

[54] **COMBINED CORONA AND LUMINESCENT DISCHARGE**
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[58] Field of Search..... 250/324, 325, 326; 317/262 A

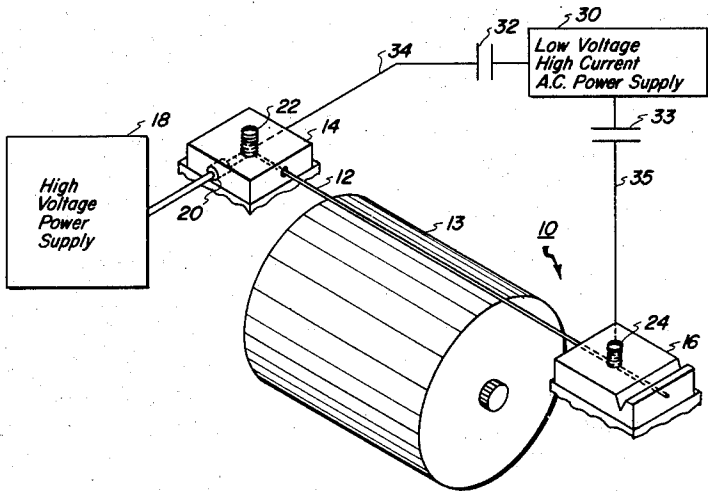
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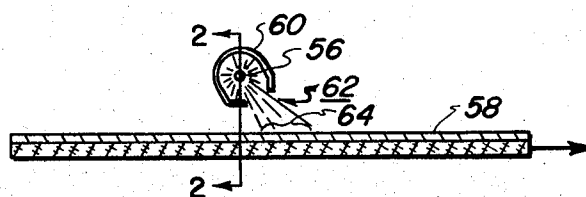
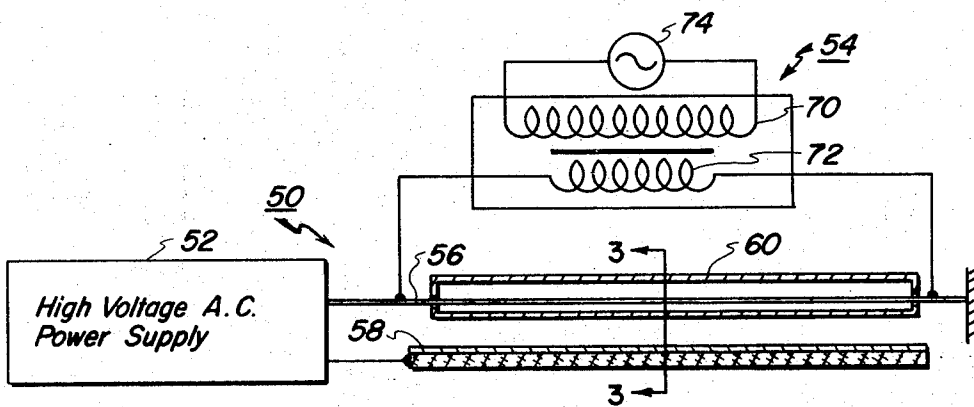
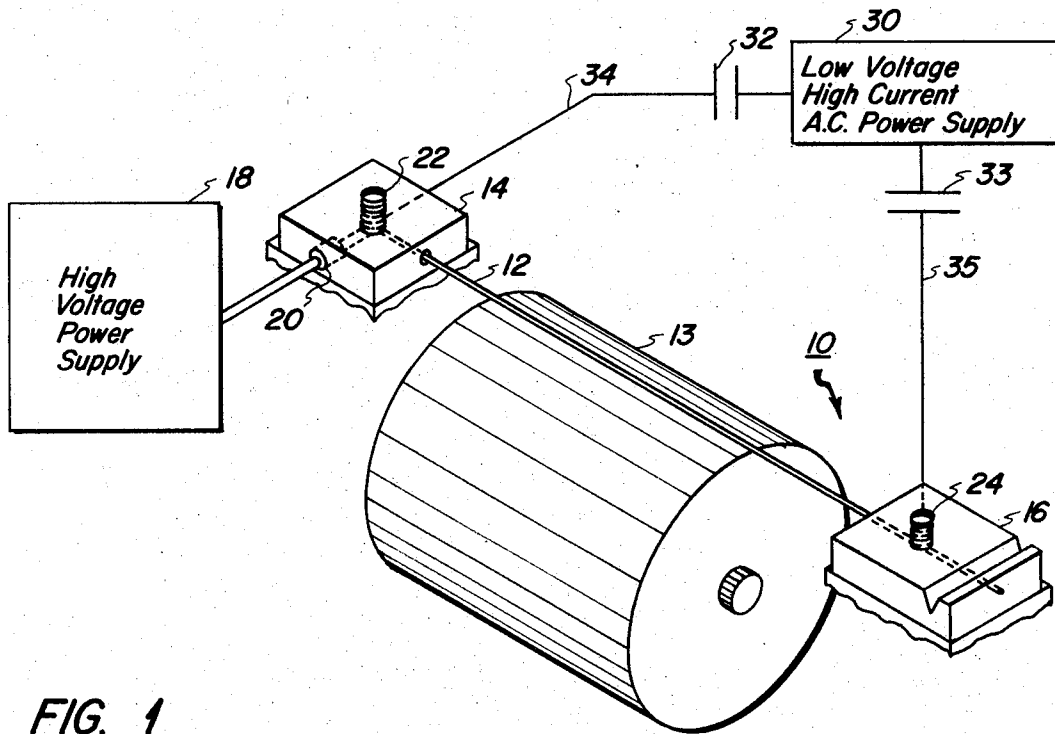
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Primary Examiner—James W. Lawrence
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[57] **ABSTRACT**
In electrophotography, wherein electrostatic charges are provided by corona wire apparatus for discharging a photoreceptor, a combined corona and luminescent discharge is provided in a single compact arrangement by connecting to the exposed corona wire, in addition to the conventional high potential for ionization, a high current, low voltage, power supply which heats the corona wire to above approximately 800° Centigrade, making it self-luminously incandescent. Optical reflectors may be provided to further direct this light onto the photoreceptor. The wire temperature is maintained below white heat, and the wire material is selected, so as not to oxidize rapidly. Transformer or capacitor electrical isolation is provided to prevent interference between the two power supplies.

11 Claims, 3 Drawing Figures





COMBINED CORONA AND LUMINESCENT DISCHARGE

BACKGROUND OF THE INVENTION

The present invention relates to photoreceptor discharge in electrophotography, and in particular to a method and apparatus for providing combined electrostatic and optical discharge of a photoreceptor in a compact structure adjacent the photoreceptor.

In electrophotography, especially xerography, both electrical and optical photoreceptor discharge is employed, often together as in the pre-clean and pre-transfer steps. Conventionally, this is accomplished by biased a.c. corotrons or other corona wire devices for the electrical discharge and by separate light sources, such as florescent lamps or electroluminescent panels, for the optical discharge. Such equipment is costly, and even more important, it occupies a substantial space adjacent the photoreceptor. This space requirement is important from a design and manufacturing standpoint because modern xerographic machines, for example, may contain six or more separate corona devices and several different lamps for various photoreceptor charging and discharging steps as well as cleaning, imaging, transfer, stripping and control devices. Thus, the available space adjacent the photoreceptor is limited, especially where the photoreceptor is a drum. The present invention alleviates this space problem and other problems by providing a simple and compact arrangement accomplishing both electrical and luminescent discharge of the photoreceptor in the same space adjacent the photoreceptor normally occupied by the corona wire apparatus itself.

The exemplary embodiment described hereinbelow discloses the incorporation of the process and apparatus of the invention in an otherwise conventional exemplary xerographic processes and apparatus. The present invention may be utilized in any type of corona wire application or arrangement; shielded, screened or otherwise, and with any conventional or future photoreceptor of sufficient photosensitivity, including various selenium alloys. Accordingly, said processes and apparatus need not be described in detail herein, since various printed publications and patents and publicly used machines are available which teach details of various suitable exemplary electrophotographic structures, materials and functions to those skilled in the art. Some examples are disclosed in the books *Electrophotography* by R. M. Schaffert, and *Xerography and Related Processes* by John H. Dessauer and Harold E. Clark, both first published in 1965 by Focal Press Ltd., London, England, and the numerous patents and other references cited in these books. All of these references and the other references noted herein are hereby incorporated by reference.

Certain of the individual features disclosed in the present apparatus are, of course, known in the art, although not for the same function, purpose or results. Reference examples are provided in U.S. Pat. Nos. 2,588,699 to C. E. Carlson issued Mar. 11, 1952; 3,433,948 to the present inventor issued Mar. 18, 1969, and 3,557,367 to the present inventor and others issued Jan. 19, 1971. Also noted is *University Physics* by F. W. Sears and M. W. Zemansky, second edition, 1955, pp. 293-4.

Further objects, features and advantages of the present invention pertain to the particular apparatus, steps and details whereby the above-mentioned aspects of the invention are attained. Accordingly, the invention will be better understood by reference to the following description and to the drawings forming a part thereof, which are substantially to scale, wherein:

FIG. 1 is a perspective view of a first exemplary corona and luminescent apparatus in accordance with the present invention;

FIG. 2 is a cross-sectional schematic view of a second embodiment of the present invention; and

FIG. 3 is a further cross-sectional view of the embodiment of FIG. 2 taken along the line 3-3 of FIG. 2.

Referring now to the drawings, there is illustrated in FIG. 1 a combined electrical corona and luminous photoreceptor discharging apparatus 10 in accordance with the present invention. The exemplary apparatus 10 includes an exemplary conventional xerographic corona wire 12 extending over and closely spaced from an exemplary chargeable photoreceptor surface 13, e.g., a conventional xerographic photoreceptor drum. The apparatus 10 here comprises a first end block 14 supporting and insulating the first end of the corona wire 12, and second end block 16 supporting and insulating the second or terminating end of the corona wire 12.

The first end block 14 is further adapted to provide the connection to a conventional corona high voltage power supply 18. This is accomplished in a shielded manner here internally of the first end block 14 by a female connector 20 extending internally into the first end block 14 under a first set screw 22. The female connector 20 is conventionally connected to the high voltage power supply 18. The first set screw 22 is preferably entirely formed from a plastic or other suitable high voltage insulating material, as are both of the end blocks. The first set screw 22 internally holds and abuts the first end of the corona wire 12 against the connector 20. The corona wire 12 extends thereto through an internal passageway in the first end block 14 extending up to the set screw 22.

Considering the second end block 16, it may be seen that it is also preferably a unitary, homogeneous block of simple construction and configuration formed in a conventional manner from any suitable plastic or other material having appropriate high voltage insulating properties. The only additional component of the end block is a second set screw 24 therein which provides the end fastening means for the corona wire. The second set screw 24 may be of the same or other suitable insulating material. It may be seen that the set screw 24 is tightly threadably fitted in a corresponding cylindrical threaded hole extending from the exterior surface of the block 16 down into the interior thereof at right angles to the corona wire 12. The screw 24 is adapted to both secure grip the corona wire 12 as well as to fill and thereby electrically insulate the threaded hole 26. It may be seen that the set screw 24 provides securing of the corona wire 12 internally of the block 16 by means which are operable externally thereof. No conductive elements are exposed by this fastening arrangement, nor is the corona wire 12 itself, except over the photoconductive surface 13.

It will be noted that high voltage power supply 18 is connected to only one end of the corona wire 12. Thus, the high voltage supply is not connected to pass current

through the wire 12, rather it provides for current flow between the corona wire 12 and the surface 13. The core of the xerographic drum is grounded and the high voltage is conventionally applied between the corona wire 12 and the photoreceptor surface 13. This provides a conventional corona effect around the wire 12.

Where the discharge of a pre-existing charge on the surface 13 is desired, as here, the high voltage power supply 18 will be conventionally either a d.c. high voltage supply of the opposite polarity to the surface charge or an a.c. high voltage supply, this may be d.c. biased. In either case the charges produced by the corona wire 12 will move toward and neutralize an opposing charge on the surface 13. 45

In addition to the above-described conventional discharging corona arrangement, it will be seen from FIG. 1 that the same corona wire 12 is also connected to a second and separate power supply comprising a low voltage, high current alternating current power supply 30. The terminal connections to the wire 12 may be as described above. However, it may be seen that the connection of this power supply 30 differs in that it connects to opposite ends of the corona wire 12 and passes its relatively high current output through the corona wire 12 rather than from the corona wire 12 to the surface 13. This passage of high current through the corona wire 12 provides by resistance heating, the desired self-luminescence of the corona wire 12. For a conventional corona wire, e.g., a tungsten, platinum alloy or stainless steel wire of 0.035 inches diameter, approximately two watts of electrical power per linear inch of corona wire dissipated through the wire is sufficient to achieve this desired temperature level.

The corona wire 12 is electrically heated by the high current power supply 30 to more than approximately 800° Centigrade, but to less than white heat or the oxidation temperature of the wire material. At this temperature the corona wire is self-luminously incandescent and will accordingly provide luminous exposure discharge of the adjacent photoreceptor surface 13, yet will not rapidly oxidize as it would at higher temperatures. The wire 12 does not have to be heated to the 3,000° or so of a conventional (enclosed) white hot light bulb filament. The light output of the wire in such an 800° Centigrade temperature range is quite low, and it is an inefficient light source. Nevertheless the light from the wire, where the wire is spaced from the surface 13 at conventional xerographic corona wire spacings, is sufficiently bright to optically discharge conventional photoreceptor materials utilized in xerographic machines, including selenium and selenium alloys.

It will be noted that the wire is not heated to electron emission temperatures and does not rely upon thermal electron emission for the electrical corona discharge. This is provided by the high voltage power supply 18. The heating of the wire 12 may assist the corona production somewhat, or make it more uniform in the case of a negative corona, but in the specified temperature range the ion production is due to the high voltage supply. To produce electron current flows to the photoreceptor surface by thermal emission effects of any significant magnitude the wire would have to be heated to a white hot temperature, which would be unsuitable. The present device can provide positive ion emissions, which clearly establishes that thermal electron emission is not a factor.

The use of an approximately 800° Centigrade thermal level of the corona wire also allows a wider choice of suitable wire materials. These may include various non-oxidizing metals such as platinum or the iron based or other alloys or plated metals which are oxidation resistant at these temperatures, including commercial electrical infrared heating wire elements.

Referring specifically to FIG. 1, means are provided for electrically isolating the high current power supply 18 and the connecting corona wire 12 from the low voltage, high current power supply 30, so as to prevent the high voltage from being impressed upon this power supply 30, wherein it might cause corona, arching or other undesired effects. This isolation is provided in the embodiment of FIG. 1 by high voltage capacitors 32 and 33 in series with the lines 34 and 35 respectively. Capacitors 32 and 33 have a sufficiently high capacitance to pass the low voltage alternating current through the lines 34 and 35 and the innerconnecting corona wire 12, yet provide high voltage isolation of the power supply 30 from the corona wire 12 and the connecting high voltage supply 18.

Considering next the second embodiment 50 of FIGS. 2 and 3, it will be seen that this embodiment is basically the same as that of FIG. 1 and the above description applies thereto except for certain specific distinctions which will be pointed out hereinbelow. This second embodiment 50 comprises a high voltage AC power supply 52 corresponding to the power supply 18 of FIG. 1, and a low voltage, high current AC power supply 54 corresponding to the power supply 30 of FIG. 1. The power supply 52 connects as described above to a corona wire 56 closely spaced above a photoreceptor surface 58.

In this embodiment 50, the corona wire 56 is additionally provided with a partially surrounding shield 60, seen especially in cross-section in FIG. 3, as well as FIG. 2. The shield 60 serves as a basically conventional corotron shield in the manner well known in the xerographic art. However, it provides here an additional and simultaneous function as an optical shield and reflector as well.

The shield 60 may be made of any suitable material providing the desired functions, although it is preferably constructed of opaque sheet metal with a reflective inner surface. It may be stainless steel of the type conventionally provided in corotron shields.

Referring particularly to FIG. 3, it may be seen that the shield 60 has a configuration, including an angular opening toward the photoreceptor surface 58, which differs from conventional corotron shields. The desired function here is to provide an apparatus in which the electrical discharge, due to the ion flow from the corotron, acts on the surface 58 at a different area than that which is being optically discharged at the same time. Thus, where the surface 58 is moving in the direction shown, the shield 60 will provide electrostatic discharge of the surface 58 prior to optical discharge. This is accomplished by the fact that ion flow for the electrical discharge will in general take the shortest possible path between the corona wire 56 and the plate, i.e., will discharge the area directly under the opening 62 in the shield 60. The movement of the ions is controlled by the electrical shields between the corona wire 56 and the surface 58, including the effect on these fields of the shield 60. That is, the ion flow is not necessarily in a straight line outwardly from the corona wire 56.

In contrast, the light output of the luminous corona wire 56 must necessarily travel in straight lines outwardly from the corona wire 56, or in straight line reflections therefrom from the interior surface of the shield 60. It may be seen that the shield 60 is so arranged here so that the opening 62 therefrom is oriented angularly with respect to the surface 58 rather than pointing downwardly directly from the corona wire 56. Therefore, the light output from the corona wire 56 is confined and directed to an area 64 on the photoreceptor surface which is not underlying the shield 60 or corona wire 56. Thus, this area 64 being subjected to light discharge is a different area than the area, directly under the opening 62, being subjected to electrical discharge. I.e., the optical reflector, provided by the shield 60 configuration directs light onto the photoreceptor 58 at a different location than the ionization from the corona 56 is being directed by the electrostatic shield function of the same shield 60.

It will be appreciated that the functions provided by the shield 60 may not be desired in all applications. A more conventional corotron shield configuration may be utilized where simultaneous common area optical and electrical discharge is desired.

Referring to FIG. 2, the low voltage, high current AC power supply 54 here, like the power supply 30, connects to opposing ends of the corona wire 56 to provide the incandescent heating current therethrough. However, it has a different type of high voltage electrical isolation means, which is preferred. The power supply 54 comprises a transformer with a primary winding 70 and a secondary winding 72. The primary winding 70 may be connected to a conventional alternating current power main supply represented by 74. The secondary winding 72 is directly connected across the corona wire 56. No capacitance isolation is required here. It may be seen that the high voltage from the power supply 52 in this connection is directly impressed on the secondary 72. However, there is no current loop therethrough for the high voltage.

The transformer needs a sufficiently high stand-off voltage insulation between the primary and secondary windings 70 and 72 to prevent any high voltage breakdown therebetween with this arrangement. However, suitable conventional transformers are available, such as insulated vacuum tube filament transformers, with such properties.

In conclusion, it may be seen that there has been disclosed herein a novel and improved apparatus and method for providing electrical corona discharging and luminescent discharge in the same simple structure and method for electrophotographic apparatus, having advantages in simplicity, economy, and space savings. The exemplary embodiments described herein are presently considered to be preferred; however, it is contemplated that numerous further variations and modifications within the purview of those skilled in the art can be made herein. The following claims are intended to cover all such variations and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In electrophotographic apparatus wherein electrical corona charges are applied to a photoreceptor by corona apparatus for discharging the photoreceptor in-

cluding at least one corona wire positioned adjacent the photoreceptor surface, which corona wire is provided with a high voltage for electrical air ionization by a connected high voltage supply means, the improvement comprising:

high current low voltage power supply means electrically connected through said same corona wire for heating said corona wire to self-luminous incandescence,

said self-luminous incandescence of said corona wire providing luminous exposure discharge of said photoreceptor surface in addition to said high voltage corona discharge.

2. The apparatus of claim 1 further including electrical isolation means between said high current power supply means and said corona wire to electrically isolate said high current power supply means from said high voltage supply means.

3. The apparatus of claim 1 wherein said corona wire is electrically heated by said high current power supply to more than approximately 800° Centigrade, but less than white heat.

4. The apparatus of claim 2 wherein said high current power supply means is an alternating current power supply and said isolation means is a high voltage insulated transformer with a primary winding connecting with said high current power supply and a secondary winding connecting to opposing ends of said corona wire.

5. The apparatus of claim 1 further including optical reflector means around said corona wire for directing light from said corona wire to said photoreceptor.

6. The apparatus of claim 5 wherein said reflector is also an electrostatic shield means for said corona wire directing ionization from said corona wire toward said photoreceptor.

7. The apparatus of claim 6 wherein said optical reflector directs light angularly onto said photoreceptor at a different location than ionization is directed by said electrostatic shield, for simultaneous but spaced discharge of said photoreceptor.

8. In an electrophotographic process, a method of providing both electrical corona discharge and luminous discharge of a charged photoreceptor surface from the same apparatus comprising the steps of applying a high voltage potential to a corona wire adjacent the photoreceptor surface to generate voltage air ionization charges for said photoreceptor,

and applying a low voltage high electrical current through the same corona wire to heat the wire to self-luminous incandescence,

and applying said incandescence from said wire to said photoreceptor surface to provide luminous exposure discharge of said photoreceptor.

9. The method of claim 8 wherein said wire is heated by said high current to above approximately 800° Centigrade, but to less than white heat.

10. The method of claim 8 wherein said high voltage potential comprises an alternating polarity potential.

11. The method of claim 8 wherein said incandescence from said wire is directed angularly onto said photoreceptor surface by shielding said incandescence.

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