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[54] CORONA CHARGING APPARATUS

[75] Inventors: **Paul A. La Chappelle**, Rochester; **Michael Mosehauer**, Spencerport, both of N.Y.

[73] Assignee: **Eastman Kodak Company**, Rochester, N.Y.

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[52] **U.S. Cl.** .....**317/4,** 317/262 A, 250/49.5 GC

[51] **Int. Cl.** **G03g 15/02,** H01t 19/04

[58] **Field of Search** .....317/4, 262 A; 250/49.5 GC, 49.5 ZC, 49.5 TC

[56] **References Cited**

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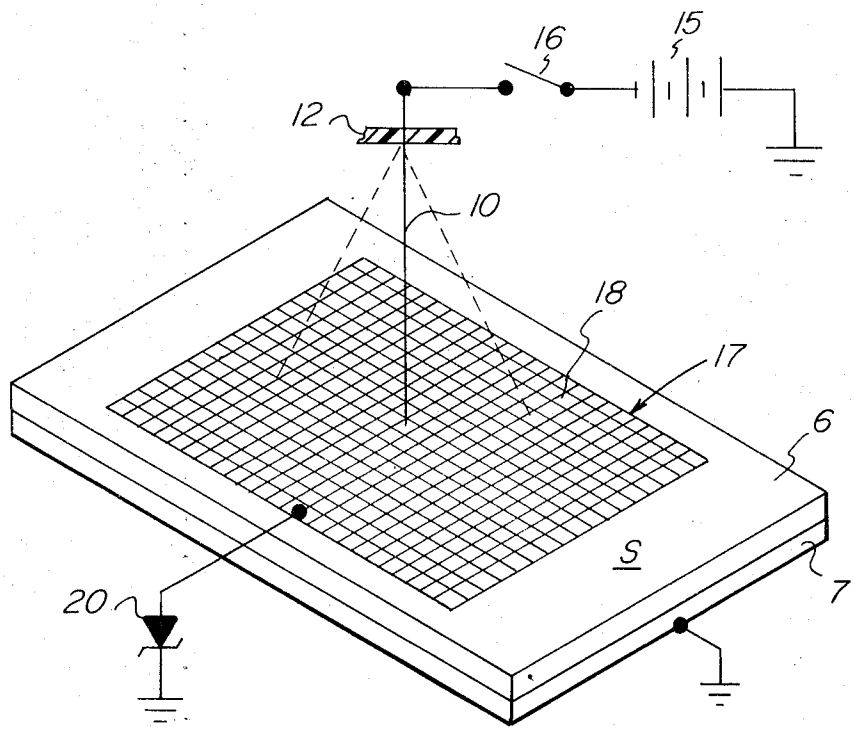
Primary Examiner—L. T. Hix

Attorney—Robert W. Hampton et al.

[57] **ABSTRACT**

Corona charging apparatus for uniformly charging the surface of a dielectric layer supported on a grounded conductive backing. Such apparatus comprises a flexible corona discharge wire which is perpendicularly arranged, in a cantilever fashion, relative to the central portion of the surface being charged, the free end portion of such wire extending toward such surface. An electrically biased corona-control electrode, positioned between the free end of the corona discharge wire and the dielectric surface, serves to control the level and uniformity of charge received by the dielectric surface. When connected to an appropriate voltage source, the free end of the corona discharge wire becomes charge-emitting and, due to the field established between it and the combination of the control electrode and the conducting backing of the dielectric layer, oscillates in a random manner, thereby uniformly charging the dielectric surface to a level proportional to the electrical bias of the control electrode.

8 Claims, 3 Drawing Figures



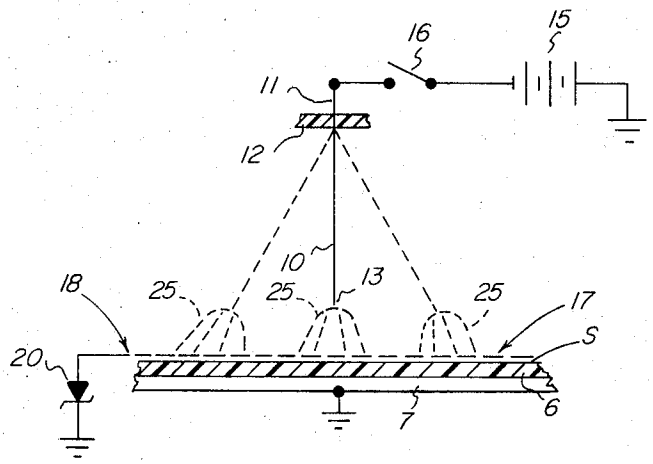


FIG. 1

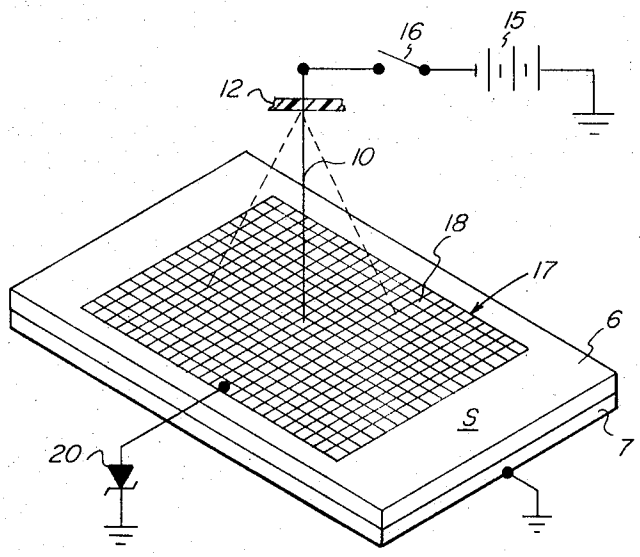


FIG. 2

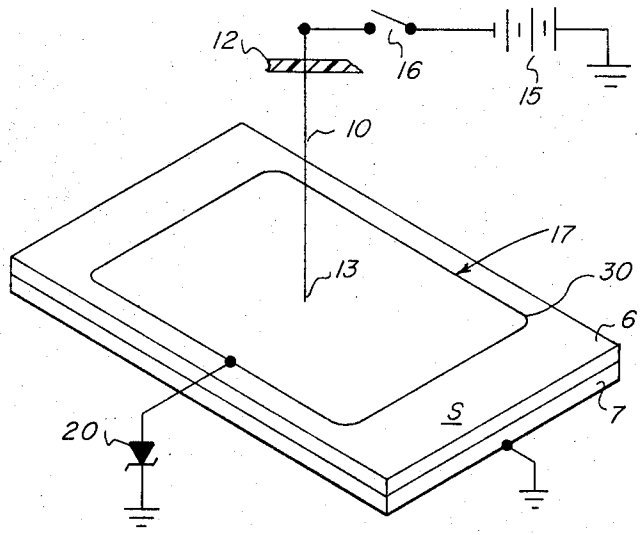


FIG. 3

CORONA CHARGING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to electrographic recording, and particularly to methods and apparatus for uniformly charging a dielectric surface, such as the surface of a photoconductive layer.

Copy-making via the electrophotographic process commonly includes the steps of uniformly electrostatically charging the photoconductive surface of an electrophotographic recording element while the element is maintained in darkness, and imagewise exposing such surface to activating radiation, thereby selectively dissipating the uniform charge to form an electrostatic image or charge pattern corresponding to the indicia on the document being copied. This electrostatic image is then rendered visible by the selective deposition of toner particles thereon.

In conventional electrostatic recording devices, uniform charging of the recording element is usually accomplished through the use of one or more corona discharge wires. These wires are connected to a source of high voltage and are arranged in spaced relationship with the photoconductive surface, extending horizontally across the entire width of the recording element. Since the corona discharge along the length of these wires tends to be uneven, especially for negative electrical polarities, various schemes have been proposed for controlling the uniformity of charge. One such scheme has been to arrange a wire grid between the corona discharge wires and the photoconductive surface, such grid being maintained at a predefined potential. This grid serves to terminate further charging of the photoconductive surface when the charge on all portions of the photoconductive surface corresponds to the grid potential.

While moderately successful in controlling the uniformity of surface charge, a disadvantage of the conventional grid-controlled corona charger is the "shadowing" effect which is characteristic of such devices; i.e., surface areas directly opposite the grid structure receive less charge than those areas positioned opposite the openings between the grid structure. This effect is particularly noticeable when the relative positions of the charging apparatus and recording element are fixed during the charging operation or, when charging the recording element "on the fly," a portion of the grid structure extends in a direction parallel to the direction of relative movement between the recording element and charging apparatus.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide an improved grid-controlled corona charger which is not subject to the disadvantages of conventional devices stated above.

In accordance with the present invention, there is provided a novel corona charging apparatus comprising a flexible conductive wire or strand which is perpendicularly supported relative to a dielectric surface which is to be charged. The wire is mounted in a cantilever fashion i.e., one end is fixed and the other is free to move) with the free end thereof arranged closer to the dielectric surface than the fixed end. An electrically biased corona-control grid, positioned between the free end of the wire and the dielectric surface, serves to

control the level and uniformity of charge received by the dielectric surface. When high voltage is applied to the wire, the free end thereof oscillates randomly, continuously spraying ions or corona charge toward the dielectric surface. Due to such oscillations, charge is directed at the dielectric surface from various angles, the result being a substantially uniform charge with no evidence of any r eduction in charge in areas on the dielectric surface directly opposite the structure of the control grid; i.e., no evidence of any of the aforementioned "shadowing effect."

In accordance with an alternate embodiment of the invention, a conductive ring arranged along the periphery of the surface being charged is used in lieu of the aforementioned corona-control grid to regulate the level and uniformity of charging. An advantage of this embodiment is the complete absence of any structure between the corona-emitting wire and the surface being charged which might otherwise intercept corona charge or interfere with charging.

Other objects and advantages of the invention will become immediately apparent to those skilled in the art from the ensuing detailed description of the preferred embodiments, reference being made to the accompanying drawing wherein like reference characters designate like parts.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic side elevation of a preferred embodiment of the corona charging apparatus of the invention, illustrating in phantom lines the movement of the vorona discharge wire upon being energized by a source of high voltage;

FIGS. 2 and 3 are perspective views of the corona charging apparatus of the invention, illustrating two different forms of the corona-control electrode.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIG. 1, a dielectric layer **6** having grounded conductive backing **7** and a surface S which is to receive a uniform charge is shown positioned beneath the vorona charging apparatus of the invention. Such apparatus comprises a flexible wire **10** (e.g., a stainless steel wire having a diameter of 1.5 mil) which is perpendicularly suspended above surface S. Wire **10** is mounted in a cantilever fashion, one end **11** being rigidly coupled to a dielectric support **12** and the other end **13** being free to move in any direction without constraint, except that inherent in the rigidity of the wire. The upper end **11** of wire **10** is operatively connected to a high voltage source **15**, such as a ten kilovolt source, through a switch **16**. The length of wire **10** is directly proportional to the surface area being charged.

Positioned between the free end **13** of wire **10** and surface S is a corona-control electrode **17** which, as shown in FIG. **2**, preferably comprises an electrically conductive grid **18** having approximately ten grid wires per inch in each direction. Electrode **17** is either electrically biased by an external source (not shown) to the desired charge potential level of surface S or, as shown, connected to ground through a zener diode **20** having a breakdown voltage approximately equal to such charge potential level. Electrode **17** serves o control the level and uniformity of charge received by surface S.

When no voltage is applied to wire **10**, it assumes the rest position indicated in the solid lines of FIGS. **1** and **2**. However, upon closing switch **16**, thereby connecting wire **10** to high voltage source **15**, wire **10** begins to oscillate or whip about in a random manner, rapidly flexing about support **12** into various positions such as those indicated in phantom lines in FIGS. **1** and **2**. During such random oscillation, a corona discharge **25** takes place between the free end **13** of wire **10** and the corona control grid **18**, and, due to the electric field between wire **10** and the combination of grid **18** and backing **7**, ions are attracted toward and deposited on dielectric surface S. When the surface of layer **6** is charged to the breakdown voltage of diode **20**, no additional charging occurs. The polarity of the deposited charge is determined by the polarity of voltage source **15** and, of course, the orientation of diode **20**.

In FIG. **3**, corona control electrode **16** is shown to comprise an electrically conductive closed loop **30** which is arranged along the periphery of the dielectric surface area being charged and slightly spaced therefrom. Like grid **18**, loop **30** is electrically biased to the level of desired surface charge potential, either by an external voltage source or by connecting loop **30** to ground through zener diode **20** as shown. During the charging operation, loop **30** serves to regulate the uniformity of charge and the charging level.

The invention is further illustrated by the following examples:

EXAMPLE 1

A ⅛ inch stainless steel wire mesh or grid was arranged ⅛ inch above a photoconductive layer which was to receive a uniform charge. The grid was connected to ground through six 100 volt zener diodes connected in series. The area being charged was approximately one square inch. Vertically suspended above the grid was a 1.5 mil stainless steel wire, approximately 1.5 inch in length. One end of the wire was rigidly connected to a plastic mount, and the other end extended toward the grid and was free to move in any direction. The spacing between the free end of the wire and grid was approximately ⅜ inch. A 10 kilovolt DC negative potential was applied to the wire for two seconds. During this period the free end thereof oscillated randomly, spraying a corona discharge toward the photoconductive surface. Due to the zener diodes, the grid quickly charged to a voltage of −600 volts. After disconnecting the voltage source, the charge on all portions of the photoconductive surface was determined to be within 5 percent of −600 volts.

EXAMPLE 2

The same experiment as that described in Example 1 was repeated except that the wire grid was replaced with a copper wire loop which was arranged about the periphery of the area being charged, spaced from such surface a distance of approximately ⅛ inch. The diameter of the wire loop was 0.073 inch. The wire loop was connected to ground via six 100 volt zener diodes connected in series. After applying the 10 kilovolt source to the corona discharge wire for approximately two seconds, all areas of the photoconductor surface within the wire loop were found to be charged to within 5 percent of −600 volts.

This invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

We claim:

1. Corona charging apparatus for substatially uniformly charging a dielectric surface to a predefined charge level; said apparatus comprising

a. a flexible wire, perpendicularly arranged relative to said surface and mounted in a cantilever fashion such that the free end thereof extends toward and is spaced from said surface;

b. means for simultaneously generating ions from said free end and causing said free end to move in a random manner relative to said dielectric surface; and

c. means for attracting said ions toward said dielectric surface.

2. The invention according to claim **1** wherein said attracting means comprises means for preventing the charging of said surface beyond said predefined charge level.

3. The invention according to claim **2** wherein said attracting means comprises a conductive electrode positioned in a plane between said free end of said wire and said dielectric surface.

4. The invention according to claim **3** wherein said electrode comprises a conductive grid.

5. The invention according to claim **3** wherein said electrode comprises a conductive band which at least partially surrounds said dielectric surface.

6. Corona charging apparatus for substantially uniformly charging a dielectric surface to a predefined charge level, said apparatus comprising:

a. a flexible wire, perpendicularly arranged relative to said surface and mounted in a cantilever fashion such that the free end thereof extends toward and is spaced from said surface;

b. a corona-control electrode, positioned between the free end of said wire and said surface;

c. means for generating a corona discharge between the free end of said wire and said electrode while causing said free end to oscillate randomly relative to said surface, whereby said dielectric surface receives a charge; and

d. means for electrically biasing said electrode at a level proportional to said predefined charge level, thereby limiting the maximum charge on said surface to said predefined charge level.

7. The invention according to claim **6**, wherein said corona-control electrode comprises a conductive grid.

8. The invention according to claim **6** wherein said corona-control electrode comprises an endless loop of conductive material.

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