United States Patent

Grier et al.

[15] 3,706,552

[45] Dec. 19, 1972

[54] **ELECTRODE CONFIGURATION FOR AC PIP ELECTROPHOTOGRAPHY**

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[22] Filed: **Dec. 28, 1970**

[21] Appl. No.: **101,764**

Related U.S. Application Data

[62] Division of Ser. No. 812,275, April 1, 1969.

[52] **U.S. Cl.** .....**96/1.4**, 96/1 R, 96/1.5

[51] **Int. Cl.** **G03g 17/00**, G03g 13/22

[58] **Field of Search** 96/1, 1.5; 340/173; 117/201, 117/218

[56] **References Cited**

UNITED STATES PATENTS

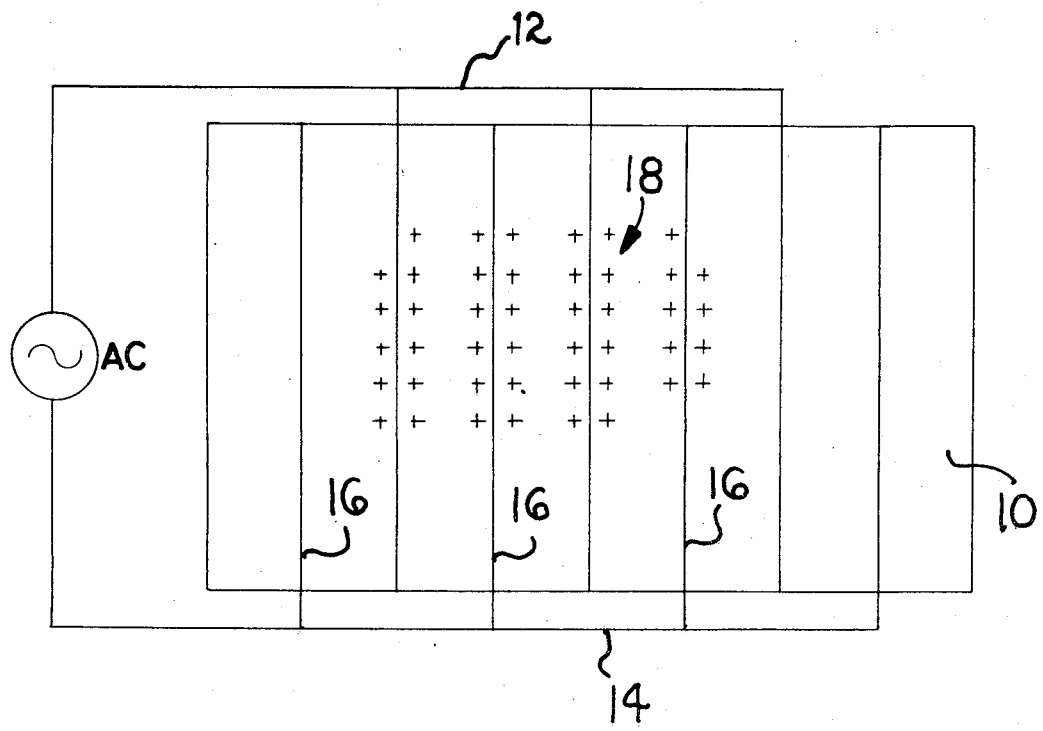
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[57] **ABSTRACT**

A persistent internal polarization (PIP) electrophotography printing or copying system uniquely adapted to be used in combination with alternating current wherein a pair of electrodes, each including a plurality of elements disposed in spaced array alternating with each other in the same plane, are utilized in combination with a PIP layer such that an alternating current electric field may be simultaneously applied to the PIP layer while permitting light radiation to reach the PIP layer. In the specific practice, the pair of electrodes are positioned on top of or embedded in the surface of the PIP layer which is to be toned; that is, the top surface.

2 Claims, 2 Drawing Figures



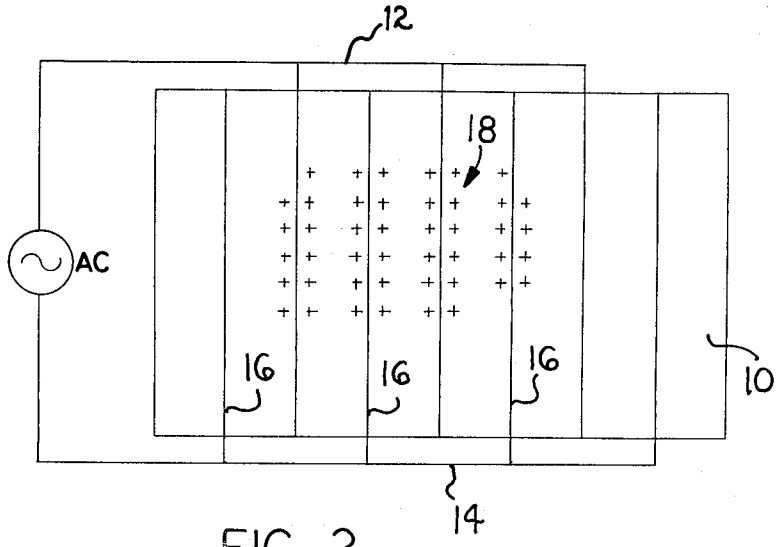


FIG. 2

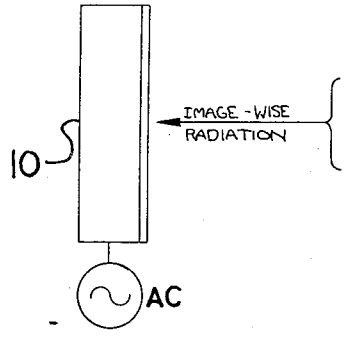


FIG. 1

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ELECTRODE CONFIGURATION FOR AC PIP ELECTROPHOTOGRAPHY

CROSS REFERENCE TO RELATED APPLICATIONS

This is a division of patent application Ser. No. 812,275, filed Apr. 1, 1969, and titled "Electrode Configuration for AC Electrophotography."

BACKGROUND OF THE INVENTION

This invention relates to novel apparatus and process for practicing electrophotographic printing or copying in combination with alternating current. 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 (Mar. 15, 1955), pages 1596 through 1610, both of which are incorporated herein by reference. Also, the general theory of alternating current (AC) PIP is well known and is disclosed in U.S. Pat. No. 3,199,086 issued to H. P. Kallmann, J. Rennert, and F. Chernow on Aug. 3, 1965.

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 radiation.

Typical PIP material contemplated herein comprise binder dispersions of photoconductors and binder free 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, alkyds, and/or epoxy resins. When using sulfide photoconductors, it is suggested that glass binders be used if they are low melting compositions which contain no lead to poison the sulfide phosphors.

The irradiation of the PIP material can be accomplished by means of any form of electromagnetic or particulate radiation or energy, visible or invisible, which will 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.

In the prior alternating current electrophotographic printing and copying art, simultaneous application of an alternating current electric field and the light from an image to a PIP material has been obtained by means of a pair of conductive electrodes separated by a layer of PIP material. Such an arrangement can be difficult to handle as the substrate layer must be conductive and variations in the thickness and composition of the PIP layer can affect the performance of the system.

SUMMARY OF THE INVENTION

In accordance with this invention, there is provided a new and novel electrode configuration which overcomes the aforementioned disadvantages associated with the prior art devices. More particularly, this invention provides a discontinuous electrode configuration wherein a pair of electrodes are positioned in the same plane or the same side of the PIP layer and which is adapted to be utilized with alternating current.

In accordance with a specific embodiment of this invention, each of the electrodes includes a plurality of elements disposed in spaced array alternating with each other in the same plane and are attached to or embedded in the top surface of the PIP layer.

When it is desired to form a latent electrostatic image in the PIP material, an alternating current electric field is applied and the PIP materials exposed to an image or other pattern of activating radiation. If the exposure to the image is continued for a sufficient time period, the irradiated area of the PIP layer will assume a potential of the sign of the less mobile of the charge carriers within the PIP material being used. Thus, the image is simulated by an internal latent electrostatic image or pattern detectable at the surface of the PIP material. Charge separation in this situation is caused by the mobility of one charge carrier and the relative immobility of the other charge carrier which depend on the properties of the PIP material selected.

This latent electrostatic image is subsequently developed with charged 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. The particular toner used will depend on the characteristics of the PIP material selected.

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, thereby returning the PIP material to a neutral condition capable of being used for the formation of a new electrostatic image.

In operation, an alternating current electric field is applied between the pair of discontinuous electrodes and the radiation is impinged upon the PIP layer through the discontinuous electrodes. Thus, an electrostatic latent image of one uniform charge is formed in the top surface of the PIP layer which is capable of being completely toned and transferred.

Other 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 pair of discontinuous electrodes positioned on the top surface of a PIP layer and being flooded with image-wise radiation in accordance with this invention.

FIG. 2 is an end view of the view of the PIP system of FIG. 1 showing schematically the electrode configuration.

DESCRIPTION OF A PREFERRED EMBODIMENT

In the drawings, the numeral **10** refers to a body of PIP material as previously described. The PIP body **10** has attached to it or embedded in it a pair of electrodes **12** and **14** which are connected to an alternating current source AC.

The pair of electrodes **12** and **14** are discontinuous in form and each electrode may take the form of a "-comb" structure which is attached to or embedded in the top surface of the PIP body **10**. It is suggested that the structure of each electrode include a plurality of elements **16** disposed in spaced array and alternating with each other in the same plane. The "comb" effect is achieved by alternately connecting elements **16** with electrodes **12** and **14**. Thus, the desired configuration has a plurality of alternating electrode elements **16** adjacent to each other in the same plane. Therefore, both electrodes **12** and **14** are positioned on the same side of the PIP body **10**, thereby eliminating the need for a back electrode or conductive substrate on the other side of the PIP body **10**.

When the system is subjected only to image-wise radiation (circle **18**) and an electric field is applied from alternating current source AC, the PIP body **10** reacts as shown in FIG. 2. Only those charge carriers subjected to radiation from the image (i.e., those within the circle of image-wise radiation **18**) undergo internal polarization under the force of the field produced by alternating current source AC. In this case, we have arbitrarily chosen charge carriers with a positive sign as the less mobile charge carriers which form the latent electrostatic image. The PIP system has thus produced a latent electrostatic image (as represented schematically by the charges within the circle of image-wise radiation **18** in FIG. 2) which is capable of being toned, transferred and printed through the use of charged electroscopic powder.

The alternating elements **16** of electrodes **12** and **14** of this invention may be formed of thin conductive metal strips attached to or embedded in the PIP layer surface; or they may be evaporated metallic strips put down onto the PIP layer surface by standard evaporization techniques. The conductive elements **16** may also be small filaments or ribbons of glass covered with a conductive coating of tin oxide so as to be substantially transparent.

Thus, it can be seen that this invention provides conductive, nonremovable, "comb-shaped" electrodes which are positioned in the same plane on the same side of the PIP layer, each of which includes a plurality of conductive elements disposed in spaced array alternating with each other. Such discontinuous electrodes can be used to simultaneously apply an electric field and permit radiation to reach the PIP layer and do not have to be removed for image toning and transfer. Since both electrodes are positioned on the same side of the PIP layer, this invention provides a compact unit which eliminates the need for a conductive substrate or back electrode. In addition, since this system is adapted to function with an electric field produced by an alternating current, the electrostatic latent image formed is of one uniform charge and is capable of being completely toned and transferred.

Therefore, this invention accomplishes a PIP electrophotography system utilizing the unique combination of alternating current and an electrode configuration which is well suited for commercial use in a copying machine.

Although this invention has been described and illustrated in detail by reference to a specific embodiment, it will be obvious to those skilled in the art that many changes and modifications may be made thereto without departing from the scope of this invention.

We claim:

1. A PIP electrophotographic printing or copying process adapted to be used in combination with alternating current comprising the steps of: subjecting a photoconductive body exhibiting PIP to an alternating current electric field between a pair of discontinuous conductive electrodes, irradiating said photoconductive body to thereby form an electrostatic latent image in the photoconductive body, 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, each of said pair of electrodes being positioned in the same plane on the same side of said photoconductive body and each comprising a plurality of individual conductive wires disposed in spaced array alternating with each other in the same plane adjacent to and in contact with said photoconductive body, said irradiating, toning, and transferring steps being conducted through the open spaces between said individual conductive wires forming said pair of electrodes while said pair of electrodes are in contact with said photoconductive body.

2. A PIP electrophotographic printing or copying process as set forth in claim 1 wherein the individual conductive wires of said pair of electrodes are completely embedded in the same surface of said photoconductive body.

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Disclaimer

3,706,552.—*John D. Grier*, Temperance, and *Maclin S. Hall*, Okemos, Mich. ELECTRODE CONFIGURATION FOR AC PIP ELECTROPHOTOGRAPHY. Patent dated Dec. 19 1972. Disclaimer filed Sept. 18, 1972, by the assignee, *Owens-Illinois, Inc.*

The portion of the term of the patent subsequent to Oct. 24, 1989, has been disclaimed.

[*Official Gazette February 12, 1974.*]