comprising a conductive substrate, a layer having a thickness of from about 0.5 to about 50 microns comprising a substantially insulating organic resin overlying said substrate and a photoconductive layer having a thickness of less than about 1 micron overlying said insulating layer, said photoconductive layer being selected from the group consisting of selenium, phthalocyanine, cadmium sulfide, 9-(o-carboxyphenyl)-6-(diethylamino)-3-xanthene-3-xylylidine - diethyl chloride, zinc oxide, and mixtures thereof, said plate being at least partially transparent; 30

## 12

- (b) substantially uniformly electrostatically charging said photoconductive layer;
- (c) bringing said charged photoconductive layer into face-to-face contact with an original to be reproduced;
- (d) exposing said photoconductive layer and original to activating electromagnetic radiation through said plate; and
- (e) separating said original from said photoconductive layer.
9. An imaging process comprising the steps of:
- (a) providing an electrophotographic plate comprising a conductive substrate, a layer having a thickness of from about 0.5 to about 50 microns comprising a substantially insulating organic resin overlying said substrate and a photoconductive layer having a thickness of less than 1 micron overlying said insulating layer said photoconductive layer comprising phthalocyanine, said plate being at least partially transparent;
- (b) substantially uniformly electrostatically charging said photoconductive layer;
- (c) bringing said charged photoconductive layer into face-to-face contact with an original to be reproduced;
- (d) exposing said photoconductive layer and original to activating electromagnetic radiation through said plate; and
- (e) separating said original from said photoconductive layer.

## References Cited

- UNITED STATES PATENTS
- 2,297,691 10/1942 Carlson ----- 96—1.5
- CHARLES E. VAN HORN, Primary Examiner
- U.S. Cl. X.R.
- 96—1.5, 1.8