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EUROPEAN PATENT APPLICATION

(21) Application number: 82302847.7

(51) Int. Cl.³: **G 03 G 15/048**
G 03 G 15/02

(22) Date of filing: 02.06.82

(30) Priority: 03.06.81 US 270169

(43) Date of publication of application:
22.12.82 Bulletin 82/51

(84) Designated Contracting States:
DE GB

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(54) **Electrophotographic imaging process and apparatus.**

(57) An imaging process utilizing a photoreceptor (13) comprising a conductive substrate, a photosensitive layer and an electrically insulating layer over the photosensitive layer wherein said photoreceptor is charged by means of an AC corotron so as to (17) provide an electrical field across the photosensitive layer only. The AC corotron drives the voltage across the electrically insulating layer to zero by means of a bias voltage (21) applied to the corotron shield.

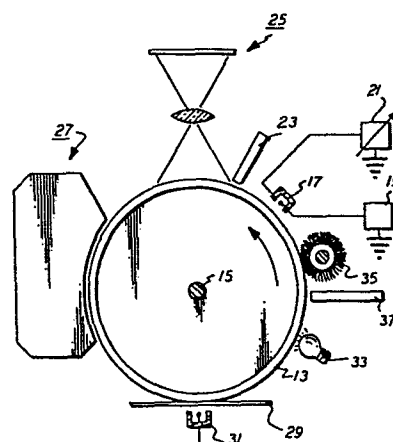


FIG. 5

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Electrophotographic imaging process and apparatus.

This invention relates to an electrophotographic imaging process and apparatus and, more particularly, to a process and apparatus for uniformly charging a photosensitive member which is overcoated with an electrically insulating layer. Such a process includes providing a photoreceptor comprising a conductive substrate, a photosensitive layer, and an electrically insulating layer over the photosensitive layer; electrically charging the photoreceptor; and exposing the photoreceptor to an imagewise pattern of electromagnetic radiation to which said photosensitive layer is sensitive whereby an electrostatic latent image is formed in said photosensitive layer.

For many years during the development of the xerographic process, the need for protecting the photosensitive layer has been appreciated. Many proposals have been made to protect the photosensitive layer by coating the layer with various materials. By coating the photosensitive layer, the wear occasioned by repeated use is absorbed by a tough, polymeric surface rather than the more delicate, expensive photosensitive material itself. One example of such an attempt to protect the photosensitive layer in the xerographic process is described by Blakney et al. in U.S. Patent No. 3,041,167 wherein the problem of charge build-up in the photoreceptor was observed. An electrically insulating, protective overcoating on a photosensitive layer was utilized to support the electrostatic latent image in a process disclosed in U.S. Patent No. 3,234,019 to Hall. In this process, as in the Blakney et al. process, an initial charge of one polarity is provided on the photoreceptor followed by a second charge of opposite polarity in order to establish an electrical field across the photoreceptor. While one may calculate voltages to be utilized in order to arrive at a condition in the photoreceptor wherein the electrical field is entirely across the photoreceptor and none is across the bonded, electrically insulating protective coating, such condition is difficult to achieve in practice. Actually, there is always a small imbalance of charges resulting in a small charge residing on the surface of the electrically insulating overcoating which charge may build up with repeated use of the photoreceptor and ultimately interfere with the quality of images provided by the process.

Other examples of photoreceptors having protective, electrically insulating coatings over the photosensitive layers include U.S. 3,895,943 and U.S. 3,904,409 to Hanada wherein the electrically insulating overcoating is utilized in conjunction with persistent internal polarization and contains the problem of charge build-up on the surface of the electrically insulating layer. As a practical matter, it is very difficult to operate a process wherein said layer is returned, at the beginning of each imaging cycle, to zero voltage. Small variations in the operation of the DC corotrons particularly utilized in the prior art to provide the sequential charging steps make the condition of zero voltage on the electrically insulating layer nearly impossible with ordinary equipment.

The present invention, is intended to provide an apparatus and process wherein an electric field is provided in a single charging step across the photosensitive layer of a photoconductive member having an electrically insulating protective layer over the photosensitive layer, which step eliminates or prevents the build-up of electrical charge on the surface of the electrically insulating layer.

The process of the invention is characterised in that the charging is carried out by means of an AC corotron, the corotron having a shield bias voltage adjusted so as to provide substantially no voltage across the electrically insulating layer.

Thus the process and apparatus of the invention enable the use of a photoreceptor containing an electrically insulating protective layer over the photosensitive layer wherein charge build-up on the electrically insulating layer is prevented. The process is simplified in that it requires a reduced number of charging units to establish an electric field across the photosensitive layer.

By adjusting the voltage applied to the corotron shield, a condition of zero voltage on the electrically insulating overcoating is achieved and an electrical field established across the photosensitive layer in a single charging step. As in any xerographic process, the charged photoreceptor is exposed to an imagewise pattern of electromagnetic radiation to which the photosensitive layer is sensitive to provide a latent electrostatic image entirely within the photosensitive layer. Typically, the latent image is developed by electroscopic materials applied to the electrically insulating overcoating, which image is then transferred to an image receiving sheet

thereby allowing erasure of the electrostatic latent image by flood exposure of the photosensitive layer and reuse of the photoreceptor.

An important feature in the present invention is the presence of a rectifying layer at the interface of the photosensitive layer and the electrically conductive substrate. In the case of an amorphous Se alloy, one typically chooses a rectifying contact which injects positive charges into the photoconductive layer and blocks negative charges. If negative charges are deposited on the top of the photoreceptor, positive charges are injected from the interface into the photoconducting layer. They travel through the photoconducting layer to the interface between the photoconducting layer and the insulating layer where they are trapped. If the surface charge on top of the photoreceptor is positive, the negative counter charge remains at the conductive substrate because of the blocking nature of the interface. If one wants to operate the photoreceptor with negative surface charges, the interface would have to be injecting for electronics and blocking for positive charges. The preferred operating mode depends on the photoreceptor materials used. For example, in the case of the utilization of a selenium alloy photosensitive layer, positive charges are injected into the photosensitive layer during periods of negative charge on the surface of the electrically insulating layer. Because of the rectifying properties of the photosensitive layer, no negative charge is injected during those periods when the charge on the surface of the electrically insulating layer is positive. In such instance, a positive voltage is established across the photosensitive layer. With the proper adjustment of bias voltage on the shield of the AC corotron, the total current influx integrated over the time of exposure to charge can be made zero on the surface of the electrically insulating layer. Such condition also eliminates charge build-up due to the polarization of the overcoating since the net total charge deposited by the AC corotron is of such polarity to counteract the overcoating polarization.

As noted above, there is thus provided, in a single charging step, an electrical field across the photoconductive layer by a single corotron in place of the two corotrons required in the prior art. Further, since the polarization or charge build-up on the surface of the electrically insulating layer is eliminated, there is no need for a corotron, typically an AC corotron, to level the charge subsequent to image development and

transfer. In accordance with this invention, a single corotron replaces three corotrons required in the prior art in order to properly provide an electrical field across the photoreceptor only and to eliminate residual charge on the electrically insulating, protective overcoating on the photosensitive layer. Typically, the AC corotron is operated in the frequency range of from about 50 Hz to about 1000 Hz in the process of this invention. Preferably, the frequency is in the range of from about 50 Hz to about 400 Hz.

The invention will be more fully described with reference to the attached drawings wherein:

Figure 1 is a diagrammatic representation of a section of a xerographic photoreceptor utilized in the process of this invention.

Figure 2 is a diagrammatic representation of a section of a photoreceptor indicating an intermediate charging condition during the process of this invention.

Figure 3 is a diagrammatic representation of a section of a photoreceptor indicating the charged condition subsequent to the charging step in the process of this invention.

Figure 4 is a diagrammatic representation of a section of a photoreceptor indicating the creation of an electrostatic latent image upon light exposure in accordance with the process of this invention.

Figure 5 is a schematic representation of a xerographic printing apparatus incorporating the process of this invention.

In Figure 1, there is shown photoreceptor 1 comprising a conductive substrate 3 supporting a photosensitive layer 5. An electrically insulating layer 7 resides on photosensitive layer 5 to provide protection from wear and contamination due to the repeated toning, transferring and cleaning which occurs in each imaging cycle and retards crystallization in the event a Se alloy is used.

In Figure 2, there is shown the intermediate charge condition of the photoreceptor during the charging step in the process of this invention. In Figure 2, photoreceptor 1 is shown receiving, at the surface of the electrically insulating layer 7, both positive and negative charges, which are provided by an AC corotron. The charged designations indicating positive and negative charges contained within circles indicate a transitory condition or charges in motion while those charge designations, both

positive and negative, without circles indicate stable charges which remain in the photoreceptor until further processing occurs. Thus, there is shown both positive and negative charges on the surface of electrically insulating layer 7 which are alternately supplied by an AC corotron. With a proper voltage bias on the corotron shield, these charges will equal each other thereby resulting in a net zero charge residing on the surface of electrically insulating layer 7. However, during periods of negative charge deposition on the surface of the electrically insulating layer 7, positive charges are presented to the photosensitive material at the interface of electrically conductive layer 3 and photosensitive layer 5. These positive charges are shown in a circle at the interface and, because of the negative charge, residing simultaneously on the surface of electrically insulating layer 7, the positive charges are drawn to the interface of photosensitive layer 5 and electrically insulating layer 7 where they are trapped. During periods in which the AC corotron is depositing positive charges on the surface of electrically insulating layer 7, negative charges are presented at the interface between conductive layer 3 and photosensitive layer 5. These charges remain trapped at said interface because of the rectifying nature of the photosensitive material in layer 5.

While Figure 2 indicates the segment of a photoreceptor, during the charging step, said segment is considered to be extremely small at any particular point in time during the charging step in the process of this invention. Figure 2 illustrates the condition for purposes of illustration only.

In Figure 3, the photoreceptor is illustrated in its charged condition wherein there are stable negative charges residing at the interface of electrically conductive layer 3 and photosensitive layer 5 while equal charges of opposite polarity reside at the interface of photosensitive layer 5 and electrically insulating layer 7. These charges provide an electrical field across the photosensitive layer with no charge residing on the surface of electrically insulating layer 7.

The thus charged photosensitive layer is ready for imagewise light exposure to establish a latent image therein as is illustrated in Figure 4. Light rays 9 are shown impinging on the surface of electrically insulating layer 7 which is transparent to said electromagnetic radiation allowing charge carriers to be created in the photosensitive material thereby

eliminating the equal amounts of charge residing at the interfaces of said layer. There are thus provided areas of charged and uncharged photoreceptor which can be detected at the surface of electrically insulating layer 7 in any suitable manner. Obviously, subsequent to image formation, development and transfer, the remaining electrical field within the photoreceptor 1 is eliminated by flood exposure of the photoreceptor.

The photosensitive layer 5 may be exposed from either side as is known in the prior art when providing a transparent conductive substrate 3 or, more commonly, a transparent electrically insulating layer 7. Apparatus convenient for the purpose of the user is constructed utilizing the principals of the process of this invention in either case. In addition, intermediate layers may be placed between the conductive layer 3 and photosensitive layer 5 to enhance the charge injecting nature of the interface. Such materials are well known in the prior art and are chosen with regard for the type of photosensitive material utilized in layer 5. In addition, adhesive layers may also be applied to the surfaces of photosensitive layer 5 in order to adhere the electrically insulating protective layer thereto, as well as providing adhesion of the photosensitive material to the conductive substrate as injection layer.

Typical electrically insulating layers include organic, as well as inorganic, materials. A particularly preferred material is polyethylene terephthalate available commercially under the Tradename Mylar from the E.I. du Pont de Nemours & Company, Inc.. Such material is preferred because of its availability and ease of handling, as well as its electrical properties. Other materials which can be typically utilized as protective layers include polyester, polyvinylchloride, polypropylene, polyvinylidenechloride, polycarbonate, polystyrene, polyamide, polyfluoroethylene, polyethylene, polyimide, polyvinylfluoride, polyvinylidene fluoride, polyvinylidenechloride, polyurethane, etc..

Photosensitive materials utilized in the process of this invention are typically those which provide a rectifying boundary at the conductive substrate. Typical photosensitive materials include selenium, selenium alloys such as selenium-tellurium alloys, selenium-arsenic alloys containing various dopants, such as cadmium sulfide, cadmium selenide, cadmium sulfoselenide, zinc oxide, zinc sulfide and zinc selenide. Of course, said photosensitive materials may be dispersed in suitable binder materials as is

well known in the art. Any suitable photosensitive material is included within the scope of this invention, such as a composite layer leaving fine photoconductive material in contact with the electrically insulating layer and relatively coarse photoconductive particles contacting the base. Each portion of the composite layer is desirably dispersed in a suitable binder. Such a photoreceptor is more fully described in U.S. Patent 3,801,317 to Tanada et al.. If desired, additional layers may be incorporated into the imaging member to aid in the various desired properties. For example, materials can be utilized at the interface between the photosensitive layer and the electrically conductive layer which promote charge injection of one polarity and suppress charge injection of another. Such materials include trigonal Se, gold, Te-alloys and carbon.

As mentioned above, the AC corotron utilized in the process of this invention is provided with a voltage bias on the shield thereof. The bias voltage to the shield is adjusted so as to provide the desired zero voltage on the surface of the electrically insulating layer. This voltage bias is typically determined empirically as it is highly dependent upon numerous operational factors such as distance between the corotron and the surface being charged, the amount of voltage desired to be utilized on the corotron wire and the nature of the surface being charged. As a typical example of the operation of the process of this invention, there is shown in Figure 5 a schematic of a xerographic apparatus indicating the major operations of the xerographic process. In Figure 5, there is shown xerographic apparatus comprising a photoreceptor 13 having the configuration of the photoreceptor illustrated in Figure 1. In this instance, photoreceptor 13 is in the form of a typical xerographic rotary drum mounted upon a grounded support 15. In the cyclic process, corotron 17 is utilized to charge photoreceptor 13 through power supply 19, either directly coupled to the wire or to the wire via a capacitance. In addition, a variable power supply 21 is utilized to supply a bias voltage to the shield of corotron 17 as indicated in Figure 5. For testing purposes only, a probe 23 is inserted subsequent to the charging operation to monitor the amount of charge on the photoreceptor. The charged photoreceptor is then rotated past a typical slit scanning optical system 25 whereby the charged photoreceptor is exposed to a pattern of electromagnetic radiation to which the photosensitive material is sensitive. The exposed photoreceptor is then rotated

past the developing station 27 whereby the electrostatic latent image in the photosensitive layer is developed. After development, the image is transferred as shown at transfer station 29 with the aid of transfer corotron 31. After transfer, the photoreceptor 13 is prepared for further use by erase lamp 33 which collapses the remaining field in the photoreceptor followed by removal of residual toner material at cleaning station 35. For testing purposes, a probe 37 is inserted in the cycle after the erase lamp 33 to determine the amount of charge remaining in the photoreceptor. Since the erase lamp collapses the field remaining across the photosensitive layer, any voltage detected by probe 37 must represent charge residing on the electrically insulating layer. Power supply 21 is adjusted so as to provide a proper bias voltage to the shield of corotron 17 which results in a zero net charge on the insulating layer as indicated by probe 37. When the voltage indicated by probe 37 is positive, then the bias voltage to the shield is made more negative. Conversely, when the indicated voltage is negative, the bias voltage to the shield is made more positive.

EXAMPLE I

In an apparatus as illustrated in Figure 5, there is provided a photoreceptor comprising an electrically conductive substrate having coated thereon a 3 micron thick trigonal selenium injecting layer over which is coated a 60 micron thick selenium-arsenic alloy doped with chlorine. Over the photosensitive layer there is applied a 12 micron thick coating of an electrically insulating polyurethane layer. At a surface speed of about 51 cm./sec. the photoreceptor is rotated past a double wire corotron 13.5 cm in length and operated at 60 Hz. The corotron shield is biased to a negative 30 volts, while the corotron wire has 16,000 volts AC peak to peak applied thereto. A field condition of +80 volts was measured at probe 23 subsequent to charging. It was established that this voltage is completely across the photosensitive layer by the fact that no voltage was detected at probe 37 subsequent to the erase lamp. Any voltage detected by probe 37 would indicate a voltage across the overcoating since there would be no field left in the photosensitive layer.

EXAMPLE II

The procedure of Example I is repeated with the exception that the photoreceptor is moved past a double wire corotron which is the same as

that of Example I except that the length was 12 cm. A positive voltage of 350 volts is measured at probe 23 while the shield voltage is held at +400 volts and the voltage applied to the corotron wires was 16,000 volts peak to peak. Again, there is no voltage measured at probe 37, indicating that the entire field of +350 volts existed across the photosensitive layer of the photoreceptor and no voltage was left residing on the surface of the electrically insulating polyurethane layer.

EXAMPLE III

A single wire corotron 20 cm in length is utilized in the process of Example I to establish a field of 500 volts which is measured at probe 23 after exposure to the AC corotron having a shield bias of +520 volts and 16,000 volts peak to peak applied to the wire. Again, no voltage was detected by probe 37 subsequent to exposure to the erase lamp.

Other modifications and ramifications of the present invention will occur to those skilled in the art upon a reading of the present disclosure. These are intended to be included within the scope of this invention. Of especial note is the fact that the procedures described herein are not limited to structures with dimensions typical of Example I. The insulating protective layer may vary in thickness from a few microns to in excess of 20 microns and the 60 micron photosensitive layer may vary in thickness from approximately 5 microns to 80 microns so that operation with a large range of electroscopic image development materials may be accommodated.

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Claims

1. An electrophotographic imaging process including providing a photoreceptor (1) comprising a conductive substrate (3), a photosensitive layer (5), and an electrically insulating layer (7) over said photosensitive layer;

electrically charging said photoreceptor; and exposing said photoreceptor to an imagewise pattern of electromagnetic radiation to which said photosensitive layer is sensitive whereby an electrostatic latent image is formed in said photosensitive layer; characterised in that said charging is carried out by means of an AC corotron (17), said corotron having a shield bias voltage (21) adjusted so as to provide substantially no voltage across said electrically insulating layer.

2. The process of claim 1 including the steps of
visibly developing (27) said latent image on said photoreceptor;
transferring (29) said developed image from said photoreceptor to an image receiving substrate;

erasing (33) said latent image by means of flood exposing said photosensitive layer to electromagnetic radiation to which it is sensitive;

measuring (37) the voltage remaining on said photoreceptor subsequent to said flood exposure, and

utilizing said measured voltage to adjust said shield bias voltage (21) so as to maintain zero voltage on the surface of said electrically insulating layer.

3. The process of claim 1 or claim 2 wherein said corotron (17) is operated in the range of from about 50 Hz to about 1,000 Hz.

4. An electrophotographic imaging apparatus including a photoreceptor (1) comprising an electrically conductive substrate (3), a photosensitive layer (15) and an electrically insulating layer (7) over said photosensitive layer, a corotron charging device (17) for electrically charging said photoreceptor, and means (25) to expose said photoreceptor

to an imagewise pattern of electromagnetic radiation to which said photosensitive layer is sensitive characterised in that said corotron charging device comprises an AC corotron (17), and means to apply a bias voltage (21) to the shield thereof so as to provide substantially no voltage across said electrically insulating layer.

5. The apparatus of claim 4 including means (27) to develop said latent image on said photoreceptor, means (29) to transfer said developed image from said photoreceptor to an image receiving substrate, means (33) to erase said latent image subsequent to said transfer, and means (37) to detect the voltage on said photoreceptor subsequent to the latent image erasure and means to adjust said bias voltage (21) on said corotron shield so as to maintain zero voltage on said photoreceptor.

6. The apparatus of claim 4 or claim 5 wherein the photoreceptor includes a charge injection layer situated at the interface between said electrically conductive substrate and said photosensitive layer.

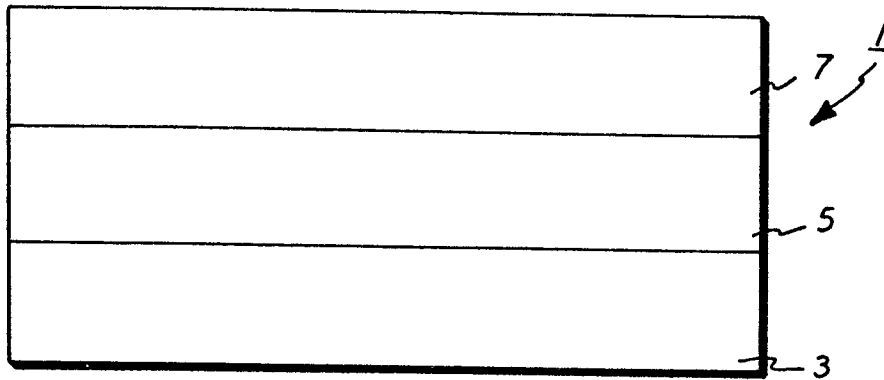
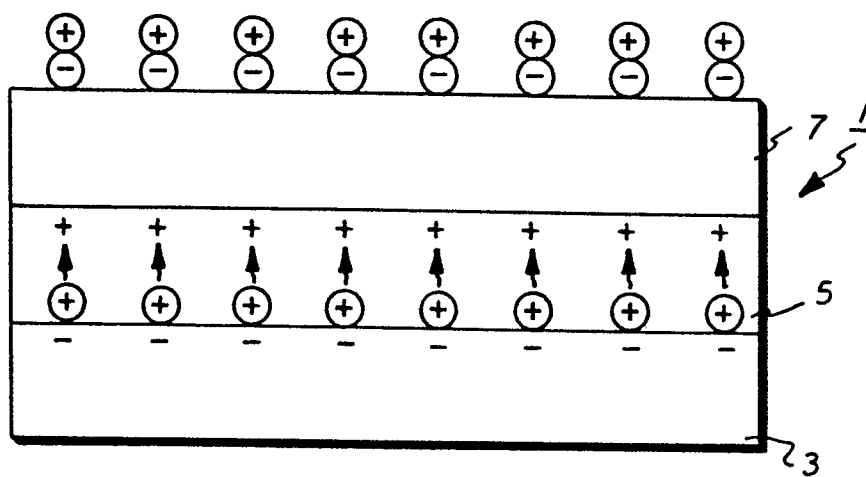
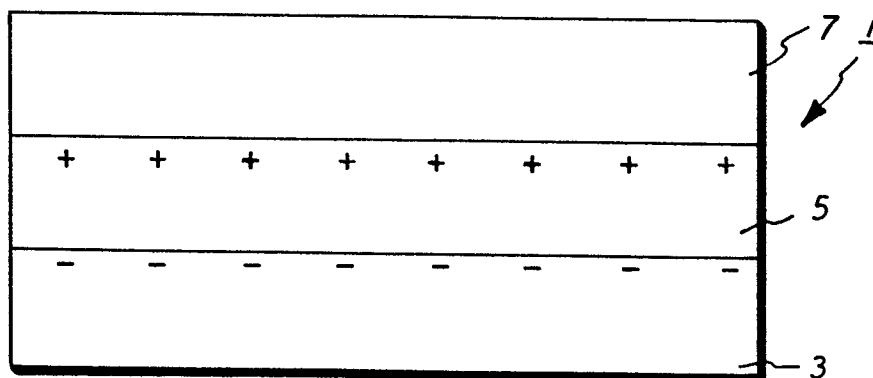
7. The apparatus of claim 6 wherein the charge injection layer comprises a rectifying layer which injects charges of one polarity into the photoconductive layer and blocks charges of the opposite polarity.

8. The apparatus of claim 7 wherein said photosensitive layer is a selenium-arsenic alloy and said injection layer comprises trigonal selenium.

9. The apparatus of claim 4 or claim 5 wherein said photosensitive layer is a composite photosensitive layer comprising one layer adjoining the electrically insulating layer containing fine particles of photoconductor and another layer adjoining the electrically conductive substrate and containing relatively larger particles of photoconductor.

10. The apparatus anyone of claims 4 to 9 wherein said electrically insulating layer is bonded to said photosensitive layer by means of an adhesive.

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*FIG. 1**FIG. 2**FIG. 3*

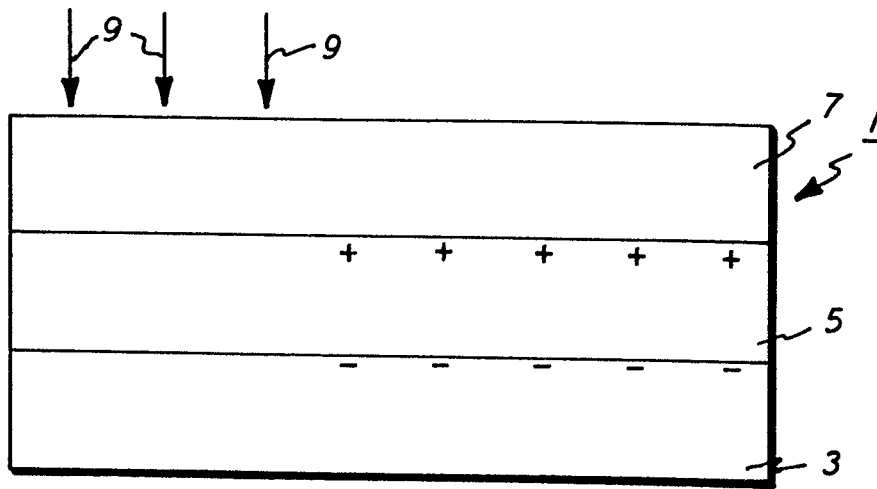


FIG. 4

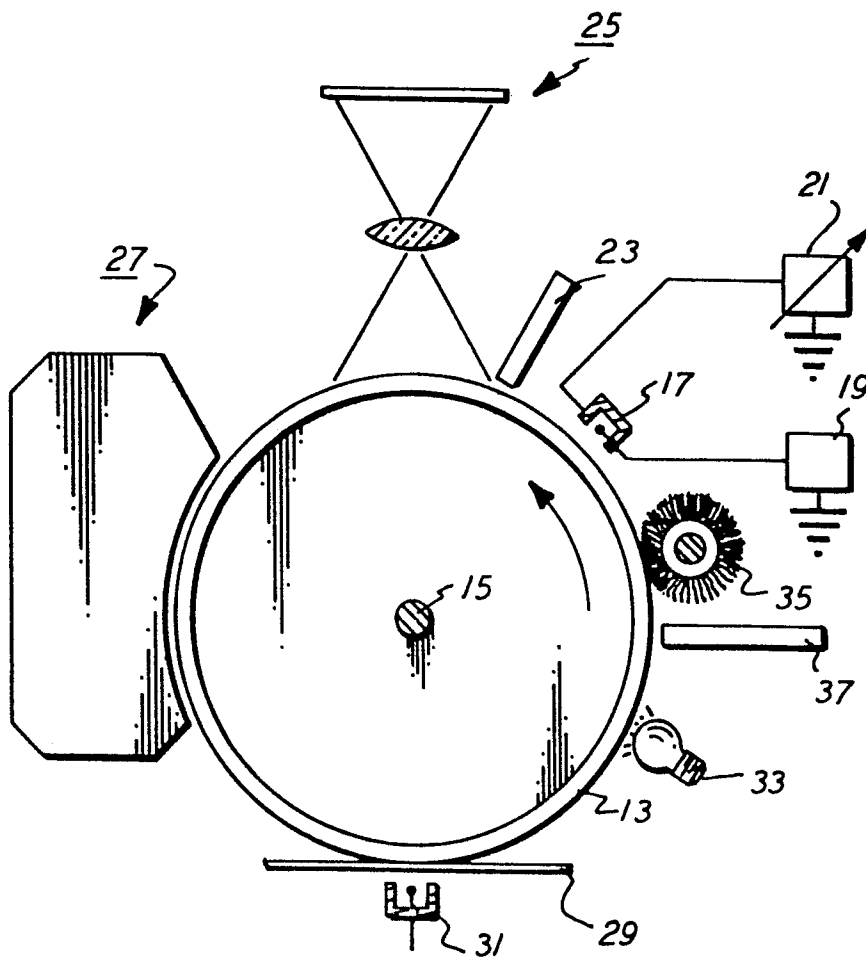


FIG. 5