Sept. 14, 1965 R. M. GOLD 3,206,600

IMAGE-FORMATION ON ELECTROPHOTOGRAPHIC MATERIAL

Filed May 21, 1963 2 Sheets-Sheet 1

FIG. 1

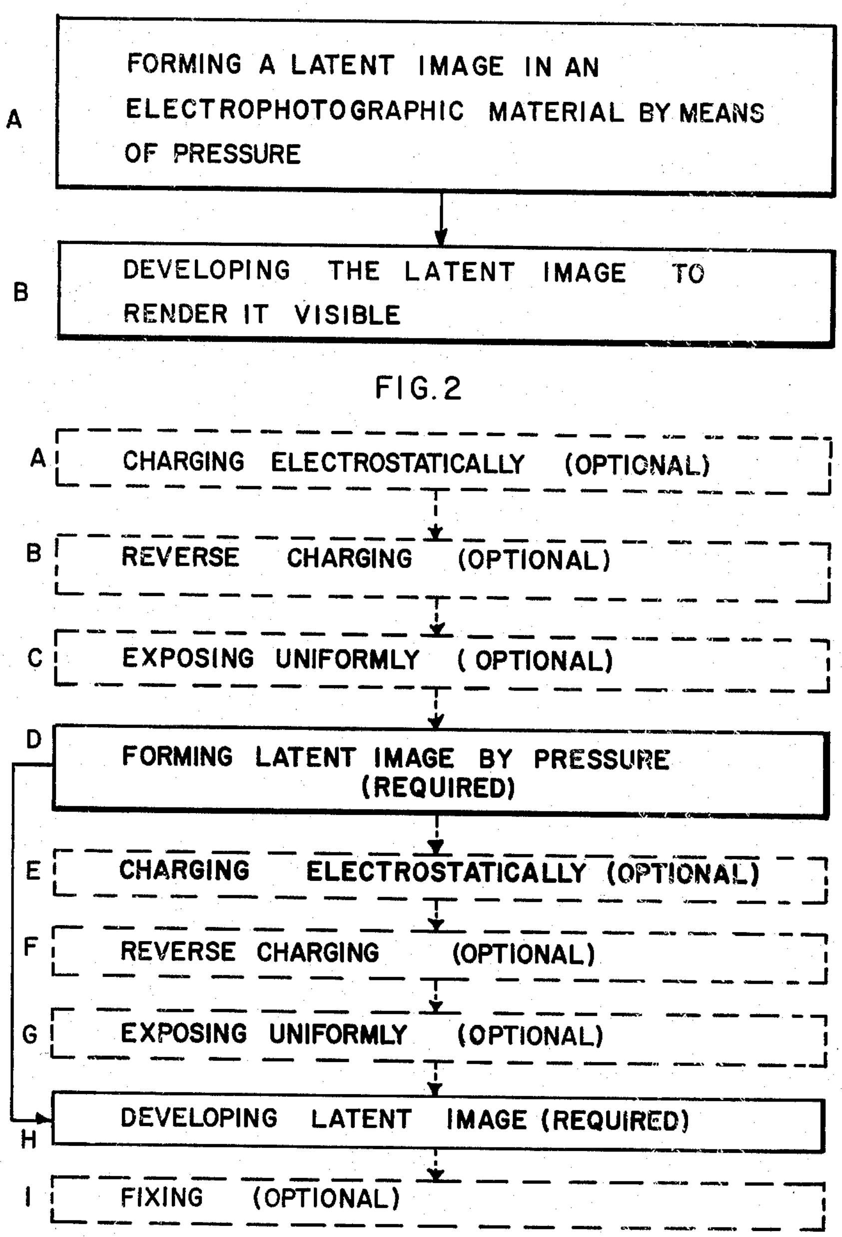

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FIG. 3A

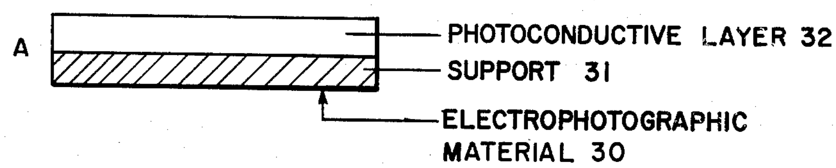

FIG. 3B

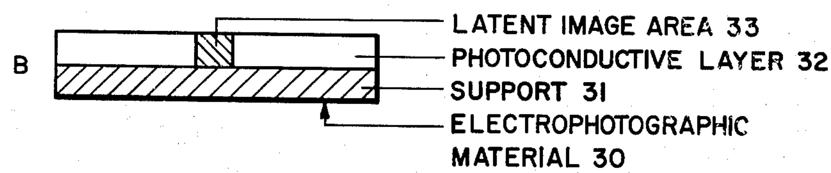

FIG. 3C

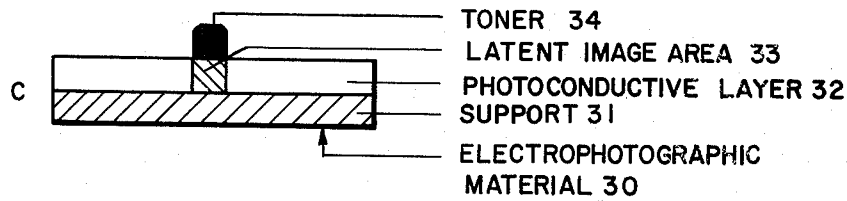

FIG. 3D

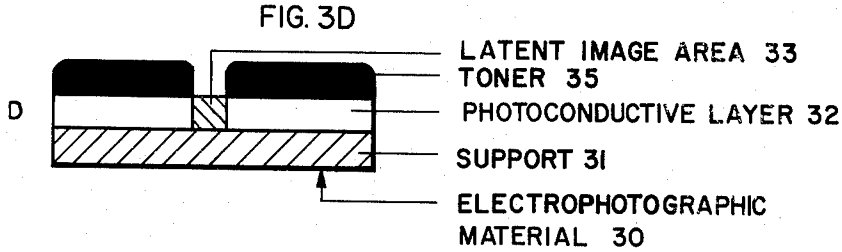

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IMAGE-FORMATION ON ELECTRO-PHOTOGRAPHIC MATERIAL

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The present invention relates to image formation and refers more particularly to image formation on electrophotographic materials by means of pressure with and without electrostatic charging.

The electrophotographic method for the production of images comprises the sequential operations of charging, exposing, developing, and fixing an electrophotographic material such as a support coated with a layer of photoconductive material. It has now been found that latent image formation can be obtained by means of pressure with and without charging. The particular sequence of charging and exposing is thus obviated. Other limitations are also avoided.

One object of the present invention is to provide a method of making images on electrophotographic materials which avoids the disadvantages of the prior art.

Another object is to provide a method of producing an image on a electrophotographic material by means of pressure with and without electrostatic charging.

Another object is to provide a method of making reproductions of graphic intelligence and the like.

Another object is to provide a method of making latent images on electrophotographic materials by means of pressure with and without electrostatic charging, said latent images being developable by electrophotographic developers.

Other objects will become apparent during the course of the specification.

In the drawing:

FIGURE 1 is a flow sheet showing the essential steps of the present invention;

FIGURE 2 is a flow sheet showing the sequence of optional steps in the practice of the present invention;

FIGURE 3A shows side sectional views of an electrophotographic material, 3B a latent image-bearing electrophotographic material, 3C a positively developed electrophotographic material, and 3D a negatively developed electrophotographic material of the present invention.

The present invention will appear more clearly from the following detailed description when taken in connection with the accompanying drawing showing, by way of example, preferred embodiments of the present invention.

It has been found in the present invention that a suitable electrophotographic material is affected by the imagewise application of pressure with and without charging so that the affected areas are distinguishably different from the unaffected areas. This difference may be developed to form a visible image. For example in FIGURE 1 a pressure pattern applied to a suitable electrophotographic material produces an invisible pressure pattern affected-area which differs from the unaffected areas of the material and which is developable to produce a visible pattern. Development is improved by charging the material as in FIGURE 2 to utilize the difference in charge acceptance or retention between the two areas. Pressure applied before charging as in steps 2D and 2E results in retention of the charge in the pressure-affected areas for a longer time than in the pressure unaffected areas, and the reverse is true when the pressure pattern is applied after charging as in steps 2A and 2B. Charging increases the difference between the two areas but development may be accomplished without it.

Pressure may also be applied to the electrophotographic material after it has been uniformly exposed to actinic radiation as in steps 2C and 2D. By varying the sequence of pressure application as in steps 2D and 2G, many different methods may be obtained.

Various combinations of pressure may be used to obtain different results. Halftones may be obtained by a pressure pattern from a silk screen or similar material. Post-pressure exposure to electrostatic charges, and uniform exposure to actinic radiation produce varying effects depending upon their order. In each case development produces a visible image.

Development may be accomplished by using electroscopic toners like those employed in the electrophotographic art. Two examples are a carrierless electroscopic powder material and an insulating liquid containing such electroscopic material. The electroscopic powder may also be intimately mixed with suitable carrier particles for enhancing the electroscopic charge by triboelectric means and for use with the well-known magnetic brush technique or the cascading technique. These electroscopic toners are applied to the latent image-bearing material as in step 2H and are then fixed as in step 2I by fusing.

The toners may be electroscopically positive or negative and they may be used in the form of particulate solids, liquid dispersions, or solutions. The toners are generally dark-colored in order to contrast with the electrophotographic material. Toners which take a positive charge include powdered asphaltum with glass beads as the carrier. The asphaltum powder takes a positive charge with respect to the glass beads. Toners with a negative charge on the particles include carbon black suspended in heptane containing 0.01% lecithin. The carbon black is negative with respect to the heptane. Other toners include those with magnetizable carrier particles. Toners comprising thermoplastic materials adhere well when heat-fused to the material.

The developing and the fixing operations may be combined by means of a liquid developer comprising a liquid medium, toner, and binder. Development occurs when the liquid developer is applied to a layer bearing a developable latent image and the toner selectively adheres to the layer to define the image. Fixing occurs when the liquid medium is removed and the binder permanently adheres the toner to the layer.

Fixing may also be accomplished by solvent fusing or by transparent adhesive film applied to the material over the toner.

The quality of the developed image is generally improved by treatments to intensify or de-intensify the developable difference between the latent image areas and the non-image areas before developing and fixing. Some of these treatments are charging, reverse-charging, exposing uniformly to ultraviolet radiation, heating, and combinations of these treatments.

Electrophotographic materials suitable for the present invention are photoconductor-coated supports such as paper, film and the like. The materials may also be self-sustaining layers. Photoconductors such as zinc oxide, lead titanate, cadmium sulfide, and polyvinyl carbazole may be used. Insulating binders such as silicone resins and styrene-butadiene polymers may be used.

One simple means of charging the surface of the material is by use of a conductive rubber roller raised to a potential of 1000 to 1500 volts and used as a pinch roller cooperating with a grounded plate or a cooperating roller. A simple source of voltage may be a series of batteries producing 1500 volts. Another means of charging is by corona discharge.

The invention is further illustrated by the following examples.

Examples

(1) An electrophotographic material 30 as in FIGURE 3A comprising a photoconductive layer 32 on a support 31 was inserted behind a sheet of conventional bond typing paper into a typewriter. The layer comprised at least one of the following photoconductors: zinc oxide, cadmium sulfide, lead titanate and polyvinyl carbazole. The bond paper was typed upon and a pressure-created latent image 33 in FIGURE 3B was simultaneously formed in the electrophotographic material. This was given a negative electrostatic charge by means of a corona discharge and treated with a positive toner 34 in FIGURE 3C to produce a visible positive image of the typing on the electroprotographic material. The developed positive image was then fixed by heating. A copy was thus produced without the use of carbon paper.

The same results were obtained with a pencil and ordinary writing pressure in place of the typewriter key.

(2) Example 1 was repeated with a negative toner 35 as in FIGURE 3D to produce a white-on-black or negative copy.

(3) Example 1 was repeated with positive charging instead of negative charging. The use of a positive toner produced a white-on-black print or negative copy.

(4) Example 1 was repeated using positive charging instead of negative charging. Development with a negative toner produced a black-on-white print or positive.

(5) The electrophotographic material of Example 1 was first given a negative electrostatic charge and then subjected to a pressure pattern. Development with a positive toner produced a white-on-black print or negative. The toner was fixed as in Example 1.

(6) Example 5 was repeated with a negative toner instead of a positive toner to produce a black-on-white positive print.

(7) Example 5 was repeated with positive charging instead of negative charging. Development with a positive toner produced a black-on-white positive print.

(8) Example 5 was repeated with positive charging. Development with a negative toner produced a white-on-black negative print.

(9) Example 1 was repeated but after charging, the electrophotographic material was uniformly exposed to ultraviolet light as in step 2G for a few seconds to reduce the intensity of the charge and to give a more accurate reproduction. The material was developed and fixed as in Example 1.

(10) Example 2 was repeated but after charging, the material was uniformly exposed to ultraviolet light for a few seconds to reduce the intensity of the charge and to give a more accurate reproduction. The material was developed and fixed as in Example 2.

(11) Example 3 was repeated but after charging, the material was uniformly exposed to ultraviolet light for a few seconds to reduce the intensity of the charge and to give a more accurate reproduction. The material was developed and fixed as in Example 3.

(12) Example 4 was repeated but after charging, the material was uniformly exposed to ultraviolet light for a few seconds to reduce the intensity of the charge and to give a more accurate reproduction. The material was developed and fixed as in Example 4.

(13) Example 5 was repeated but after charging, the material was uniformly exposed to ultraviolet light for a few seconds to reduce the intensity of the charge and to give a more accurate reproduction. The material was developed and fixed as in Example 5.

(14) Example 6 was repeated but after charging, the material was uniformly exposed to ultraviolet light for a few seconds to reduce the intensity of the charge and to give more accurate reproduction. The material was developed and fixed as in Example 6.

(15) Example 7 was repeated but after charging, the material was uniformly exposed to ultraviolet light for a few seconds to reduce the intensity of the charge and to give a more accurate reproduction. The material was developed and fixed as in Example 7.

(16) Example 8 was repeated but after charging, the material was uniformly exposed to ultraviolet light for a few seconds to reduce the intensity of the charge and to give a more accurate reproduction. The material was developed and fixed as in Example 8.

(17) Example 1 was repeated but after charging the material, it was reverse charged with the opposite polarity as in step 2F to reduce the intensity of the initial charge and to give a more accurate reproduction. The material was developed and fixed as in Example 1.

(18) Example 2 was repeated but after charging the material, it was reverse charged with the opposite polarity to reduce the intensity of the initial charge and to give a more accurate reproduction. The material was developed and fixed as in Example 2.

(19) Example 3 was repeated but after charging the material, it was reverse charged with the oppoiste polarity to reduce the intensity of the initial charge and to give a more accurate reproduction. The material was developed and fixed as in Example 3.

(20) Example 4 was repeated but after charging the material, it was reverse charged with the opposite polarity to reduce the intensity of the initial charge and to give a more accurate reproduction. The material was developed and fixed as in Example 4.

(21) Example 5 was repeated but after charging the material, it was reverse charged with the opposite polarity to reduce the intensity of the initial charge and to give a more accurate reproduction. The material was developed and fixed as in Example 5.

(22) Example 6 was repeated but after charging the material, it was reverse charged with the opposite polarity to reduce the intensity of the initial charge and to give a more accurate reproduction. The material was developed and fixed as in Example 6.

(23) Example 7 was repeated but after charging the material, it was reverse charged with the opposite polarity to reduce the intensity of the initial charge and to give a more accurate reproduction. The material was developed and fixed as in Example 7.

(24) Example 8 was repeated but after charging the material, it was reverse charged with the opposite polarity to reduce the intensity of the initial charge and to give a more accurate reproduction. The material was developed and fixed as in Example 8.

(25) Five sheets of zinc oxide coated electrophotographic paper were inserted into a typewriter with a cover sheet of conventional bond typing paper. The usual typewriter ribbon copy was made on the cover sheet with corresponding pressure patterns on the copy pages. Thereafter the plurality of sheets of zinc oxide and resin coated copy paper were each subjected to a corona discharge to produce an electrostatic charge on the zinc oxide coated surface of each sheet of electrophotographic paper. These sheets were then uniformly subjected to actinic light over their entire surface. An electroscopic toner was then applied to each sheet, and a clear image of the typing was developed. The toner was then fixed by heating to produce a permanent copy on each sheet. This method avoided the use of carbon paper in making multiple copies and thus avoided the objectionable smudged areas which frequently occur in the use of conventional carbon paper in making multiple copies. All copies were black-on-white positives.

(26) The zinc oxide surface of an electrophotographic paper was subjected to pressure through a 100 x 100 mesh silk screen between flat surfaces to form a fine pressure-affected grid pattern on the coating. The paper was subsequently electrostatically charged by a corona discharge and exposed through a positive transparency to actinic light to form a latent image. A thermoplastic particulate toner was applied directly to the latent electro-

static image. It adhered to a greater extent in the pressure affected areas of the image area to produce a half tone black-on-white copy of the image.

(27) A sheet of electrophotographic paper was placed under a bond paper sheet in a typewriter. Pressure from the typewriter key produced a latent image on the sheet of electrophotographic paper simultaneously with the character impression on the bond paper sheet. Development of the latent image on the electrophotographic sheet without charging with positive toner produced a black-on-white image which was fixed by conventional means.

(28) Example 27 was repeated with a negative toner instead of a positive toner to produce a white-on-black image.

(29) Latent images were produced in a electrophotographic sheet placed under a bond paper sheet which was written upon with a pencil using ordinary pressure. The latent images were developed by using a positive toner with a magnetic brush. After sufficient brushing a black-on-white image was produced. This was fixed in a conventional manner.

(30) Example 29 was repeated with a negative toner instead of a positive toner to produce a white-on-black image which was fixed in a conventional manner.

(31) Finger prints were produced on electrophotographic material by charging the surface of the paper contacting the surface with the fingertips, and developing with a suitable toner. The developed image was fixed to produce a permanent record. A black-on-white print was produced with a negative toner.

It is apparent that the described examples are capable of many variations and modifications within the scope of the present invention. All such variations and modifications are to be included within the scope of the present invention.

What is claimed is:

1. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas; and

developing said latent image by applying electroscopic toner which contrasts with the layer and which selectively adheres to the image areas of said layer to render the latent image visible.

2. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas; and

developing said latent image by applying electroscopic toner which contrasts with the layer and which selectively adheres to the non-image areas of said layer to render the latent image visible.

3. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas;

charging said layer electrostatically with one polarity to produce a charge image corresponding to said latent image; and

developing said charge image by applying an electroscopic toner which contrasts with the layer and which selectively adheres to the image areas of said layer to render the latent image visible.

4. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas;

charging said layer electrostatically with one polarity to produce a charge image corresponding to said latent image; and

developing said charge image by applying an electroscopic toner which contracts with the layer and which selectively adheres to the non-image areas of said layer to render the latent image visible.

5. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas;

charging said layer electrostatically with one polarity to form a charge image corresponding to said latent image;

exposing said layer uniformly to ultraviolet radiation to reduce the intensity of the charge on said layer; and

developing said charge image on said layer by applying electroscopic toner which contrasts with the layer and which selectively adheres to the image areas of said layer to render the latent image visible.

6. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas;

charging said layer electrostatically with one polarity to form a charge image corresponding to said latent image;

exposing said layer uniformly to ultraviolet radiation to reduce the intensity of the charge on said layer; and

developing said charge image on said layer by applying electroscopic toner which contrasts with the layer and which selectively adheres to the non-image areas of said layer to render the latent image visible.

7. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas;

charging said layer electrostatically with one polarity to form a charge image corresponding to said latent image;

reverse-charging said layer with an electrostatic charge of opposite polarity to reduce the intensity of the first charge; and

developing said charge image in said layer by applying electroscopic toner which contrasts with the layer and which selectively adheres to the image areas of said layer to render the latent image visible.

8. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas;

charging said layer electrostatically with one polarity to form a charge image corresponding to said latent image;

reverse-charging said layer with an electrostatic charge of opposite polarity to reduce the intensity of the first charge; and

developing said charge image in said layer by applying electroscopic toner which contrasts with the layer and which selectively adheres to the non-image areas of said layer to render the latent image visible.

9. A method of making an image on a single photocon-

ductive electrophotographic layer, which comprises the steps of:

uniformly charging said layer electrostatically with one polarity;

pressure-imaging a pattern on said charge layer to form a relatively permanent, latent, developable image surrounded by non-image areas; and

developing said latent image on said material by applying electroscopic toner which contrasts with the layer and which selectively adheres to the image areas of said layer to render the latent image visible.

10. A method of making an image on a single protoconductive electroprotographic layer, which comprises the steps of:

uniformly charging said layer electrostatically with one polarity;

pressure-imaging a pattern on said charge layer to form a relatively permanent, latent, developable image surrounded by non-image areas; and

developing said latent image on said material by applying electroscopic toner which contrasts with the layer and which selectively adheres to the non-image areas of said layer to render the latent image visible.

11. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

uniformly charging said layer electrostatically with one polarity;

reverse-charging said layer with an electrostatic charge of opposite polarity to reduce the intensity of the first charge;

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas; and

developing said image in said layer by applying electroscopic toner which contrasts with the layer and which selectively adheres to the image areas of said layer to render the latent image visible.

12. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

uniformly charging said layer electrostatically with one polarity;

reverse-charging said layer with an electrostatic charge of opposite polarity to reduce the intensity of the first charge;

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas; and

developing said image in said layer by applying electroscopic toner which contrasts with the layer and

which selectively adheres to the non-image areas of said layer to render the latent image visible.

13. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

uniformly charging said layer electrostatically with one polarity;

exposing said layer uniformly to ultraviolet radiation to reduce the intensity of the charge on said layer;

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas; and

developing said image on said layer by applying electroscopic toner which contrasts with the layer and which selectively adheres to the image areas of said layer to render the latent image visible.

14. A method of making an image on a single photoconductive electrophotographic layer, which comprises the steps of:

uniformly charging said layer electrostatically with one polarity;

exposing said layer uniformly to ultraviolet radiation to reduce the intensity of the charge on said layer;

pressure-imaging a pattern on said layer to form a relatively permanent, latent, developable image surrounded by non-image areas; and

developing said image on said layer by applying electroscopic toner which contrasts with the layer and which selectively adheres to the non-image areas of said layer to render the latent image visible.

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