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[54] **INFRARED SENSITIVE IMAGE RETENTION PHOTORECEPTOR**

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[52] **U.S. Cl.** ....**96/1 R,** 96/1.5, 250/65 ZE

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[58] **Field of Search** 96/1, 1.5; 252/501; 117/17.5, 117/201

[56] **References Cited**

UNITED STATES PATENTS

3,501,343	3/1970	Regensburger	117/215
3,427,157	2/1969	Cerlon	96/1.4

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[57] **ABSTRACT**

A photosensitive member which includes a layer of photoconductive vitreous selenium or selenium and arsenic containing thallium in a concentration of about 2 to 5,000 parts per million. The member is imaged by uniformly electrostatically charging the surface, followed by uniformly exposing the photoconductive layer to a source of visible radiation below the red portion of the visible spectrum. The member is then exposed to infrared radiation in the form of an image which results in the formation of a developable latent electrostatic image contained within the photoconductive layer.

9 Claims, 1 Drawing Figure

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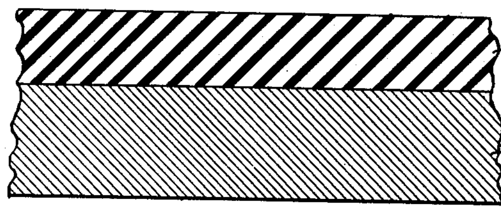

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INFRARED SENSITIVE IMAGE RETENTION PHOTORECEPTOR

BACKGROUND OF THE INVENTION

This application relates to xerography, and more specifically, to a novel method of imaging a photoconductive device.

In the art of xerography, a xerographic plate containing a photoconductive insulating layer is imaged by first uniformly electrostatically charging its surface. The plate is then exposed to a pattern of activating electromagnetic radiation such as light, which selectively dissipates the charge in the illuminated areas of the photoconductive insulator while leaving behind a latent electrostatic image in the non-illuminated areas. This latent electrostatic image may then be developed to form a visible image by depositing finely-divided electroscopic marking particles on the surface of the photoconductive insulating layer. This concept was originally described by Carlson in U.S. Pat. No. 2,297,691, and is further amplified and described by many related patents in the field.

When used in the conventional xerographic mode, a xerographic photoreceptor, which is normally in the form of a drum, is usually cycled through at least six basic steps. These include; (1) uniformly electrostatically charging the surface; (2) imaging the charged drum in the dark by exposure to a pattern of light which results in the formation of a latent electrostatic image on the drum surface; (3) developing the latent electrostatic image by cascading the drum with electroscopic toner particles which adhere to the drum surface to form a powder image; (4) transferring the powder image to a sheet of plain bond paper; (5) fusing the transferred image to the paper to form a permanent visible copy; and (6) cleaning the drum surface. In order to prepare the drum for a second duplicate image, all of the above six steps are employed a second time.

It can therefore be seen that if a photoreceptor drum is to be used in a high speed duplicating manner, where the same image is copied a plurality of times, each of the above six steps must be repeated when using the conventional xerographic imaging mode. In repeating the above six steps a great many times, the photoreceptor will exhibit gradual deterioration due to repeated exposure to light, chemical solvents, abrasion and heat. It can also be seen that the elimination of one or more of these steps would significantly increase the speed of the process and also add to the useful life of the drum.

An alternative method of xerography which uses special xerographic techniques, and usually a specially treated or constructed photoreceptor, involves the concept of persistent conductivity in the formation of useful images. Persistent conductivity may be defined as a latent image which exists as a state of electrical conductivity in a photoconductive layer, and persists as an after effect of the exposure radiation. An example of this phenomena is as follows: A photosensitive member which includes a layer of a suitable photoconductive insulator contained on a conductive substrate is exposed to an optical image in the form of a pattern of light. The exposed image area becomes more or less conductive depending upon the amount of light impinging on the photoconductive surface during the exposure step. This conductivity pattern in the exposed area persists in the dark after exposure, while on the other hand, the background or dark areas remain relatively nonconductive.

One way in which this concept may be used to form useful images is to first expose a photoconductive surface to an optical image which causes the formation of a latent conductivity image. Using a corona charging device, an electrical surface charge is then uniformly applied to the photoconductive surface. The areas previously exposed to light, which are of course conductive, dissipate the surface charge in the previously exposed areas, while the dark areas will retain a surface charge, thus forming an electrostatic image which is a reversal of the latent conductivity image. This electrostatic image may then be developed by any conventional developing technique used in xerography. One example of this technique is more fully defined in U.S. Pat. No. 3,427,157 in which a photoconductor which exhibits persistent conductivity comprises amorphous selenium containing about 0.001 to 5 weight percent thallium. In one embodiment, this structure is imaged by exposure to a pattern of light which forms a pattern of persistent conductivity on the photoconductor surface. The plate is uniformly charged to a negative polarity which results in a charge pattern being formed on the unexposed areas of the plate. The charge pattern is then developed with toner particles and the toner image transferred to a sheet of paper and fixed to form a permanent copy. In forming additional copies of the first image, the plate need only be charged again to retain a charge pattern in the unexposed areas. It can readily be seen that this technique, unlike conventional xerography, allows a great number of duplicate copies of an original to be made without re-exposing the photoconductor layer for each cycle of operation.

OBJECTS OF THE INVENTION

It is, therefore, an object of this invention to provide a novel method of imaging a photosensitive member.

It is a further object of this invention to provide an improved method of imaging suitable for duplicating.

It is another object of this invention to provide a novel method of forming a storage image within a photoconductive layer.

SUMMARY OF THE INVENTION

The foregoing objects and others are accomplished in accordance with this invention by providing a xerographic plate containing a vitreous selenium or selenium alloy layer containing less than one percent thallium. The plate is imaged by first charging to a positive potential, followed by exposing to imaging light in the visible region of the spectrum. This exposure must be in the range of about 4,000 to 5,500 Angstrom Units. At this point no surface charge remains on the photoreceptor. It is believed that the charge has been trapped within the bulk of the photoreceptor. The plate is then exposed to a source of infrared radiation in the form of the desired image. This exposure is in the range of about 0.75 **microns** (7,500 Angstrom Units) to 2.75 microns. This exposure results in the formation of a latent electrostatic image slightly below the surface of the photoreceptor in the areas not exposed to the infrared radiation. This latent image may then be developed with toner particles to form a visible image.

If desired, the toner image may be transferred to a sheet of paper and fixed to form a permanent copy of the image. After transfer of the toner image, the plate may be retoned without charging again to form a duplicate image which is transferred to a second sheet of paper. A plurality of duplicate images may be made in this manner. To form a second image, the plate is then uniformly exposed to a source of infrared radiation which discharges the plate completely making it ready for a second imaging cycle. Photoreceptors of this type have been found to be substantially insensitive to the visible portion of the spectrum.

BRIEF DESCRIPTION OF THE DRAWING

The advantages of the instant invention will become apparent upon consideration of the following disclosure of the invention, especially when taken in conjunction with the accompanying drawing, wherein:

The FIGURE represents a schematic illustration of one embodiment of a xerographic member as contemplated for use in the instant invention.

DETAILED DESCRIPTION OF THE DRAWING

In the drawing, reference character **10** illustrates one embodiment of an improved photoreceptor device of the instant invention. Reference character **11** designates a support member which is preferably an electrically conducting material. The support may comprise a conventional metal such as brass, aluminum, steel or the like. The support may also be of any convenient thickness, rigid or flexible, and in any suitable form such as a sheet, web, cylinder, or the like. The support may also comprise other materials such as metallized paper, plastic sheets covered with a thin coating of aluminum or copper iodide, or glass coated with a thin conductive layer of chromium or tin oxide. An important consideration is that the support member be somewhat electrically conductive, or have a conductive surface or coating, and that it be strong enough to withstand a certain amount of handling. Reference character **12** designates a photoconductive layer which is formed on support **11**. This photoreceptor comprises vitreous selenium containing a small, but critical amount of thallium. The thallium concentration is in the range of about 2 to 5,000 parts per million weight of the photoconductive layer. The selenium is a high purity xerographic grade material (about 99.999 percent pure) available from Canadian Copper Refiners. Vitreous selenium alloyed with a small amount of arsenic in the range of about 0.1 to 2.5 weight percent arsenic (balance selenium) is also suitable for use as a photoconductive layer in the instant invention.

The thickness of the thallium doped vitreous selenium layer is not particularly critical, and may vary from about 10 to 200 microns. Thicknesses in the range of 20 to 80 microns have been found to be particularly satisfactory.

The photoreceptor layer of the instant invention may be prepared by any suitable technique. A preferred technique includes vacuum evaporation under vacuum conditions varying from about 10^{-5} to 10^{-7} Torr.

The substrate onto which the photoconductive material is evaporated is maintained at a temperature of about 50° to 80° C. If desired, a water cooled platen or other suitable cooling means may be used in order to maintain a constant substrate temperature. In general, a selenium layer thickness of about 60 microns is obtained when vacuum evaporation is continued for about 1 hour at a vacuum of about 10^{-5} Torr. at a crucible temperature of about 280° C. U.S. Pat. Nos. 2,803,542 to Ullrich; 2,822,300 to Mayer et al.; 2,901,348 to Dessauer et al.; 2,963,376 to Schaffert; and 2,970,906 to Bixby all illustrate vacuum evaporation techniques which are suitable in the formation of the alloy layers of the instant invention. The crucibles which are used for the evaporation of the photoreceptor layers may be of any inert material such as quartz, molybdenum, stainless steel coated with a layer of silicon monoxide, or any other equivalent material. In general, the selenium or selenium alloy being evaporated is maintained at a temperature above about its melting point.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following examples further specifically define the present invention with respect to a method of making, testing, and imaging thallium doped selenium photoreceptors. The percentages in the disclosure, examples, and claims are by weight unless otherwise indicated. The following examples and data are intended to illustrate various preferred embodiments of the instant invention.

EXAMPLE I

A 50 gram sample of a vitreous selenium containing 100 parts per million by weight of thallium is placed in a silicon monoxide coated stainless steel crucible which is contained within a vacuum evaporation chamber. The vacuum chamber is then evacuated to a vacuum of about 10^{-5} Torr. A boat containing the thallium doped selenium is heated by raising the boat temperature to about 290° C while an aluminum drum about 3 inches in diameter and 9 inches long is rotated about 10 to 15 revolutions per minute 6 inches above the thallium doped selenium source. The crucible temperature is maintained for about 1 hour resulting in a 60 micron thick thallium doped selenium layer being formed on the surface of the aluminum drum. Following the vacuum evaporation, the chamber is cooled to room temperature, the vacuum broken, and the alloy coated drum removed from the chamber.

The photoreceptor drum is placed in a xerographic scanner and charged to a positive potential of 800 volts. The drum is then exposed to a cool white fluorescent lamp containing visible radiation in the range of about 4,000 to 6,500 Angstrom Units, which is believed to cause most of the surface charge to penetrate into the bulk of the photoreceptor. Using an electrometer probe, a reading of 755 volts positive potential is recorded as a stored positive space charge. A negative with an opaque dot pattern is then placed over the surface of the photoreceptor and exposed to an incandescent lamp which emits infrared radiation within the range of about 7,500 Angstrom Units to 2.75 microns. This exposure to infrared radiation results in the formation of a latent image within the bulk of the photoreceptor. The stored image is then developed using electroscopic marking particles and transferred electrostatically to a sheet of paper. The photoreceptor is then developed or retoned a second time. A total of five imaging cycles are made over the course of several minutes. The image remained stored in the photoreceptor film for more than 10 minutes.

EXAMPLE II

A second drum containing vitreous selenium having a thallium concentration of 50 parts per million by weight is vacuum coated onto an aluminum drum blank as in Example I. The electrical results are similar to those observed in Example I, except that the usable image persisted for more than 20 minutes. It was found that the drum was not sensitive to any part of the visible spectrum, however, when infrared filters are used, it was found that the photoconductor is sensitive to a band from about 0.75 micron (7,500 Angstrom Units) to 2.75 microns, indicating that the structure is suitable for infrared detection work.

Although specific components and proportions have been stated in the above description of the preferred embodiments of this invention, other suitable materials and procedures such as those listed above may be used with similar results. In addition, other materials and modifications may be utilized which synergize, enhance, or otherwise modify the photoreceptor layer.

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

What is claimed is:

1. A method of imaging which comprises:

a. providing a photosensitive member which includes a layer of photoconductive vitreous selenium containing thallium in a concentration of about 2 to 5,000 parts per million;

b. uniformly electrostatically positively charging the surface of said member;

c. uniformly exposing the photoconductive layer to a source of visible radiation below the red portion of the visible spectrum; and

d. exposing said member to infrared radiation in the form of an image resulting in the formation of a developable latent electrostatic image contained within the photoconductive layer.

2. The method of claim **1** in which the exposure in step (c) is in the range of about 4,000 to 5,500 Angstrom Units and the exposure in step (d) is in the range of about 0.75 to 2.75 microns.

3. The method of claim **1** in which the latent electrostatic image is developed to form a visible image.

4. The method of claim **3** in which the imaging and developing steps are repeated at least one additional time.

5. The method of claim **4** in which the member is uniformly exposed to infrared radiation after the development step which results in the latent electrostatic image being erased.

6. The method of claim **1** in which the photoconductive layer is contained on a supporting substrate.

7. The method of claim **6** in which the substrate is electrically conductive.

8. The method of claim **1** in which the photoconductive layer is about 10 to 200 microns in thickness.

9. The method of claim **1** in which the photoconductive layer comprises thallium doped vitreous selenium containing arsenic in a concentration of about 0.1 to 2.5 weight percent.

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