REFLEX XEROGRAPHY

Filed Aug. 26, 1955

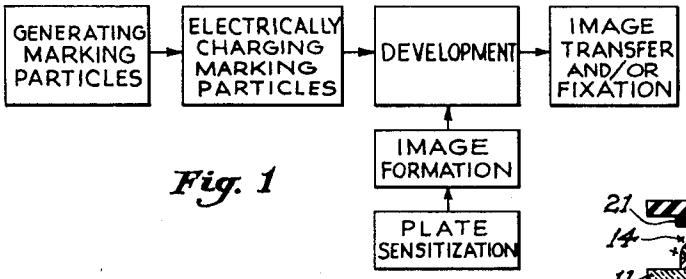


Fig. 1

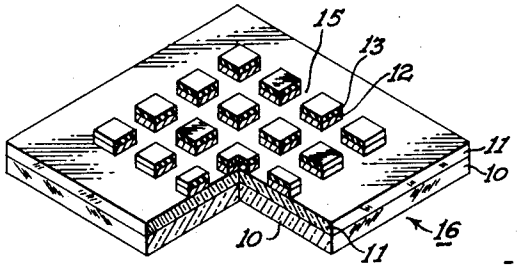


Fig. 2

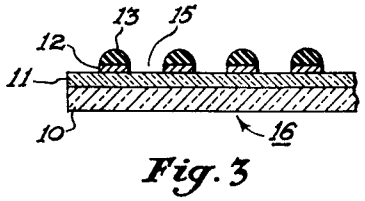


Fig. 3

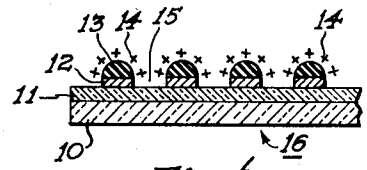


Fig. 4

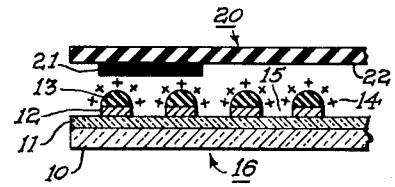


Fig. 5

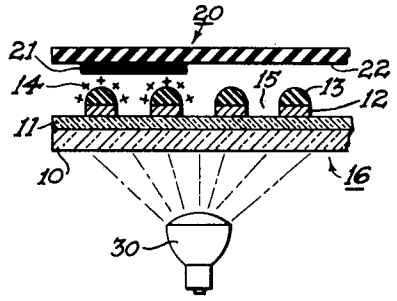


Fig. 6

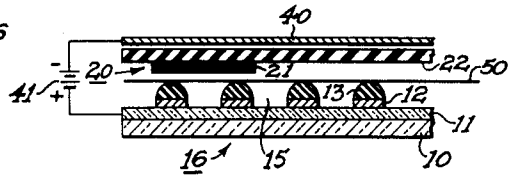


Fig. 7

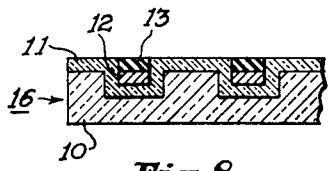


Fig. 8

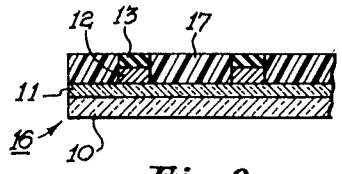


Fig. 9

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United States Patent Office 2,917,385
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2,917,385

REFLEX XEROGRAPHY

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Application August 26, 1955, Serial No. 530,700

14 Claims. (Cl. 96—1)

This invention relates to xerography and particularly to a xerographic plate and a method of using it.

In xerography it is usual to form an electrostatic latent image on a surface. One method of doing this is to charge a photoconductive, insulating surface and then dissipate the charge selectively by exposure to a pattern of activating radiation. Other means of forming electrostatic latent images are set forth in U.S. 2,647,464 to James P. Ebert. Whether formed by these means or any other, the resulting electrostatic charge pattern is conventionally utilized by the deposition of an electroscopic material thereon through electrostatic attraction whereby there is formed a visible image of electroscopic particles corresponding to the electrostatic latent image. Alternatively, the electrostatic charge pattern may be transferred to an insulating film and the electroscopic particles deposited thereon to form the visible image. In any case, this visible image, in turn, may be transferred to a second surface to form a xerographic print.

Previously it has not been possible to utilize the xerographic process with reflex-type exposure. The mechanism of conduction in a photoconductive material in general involves the liberation of holes or electrons (depending on the material) due to absorption of light quanta. Thus, in the thicknesses generally used for photoconductivity the photoconductive layer is relatively opaque. Further, any illumination of sufficient intensity to penetrate the photoconductive layer would be sufficient itself to discharge any electrostatic charge placed on the photoconductive layer in a sensitizing process irrespective of any additional radiation reflected back to the photoconductive surface from any image surface as in a reflex system.

However, a reflex system has many advantages over other reproduction methods. The reflex principle is used in many processes in the graphic arts field. Two of the main reasons are the savings possible—savings of money and space. In a reflex system lenses are not necessary. Lenses of good optical quality are expensive. Their elimination is an appreciable saving. Further, placing the copy either in contact with the plate or almost so rather than at a distance determined by the focal length of the lens system makes possible substantial reductions in space requirements with consequent increased flexibility of design.

There has now been discovered a novel image bearing member which now makes possible reflex copying in a xerographic system. For a better understanding of this invention, reference is now directed to the following description taken in connection with the accompanying drawings. The scope of my invention will be pointed out in the appended claims.

Fig. 1 of the attached drawings is a block diagram showing the position of the development step in an overall xerographic process which results in a visible image;

Fig. 2 is an isometric drawing of a xerographic plate embodying features of the present invention with a cut-away section to facilitate illustration of the construction of the plate;

Fig. 3 is a fragmentary cross section of the plate of Fig. 2;

Figs. 4, 5, and 6 are similar views of a cross section of Fig. 2 illustrating the formation of an electrostatic image thereon according to one embodiment of the invention; and

Fig. 7 is a fragmentary cross section of apparatus according to another embodiment of the invention.

Fig. 8 is a fragmentary cross section of a xerographic plate according to another embodiment of the invention.

Fig. 9 is a fragmentary cross section of a xerographic plate according to still another embodiment of the invention.

The present invention contemplates a xerographic plate comprising a transparent or translucent conductive support for a pattern of opaque conductive material, each opaque pattern portion itself being covered by a layer of a photoconductive insulating material and a method of xerography in which the exposure of the xerographic plate is accomplished by passing light through the backing of the plate. The exposure of the plate is preferably accomplished by reflection of light from the sheet to be copied and the invention contemplates within its scope a new method of xerography embodying such a mode of exposure.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the construction of parts without departing from the spirit of the invention. In the following descriptions and in the claims, parts will be identified by specific names if convenient but they are intended to be as generic in their application as similar parts of the art will permit. For greater ease in comprehension, where the same part appears in more than one figure the same number will be applied thereto in each figure.

As shown in Fig. 1, the general xerographic process involves the formation of an electrostatic image. This is generally, although not always, preceded by a treatment to sensitize the surface on which the electrostatic image is to be formed. The electrostatic image to be useful must then be rendered visible, which is done in a development step. This is accomplished by depositing electroscopic particles either on the surface on which the image was formed or on an insulating surface to which the electrostatic image has been transferred. The basic xerographic process is set forth in some detail in U.S. Patent 2,297,691 to Chester F. Carlson.

In the preferred method of reflection copying of the present invention the transparent or translucent xerographic plate is electrically charged to provide a resident charge on the surface of the photoconductive insulating pattern and the plate is then placed against the sheet to be copied with the photoconductive insulating pattern facing the sheet. Light is then passed through the plate from behind and the opaque conducting pattern prevents the light from illuminating, and therefore discharging, the photoconductive insulating material which overlies only the opaque conducting material. The light passes through the transparent or translucent interstices in the opaque pattern to illuminate the surface of the sheet to be copied. Where the light strikes a black area of the sheet it is largely absorbed. However, in the white areas of the sheet a portion of the light is reflected into the photoconductive material overlying the opaque conductive pattern. Since the photoconductive insulating material is rendered conductive by illumination, the portions of the photoconductive material receiving reflected light from the white areas of the sheet being copied are partly or fully discharged. There is thus left on the plate a series

of charged areas only where black areas appear on the sheet being copied. After exposure the plate is developed by depositing a finely-divided electrostatically attractable material as described, for example, in the above-mentioned Carlson patent or in U.S. Patent 2,618,552 to E. N. Wise. Alternatively, the paper, plastic or other material on which it is desirable to place the visible image may itself be placed in contact with the xerographic plate bearing the electrostatic image and the electrostatically attractable material deposited directly thereon thereby obviating the necessity for transferring the developed image from the plate to the paper as well as eliminating having to clean the plate.

Referring to Figs. 2 and 3, the xerographic plate **16** illustrated therein comprises a transparent sheet backing **10** such as a plate of glass or of transparent plastic material such as polystyrene, polymethyl methacrylate, cellulose acetate or other similar transparent sheet material. The plate may be sufficiently thick and rigid to be substantially non-flexible, or the backing **10** may, if desired, be flexible enough to permit bending, rolling, or winding the plate. Backing **10** may itself be conductive or, as here, be coated with a transparent conductive layer **11**, such as tin oxide on a glass backing. On top of the transparent conductive layer **11** is placed a pattern of opaque conductive material **12** such as aluminum, silver, etc. For convenience this pattern will be termed a dot pattern although it is understood that no limitation is placed on the geometrical shape of the individual particles of the pattern. On top of the individual dots **12** of the opaque conductive material is placed a coating of a photoconductive insulating material **13** such as selenium, sulfur, anthracene, etc. The dot pattern desirably has between 100 and 500 or more dots per linear inch and the number preferably exceeds 200 per inch. In the drawing the size of the dots has been exaggerated to more clearly depict their structure. While the opaque conductive material **12** is shown as being broken up into a dot pattern by both horizontal and vertical separations **15**, if desired the opaque material **12** may be divided only by parallel lines running either horizontally, vertically, or diagonally. In this case the "dot" pattern would be in the form of parallel lines of opaque conductive material. In the preferred embodiment the opaque material is divided both horizontally and vertically, the width of each opaque particle being substantially equal to the spacing between particles.

Dot patterns may be applied to the plate in several ways. One method comprises placing against the face of conductive coating **11** a mask having a dot pattern therein as is used in making color TV tubes or a mask comprising merely a frame supporting a series of fine parallel wires. The assembly is then placed in a vacuum and a metal such as aluminum, silver, lead, tin, copper, or the like is evaporated onto the layer **11** until a sufficiently non-transparent layer is built up between the interstices of the mask. The evaporation of the metal is then stopped and a photoconductive insulating material such as selenium, sulfur, anthracene, or mixtures thereof, evaporated on top of the opaque metal coating. The photoconductive insulating coating may be anywhere from a few microns to a few hundred microns thick. When the desired thickness has been attained air is admitted and the mask removed to leave the dot pattern on the plate. Desirably the plate **10** is positioned on a platen which maintains the assembly at a fixed temperature during deposition. For deposition of selenium a temperature of about 60° to 80° C. is desirable.

Another method of applying a dot pattern comprises spraying onto the plate a suspension of finely divided opaque conductive material as graphite, metal, or other material, with a resin binder in a solvent for the binder such as alcohol using the mask previously described. The photoconductive insulating material may also be applied in a resin binder, thus eliminating the necessity for vacuum apparatus.

A further method comprises placing on layer **11** first a uniform coating of opaque conductive material followed by a uniform coating of photoconductive material either by vacuum evaporation or by solvent application of a finely ground dispersion in a resin binder. The plate then has parallel lines engraved into the transparent conductive coating **11** using a mechanical engraver. The groove can also be formed in the plate by chemical etching, using a masking material such as a wax coating to cover the intervening spaces.

Another method of forming the grid comprises again applying uniform layers of opaque conductive metal and photoconductive material followed by coating the photoconductive material with a thin layer of bichromated gelatin and exposing to an optical image of the grid after which the non-exposed intervening material is removed. The areas not protected by the hardened gelatin are then removed by chemical etching after which the hardened gelatin is removed, as by hot water.

If desired the dot pattern instead of extending above the surface of the plate as shown in Figs. 2 and 3 may be countersunk into the surface to give a smooth-faced plate. This may be done by etching or pressing hollows which are filled with layers **12** and **13**. Such a plate is shown in Fig. 8. A smooth-faced plate has obvious advantages such as improved cleanability, etc. The process for using such a plate is of course the same as that described for the plate of Figs. 2 and 3.

Where the photoconductive material is applied in a resin binder, not only may materials such as selenium, sulfur, anthracene, etc. in a finely ground condition be used, but also photoconductive phosphors such as zinc oxide, zinc sulfide, cadmium sulfide, cadmium selenide, mixtures thereof, lead iodide, lead chromate, etc. Suitable resin binders include vinyl resins, silicones, cellulose esters and ethers, natural resins such as shellac, etc. Inorganic binders such as sodium silicate may also be used.

Figs. 4, 5, and 6 illustrate a method of operation using such a plate. As shown in Fig. 4, a uniform electrostatic charge is first placed on the photoconductive insulating material, thereby sensitizing the plate. Any means of doing this known to those skilled in the art may be used. Examples are frictional charging as disclosed in the above Carlson patent, and applying an ion current as from a corona generating means as in U.S. 2,705,675 to W. E. Bixby or from a radioactive source in the presence of an electrostatic field as in U.S. 2,701,764 to Chester F. Carlson. The plate is now sensitized and must be kept in the dark. The distribution of electrostatic charges **14** is as shown in Fig. 4. Next a sheet of copy to be reproduced **20** having thereon a dark image area **21** and a white non-image area **22** is placed against the sensitized photoconductive insulating layer as shown in Fig. 5. In general the copy should be placed close enough to the plate so that spreading of the reflected light does not seriously affect image quality. Light now illuminates the plate from a suitable source **30**, as a light bulb. The light passes through the transparent backing **10**. Where a light ray hits the opaque material **12** it is reflected. In the areas between the opaque dots **12**, nothing reflects the light and, accordingly, it passes through the open areas **15** in the dot pattern and illuminates the copy **20**. Where the light strikes the dark image areas **21**, it is absorbed thereby. Thus, the photoconductive dots immediately underneath the dark image areas are not discharged and retain their electric charge. Where the light strikes the white non-image areas **22** of the copy **20** a portion of the light is reflected and scattered, thereby striking the photoconductive material **13**. Wherever the photoconductive material is struck by light it is rendered conductive, thereby permitting the charge on the surface thereof to pass through into the opaque conductive portion of the dot pattern **12** and in turn to the transparent

conductive layer **11**. After exposure, there will be a distribution of charge on the plate as shown in Fig. 6, wherein the image areas **21** represent charged areas on the plate and non-image areas **22** are represented by plate areas having no electrostatic charge thereon.

This electrostatic image is then rendered visible by depositing electrostatically attractable material thereon as shown either in U.S. 2,297,691 or U.S. 2,618,552, or any other means known to those skilled in the art. Alternatively, the paper or plastic on which it is desired to place a visible image may be placed directly on the plate surface bearing the electrostatic latent image. The electrostatically attractable material is now deposited directly on the surface of the paper or plastic underlying the xerographic plate. This eliminates the necessity of cleaning the plate when development takes place directly on the plate and makes possible the preparation of multiple copies from one electrostatic image. The electrostatic image may also be transferred to a sheet of insulating material such as polyethylene terephthalate and developed thereon.

For better image quality, it is desirable to position a conductive electrode, as either a continuous conductive surface or a grid of conductive material as wires, relatively closely to the surface of the paper or plastic. This conductive grid, termed a "development electrode," is desirably grounded and will act to pull the lines of force externally above the electrostatic image-bearing surface, thereby facilitating the deposition of developer particles. Spacing desirably should be no more than ½ inch from the image bearing surface and preferably no more than about $\frac{1}{40}$ inch or less, whatever minimum spacing is permitted by the system selected for deposition of electroscopic powder.

Where the developer has a resin base as in U.S. 2,618,552, it may be fixed to the paper or other record material by fusing as by sufficient temperature to melt the resin and cause it to adhere to the paper, or by application of solvent vapors to tackify the resin. Where the developer particles consist of dye particles, they may be fixed to the paper by dampening the paper. Spraying the paper with a selective coating as an acrylic resin, shellac, or the like, also may be used. Other means of fixing the visible image will at once be obvious to those skilled in the art.

Fig. 7 shows an alternative embodiment of the present invention. A plate having a dot pattern as shown in Figs. 2 and 3 has a sheet of copy placed in contact therewith as shown in Fig. 5. Unlike Fig. 5, there is no prior sensitization of the xerographic plate to apply a uniform electrostatic charge to the photoconductive material. In back of the copy **20** is placed a conductive electrode **40**. A source of potential is then applied between electrode **40** and the transparent conductive layer **11**. With this voltage applied, the copy is then illuminated by passing light through the transparent plate **10**. The light which passes through the interstices **15** in the opaque pattern is reflected back to the photoconductive dots of the white non-image areas causing charge to flow in those areas only. Where the light strikes the dark image areas **21**, no light is reflected, the photoconductive dots immediately thereunder are not rendered conductive, and no current flows. In the non-image areas, however, with the polarity of charge as shown applied between **11** and **40**, positive charge will flow to the top of the photoconductive material **13**. When the illumination is turned off, a positive charge will then be trapped in the non-image areas of the xerographic plate. This gives a negative electrostatic image of the original copy. Where oppositely charged developer particles are used to develop the image, a negative visible image will be developed. Where developer particles having the same polarity as the image are used, a positive visible image will be obtained. If desired the copy may be omitted and uniform illumination applied. This will result in uniform sensitization of the plate. The copy is then positioned, exposed, and the plate developed as in Figs. 5 and 6.

Where the sheet to be copied **20** has undesirable electrical properties so as to cause lateral conductivity on the face of the xerographic plate, it may be necessary to place a thin transparent insulating material **50**, as a film of polyethylene terephthalate, between the copy and the plate.

This method of forming an image shown in Fig. 7 also makes possible the utilization of the type of smooth-faced plate shown in Fig. 9. The plate is similar to that shown in Figs. 2 and 3 except that the interstices **15** between the dots are filled with any transparent or translucent insulating material **17** such as polystyrene, sodium silicate, vinyl resins, cellulose esters and ethers, urea-formaldehyde resins, silicones, etc. The material **17** must be transparent or translucent enough to permit the light to reach the copy. In case the material **17** is applied in such a manner as to cover all or part of the dots, the plate may be subjected to a careful grinding or polishing if it is desired to have a surface consisting of alternate areas of material **17** and photoconductor **13**. If desired, however, a layer of transparent insulating material either the same as or different from that used for **17** may be applied to cover the photoconductor **13** with a protective coating a few microns (say 3–15) thick. Such a layer would protect the photoconductor from abrasion and thereby extend the life of the plate. The use of the process of image formation illustrated in Fig. 7 with the plate of Fig. 9 eliminates the problem of the charge placed on material **17** by prior sensitization with a corona.

While the present invention has been described herein as carried out in specific embodiments thereof, there is no desire to be limited thereby, but it is intended to cover the invention broadly within the spirit and scope of the appended claims. Thus the novel xerographic plates described herein while particularly adapted to a reflex copying system are not necessarily limited thereto but may be utilized in a regular xerographic copying process.

I claim:

1. A xerographic plate comprising as an integral member a continuous solid support having a uniform pattern of finely-interspersed transparent and opaque areas, at least the opaque areas being electrically conductive, a photoconductive insulating material coated on and covering only said opaque areas so that illumination through said support passes through said plate in one direction without activating said photoconductive insulating material, and means to apply a ground potential to each of the conductive opaque areas in said support layer, said plate being adapted to be electrostatically charged on the surface of said photoconductive insulating material, and uniformly illuminated through said support while a facsimile copy contacts said photoconductive insulating material.

2. A xerographic plate as claimed in claim 1 in which said means to apply a ground potential comprises having as said support a transparent electrically conductive material.

3. A xerographic plate as claimed in claim 1 in which said support is a transparent insulating material in which said means to apply a ground potential comprises a uniform layer of transparent electrically conductive material coated on said support.

4. A xerographic plate as claimed in claim 1 in which said opaque electrically conductive areas having thereon a photoconductive insulating material are recessed into the surface of said plate so that the said plate is smooth faced.

5. A xerographic plate as claimed in claim 1 in which the areas between said opaque electrically conductive areas having thereon a photoconductive insulating material are filled with a transparent material so that the said plate is smooth faced.

6. A xerographic plate as claimed in claim 1 in which

the photoconductive insulating material is vitreous selenium.

7. A xerographic plate comprising as an integral member a continuous support having a uniform pattern of finely interspersed transparent and discontinuous, discrete opaque areas, at least the opaque areas being electrically conductive, a photoconductive insulating material coated on and covering only said opaque areas so that illumination through said support passes through said plate in one direction without activating said photoconductive insulating material, and means to apply a ground potential to each of the conductive opaque areas in said support layer, said plate being adapted to be electrostatically charged on the surface of said photoconductive insulating material, and uniformly illuminated through said support while a facsimile copy contacts said photoconductive nisulating material.

8. A xerographic plate as claimed in claim 7 in which said opaque conductive areas are composed of metal.

9. A xerographic plate as claimed in claim 7 in which said opaque electrically conductive areas are composed of a finely-ground opaque electrically conductive material dispersed in a binder.

10. A xerographic plate as claimed in claim 7 in which the photoconductive insulating material is vitreous selenium.

11. A method of xerography which comprises electrostatically charging the surface of a layer of photoconductive insulating material arranged in a dot pattern on a light transmitting electrically conductive support, contacting said surface with a facsimile original to be copied, uniformly illuminating said layer so as to project light through said layer onto said facsimile original whereby the differential reflection of light from said original creates an electrostatic charge pattern on said photoconductive insulating material corresponding to said copy, cutting off said light, removing said layer from said original, positioning an electrically insulating sheet on said surface, and depositing a finely-divided, electrostatically attractable material on said sheet in conformity with said electrostatic image.

12. A process according to claim 11 including the added step of drawing the lines of force of said electrostatic image externally through said sheet while depositing said electrostatically-attractable material.

13. A method of xerography which comprises placing an electrically insulating transparent pellicle on the surface of a layer of photoconductive insulating material arranged in a dot pattern on a light-transmitting electrically conducting support, placing a facsimile original to be copied on said pellicle facing said surface, positioning an electrically conductive electrode on the side of the original not in contact with said pellicle, connecting a source of potential between said conductive support and said conductive electrode, uniformly illuminating said layer so as to project light through said support and said pellicle onto said original while said potential source is connected, the differential reflection of light from said original creating an electrostatic charge pattern on said photoconductive insulating material corresponding to said original, then cutting off said light, removing said original from contact with said pellicle and depositing finely-divided electrostatically attractable material on said pellicle in conformity with said electrostatic image.

14. A process according to claim 13 including the added step of drawing the lines of force of said electrostatic image externally through said sheet while depositing said electrostatically-attractable material.

References Cited in the file of this patent

UNITED STATES PATENTS

2,026,292	Van der Grinten	Dec. 31, 1935
2,051,583	Van der Grinten	Aug. 18, 1936
2,297,691	Carlson	Oct. 6, 1942
2,572,497	Law	Oct. 23, 1951
2,599,542	Carlson	June 10, 1952
2,672,416	Stanton	Mar. 16, 1954
2,673,153	Talbot	Mar. 23, 1954
2,725,304	Landrigan	Nov. 29, 1955
2,727,808	Thomsen	Dec. 20, 1955
2,764,693	Jacobs et al.	Sept. 25, 1956
2,803,542	Ullrich	Aug. 20, 1957
2,808,328	Jacob	Oct. 1, 1957
2,833,648	Walkup	May 6, 1958

OTHER REFERENCES

Van der Grinten: The Photographic Journal, vol. LXXVII, September 1938, pages 579–583. (Copy in Sci. Libr.)

Wainer: Phot. Eng., 1952, vol. 3, No. 1, pages 12 to 22. (Copy in Science Library.)