United States Patent

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[54] **SELF-BIASING DEVELOPMENT ELECTRODE FOR ELECTROPHOTOGRAPHY**
5 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **118/637,** 117/17.5
[51] **Int. Cl.** **G03g 13/00**
[50] **Field of Search** 118/637; 117/17.5

[56] **References Cited**
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3,160,091	12/1964	Schwertz	117/17.5
3,166,432	1/1965	Gundlach	118/637
3,428,025	2/1969	Sullivan, Jr.	118/637

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ABSTRACT: A self-biasing electrode system for the development of latent electrostatic images provides low background and good solid area image fill by positioning a conductive electrode adjacent to the image surface as the image is being developed by charged making particles. The electrostatic image induces a charge on the electrode whose magnitude is controlled by grounding the electrode through an electrical impedance, for example, either a resistor along or a resistor and capacitor arranged in parallel.

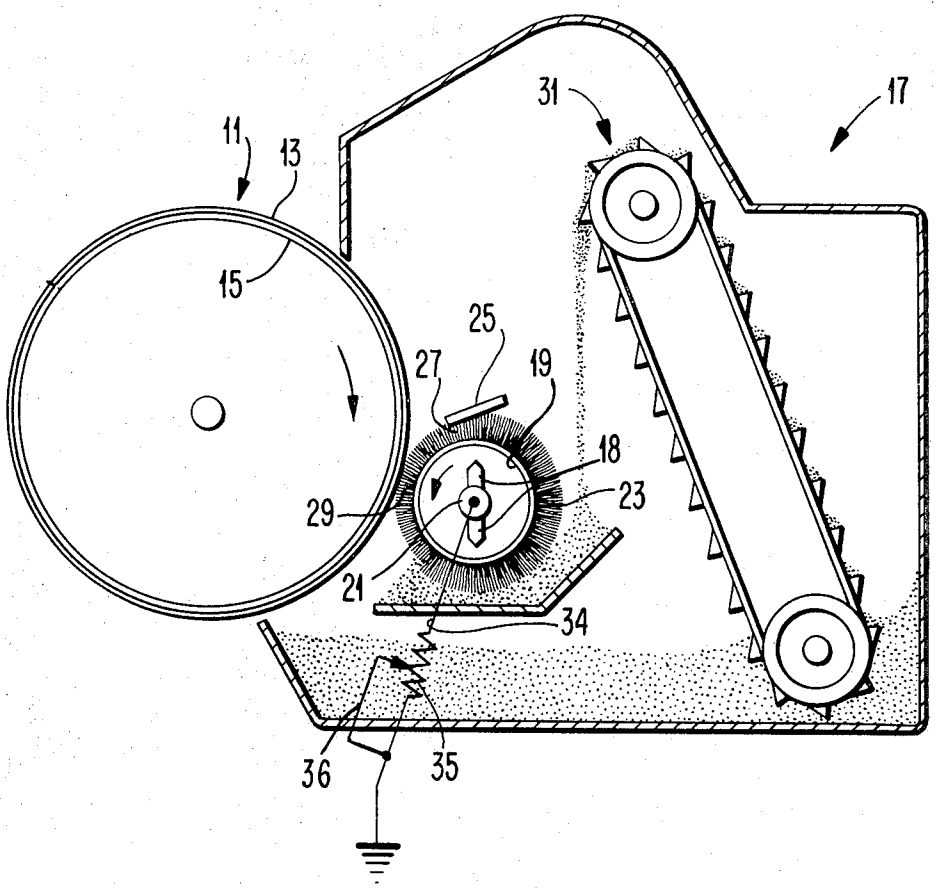


FIG. 1

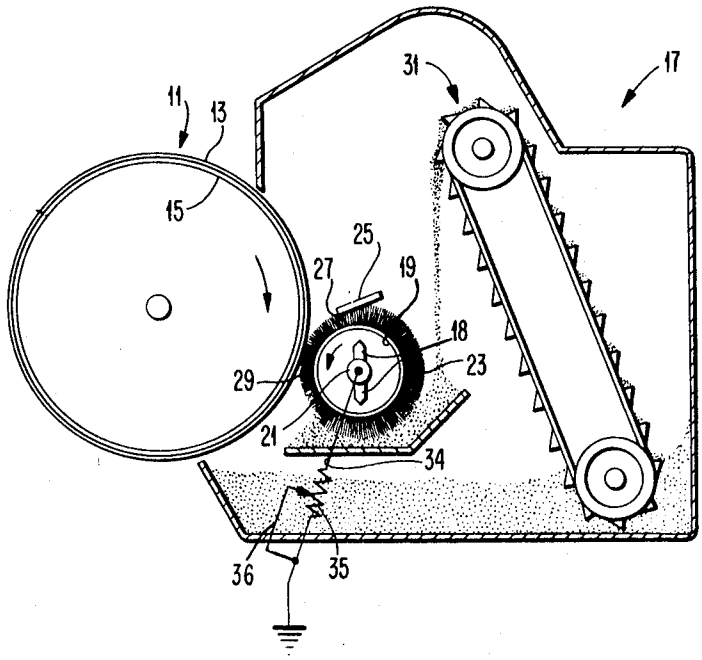
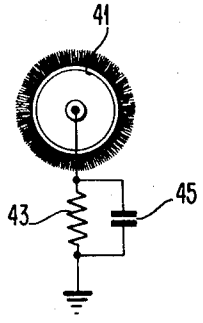


FIG. 2



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SELF-BIASING DEVELOPMENT ELECTRODE FOR ELECTROPHOTOGRAPHY

BACKGROUND OF THE INVENTION

Electrophotography using photoconductive insulating layers by which an electrostatic image is formed, for example, as is described in U.S. Pat. No. 2,297,691, has become embodied in a number of high speed copying processes. The photoconductive insulating layer is backed by a conductive layer and can be formed in the shape of a cylinder which is rotated to bring the photoconductive surface to a number of stations involved in the electrophotographic process. An electrical potential is first applied across the photoconductive insulating layer. The charged photoconductive layer is then exposed imagewise to light and the electrical potential decays in the surface areas which are struck by light. The dark areas on the projected image retain their electrostatic charge and the image is then developed by exposing the surface of the photoconductive layer to small colored particles known as toner particles which have the desired charge relative to that of the image. The charged toner particles are attracted to the charged image areas of the photoconductor surface and thereby develop the electrostatic image. The image can then be transferred from the photoconductive surface to a copy sheet.

A number of ways are conventionally employed to develop the electrostatic image such as cascade development described, for example, in U.S. Pat. No. 2,618,552; powder cloud development described, for example, in U.S. Pat. No. 2,221,776; magnetic brush development described, for example, in U.S. Pat. No. 2,874,963 and liquid development.

One problem associated with the development of latent electrostatic images, which exist on either a photoconductor or other charged insulating member, with charged marking particles is that wide image areas such as those produced in copying photographs or thick lettering in line copy are not developed in the center portion by the toner particles. The reason for this is that the electric field of the charged image is concentrated at the edges but is weak over the middle of the charged area. One way to obtain good fill in these areas is to utilize a conductive member or development electrode which is placed close to the surface which is being developed. The effect of the electrode is to produce an increased, uniform field over the whole area being developed so that the toner particles will be attracted to and develop the center portion of the wide image areas. One problem associated with the use of a development electrode is that a corresponding rise in background development occurs because of the resulting increased field which is produced by the electrode over the background areas. These areas, although at a low potential with respect to the image areas, still carry sufficient residual charge to attract toner particles. This problem has been reduced in the past by applying an external power source to the electrode to bias the charge on the electrode such that it is kept at an electrical potential greater in magnitude than the background area. This inhibits background deposition of toner. The potential is sufficiently less than the potential on the image areas so that development of the image areas is not suppressed. Various means have also been provided to sense the charge on the surface which is to be developed so that the potential can be adjusted according to the particular image. While these apparatus accomplish the purpose, they require external power sources and expensive, relatively complex sensing devices and circuitry.

BRIEF DESCRIPTION OF THE INVENTION

It is now been found that a development electrode can be provided with a self-biasing feature to suppress background development and yet still obtain wide area fill which apparatus does not involve external power supplies nor complex control features.

In accordance with this invention, in an apparatus for developing a latent electrostatic image on a charged member employing a development electrode in close proximity to the surface of the member being developed and having means for contacting the image with electroscopic-marking particles an improvement which comprises impedance means connected to the electrode to absorb a portion of the charge induced on the electrode by the image to thereby bias the electrode to an average potential which is somewhat greater in magnitude than the background potential of the image on the member.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic side view of an embodiment of an apparatus of the invention.

FIG. 2 is a schematic side view of another embodiment of the apparatus of the invention.

DETAILED DESCRIPTION

The foregoing and other objects, features and other advantages will be apparent from the following more particular description of preferred embodiments of the invention as illustrated in the accompanying drawings.

Turning now to FIG. 1, 11 represents a drum mounted for rotation which has on its surface a photoconductive insulating layer 13 such as, for example, vitreous selenium or a mixture of a polyvinyl carbazole and a Lewis acid beneath which is an electrically conductive layer 15. A latent electrostatic image is formed on the photoconductor, for example by charging the photoconductor with a corona discharge unit and then discharging portions of the photoconductor, for example, by exposing the photoconductor imagewise to electromagnetic radiation. The photoconductor surface is then rotated to developer station 17 where the surface is contacted by charged, electroscopic, finely divided marking particles which usually comprise, as is well known in the art, a heat softenable resin binder material, for example, a natural, or a synthetic organic polymer such as styrene polymers and copolymers, epoxy resins, rosin, rosin esters, and various combinations thereof mixed with coloring matter, for example carbon black so that a colored image can be easily fused onto a copy sheet.

The developer station 17 can be any convenient developer means such as, for example, a cascade developer unit, powder cloud developer unit or a magnetic brush developer unit. The station illustrated at 17 is a magnetic brush developer unit in which a steel cylinder 19 is mounted for rotation on shaft 21 and adapted to be driven by a drive means (not shown). Inside the steel cylinder are a series of permanent magnets 18 which are arranged along the axis of the cylinder.

The developer mix utilized in magnetic brush development contains, in addition to the toner particles, carrier particles which are ferromagnetic and probably conductive, for example, iron or steel shot. The particles can be coated with a resin to give the carrier the correct triboelectric properties such as is described, for example, in U.S. Pat. No. 2,618,551 so that the toner particles will assume the desired charge relative to that of the image areas and adhere to the carrier particles by electrostatic forces. The carrier particles are held by magnetic attraction to the surface of the cylinder 19 in the form of brushlike tendrils 23 of carrier and toner. These brushlike tendrils are then brought into contact with the latent image by rotating the cylinder 19 with the gap 27 between the surface of the photoconductive layer 13 and the cylinder 19 being adjusted so that the tendrils 23 contact the surface of the photoconductor. The charged image attracts the toner particles away from the carrier so that the marking particles adhere to and develop the latent electrostatic image on photoconductive layer 13. A doctor blade 25 is mounted adjacent to cylinder 19 to control the length of the magnetic brush tendrils and therefore, the contact area or "footprint" of the magnetic brush which contact the surface of the photoconductive layer 13. The gap 27 between the surface of cylinder 19 and conductor blade 25 is made slightly wider than the gap 29

between the surface of the cylinder **19** and the photoconductive layer **13**. Usually, the gaps will be from about a few thousandths of an inch to about one-fourth of an inch. Bucket conveyor **31** carries a fresh supply of toner and carrier to cylinder **19** so that the tendrils which have contacted the surface of the photoconductor and has become depleted in toner are continuously replenished with toner particles.

The surface of the cylinder **19** in closest proximity to the surface of photoconductive layer **13**, (i.e. the surface adjacent to the "footprint" of the brush) acts as a conductive development electrode. The charge on the photoconductor passing by the development station **17** induces a charge on the cylinder **19**. The magnitude of this induced charge is sufficient so that if cylinder **19** is allowed to "float," i.e. electrically insulated from its surroundings, then the charge will build up to the point where sufficient toner particles will not be attracted away from the carrier and cylinder **19** to the electrostatic image on the surface of the photoconductor and the image will be underdeveloped. On the other hand, if the cylinder **19** is grounded, the development electrode effect will not only enhance development of the image areas but will also increase the field over the background areas so that these areas attract toner away from the carrier and develop the background areas of the image.

The apparatus described to this point is known in the art and in the past, these difficulties have been offset by providing an external power supply and complicated control means to adjust the potential on the electrode to a predetermined value in order to obtain satisfactory development of the image.

In the embodiment of the invention illustrated in FIG. **1**, cylinder **19** is grounded through an electrical impedance circuit in this instance comprising wire **34** and resistor **35**. A movable wiper **36** enables adjustment of the impedance where desired to obtain development of various types of image information. This circuit retards the flow of charge from cylinder **19** and has the effect of maintaining the cylinder at a potential above ground during the time that an electrostatic image is being developed but allows a portion of the charge to bleed off so that cylinder **19** is at a potential less than the potential that would accumulate on cylinder **19** if it was allowed to float. The resistance is chosen to provide the potential necessary to give the desired background suppression. The size of the resistance used depends upon the potential on the photoconductor and can be easily determined empirically by those skilled in the art.

In operation, the apparatus was utilized to produce and develop latent electrostatic images on the surface of photoconductor layer **13** which comprised both line copy and continuous tones and mixtures thereof with the resistance being varied from infinity to ground. When the resistance was at infinity (electrode floating), a negative potential of about 700—750 volts was measured on the development electrode and almost no image could be developed on the photoconductor by the toner particles. When the electrode was grounded by removing the resistance, the image was fully developed but the background area was very dark. With resistances varying from about 1×10^8—10×10^8 ohms, the induced voltages measured on the development electrode are shown in table I.

TABLE I

Resistance Ohms	Induced Voltage on Cylinder 19 (−volts)
Ground	0
1×10^8	100—300
2.0×10^8	125—425
3.33×10^8	350—550
10.0×10^8	450—600
∞	600—750

It can be seen from the results recorded in table I that as the resistance was increased, the voltage on the cylinder **19** increased. The voltage varied about 200 volts because the total charge on the area of surface **13** passing cylinder **19** varied with the ratio of the amount of charged image areas versus the discharged areas. As the electrode voltages increased, the images showed a progressive drop in background until at 3.33×10^8 ohms a loss in fill was observed to take place which became even more marked at the 10×10^8 ohms level. The 2.0×10^8 ohm resistance gave the best combination of wide area fill and background suppression.

The variation in voltage of about 200 volts which was observed at each resistance level apparently did not effect overall image quality except when solid images and line copy were being developed side-by-side. When this occurred, a sudden surge in voltage caused by the passage of the large charged areas past the electrode sometimes resulted in a tendency to underdevelop the line copy. This effect is offset by dampening the variation in the voltage in accordance with the embodiment of the invention illustrated in FIG. **2**. Magnetic brush unit **41** is grounded through a resistor **43**. Capacitor **45** is mounted in parallel with resistor **43**. The values of the resistor and capacitor can be easily determined empirically by one skilled in the art depending upon the type of images which are to be developed. In operation, the variation in voltage due to the variation in the amount of charged image passing by cylinder **41** was reduced by the capacitor which dampened the sharp peaks observed when the resistor was used alone. The overall variation in the voltage was reduced to about 100 volts for the same master image which produced about a 200 volt variation using a resistor alone. For example, a capacitor **45** of 0.01 microfarad in parallel with a resistor **43** of 6.0×10^8 ohms developed an image, which was a combination of line and half tone copy, having excellent fill with no background being observable.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

We claim:

1. In an apparatus for developing a latent electrostatic image on a member employing a development electrode positioned in close proximity to the surface of the member and means for contacting said image with electroscopic marking particles, the improvement which comprises:

circuit means connected to said electrode and to ground and solely including impedance means of a size selected so that a portion of the charge induced on the electrode by the charge on the member biases the potential on the electrode to an average potential which is somewhat greater in magnitude than the background potential of the image on the member.

2. The apparatus of claim **1** wherein said impedance means comprises a resistor.

3. The apparatus of claim **1** wherein said impedance means comprises a resistor and a capacitor connected in parallel.

4. The apparatus of claim **1** wherein said impedance means comprises at least one adjustable impedance element.

5. The apparatus of claim **1** wherein the impedance means includes an adjustable resistor.