

[72] Inventor **Robert G. Blanchette**  
Elk Grove Village, Ill.  
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[73] Assignee **Addressograph-Multigraph Corporation**  
Mount Prospect, Ill.  
a corporation of Delaware

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Primary Examiner—Morris Kaplan  
Attorney—Sol L. Goldstein

[54] **DEVELOPING APPARATUS**  
12 Claims, 2 Drawing Figs.

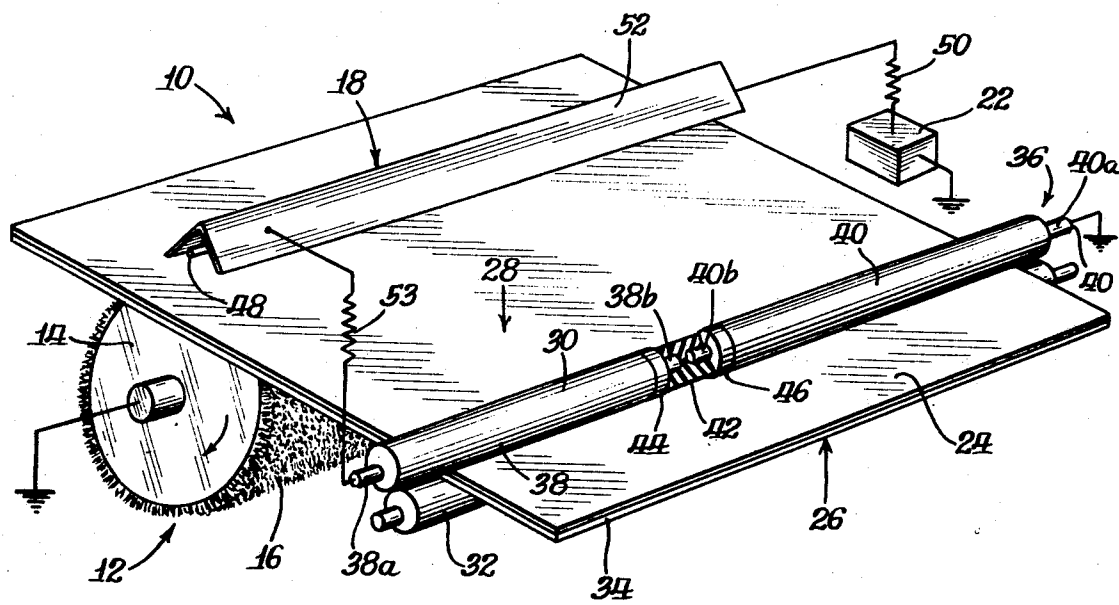
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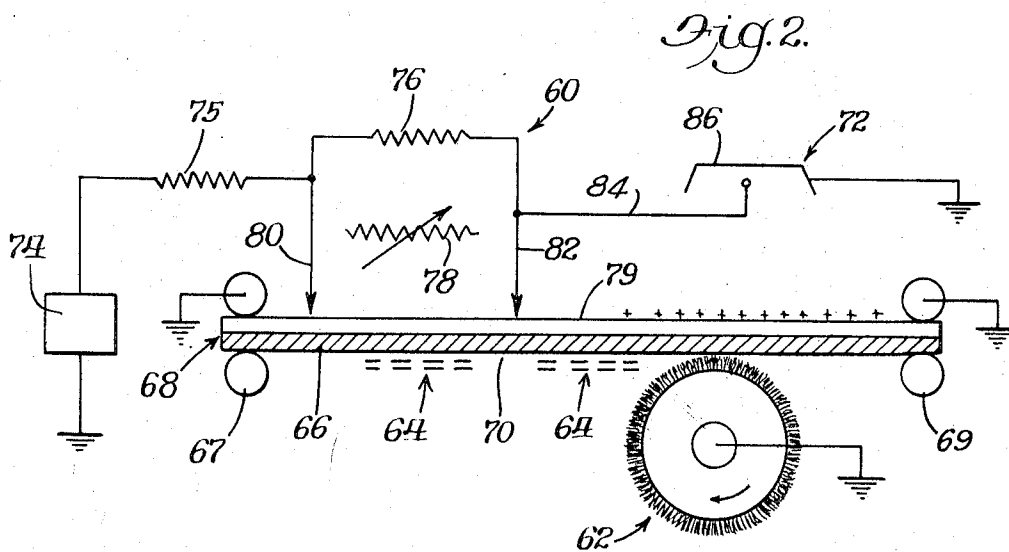
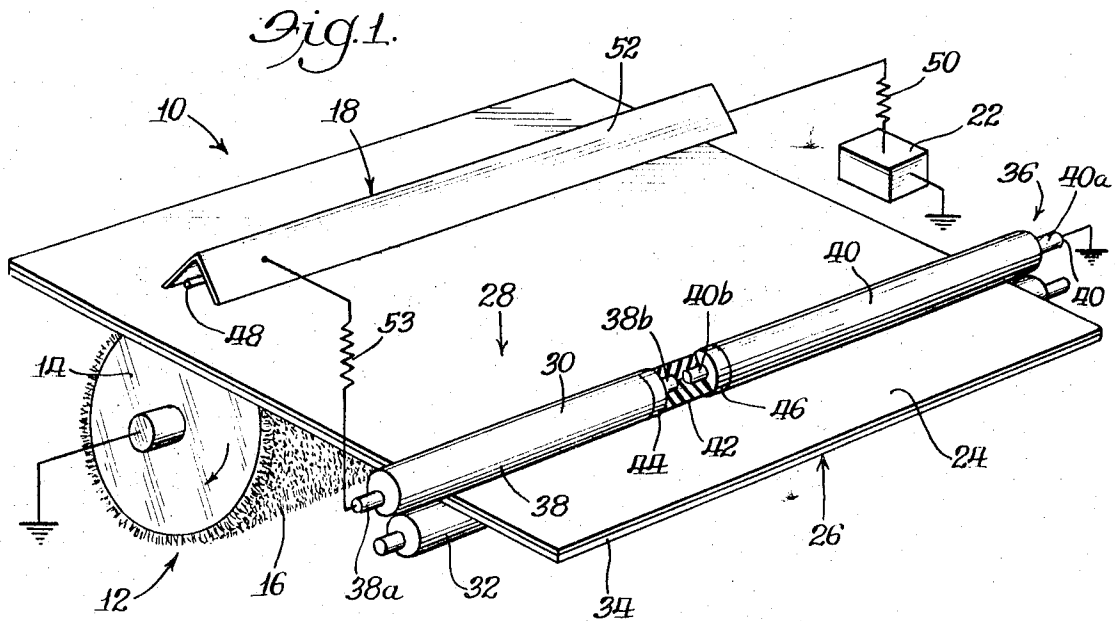
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**ABSTRACT:** The apparatus uses a corona discharge electrode at the developing station which governs the application of developing powder to nonimage areas of the member. The electrode is provided with a control device that automatically regulates the corona emission of the former as a function of the conductivity of the paper base of the member. The control device includes conductors which electrically couple the base with a source of electrical power and the electrode to sense the conductivity of the base.





Inventor:  
Robert G. Blanchette  
By: Sd L. Holdstein  
Ronald J. LaPorte  
Atty

## DEVELOPING APPARATUS

## BACKGROUND OF THE INVENTION

This invention relates to an improved developing apparatus useful in developing a latent electrostatic image retained on the light-sensitive photoconductive surface of a photoelectrostatic recording member. More particularly, this invention relates to an apparatus of the above type which is capable of monitoring the base portion of the recording member, sensing a change in conductivity due to a corresponding change in the moisture content thereof brought about by a change in humidity of the surrounding atmosphere, and in accordance therewith ultimately controlling the application of electroscopic developing powder to the nonimage surface areas of the member.

A photoelectrostatic recording member imaged in accordance with a well-known photoelectrostatic copying process is developed by selectively applying electroscopic developing powder to the latent electrostatic image on the photoconductive surface of the member to convert the image into a visible form. Means for governing the application of powder to the nonimage areas on the recording surface, such as disclosed in U.S. Pat. No. 3,369,917, assigned to the same assignee, are frequently employed in the photoelectrostatic copying art. Devices of this type generally include a source of electrical power and, an electrode coupled to the source, disposed adjacent the moisture-sensitive base. A current provided by the electrode impinges upon the recording member. A voltage opposite in polarity from that of the face or photoconductive surface of the recording member is thereby produced and in turn causes the repulsion of the powder from the nonimage areas of the latter. Thus, background areas thereon are maintained free of unwanted, spurious powder deposition. In the case of a corona-type electrode which is commonly used for biasing purposes, the current or voltage produced thereby is dependent upon the potential difference between a discharge wire and a shield portion making up the electrode. A change in the conductivity of the base of the recording member disrupts the repelling of unwanted powder deposition on the background areas of the photoconductive layer of the recording member so that the utilization of the corona bias voltage becomes less efficient when the conductivity of the base is great.

In the case wherein the base employed is paper, the humidity of the surrounding atmosphere effects its conductivity. As the moisture content of the base increases, the base becomes more conductive. When the base is in a highly conductive state, the amount of current being supplied by the electrode which generates the bias voltage to the recording member for the purpose of repelling electroscopic developing powder from the nonimage areas thereof, must be increased, since the base tends, at this time, to conduct current laterally therealong, establishing a shunt circuit on the backside of the recording member.

Prior art devices are provided with manually operated controls for varying the current being supplied by the electrode to maintain the bias voltage on the recording member. Necessarily, such known devices must rely on the judgement of the operator to properly assess the moisture condition of the base. Frequently, as a result of errors in judgement on the part of the operator, improper development of the recording member occurs.

## SUMMARY OF THE INVENTION

Accordingly, it is a primary object of the present invention to provide an improved developing apparatus which prevents automatically the deposition of electroscopic developing powder on the nonimage areas of the photoconductive surface of a recording member as a function of the conductivity of the base of the member.

In accordance with the foregoing object, the developing apparatus of this invention includes a developer assembly for applying electroscopic powder to the photoconductive surface

of the recording member, thereby reducing the latent electrostatic image on the surface to a visible form; means for govern the application of the powder to the nonimage areas on the surface including a source of electrical power and coupled to the source, an electrode disposed adjacent the moisture-sensitive base, the electrode imparting a bias voltage to the member opposite to that on the face or photoconductive surface thereof to repel the charged powder from the nonimage areas; and means connected to the governing means for monitoring the conductive state of the base portion of the recording member and in accordance therewith, controlling automatically the energization of the electrode. The monitoring or sensing means in one embodiment of the invention comprises a pair of insulatively spaced conductors, each in electrical contact with the base. The conductors are electrically coupled to the electrode and power source, so that as the conductivity of the base changes, the current supplied by the electrode is varied accordingly to maintain the bias voltage at a proper level. The base, in effect, acts as a variable resistor changing its resistivity as a function of the conductivity thereof.

In the preferred embodiments of this invention, a conventional magnetic brush applicator is employed, and the electrode used is of the corona type which includes at least one discharge wire surrounded in part by a conductive shield. The corona electrode establishes a corona current to ground through an air dielectric and the member. The base can be coupled either between the power source and discharge wire or between the shield and ground.

## DRAWINGS

For a better understanding of this invention, as well as other objects and features thereof, reference is had to the accompanying drawings in which:

FIG. 1 is a perspective view of one embodiment of the present invention wherein the base is connected between the shield of the corona electrode and ground; and

FIG. 2 is a schematic drawing of another embodiment of this invention wherein the base is connected between a source of electrical power and the discharge wire of the corona electrode.

## DETAILED DESCRIPTION

Referring to FIG. 1, there is shown one embodiment of the developing apparatus of this invention, indicated generally as 10. The apparatus 10 includes a conventional magnetic brush developing assembly 12, comprising a rotatably mounted cylinder 14 and a magnetic brush 16, made up of magnetic carrier particles and electroscopic developing powder, herein, having a positive polarity. A corona electrode 18 is connected to the positive terminal of a DC power source 22, and means, indicated generally as 28, are provided for controlling the operation of the electrode 18 in accordance with the conductivity of the base 24 of the photoelectrostatic recording member 26 being developed, thereby to regulate the bias voltage, which is of the same polarity as the developing powder for repelling unwanted powder deposition on the nonimage areas of the photoconductive surface of the recording member.

The member 26 is conveyed past assembly 12 by a pair of driven rollers 30 and 32, the exterior coverings of which are formed of an insulating material, such as rubber or nylon. As the member 26 is moved past the assembly 12, the photoconductive layer 34, bearing a latent electrostatic image thereon of a negative polarity in this case, comes into tangential contact with the magnetic brush 16 whereby powder is applied to the latent image to convert it into a visible form. The cylinder 14 is as long axially as the member 26 is wide, is disposed transversely to the path of movement of the member, and is connected to ground. Many suitable magnetic developing assemblies are available, such as, for example, of the type disclosed in detail in U.S. Pat. No. 3,003,462.

The upper roller 30, as shown in FIG. 1, is formed into separate halves 38 and 40. Each half is supported on a cor-

responding metallic, electrically conductive half shaft 38a and 40a, respectively. A pair of metallic, conductive discs 44 and 46 are fixedly mounted on respective opposing end portions 38b and 40b of the half shafts 38a and 40a so as to be both mechanically and electrically connected thereto, and a cylindrical insulating spacer element 42 of a plastic, rubber or the like material (shown in Section in FIG. 1) is interposed between the opposing end portions 38b and 40b with the latter being imbedded in respective ends thereof without making contact with each other. The diameter of each of the discs 44 and 46 is equal to that of the outer diameter of the roller 30; thus both the exterior insulating jackets of the roller and the conductive outer circumferential surfaces of the discs are in contact with the base portion 24 of the recording member as it passes between rollers 30 and 32.

The corona electrode 18 disposed above the moisture-sensitive base 24 includes a discharge wire 48 connected through a resistor 50 to the power source 22, and a conductive metal shield 52 which partially surrounds the wire. The wire 48, being maintained at a potential in the range of from 4,000—6,000 volts, ionizes the atmosphere in the vicinity of the wire to establish a corona current flow via the air dielectric between the electrode and recording member 26.

The shield 52 is connected to ground via the circuit including a limiting resistor 53, half shaft 38, disc 44, the base 24, disc 46, and half shaft 40.

The corona current flow to ground over the last mentioned path depends on the conductivity of the base 24 which effects the potential difference between the wire 48 and shield 52. As mentioned heretofore at high humidity conditions the base 24 is highly conductive and a shunt circuit to ground is established which drains off a portion of the corona current being provided by electrode 18. If this drain in corona current is not compensated for, the bias voltage will be decreased accordingly and the background or nonimage areas of the member 26 will receive a spurious deposition of powder. In order to compensate for this current drain, the potential difference between the wire 48 and shield 52 must be increased.

By coupling the base 24 to the electrode 18, as shown, the potential difference between the shield 52 and the wire 48 increases or decreases in direct proportion with increases or decreases in the conductivity of the base, so that, even though a portion of the corona current is being diverted at high humidity conditions, a greater amount of current is made available automatically to maintain the bias voltage on the member 26 at a predetermined level.

Explaining this more fully and in more detail, the base 24 of the recording member acts as a variable resistor; that is, the resistance of the base portion changes with a variation in moisture content or other factors which effect the conductivity of the base. As described above, the greater the moisture content, the greater the conductivity thereof. Thus, by including the base portion 24 of the recording member in the circuit heretofore described, a change in resistance of the base produces a resistance change in the circuit; consequently, the current flow from the electrode 18 producing the bias voltage, will be affected.

In the embodiment of the invention of FIG. 1, the base 24 is employed as a conductor between discs 44 and 46 to complete the circuit from shield 52, through half shaft 38, half shaft 40 and to ground. As the resistivity (conductivity) of the base 24 changes due to a change in moisture content thereof caused by a variation in the humidity of the surrounding atmosphere, the current permitted to flow through the last mentioned circuit is inhibited or enhanced, as the case may be. The change in the current flow through the last mentioned circuit in turn effects the current flow from the discharge wire to member 26 and the assembly 12. Thus, when the base becomes highly conductive and a greater flow of current is permitted in the circuit comprising shield 52, half shaft 38, disc 44, base 24, disc 46, and half shaft 40 to ground, the potential difference between shield 52 and discharge wire 48 is great. In turn a greater current flow is provided from the power source 27,

through wire 48 and the air dielectric. By the same token when the moisture content of the base 24 is small and the base is nearly dry, having relatively no moisture therein, the resistance of the base 24 is very high and controls the shield circuit. The potential difference between the shield 52 and the discharge wire at this time is reduced and consequently a lesser current flow is provided in the circuit including the discharge wire and the air dielectric.

Thus, the arrangement according to the invention automatically adjusts the potential difference between the discharge wire 48 and shield 52 to in turn control the current flow for repelling unwanted, spurious developer powder deposition in the background or nonimage areas on the photoconductive surface of the recording member.

Referring now to FIG. 2 of the drawings, there is shown another embodiment of the developing apparatus of the present invention, indicated generally as 60. Developing apparatus 60 comprises a magnetic developing assembly 62 which applies developing powder to the latent electrostatic image 64 on the photoconductive surface 66 of the recording member 68 as it is moved past the apparatus by the roller pairs 67 and 69, and means for governing the application of powder to the nonimage area 70 on the surface 66, made up of a corona electrode 72 connected to the positive terminal of a DC power source 74. The discharge wire 84 of the electrode 72 is connected to a parallel combination of resistances made up of resistor 76 and the variable resistance indicated as 78 of the base 79 of recording member. The base is coupled to the resistor 76 by means of monitoring or sensing conductors 80 and 82 which contact the base 79 at predetermined spaced apart points therealong. The parallel resistance combination is in turn connected through another resistor 75 to a grounded power source 74.

The operation of this circuit configuration is similar to that of the embodiment of FIG. 1. As the resistance of the base 79 decreases due to a greater moisture content, caused by an increase in the surrounding humidity, the potential difference between the shield 86 and discharge wire 84 increases causing a greater current flow therebetween, thus maintaining the bias voltage at a proper level to repel spurious developer powder deposits on the nonimage areas of the photoconductive layer 66 of the powder.

In this case the shield 86 of electrode 72 is always at ground potential, and through the regulation of the potential difference between the discharge wire and ground, the bias voltage provided thereby is maintained. plate-type

Although the present invention has been described with reference to a number of illustrative embodiments thereof, it should be understood that other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of this invention. For example, it is contemplated that the principles disclosed herein can be embodied in developing devices using plate-type contact electrodes instead of the preferred corona electrode.

The aim in the appended claims is to cover all such changes and modification as come within the true spirit and scope of the invention.

I claim:

1. In apparatus for developing a latent electrostatic image retained on the photoconductive surface of a photoelectrostatic recording member, said member having a moisture-sensitive base supporting said surface, the combination comprising:

developer means for applying electroscopic powder to the photoconductive surface of said recording member whereby the latent image is converted into a visible form; a source of electrical power; electrode means coupled to said power source and disposed adjacent said base support, said electrode means providing a bias voltage of a predetermined level to said member for repelling the powder from the nonimage areas; and

means connected to said electrode means for automatically regulating the operation of said electrode means to maintain said bias voltage at said predetermined level in accordance with the moisture content of the base of said recording member.

2. The combination as defined in claim 1, wherein said automatic regulating means include conductive monitor means in electrical contact with the base for electrically connecting said base to said electrode means and said source.

3. The combination as defined in claim 2, wherein said electrode is of the corona-type having at least one discharge wire surrounded partially by a conductive shield and which establishes current through an air dielectric to said member.

4. The combination as defined in claim 3, wherein said conductive monitor means couple said base between said source and said discharge wire.

5. The combination as defined in claim 3, wherein said conductive monitor means couple said base in series connection between said shield and ground.

6. The combination as defined in claim 1, wherein said developer means comprises a magnetic brush made up of magnetic carrier particles and said powder and wherein the polarity of said powder and said bias voltage are the same.

7. The combination as defined in claim 1, wherein said electrode means is coupled electrically through said base support, whereby due to an increase in the moisture content of said base support, the conductivity thereof increases proportionally, causing a corresponding increase in electrical current through said electrode means thereby to maintain said bias voltage at said predetermined level.

8. The combination as defined in claim 7, wherein said regulating means further includes resistance means connected in parallel relation with said base support and interposed between said electrode means and said power source.

9. In an apparatus for developing a latent electrostatic image retained on the photoconductive surface of a photoelectrostatic recording member, said member having a base supporting said surface, said base varying in conductivity in accordance with changes in the humidity of the surrounding atmosphere or the like, the combination comprising:

developer means for applying electroscopic powder of a predetermined polarity to the surface of said recording member whereby the latent image is converted into a visible form;

a source of electrical power;

electrode means coupled to said power source and disposed adjacent said base support, said electrode means providing a bias voltage having a polarity the same as that of said electroscopic powder applied to said member for repelling the powder from the nonimage areas of the photoconductive surface of said recording member; and sensor means coupled to said electrode means and the base support of said recording member for automatically regu-

lating the operation of said electrode means to maintain said bias voltage at said predetermined level in accordance with the conductivity of said base support.

10. The combination as claimed in claim 9, wherein said sensor means includes a pair of spaced conductors coupled to said base support and connected to said electrode means, said base support completing a circuit between said conductors, whereby a change in conducting of said base support causes a corresponding change in current flow from said power source through said electrode means, thereby to maintain the level of said bias voltage on said member for repelling said electroscopic powder.

11. In an apparatus for developing a latent electrostatic image retained on the photoconductive surface of a photoelectrostatic recording member, said member having a moisture-sensitive base supporting said surface, the combination comprising:

developer means for applying electroscopic powder to the surface whereby the latent image is converted into a visible form;

a source of electrical power;

a corona-type electrode disposed adjacent said base support providing an electrical current to said member to produce a bias voltage of a predetermined level for repelling the powder from the nonimage areas of said photoconductive surface and including a discharge wire surrounded partially by a conductive shield, said wire being electrically connected to said power source;

a roller member mounted for rolling engagement with said recording member along the base support thereof, said roller member including first and second electrically conductive halves insulatively spaced from each other, said first roller half being connected to the conductive shield of said corona electrode and said second roller half being connected to ground potential; and

said first and second roller halves being electrically interconnected through said base support, whereby when the moisture content of said base support increases, the conductivity thereof increases proportionally, thereby to in turn maintain said predetermined bias voltage for the repulsion of developer powder from the nonimage areas of said photoconductive surface.

12. The combination as defined in claim 11, wherein each of said roller halves of said roller member comprises a conductive core extending axially thereof with a cylindrical insulating jacket formed thereabout, and wherein said roller halves include mounted at opposing ends thereof, electrically conductive disc members, each of which is connected to a respective one of said conductive cores of said roller halves, said disc members being joined by means of an insulating spacer and being in rolling engagement with the base support of said recording member.

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