Nov. 19, 1968 S. NAROFF 3,411,846

ELECTROPHOTOGRAPHY

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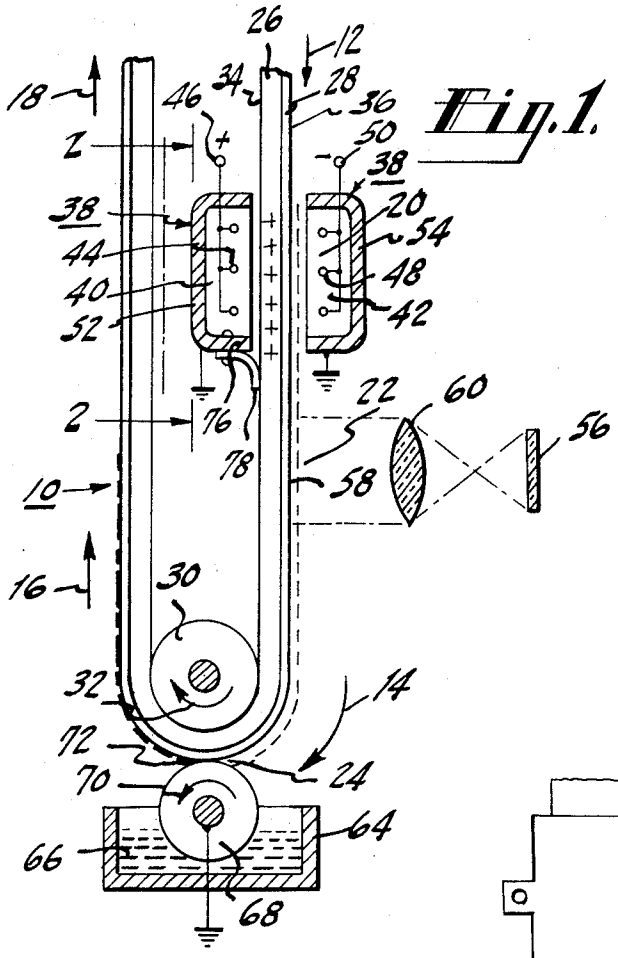



Fig. 1.

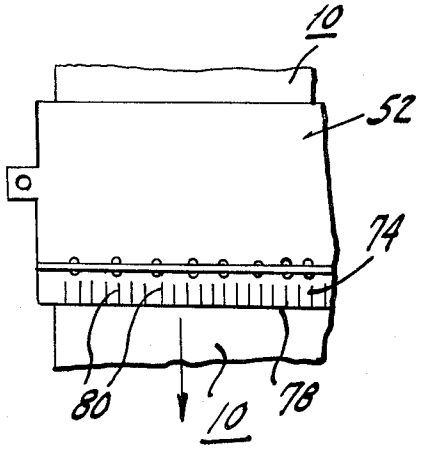



Fig. 2.

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# ELECTROPHOTOGRAPHY

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## ABSTRACT OF THE DISCLOSURE

In compact electrophotographic apparatus, using double corona charging devices and a grounded electroscopic toner applicator, unwanted spurious currents that tend to flow along the conductive backing of a recording element are prevented by providing a current path for the spurious currents adjacent one of the corona discharge devices. The conductive path comprises a grounding finger connected to a grounded shield of a corona discharge device and disposed to contact the backing of the recording element.

This invention relates generally to electrophotography, and more particularly to improved apparatus for charging an electrophotographic recording element in an electrophotographic process. The improved apparatus is particularly useful for charging a recording element in relatively compact electrophotographic apparatus employing a double charging arrangement.

In an electrophotographic process of the type described in RCA Review, vol. XV, p. 469, December 1954, for example, an electrophotographic recording element, comprising a layer of photoconductive zinc oxide dispersed in a resin binder on a backing of suitable conductivity, is charged negatively so that the photoconductive layer carries a fairly uniform electrostatic charge on its surface. The recording element is then exposed to a light image to discharge the surface in accordance with the intensity of light falling on it and to leave a latent electrostatic image thereon. The latent image is then developed by applying a finely divided electrostatically attractable material, such as electroscopic toner particles, thereon. The developed image may be either fixed to the recording element, as by applying heat to the toner particles to fuse them, or the unfixed developed image may be transferred to another surface, as desired.

During the electrostatic charging and light image exposure operations, it is necessary for the back of the recording element to be at a different potential from that on the photoconductive layer. Where a single corona discharge device is used for the charging operation, the recording element is usually disposed during the charging thereof on a conductive, grounded plate, that is, on a plate at zero potential. In certain electrophotographic apparatus where it is not convenient to use a grounded plate, a double charging arrangement is used wherein the recording element to be charged is passed between a pair of charging devices. One of the charging devices produces a negative corona, bombarding one major surface of the recording element with negative ions. The other charging device produces a positive corona discharge, bombarding the opposite major surface of the recording element with positive ions. This double charging arrangement, usually referred to as a double corona discharge device, charges the opposite surfaces of the recording element with charges of opposite polarity.

In certain electrophotographic apparatus, especially that of the compact type, wherein a double charging arrangement is used for charging the recording element, and wherein the recording element has a backing of relatively high conductivity, it has been found that an undesirable current flow, in addition to that produced



by the desired latent electrostatic image, occurs at the developing station, thereby causing an undesirable deposition of toner on the recording element.

It is an object of the present invention to provide improved charging means for charging an electrophotographic recording element in electrophotographic apparatus employing a double charging arrangement.

Another object of the present invention is to provide improved charging means for effectively charging the photoconductive layer of a recording element with a double charging arrangement and preventing undesirable current along the recording element between a grounded component in the developing section and the charging means of the apparatus.

The improved charging means is employed in combination with a double charging arrangement. Relative motion is produced betwen the double charging arrangement and a recording element so that the recording element is either virtually or actually passed between two charging devices of the double charging arrangement. The two charging devices are energized to provide positive and negative ions to charge the opposite major surfaces of the recording element positively and negatively, respectively. An electrically conductive path, including the backing of the recording element at the site where the recording element emerges from the double charging arrangement after it has been charged, is provided to shunt current in a direction that would tend to prevent the aforementioned undesirable current. In a preferred embodiment, the conductive path is a conductive member disposed to contact the backing of the recording element and adapted to be connected to a source of potential of a value that is between that resulting from the positive and negative charging of the opposite major surfaces of the recording element. The conductive member is connected preferably to the trailing edge of a grounded shield of the discharge device that charges the backing of the recording element.

Other novel features of the invention, both as to its organization and method of operation, will be described in greater detail by reference to the accompanying drawing, and in which:

FIG. 1 is a fragmentary, side, elevational view, partly in cross-section, of electrophotographic apparatus employing the improved charging apparatus, and

FIG. 2 is a fragmentary view of the improved charging apparatus, taken along the line 2—2 in FIG. 1, and viewed in the direction indicated by the arrows.

Referring now to FIG. 1 of the drawing, there is shown an electrophotographic recording element **10** disposed for movement along a predetermined path, indicated by arrows **12**, **14**, **16**, and **18**, through a charging station **20**, an exposure station **22**, and a developing station **24** of an electrophotographic process. The recording element **10** may be in the form of a single sheet or a continuous web and comprises a relatively conductive backing **26**, such as paper having a resistivity less than $10^9$ ohm-cm., and a relatively insulating (in the dark) photoconductive layer **28**, such as photoconductive zinc oxide, thereon. The recording element **10** is guided along its path by means including an electrically insulated roller **30** driven by any suitable means in the direction indicated by the arrow **32**.

Means are provided at the charging station **20** to charge the opposite major surfaces **34** and **36** of the recording element **10** with charges of opposite polarity, the surface **34** being that of the backing **26**, and the surface **36** being that of the photoconductive layer **28**. To this end, a double charging arrange **38**, comprising a pair of charging devices **40** and **42**, disposed adjacent to the opposite major surfaces **34** and **36** of the recording element **10**,

respectively, is provided so that, when energized from a suitable power supply (not shown), a positive corona discharge is directed onto the major surface **34** and a negative corona discharge is directed onto the major surface **36**. The discharge device **40** includes corona discharge wires **44** which are connected to a source of positive potential of, e.g., 3,000 volts, with respect to a reference potential such as ground, through a terminal **46**. The corona discharge device **42** includes corona discharge wires **48** which are connected to a source of negative potential of, e.g., −3,000 volts, with respect to the reference potential, through a terminal **50**. Shields **52** and **54** of the charging devices **40** and **42**, respectively, are connected to the reference potential, ground. When the charging devices **40** and **42** are energized, the recording element **10** is given a positive charge on its surface **34** and a negative charge on its surface **36** as it passes through the charging station **20**.

The charged recording element **10** is exposed to a light image at the exposure station **22**. For example, an image on a photographic slide **56** may be projected onto the photoconductive surface **36**, as at **58**, by means of an optical system, represented herein merely by a lens **60**. The charge on the photoconductive surface **36** is modulated, that is, selectively reduced, by the light image projected on it to form an electrostatic latent image, and the latent image is developed at the developer station **24**.

A reservoir **64** of electrophotographic developer **66**, comprising electroscopic toner particles disposed in a carrier fluid, is disposed at the developing station **24**. A suitable developer **66** is a 2%, by weight, mixture of Lampblack No. 8 (Columbian Carbon Co.) in molten microcrystalline wax (Sunoco No. 1290 Yellow). The average particle size of the Lampblack No. 8 toner should be about 0.6 micron in diameter.

A grounded, conductive roller **68** is mounted for free rotation by the recording element **10** in the direction indicated by the arrow **70**. The lower portion of the roller **68** is disposed in the liquid developer **66** so that, as the roller **68** is rotated by the recording element **10**, the toner particles of the developer **66** are applied to the electrostatic latent image on the recording element **10** to develop it, as at **72**. The developed latent image may now be fixed by any suitable means known in the art, as by heating. If the developer **66** is of the "hot-melt" type, that is, comprising toner particles in a fusible solid carrier, it has to be molten before it can be used. Some hot-melt developers are self-fixing, no additional heating being necessary.

In the aforementioned electrophotographic process, especially in compact electrophotographic apparatus where the conductivity of the backing **26** is relatively high, it has been found that an unwanted charge appears across the insulating layer **28**, at the site of the grounded, toner applying roller **68**, at the developing station **24**, resulting in heavy, excessive deposits of toner particles on the surface **36**. This unwanted charge is probably due to unwanted current along the conductive backing **26** of the recording element **10** resulting from the proximity of the positive corona discharge device **40** to the grounded roller **68**. It is believed that negative ions in the backing **26** tend to be attracted to the positive corona discharge device **40**, leaving a positive charge on the backing **26** balanced by a negative charge supplied by the grounded roller **68**. Such an unwanted charge is eliminated, or greatly reduced, by the improved charging means of the invention which provides a short circut path for the aforementioned unwanted current.

To this end, an electrically conductive member **74**, such as a strip of spring metal, is secured to the trailing edge **76** of the shield **52** by any suitable means, such as by welding, solder, or bolts, for example, so that an edge **78** of the conductive member **74** extends to the path of the recording element **10** and contacts the backing **26** of the recording element **10**. The conductive member **74** may be made very resilient by a plurality of substantially parallel cuts or slits **80** therein, extending perpendicularly from the edge **78**.

Since the shield **52** is connected to the reference potential, ground, a portion of the available positive charge is grounded by the conductive member **74** at the site where the recording element **10** leaves the discharge device **40**. The conductive member **74** functions as a short current path to ground, a shunt for current between the backing **26** and ground at the site of the charging device **40**, thereby tending to eliminate current flowing through the backing **26** to the grounded roller **68**. Thus, by eliminating or reducing the latter unwanted current, an excessive charging of the recording element **10** at the site of the grounded roller **68** is eliminated, and excessive deposits of toner particles on the recording element **10** are thereby prevented.

It is also within the contemplation of the invention to prevent unwanted charging by the conductive member **74** in an electrophotographic process wherein the double charging arrangement **38** is moved relative to a stationary recording element **10**. Thus, the charging devices **40** and **42** may be moved parallel to the recording element **10** by any suitable means, thereby producing relative motion between the recording element and the charging devices **40** and **42**. In charging the recording element **10**, the double charging arrangement should be moved initiallly in a direction resulting in the conductive member **74** being on the trailing edge of the charging device **40**. Thus, the conductive member **74** can act as a grounding finger current path to ground for an excess charge at the site where it is substantially produced.

Form the foregoing description, it will be apparent that there has been provided improved apparatus for charging an electrophotographic recording element whereby a conductive path for shunting current to ground is provided to eliminate, or greatly reduce, unwanted currents which would otherwise tend to flow along the recording element between the charging means and a component at the developing station, thereby substantially eliminating spurious toner deposits at the developing station. While the improved apparatus has been illustrated in a preferred embodiment, variations in the apparatus, all coming within the spirit of this invention, will, no doubt, suggest themselves to those skilled in the art. For example, the conductive member **74** may comprise a plurality of resilient wires, instead of a slotted strip of spring metal, and the wires may be connected to a suitable neutralizing potential through means other than the grounded shield of a charging device. Hence, it is desired that the foregoing description shall be considered merely as illustrative and not in a limiting sense.

What is claimed is:

**1.** In electrophotographic apparatus of the type wherein relative motion is produced between an electrophotographic recording element and a double charging arrangement, said recording element having opposite major surfaces, and said double charging arrangement comprising means disposed opposite said major surfaces to apply a charge of one polarity to one of said major surfaces and a charge of an opposite polarity to the other of said major surfaces, the improvement comprising:

an electrically conductive member disposed to contact only one of said surfaces as said recording element leaves said charging means, after said recording element has been charged, and

means to connect said member to a potential which is different from said charge of one polarity, whereby current may flow through said member.

**2.** In electrophotographic apparatus of the type described in claim **1**, wherein said charge applying means includes a grounded shield, and said member is connected to said shield.

**3.** In electrophotographic apparatus of the type described in claim **1**, wherein said charge of one polarity is positive, said one major surface comprises a relatively conductive backing of said recording element, said charge

applying means includes shielding means connected to said conductive member, and said apparatus includes toner applying means electrically connected to said shielding means by a common connection.

4. Apparatus for charging an electrophotographic recording element, said apparatus comprising, in combination:

a double charging arrangement comprising a pair of positive and negative charging devices, said pair of devices being disposed opposite to, and spaced from, each other, to receive said recording element therebetween to charge opposite major surfaces of said recording element with potentials of opposite polarity, respectively,

means causing relative motion between said recording element and said pair of devices,

electrically conductive means disposed to contact one of said major surfaces after it has been charged,

one of said devices including an electrically conductive shield,

means connecting said conductive means to said shield, and

a common connection connected to said shield for applying a reference potential of an amplitude between that of said potentials of opposite polarity, whereby to apply said reference potential to said one surface.

5. Apparatus for charging an electrophotographic recording element as defined in claim 4, wherein said conductive means comprise resilient fingers connected to the trailing edge of said shield with respect to the motion of said recording element.

6. Apparatus for charging an electrophotographic recording element as described in claim 4, wherein said one major surface comprises a conductive backing, the one of said potentials of opposite polarity applied to said one major surface is positive, and said apparatus comprises a conductive toner applicator connected to said common connection.

7. Electrophotographic apparatus comprising, in combination:

means to move an electrophotographic recording element along a predetermined path, said recording element comprising a layer of photoconductive material disposed on relatively conductive backing, said backing comprising a first major surface of said recording element, and said layer comprising a second major surface of said recording element,

a double charging arrangement disposed at a first station along said path, said double charging arrangement comprising a first corona discharge device disposed adjacent to, and spaced from, said first major surface and a second corona discharge device disposed adjacent to, and spaced from, said second major surface, whereby to apply charges of opposite polarity to said first and said second major surfaces,

means to expose said second major surface to a light image at a second station along said path, whereby



to produce an electrostatic latent image on said second surface,

developing means disposed at a third station along said path, whereby to apply electroscopic toner particles to said latent image, to develop said latent image,

said first corona discharge device including an electrically conductive shield,

electrically conductive means extending from said shield and disposed to contact said first major surface, and

a common connection electrically connecting together said shield, said developing means, and said electrically conductive means.

8. Electrophotographic apparatus as defined in claim 7, wherein said polarity of said charge applied to said first major surface is positive, and said electrically conductive means is disposed between said first station and said second station.

9. In an electrophotographic apparatus of the type wherein a recording element is moved between positive and negative corona discharge devices at a charging station to apply charges of opposite polarity to the opposite major surfaces, respectively, of said recording element, wherein said recording element is moved successively past an image exposure station and an image developing station, and wherein unwanted electrical current tends to flow along the backing of said recording element between said charging station and an electrically conductive toner applicator at said developing station; the combination therewith of means disposed between said charging station and said exposure station which serves to short circuit said unwanted electrical current which would otherwise exist between said charging station and said developing station.

10. In an electrophotographic apparatus of the type wherein a recording element is moved between positive and negative corona discharge devices at a charging station to apply charges of opposite polarity to the opposite major surfaces, respectively, of said recording element, wherein said recording element is moved successively past an image exposure station and an image developing station, and wherein unwanted electrical current tends to flow along the backing of said element between said charging station and an electrically conductive toner applicator at said developing station; the combination therewith of means disposed between one of said charging devices adjacent said backing and said developing station which establishes a circuit with said one device thereby short circuiting through said backing said unwanted current between said charging station and said developing station.

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