

[54] **METHOD OF TRANSFERRING
ELECTROSTATIC LATENT IMAGES
USING MULTIPLE
PHOTOCONDUCTIVE LAYERS**

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Related U.S. Application Data

[62] Division of Ser. No. 581,602, Sept. 23, 1966, Pat. No. 3,539,255.
[52] U.S. Cl.96/1, 96/1.5
[51] Int. Cl.G03g 5/04
[58] Field of Search.....96/1

References Cited

UNITED STATES PATENTS
3,394,002 7/1968 Bickmore96/1

3,477,846 11/1969 Weigl et al.96/1

OTHER PUBLICATIONS

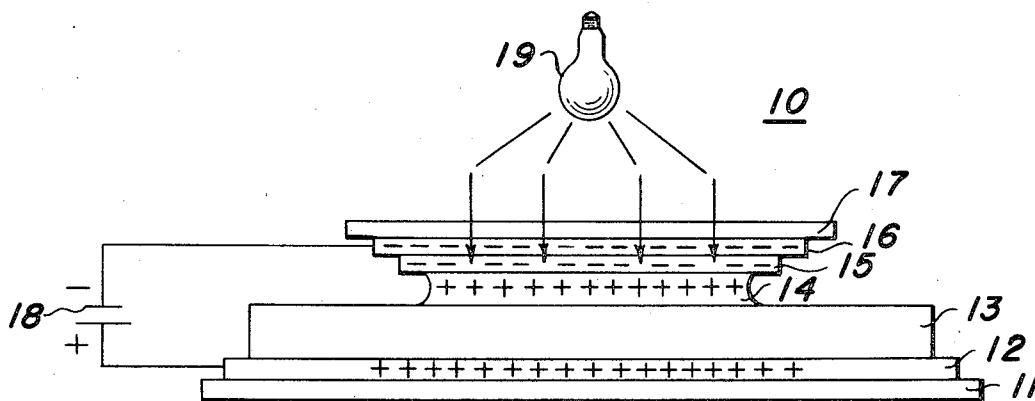
Schaffert, "Electrophotography," 1965, Focal Press Limited, pp. 25, 26, 89, 93, 96 and 185.

Primary Examiner—George F. Lesmes
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[57] **ABSTRACT**

A photosensitive element comprising a photoconductive light controlled storage layer and adjacent thereto a photoconductive multiplying layer which has an electric field placed across the two layers. The storage layer is exposed to uniform illumination and subsequently the multiplying layer is exposed to the image illumination. Following the cessation of exposure and removal of the charging field, the two layers are stripped apart and the storage layer developed by a conventional method.

4 Claims, 4 Drawing Figures



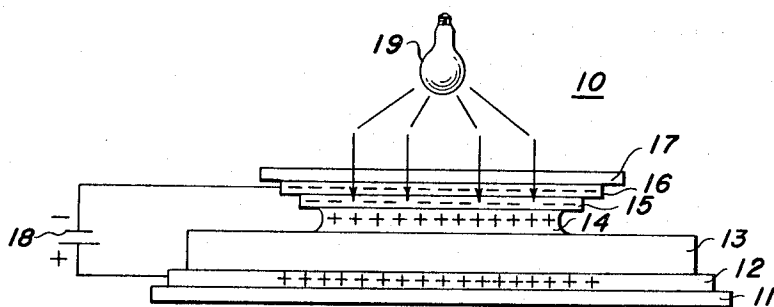


FIG. 1

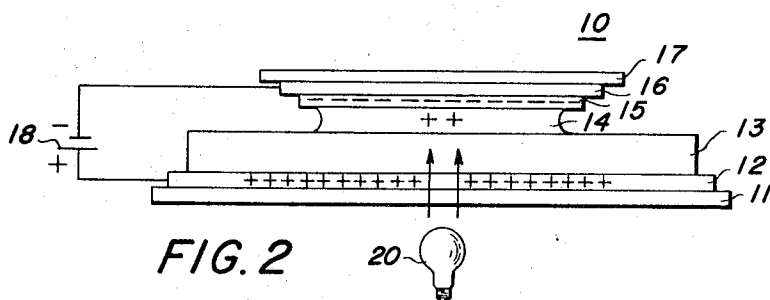


FIG. 2

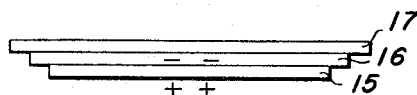


FIG. 3

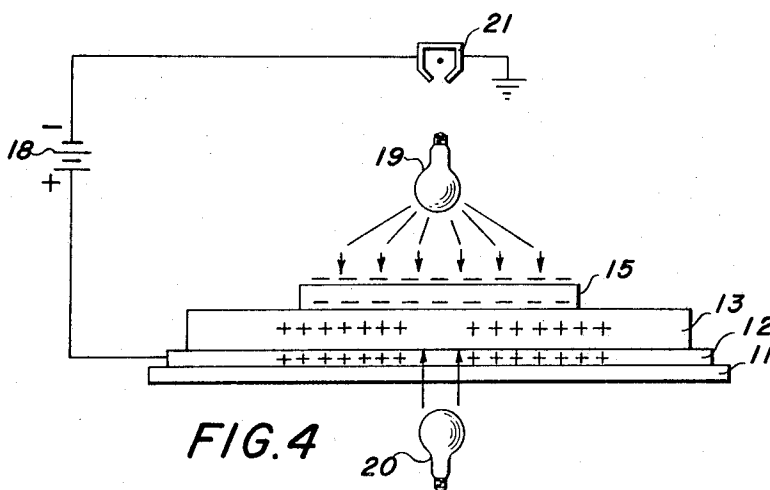


FIG. 4

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METHOD OF TRANSFERRING ELECTROSTATIC LATENT IMAGES USING MULTIPLE PHOTOCONDUCTIVE LAYERS

This application is a divisional of application, Ser. No. 581,602, filed Sept. 23, 1966 now U.S. Pat. No. 3,539,255.

This invention relates in general to the art of xerography, and in particular, to a novel photosensitive element.

In the art of xerography, a xerographic plate containing a photoconductive insulating layer is first given a uniform electrostatic charge in order to sensitize its surface. The plate is then exposed to an image of activating electromagnetic radiation such as light, X-ray or the like which selectively dissipates the charge in the illuminated areas of the photoconductive insulator, while leaving behind a latent electrostatic image in the nonilluminated areas. The latent electrostatic image is then developed or made visible by depositing finely divided electroscopic marking particles on the surface of the photoconductive insulating layer. This concept was originally disclosed by Carlson in U.S. Pat. No. 2,297,691, and is further amplified and described by many related patents in the field.

To a large extent vitreous selenium has become a standard photoconductor in commercial xerography. It has been discovered, however, that some of the limitations of vitreous selenium can be improved by the addition of alloying elements which enhance such properties as spectral response, light sensitivity, photoconductive stability, etc., U.S. Pat. Nos. 2,803,542 to Ullrich, and 2,822,300 to Mayer et al. both show the advantages of modifying vitreous selenium by the addition of appreciable amounts of arsenic in order to yield a broader range of spectral sensitivity, increase the overall photographic speed, and in general improve the stability of the photoconductive layer. In addition, U.S. Pat. No. 2,803,541 to Paris sets forth the advantage of added spectral response by the addition of tellurium to selenium to form a more panchromatic photo-receptor.

To a large extent commercial photoconductive layers are uniformly charged prior to image exposure through the use of a corona charging device such as that shown in U.S. Pat. No. 2,777,957 to Walkup.

In addition to the above-named photoconductors, binder plates comprising an inorganic or organic photoconductor dispersed in a substantially insulating binder such as that shown in U.S. Pat. Nos. 3,121,006 and 3,121,007 to Middleton et al. also are illustrative of conventional photoconductive materials known to the art. Certain photoconductors, such as for example vitreous selenium overlaid with a thin layer of selenium-tellurium, cadmium sulfide, and others, although having generally good photosensitivity, show a high dark current or dark decay when used in the conventional xerographic mode. In addition, these and other photoconductors exhibit an undesirable high background.

It is, therefore, an object of this invention to provide an improved photosensitive element which overcomes the above noted disadvantages.

It is another object of this invention to provide a photosensitive element which has substantially no background.

It is another object of this invention to provide an imaging system utilizing high dark current photoconductors.

It is a further object of this invention in which conventional type-charging methods may be eliminated.

It is yet another object of this invention to provide a novel photosensitive element.

The foregoing objects and others are accomplished in accordance with this invention by providing a photosensitive device comprising a photoconductive light-controlled-storage layer employed adjacent to a photoconductive multiplying layer. To form an image, an electric field is placed across the sandwich formed by the two photosensitive layers, and the storage layer exposed to uniform illumination. The illumination on the storage layer is then removed from the storage layer simultaneously with the start of imagewise illumination of the multiplying layer, with the image illumination and field being then simultaneously removed, leaving a charge pattern on the aforementioned storage layer. The storage layer and

multiplying layer are then stripped apart and the storage layer containing the charge pattern on its surface developed by any conventional technique.

Through the use of this technique, conventional type xerographic charging such as corona charging may be entirely eliminated, and in addition, it is possible to utilize high dark current photoconductors and operate them with quantum efficiencies above unity.

The advantages of the improved photosensitive storage layer will become apparent upon consideration of the following disclosure of the invention; especially when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic sectional view of one form of apparatus for carrying out the invention.

FIG. 2 is a schematic sectional view of the apparatus of FIG. 1 during exposure to imaging light.

FIG. 3 is a schematic sectional view of the storage layer portion of the apparatus of FIGS. 1 and 2.

FIG. 4 is a schematic sectional view of a second embodiment of carrying out the invention.

Referring to FIG. 1, reference character 10 designates a temporary sandwich configuration made up of a plate having a photoconductive multiplying layer and a separable storage layer overlaying said plate with a thin layer of charge transfer liquid disposed between said multiplying layer and said storage layer. The multiplying layer portion of said plate comprises a transparent backing 11 such as glass or plastic. Overlaying said transparent support member is a conductive base portion 12 comprising any suitable conductive substrate. Typical conductive substrates include metals such as copper iodide, aluminum, tin oxide, gold, and silver. The conducting layer over the transparent support member must be at least partially transparent, in order to allow light sources 19 and 20 to function effectively. Overlaying said conductive support is a photoconductive multiplying layer 13 which may comprise any suitable photoconductor. Typical photoconductors are: vitreous selenium, vitreous selenium undercoated with a more sensitive photoconductor such as an alloy of vitreous selenium and tellurium, and binder plate configurations such as those set forth in U.S. Pat. No. 3,121,006 to Middleton et al. Overlaying the multiplying layer is a thin layer of charge transfer liquid 14 such as silicone oil or fluorocarbons. Suitable liquids are silicone (polysiloxane) liquids, and the fluorocarbons FC-75, FC-76, FC-43 (Minnesota Mining and Manufacturing Co.). To improve their charge transfer capability by increasing their conductivity these charge transfer liquids are doped with such materials as bis (tributyl tin) oxide, trifluoroacetic acid, trifluoroethanol, and methyl trifluoroacetate. Other suitable liquids include: Octoil (Consolidated Vacuum Corp.), and flexol (Di2-ethylhexyl phthalate) Union Carbide and Carbon Corporation. The thickness of the liquid between the sandwiching layers is not particularly critical and may conveniently range from about 0.2 to 1 micron in thickness.

The thickness of multiplying layer 13 generally falls within the range of conventional commercially used photoconductors which range from about 10 to 50 microns in thickness, but may function at thicknesses greater or less than the above-mentioned range.

Overlaying the charge transfer liquid is a light control storage layer 15 which may consist of any conventional photoconductor such as vitreous selenium or a conventional photoconductor binder layer configuration such as that shown in the above-mentioned patent to Middleton et al. This storage layer is in general thinner than the multiplying layer below and ranges in thickness from about 1/2 to 4 microns. The light control storage layer 15 is backed with a conductive backing 16 which may comprise any conductive member such as that used for conductive backing 12. A transparent backing sheet 17 is used in back of conductive member 16 and may comprise any material such as that used in backing member 11 described above. If desired, the transparent backing members 11 and 17, may be eliminated entirely. Electrical circuit 18 provides a potential between the conductive substrates 12 and

16. A source of illumination for uniform control light through the back of the light control storage layer 15 is provided at 19.

In FIG. 2 the same apparatus as shown in FIG. 1 is again shown with a light source 19 removed and imaging light source positioned below multiplying layer 13.

In FIG. 3 storage layer 15 is illustrated showing a developable electrostatic charge pattern shown on its surface.

The operation of the device shown in FIGS. 1, 2 and 3 will now be described in detail.

In FIG. 1 a "constant potential" system is shown with the potential and the uniform control light turned on. The positive charge transferred to the storage layer as a result of sweep out and displacement dark current is not stored because of the high photoconductivity of the storage layer. After the dark current has settled to an equilibrium value, and the multiplying mechanism has become fully operative, the control light is turned off simultaneously with the image light being turned on. This point in the sequence is illustrated by FIG. 2 wherein the image light now being turned on the storage layer is no longer illuminated and becomes a good insulator and stores the charge transferred to it. When the light exposure has been completed, the applied potential is removed, the storage layer is then separated from the multiplying layer as shown in FIG. 3. The stored electrostatic charge image shown in FIG. 3 is then developed by conventional technique well known to the art.

In a modification of the imaging procedure described, the control light is also on during the image-light exposure. The intensity of the control light is chosen so that the photocurrent through the storage layer is equal to the dark current through the multiplying layer. Consequently, only the charge transferred as a result of the image light exposure is stored. In a further embodiment of this invention, the structure of device shown in FIG. 1, the storage layer is attached with a blocking contact directly to the top of the multiplying layer. In this configuration the oil is used between the upper electrode and the storage layer. The resulting constant potential system is operated in a manner similar to that previously described. In a further embodiment, as shown in FIG. 4, a corotron 21 is used in place of the upper electrode and its oil contact to the storage layer. This corotron is so designed that a constant potential is maintained between the top electrode and the conducting substrate of the multiplying layer during the image light exposure. The operation of this system is similar to those described above.

In a further modification of this embodiment, the liquid oil transfer medium 14 as shown in FIG. 1 may be replaced by an airgap which may range in thickness from about 0 to 25 microns.

The following examples further specifically define the present invention with respect to a method of forming an electrostatic image using a light control charged storage layer in conjunction with a conventional photoconductive multiplying layer. The parts and percentages in the disclosure, examples, and claims are by weight unless otherwise indicated. The examples below are intended to illustrate the various preferred embodiments of carrying out a method of forming an image using a light-controlled charge storage layer.

EXAMPLE I

The device of FIG. 1 in the drawings consisting of an image forming multiplying photoconductor layer of selenium 25 microns thick on a 35 percent tellurium-selenium alloy 0.1 microns thick is provided on a NESA substrate. A 1/16-inch glass base support is placed below the multiplying layer. A layer about 1/2 micron thick of 0.4 percent dibutyl tin dilaurate in 50cSt silicone liquid is placed between the multiplying photoconductor layer and an overlaying storage layer comprising a 4 micron thick layer of vitreous selenium having a backing of semitransparent aluminum on Mylar 25 microns in thickness, and being further backed with a 1/16 inch transparent glass plate. The device described above and as illus-

trated in FIG. 1 is imaged in the following manner: a potential of 400 volts is imposed on the circuit which connects the NESA and aluminized Mylar conductive coating. The NESA is maintained at a negative polarity. The potential is held at 400 volts, the voltage being pulsed for 1/2 to 1 second with the circuit simultaneously opening an exposure shutter which allows an imaging light source of 1,260 foot lamberts through an f/8 lens to contact the NESA plate supporting the selenium-tellurium photoconductor. The circuit is short circuited for one-fifth of a second after the voltage pulse is completed and the structure is then separated. A uniform control light supplying 1.5×10^{12} photons per second per cm^2 of 4,000 angstrom light is maintained on during the entire light pulse which lasts for one-fiftieth of a second. After separating the sandwich configuration a resulting electrostatic image of -120 volts is formed on the storage layer as measured with an electrometer probe. There is substantially zero background potential on the resulting stripped storage layer.

EXAMPLE II

The stripped storage layer containing the electrostatic image is then developed by cascading said layer with electroscopic marking particles. The image is then transferred to a sheet of paper and heat fused to form a permanent image having high quality and substantially no background.

EXAMPLE III

Using the device of Example I, with a storage layer of selenium 2 microns thick instead of 4 microns thick, on aluminized Mylar, the structure is imaged in the following manner: A source of potential of 400 volts is imposed between the conductive substrates with the NESA substrate being maintained at negative polarity. The imaging exposure time is one-twentieth of a second to a source of brightness of 650-foot lamberts full sun daylight. The lens is f/12.4 with the image light being directed to the selenium tellurium multiplying layer. The voltage pulse is for a period of one-fourth of a second with the shutter being simultaneously open with the voltage pulse. The circuit is short circuited for 1 second after the voltage pulse. The storage layer of selenium is exposed to 7×10^{11} photon seconds cm^2 of 4,000 angstrom light during the entire voltage pulse which lasts for one-fourth of a second. This results in an electrostatic image of -60 volts on the storage layer with substantially zero background potential.

EXAMPLE IV

The storage layer is then stripped away from the photoconductive layer and developed with electroscopic marking particles by the method set forth in Example II. This results in a high quality image having substantially no background.

Although specific components, proportions and procedures have been stated in the above description of a preferred embodiment of the novel imaging step employing a charged storage layer, other suitable materials, as listed above, may be used with similar results. In addition, other materials and procedures may be employed to synergize, enhance or otherwise modify the novel method and device described above.

Other modifications and ramifications of the present invention would appear to those skilled in the art upon reading of the disclosure. These are intended to be within the scope of the invention.

What is claimed is:

1. A method of imaging which comprises:

a. exposing a photoconductive vitreous selenium monolayer of an imaging device to a uniform control light, the first layer of said imaging device comprising a composite photoconductive layer which comprises vitreous selenium-tellurium overlaying a substantially transparent conductive support member with a second layer of vitreous selenium overlaying the selenium-tellurium layer, a photoconductive vitreous selenium monolayer having a substantially transparent conductive support member

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positioned behind said monolayer with said photoconductive monolayer and photoconductive composite layer contacting each other through a thin layer of charge transfer liquid, electrical means for inducing a potential between said conductive members, uniform light control means located above said photoconductive monolayer, and imaging light means located below said composite photoconductive layer, with said potential means and light means connected so as to allow for control of either or both illumination means with a voltage pulse, while

b. generating a potential between said conductive supports, and

c. exposing said composite photoconductive layer to a pattern of activating light simultaneously with a voltage pulse, whereby a latent electrostatic image is formed on

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said photoconductive monolayer when said voltage and both sources of light are turned off.

2. The method of claim 1 wherein the uniform control light is turned off immediately upon completion of the voltage pulse.

3. The method of claim 2 wherein the photoconductive monolayer is stripped away from the composite photoconductive layer and developed.

4. The method of claim 1 wherein a corotron is used in place of the conductive backing on the photoconductive monolayer, and further in place of the charge transfer liquid, so as to maintain a constant potential between the top electrode and the conducting substrate of the composite photoconductive layer during the image-light exposure.

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