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L. CORRSIN

3,238,041

RELIEF IMAGING OF PHOTORESPONSIVE MEMBER AND PRODUCT

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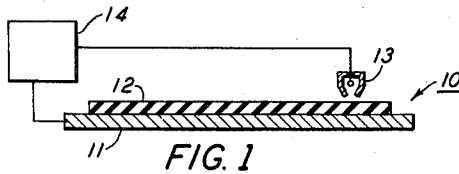


FIG. 1

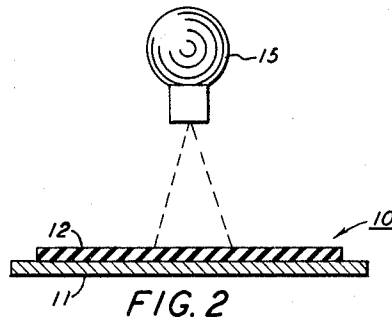


FIG. 2

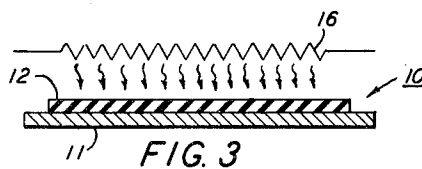


FIG. 3

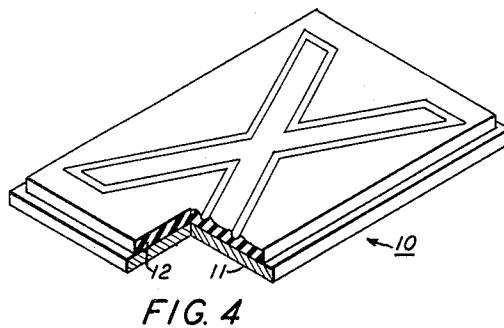


FIG. 4

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RELIEF IMAGING OF PHOTORESPONSIVE MEMBER AND PRODUCT

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This invention relates to xerography and more particularly to novel electrostatic methods of forming visible patterns in response to optical images.

In the usual forms of xerography an electrostatic latent image is formed by the combined action of an electric field and a pattern of light and shadow on a photoconductive insulating layer. The latent image is immediately, subsequently, or in some cases, simultaneously, converted into a visible image by the selective attraction, repulsion, or redistribution in image configuration of finely divided solid or liquid particles.

A variety of xerographic methods are known which generally conform to the above description and which enjoy widespread commercial use as well as being fully described in various patents and other publications. Methods are also known in which an image is electrostatically reproduced as surface deformations in a continuous layer of material, but such methods have required high vacuum systems to form the image or have required the use of separate and distinct layers of deformable materials in addition to the other materials and structures heretofore required in xerography.

Now in accordance with the present invention there is provided a new form of xerography in which an electrostatic pattern is made visible by the selective deformation in image configuration of a photoconductive insulating layer itself. It is accordingly an object of the invention to provide a xerographic reproduction system in which images are made visible without the use of any additional materials beyond those required to form an electrostatic latent image. It is a further object to provide xerographic systems in which a plurality of images may be formed in sequence on a single xerographic plate. These and other objects will become apparent from the following description and the drawings in which:

FIG. 1 is a schematic representation of charging a xerographic plate;

FIG. 2 is a schematic representation of exposing a xerographic plate;

FIG. 3 is a schematic representation of softening a xerographic plate; and,

FIG. 4 is a perspective view of a partially sectioned view of a plate carrying an image according to this invention.

FIG. 1 shows electrostatic charging of xerographic plate 10 comprising a support member 11 (which may be omitted in some cases), and a layer of photoconductive insulating material 12 coated thereover. Support member 11 is generally and preferably an electrical conductor or a supported electrically conductive layer in contact with photoconductive insulating layer 12. It may thus comprise in accordance with conventional xerographic usage such materials as aluminum, brass or other metals, metallized paper or paper with a relatively high moisture content, glass with a transparent or other conductive coating, or like known layer. Support layer 11 may comprise a non-conductor as is taught in the art in which case some of the manipulations described herein are modified in accordance with the knowledge of the art. Layer 12 may comprise any of a number of the photoconductive insulating materials known to be useful in the art of xerography. Layer 12 is generally characterized as being a good electrical insulator capable of maintaining a surface charge in the dark, but becoming substan-

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tially more conductive when illuminated by visible light, X-rays, or other forms of activating radiation. In accordance with the present invention, layer 12 should additionally be capable of being softened, preferably temporarily softened, by the application of heat, solvent vapors, or other means without permanent damage to its electrical properties. Suitable materials include vitreous selenium, dispersions of photoconductive pigments such as zinc oxide in softenable resins, or other electrically insulating binder materials as well as various organic photoconductor materials in the form of homogeneous layers, micro-crystalline layers, or dispersions in other insulating materials. Layer 12 may have a thickness lying in the range generally employed in xerography, i.e., from a thickness on the order of one micron up to a thickness of several hundred microns. Layer 12 will be described at greater lengths subsequently, but for present illustrative purposes only, it may be considered to be a layer of vitreous selenium 20 microns in thickness.

As is further shown in FIG. 1, plate 10 is electrostatically charged by moving it relative to a corona charging device 13 which is connected to a high voltage power supply 14. Corona charging devices are well known in the xerographic art and suitable ones are described, for example, in U.S. Patents 2,777,957 and 2,836,725. Other methods of applying a uniform potential onto an insulating surface are known and may be employed. In accordance with conventional xerographic practice, a potential of several hundred volts may be applied to plate 10. The polarity of applied charge may be either positive or negative depending upon the particular properties of layer 12. The next step is exposure of plate 10 to a pattern of light and shadow as illustrated in FIG. 2. Exposure may be made by means of a photographic enlarger 15 as illustrated, or in a camera, or by contact exposure or by other means. If support member 11 is transparent, exposure may be made through member 11 rather than in the manner illustrated. Where struck by light, photoconductive insulating layer 12 becomes electrically conductive and permits the charges at the surface thereof to be dissipated. There thus results on the surface of layer 12 a pattern of charge in image configuration and accordingly a pattern of electric field through layer 12 which is likewise in image configuration.

The next step is to temporarily soften photoconductive insulating material 12 so that it becomes altered in shape or surface configuration by the mechanical forces associated with the electrostatic pattern thereon. Any softening method may be employed, provided it does not excessively increase the electrical conductivity of layer 12 to cause the electrical charges thereon to rapidly leak away or become dissipated and provided it does not permanently damage layer 12. The most common methods of softening are either to expose layer 12 to an atmosphere of solvent vapors for the material of layer 12, or else to heat it. The latter method is illustrated in FIG. 3 wherein plate 10 is shown positioned beneath heating element 16. Where layer 12 comprises vitreous selenium as described, it will be appreciated that softening must be accomplished by heating rather than the solvent vapors since selenium is characterized by its resistance to nearly all common solvents. Selenium can instead be softened by temporarily heating it to a temperature of about 60° C. It has been found that heating to this temperature will not damage the selenium provided the time of heating is kept short. As the material of layer 12 is softened, it is enabled to flow in response to the electrostatic forces acting upon it and develops a deformed surface pattern which corresponds to the original pattern of light and shadow applied during the exposure step illustrated in FIG. 2. This pattern may be viewed by reflected light or by transmitted light where both support member 11 and

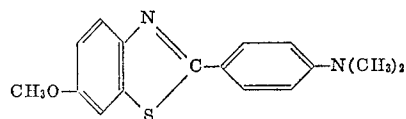
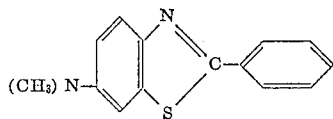
photoconductive insulating layer 12 are substantially transparent. Conventional methods of projection by transmitted light or specularly reflected light may also be employed.

The next processing step is generally to reharden layer 12, thereby freezing the deformed surface pattern in place. This can be accomplished, for example, by removing the source of heat, solvent vapor or the like, used to soften photoconductive insulating layer 12. It is generally desired to reharden layer 12 as soon as the image pattern appears. Excessive softening or excessive prolonged softening of layer 12 is also to be avoided because it may cause a loss of the image pattern. Excessive softening by heating is also to be avoided in order to minimize the risk of damage to photoconductive insulating layer 12.

Where a permanent image is required, the foregoing process steps complete the invention. Generally, however, it is desired to reuse plate 10 and it becomes necessary to erase the image therefrom. This can be done by employing the same procedures which may be used for softening layer 12 in the first place. Thus, layer 12 may again be heated or exposed to solvent vapors, preferably in the presence of light. The light causes dissipation of the electrical charges on layer 12 which softening layer 12 also permits diffusion and neutralization of the charges thereon and permits surface tension forces to restore the surface of layer 12 to a smooth condition. Where repetitive processing is contemplated, it is particularly important to keep dust particles away from layer 12 which otherwise may cause permanent artifacts to appear in the images formed on layer 12.

There is thus formed on a xerographic plate a visible image through physical manipulations performed upon the plate itself and without the use of any special inks, pigments, toners, plastics or other electrostatic image development materials. Various modifications of the foregoing procedures can also be employed. Thus, layer 12 may first be softened and then be subjected to charging and exposure before it has had a chance to reharden. It is also possible in accordance with known xerographic procedures, to expose the xerographic plate to a pattern of light and shadow at the same time that it is being electrostatically charged and while it is in a softened condition.

While the invention has been described illustratively in terms of a vitreous selenium photoconductive insulating layer, other materials may be employed and may be preferred. A particularly useful class of materials comprises organic photoconductors since they are generally solvent softenable as well as being able to withstand sufficient heat to be softened without the likelihood of suffering permanent damage thereby. Particularly useful materials are described in Canadian Patents 568,707; 586,057; 586,894; and 580,075. Another useful material comprises anthracene either in the form of a vacuum evaporated film or in the form of a slice from a single crystal. The so-called optical brighteners or optical bleaches comprise another useful class of materials. These are organic materials which absorb ultra-violet light and fluoresce in the blue region of the visible spectrum. They frequently also have photoconductive insulating properties. From the chemical standpoint, they are generally asymmetrical, sometimes unsymmetrical organic compounds with conjugated double bond structures, usually with terminal groups of benzocyclic or heterocyclic rings of aromatic character. Characteristically, they may have tertiary amino end groups in the para position. Structural formulas of several useful materials in this category are reproduced below.



Materials of this character are available, among other sources, from Geigy Chemical Corporation, Ardsley, New York. Useful materials from this source include Tinopal E-Tinopal SPG and particularly Tinopal PCR. This latter material is soluble in ethylene dichloride and a homogeneous coating may be formed by dipping, spreading or spraying an ethylene dichloride solution on a suitable surface or by evaporating the solid material directly onto a suitable support member 11.

Useful photoconductive insulating materials also comprise dispersions or suspensions of various photoconductive materials in deformable electrically insulating film forming binding materials. A particularly useful type of binder comprises a low molecular weight polystyrene such as Piccolastis A-75 available from the Pennsylvania Industrial Chemicals Company. Suitable photoconductors for use in such a dispersion include zinc oxide as well as the photoconductor grades of cadmium sulfide, zinc sulfide, or various other known photoconductive pigments. It is often desired to have layer 12 as nearly transparent as possible in appearance and where the layer comprises a dispersion of zinc oxide or the like in a binder, transparency of layer 12 can be improved by using a binder material with a high refractive index which approximates as closely as possible that of the zinc oxide or other pigment. This can be accomplished in a polystyrene binder, for example, by adding bromine or chlorine to the phenol groups of polystyrene material.

Deformable binder materials may also be used as a mixture for supporting dispersions of organic photoconductive materials as well as inorganic photoconductive pigments. Thus, for example, layer 12 may comprise a suspension of bis-1,3-diethylaminophenyloxadiazole in a low molecular weight polystyrene. Layer 12 may also comprise a mixture or dispersion in a deformable insulating binder of an optical brightener or a mixture of optical brighteners or other organic photoconductors, since the binder tends to inhibit the tendency toward crystallization found in certain of these materials. Further information on such mixtures of binders and photoconductors may be found in the aforementioned Canadian patents.

FIGURE 4 shows a typical image formed by the method of this invention. As shown in that figure, the image is formed in outline or "relief" by deformation of the photoconductor into valleys or depressions. It is presently believed that this outline deformation is caused by the effect of the rapid change of the electric field strength on the photoconductor at the edge of an image.

The term "xerographic plate" as used in this specification and the appended claims should be read in its broadest sense. Thus, xerographic plates of the chemographic type described in Canadian Patent 618,521 which are photolytic rather than photoconductive are also comprehended.

While the invention has been described in terms of certain specific materials, it is to be understood that these are given for illustrative purposes only, that other materials in accordance with the teachings of the invention will occur to those skilled in the art and there is accordingly no intention to limit the invention except in terms of the following claims.

What is claimed is:

1. The method of forming a photoexact reproduction of a light pattern comprising electrostatically charging a xerographic plate including a heat softenable photoconductive insulating layer of vitreous selenium, exposing said plate to said light pattern to form an electro-

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static image thereon, and heat softening said photoconductive insulating layer, whereby said layer is mechanically distorted in accordance with areas of high potential gradient in said electrostatic image.

2. The method of forming a photoexact reproduction in accordance with claim 1 including freezing said material in the deformed condition.

3. A xerographic plate bearing a photoexact reproduction of an original pattern, said plate comprising an electrically conductive mechanical support layer and coated thereover a photoconductive insulating layer of vitreous selenium, the surface of said photoconductive layer being mechanically deformed in accordance with the original pattern.

References Cited by the Examiner

UNITED STATES PATENTS

2,946,682	7/1960	Lauriello	96—1
2,985,866	5/1961	Norton	340—173

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3,055,006	9/1962	Dreyfoos et al.	96—1 X
3,063,872	11/1962	Boldebuck	117—211
3,095,324	6/1963	Cusano et al.	117—215
3,169,061	2/1965	Hudson	96—1

FOREIGN PATENTS

592,152	6/1960	Belgium.
598,591	12/1960	Belgium.
612,087	1/1962	Belgium.

OTHER REFERENCES

- Cross, "Deformation Image Processing" IBM Technical Discl. Bulletin, vol. 4, No. 7, December 1961, pages 35—36.
- 15 Selenyi, "Photography on Selenium," Nature, vol. 161, page 522, April 3, 1948, col. 1.

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