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3,625,682

NONREMOVABLE DISCONTINUOUS ELECTRODE FOR ELECTROPHOTOGRAPHY

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FIG. 1

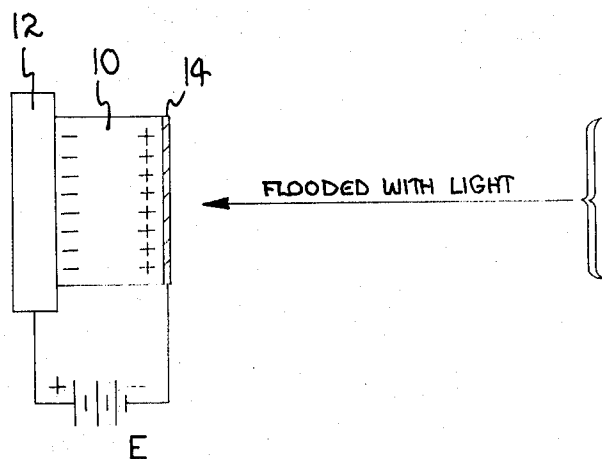


FIG. 2

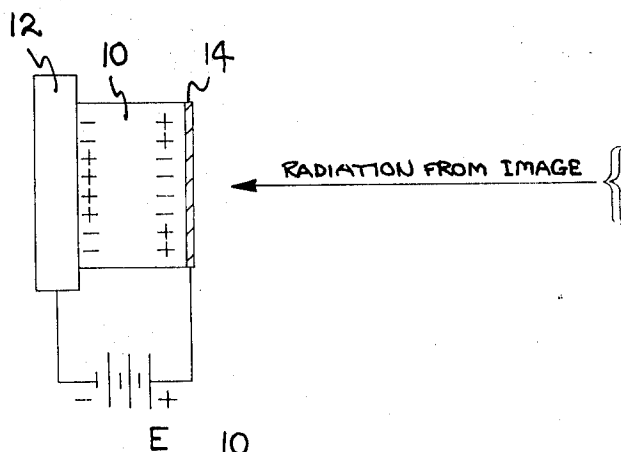
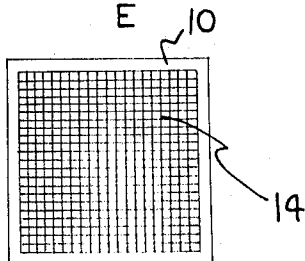


FIG. 3



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NONREMOVABLE DISCONTINUOUS ELECTRODE FOR ELECTROPHOTOGRAPHY

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5 Claims

ABSTRACT OF THE DISCLOSURE

A persistent internal polarization (PIP) electrophotography printing or copying system comprising stationary electrodes which are not removed during development, and wherein at least one electrode is of a discontinuous configuration, such as a foraminous conductive mesh, which is embedded in or attached to the surface of the PIP layer which is to be toned (the top layer), such that an electric field can be applied to the PIP layer while permitting radiation to reach the PIP layer, and whereby toning and transfer may be accomplished without removing either electrode.

BACKGROUND OF THE INVENTION

This invention relates to novel apparatus and process for practicing electrophotographic printing or copying. More particularly, this invention relates to printing apparatus and process utilizing photoconductive insulating materials and the principles of persistent internal polarization.

Persistent internal polarization (abbreviated herein as PIP) involves the separation of positive and negative charges in a photoconductive insulating material by subjecting it to irradiation and an electric field. The charges are subsequently trapped and remain fixed or frozen so as to form an internal polarization field for a period of time sufficient to permit toning. PIP and the theory thereof are well known in the electrophotography art. See, for example, *Electrophotography*, by R. M. Schaffert, The Focal Press, London and New York (1965), pages 59 through 77, and *Persistent Internal Polarization*, by Kallmann and Rosenberg, *The Physical Review*, volume 97, No. 5 (March 15, 1955), pages 1596 through 1610, both of which are incorporated herein by reference.

In general, a PIP electrophotography system includes a layer of photoconductive insulating material sandwiched between a pair of field producing electrodes. The phenomenon of PIP can be achieved in any material which exhibits the following characteristics:

- (1) The material must have a high resistivity in the dark (a low density of free charge carriers), whereby it is a good insulator in the absence of irradiation.
- (2) The material must be photoconductive. In other words, it must have decreased resistivity when excited with appropriate irradiation.

Thus, a PIP material is one which will become persistently internally polarized due to the separation of positive and negative charges when it is subjected to irradiation and the action of an electric field.

Typical PIP materials contemplated herein comprise binder dispersions of photoconductors and binder-free thin films of photoconductors.

Examples of inorganic photoconductors contemplated in the process of this invention include, not by way of limitation, appropriately activated zinc sulfide, cadmium sulfide, zinc selenide, cadmium selenide, cadmium oxide, zinc-cadmium selenides, and zinc-cadmium sulfides. Examples of organic photoconductors include anthracene, chrysene, and poly(vinylcarbazole).

Examples of resin binders contemplated herein include, not by way of limitation, cellulose acetate, cellulose ether, cellulose ester, silicones, vinyl resins, alkyls, and/or epoxy resins.

- 5 When it is desired to form a latent electrostatic image in the PIP material, it is flooded with radiation and an electric field is applied so as to polarize the PIP layer. After termination of the flooding radiation, the polarity of the electric field across the PIP material is reversed
- 10 and the PIP materials exposed to an image or other pattern of activating radiation. The reversal of the electric field will cause rapid depolarization of that portion of the PIP material rendered photoconductive under the influence of the imagewise radiation.
- 15 If the exposure to the image is continued for a sufficient time period, the irradiated area of the PIP layer will repolarize and assume a polarization opposite to that of the non-irradiated or dark portion of the PIP layer. Thus, the image is simulated by an internal latent electrostatic image or pattern detectable at the surface of the PIP material.

This latent electrostatic image is subsequently developed with charged or dipolar toner particles so as to produce a visible reproduction of the image which is capable of being viewed, photographed, or transferred, utilizing known methods in the electrophotography printing or copying art.

- 25 It should be noted that, due to the characteristics of the PIP material, the latent electrostatic image produced in the PIP material will typically remain fixed such that a finite number of reproductions can be made. The image can be erased by overall irradiation with or without an electric field, thereby returning the PIP material to a prepolarized or neutral condition capable of being used
- 30 for the formation of a new electrostatic image.

The irradiation of the PIP material (for polarization and/or imaging) can be accomplished by means of any form of electromagnetic or particulate radiation or energy, visible or invisible, which excite the PIP material so as to permit charge separation in an electric field. Such radiation includes not by way of limitation visible light, infrared, ultraviolet, X-rays, gamma rays, and beta rays. For printing or copying purposes, the typical radiation is light in the visible range.

- 45 In the prior electrophotographic printing and copying art, simultaneous application of the electric field and the light from an image to a PIP material has been obtained by means of at least one continuous electrode which is substantially transparent. Typically, these electrodes have been conductive liquids or glass with conductive coatings. Conductive liquid electrodes are difficult to handle and the use of conductively coated glass makes it difficult to obtain uniform electrode contact. Likewise, such prior art electrode systems are limited by the spectral absorption of
- 50 the substrate and/or conductive coating.

In addition, the invention as described herein is to be distinguished from the prior art in that there is not required a discrete dielectric layer contiguous with the PIP layer.

SUMMARY OF THE INVENTION

- 60 Thus, it is an object of this invention to provide a non-removable electrode configuration which can be used to simultaneously apply an electric field and permit the imaging radiation to reach the PIP layer and which does not have to be removed for image toning and transfer.

It is a further object of this invention to provide a non-removable electrode which is partly or entirely embedded in or otherwise permanently attached to the surface of the PIP layer to be toned, i.e., the top surface of the PIP layer.

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This invention features the partial or complete embedding of a thin metal mesh grid electrode in the top surface of a PIP phosphor layer. The second electrode is a permanent metal back electrode which is the strong mechanical member holding the PIP material. Thus, a sandwich configuration is achieved whereby the base electrode can be a metal drum, the PIP layer is applied on top of the base electrode to a suitable thickness, and the mesh electrode is attached to or embedded in the top of the PIP layer.

In operation, an electrical field is applied between the base electrode and the embedded screen mesh electrode and the imaging radiation is impinged upon the PIP layer through the interstices of the mesh. The use of a top mesh electrode directly overcomes the spectral absorption limitations of the coated glass electrodes by providing sufficient electric field and light intensity in the PIP material so as to generate adequate PIP for printing purposes. Furthermore, an embedded discontinuous electrode (wire mesh) does not act as a shield between the PIP image and the charged toner particles as would a continuous electrode. A continuous electrode necessitates removal prior to the transfer of the image because of the overall presence of image charges which shield the toner from the image.

Other objects, features, and advantages of the subject invention will become obvious to those skilled in the art upon reference to the following detailed description and the drawings illustrating a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a schematic view of a PIP system having a nonremovable, discontinuous electrode in accordance with this invention.

FIG. 2 is a schematic view of the PIP system of FIG. 1 upon the formation of a latent electrostatic image.

FIG. 3 is a schematic view of a nonremovable, discontinuous electrode in the form of a flat wire mesh embedded in the surface of a PIP layer.

DESCRIPTION OF A PREFERRED EMBODIMENT

In the drawings, the numeral 10 refers to a body or layer of PIP material as previously defined. The PIP body 10 is sandwiched between a pair of electrodes 12 and 14 which are connected to a DC source E. For the purposes of explanation, the electrode 12 is connected to the positive terminal of the DC source E and, accordingly, the electrode 14 is connected to the negative terminal of the DC source E.

The electrode 14 is discontinuous in form and may be partly or entirely embedded in the top surface of the PIP body 10. The electrode 14 should be sufficiently embedded in the top surface of PIP body 10 so as to be flush with the outer face thereof.

Thus, as provided by this invention, the electrode 14 is constructed of a discontinuous conductive material and may take the form of a screen mesh or like structure, such as is shown in FIG. 3. One possible mesh material would be an electroformed nickel mesh which can be obtained commercially as fine as two thousand lines per inch. The light transmission property of such mesh can be varied by controlling the space and the wire dimensions. Typical transmission in the range of 60 to 95 percent is readily available. Thus, it can be seen that light can easily pass through the openings of such a mesh so that the electrode formed from such a mesh provides no spectral limitation on the light one may choose for imaging so as to be virtually transparent for PIP purposes.

To initially prepolarize the PIP body 10, the system is flooded with light as shown in FIG. 1. Under the combined action of the light and the DC source E, it is shown schematically (in FIG. 1) that negative charges are effectively conducted toward the edge of the PIP body 10 adjacent to the electrode 12 connected to the positive terminal of the DC source E, and, conversely, positive charges are conducted to the edge of the PIP body 10 adjacent to the

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embedded mesh electrode 14 connected to the negative terminal of DC source E. A number of such charges remain trapped upon termination of irradiation.

When the system is subjected only to image-wise radiation while the polarity of the DC source E is reversed, the PIP body 10 reacts as shown in FIG. 2. It can be seen that only those areas of the PIP body subjected to the image-wise radiation undergo internal polarization under the force of the field produced by the reversed polarity of source E. The system has thus produced a latent electrostatic image (as represented schematically by the four negative charges on the right side of PIP body 10 adjacent to embedded mesh electrode 14 in FIG. 2) which is capable of being toned and transferred through the use of charged electroscopic particles (not shown).

A continuous electrode has an inherent disadvantage in that it must be removed in order to tone and transfer the latent electrostatic image as it acts as a shield between the latent electrostatic image and the electroscopic particles because of the overall presence of image charges. In contrast to this, the discontinuous embedded electrode of this invention with its high percentage of openings appreciably reduces the shielding of the electroscopic particles from the latent electrostatic image and, therefore, need not be removed during the toning and transfer stages. Thus, an embedded discontinuous electrode has a distinct advantage in that its nonremovability saves considerable time and facilitates the transfer speed necessary to use a PIP system in a printing or copying machine.

In commonly available copying machines, it has been found that the toning of a large solid area often results in decreased toner density; that is, deterioration of the image in areas furthest away from the edges. In other words, the middle portions of a large solid area which has been toned and transferred from such an image often appear less distinct than do the edge portions. The use of a discontinuous electrode (such as a mesh) electrically breaks up the large areas, resulting in a uniform development over the large areas of the latent image.

An advantage of a nonremovable electrode is its ability to avoid dust collection between the electrode and the PIP layer. Removable electrodes frequently pick up dust particles which, when they become positioned between the electrode and the PIP layer, distort the effect of the field lines on the PIP layer. A nonremovable electrode embedded in the top surface of the PIP layer, such as the mesh of this invention, eliminates the possibility of dust particles gathering between the electrode and the PIP layer, and the resulting distortion of the field lines.

A further advantage accrues in this PIP system. The possibility exists that in transferring toner from the PIP drum to the substrate to be printed, the application of the electric field which transfers the electrostatically charged powder may deteriorate the PIP image and thus minimize the possibility of repeatedly toning and transferring from a single imaging. With the embedded screen mesh of this invention, this potential difficulty is eliminated. For this purpose, the electric field used to transfer the toner particles to a substrate to be printed is applied to both the screen mesh 14 and the metal backing plate 12 so that both electrodes are at the same potential. The other electrode is placed on the opposing side of the substrate to be printed. This produces an electrostatic field between the embedded screen mesh and the substrate, which moves the toner particles between them to the substrate surfaces. It also provides that there will be no applied force within the PIP layer and thus eliminates any degradation effect which transfer electric fields frequently cause.

Given the nonremovable, embedded mesh electrode of this invention, there are a number of variations which can be utilized within the scope of this invention. All of the presently known methods of polarizing the PIP material can be used, including the image reversal method,

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as well as the direct polarization method. Either an electrostatic toner or a dipolar-type toner can be used. The mesh electrode can be of a screen mesh, either woven or electrically formed mesh, with various thickness to aperture ratios; or it can be of metal evaporated onto the PIP layer surface by standard evaporation techniques. Additionally, the electrode can be formed by applying known or standard printing techniques, such as silk screening.

Thus, the invention as described herein provides a non-removable discontinuous electrode which can be used to simultaneously apply an electric field and permit the light radiation to reach the PIP layer and which does not have to be removed for image transfer and printing purposes. It should be noted that, although this invention has been described in connection with a planar system, it is well suited to be used in conjunction with a rotary drum system.

Although but one embodiment of the subject invention has been shown and described in detail, it should be clear to those skilled in the art that in accordance with the preceding description, many changes and modifications may be made thereto without departing from the scope of the invention. Therefore, this invention is not intended to be limited except as defined in the claims hereinafter.

We claim:

1. A PIP electrophotographic printing or copying process comprising the steps of subjecting a photoconductive layer exhibiting PIP to an electric field between two electrodes, irradiating said photoconductive layer to thereby form an electrostatic latent image in the photoconductive layer, toning the electrostatic latent image with charged toner particles, and transferring said image via said toner particles to an article to be printed with said image, one of said pair of conductive electrodes comprising a substantially transparent, mechanically discontinuous conductive metal mesh electrode having a plurality of open interstices and being at least partially embedded in the photoconductive layer, said irradiating, toning, and transferring steps being conducted through said plurality of open interstices in said mesh electrode without removing the electrode from said photoconductive layer.

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2. A PIP electrophotographic printing or copying process as set forth in claim 1 wherein said plurality of open interstices constitute between 60% and 95% of the surface of said substantially transparent, mechanically discontinuous conductive metal mesh electrode.

3. A PIP electrophotographic printing or copying process as set forth in claim 1 wherein said substantially transparent, mechanically discontinuous conductive metal mesh electrode is a foraminous wire mesh.

4. A PIP electrophotographic printing or copying process as set forth in claim 1 wherein said substantially transparent, mechanically discontinuous conductive metal mesh electrode is an electroformed nickel mesh.

5. A PIP electrophotographic printing or copying process as set forth in claim 1 wherein said substantially transparent, mechanically discontinuous conductive metal mesh electrode is completely embedded in the surface of said photoconductive body.

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