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Tokyo, Japan
 [32] Priority **July 14, 1967**
 [33] **Japan**
 [31] **45-468/67**

[50] Field of Search..... 317/4, 262;
 250/49.5 (60), 49.5 (61)

[56] **References Cited**
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[54] **CORONA DISCHARGING DEVICE FOR
 ELECTROPHOTOGRAPHIC PROCESS**
8 Claims, 10 Drawing Figs.

[52] U.S. Cl..... 317/4,
 317/262, 250/49.5
 [51] Int. Cl..... H05h 1/00

ABSTRACT: Apparatus for use in imparting charge to a member including a conductive element having an end juxtaposed with the surface of the member being charged and a needle-form corona discharge electrode providing a discharge directed principally onto the conductive element. The corona discharge electrode is disposed in a plane substantially non-perpendicular to the member being charged and intersecting the plane containing the conductive element.

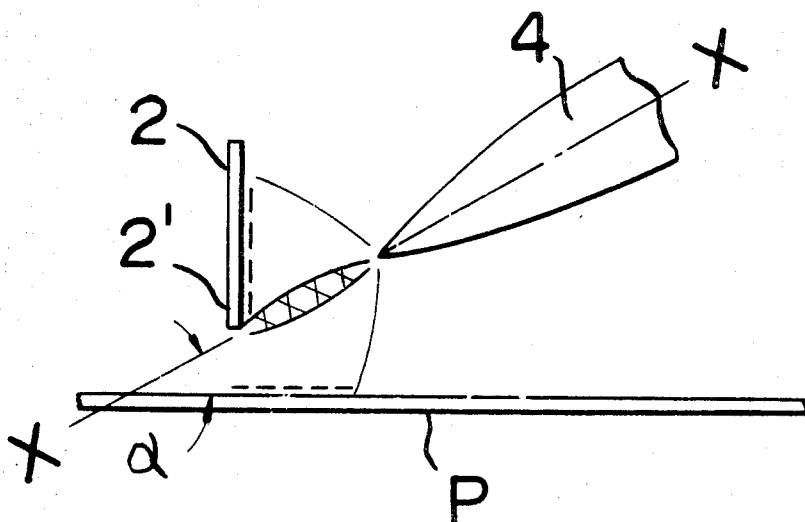


FIG. 1

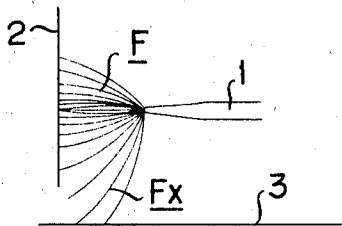


FIG. 2

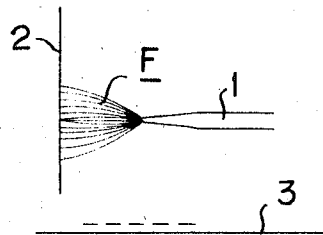


FIG. 3

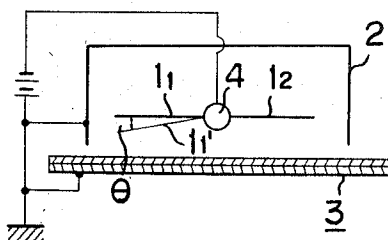


FIG. 4

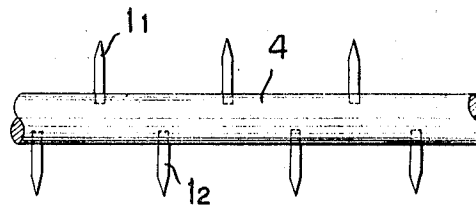


FIG. 5

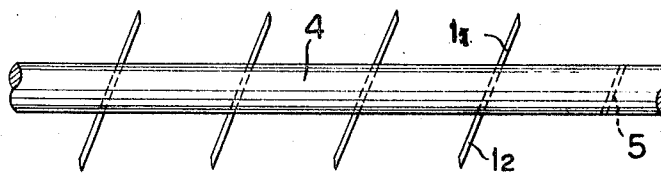


FIG. 6

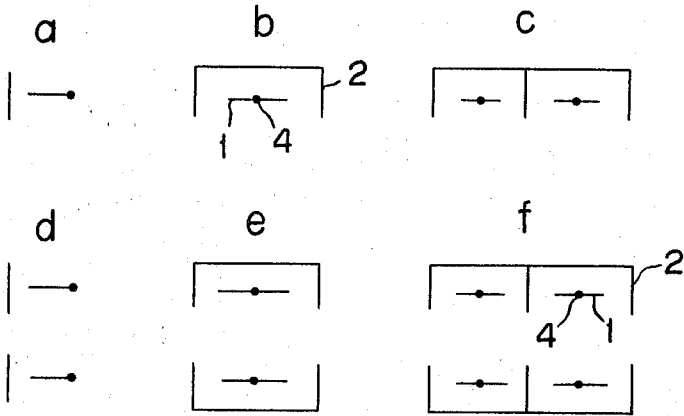


FIG. 7

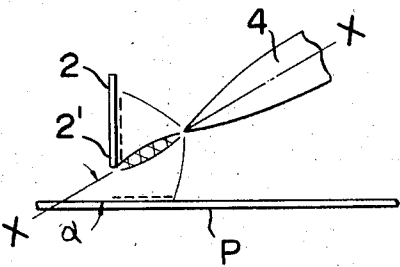


FIG. 8

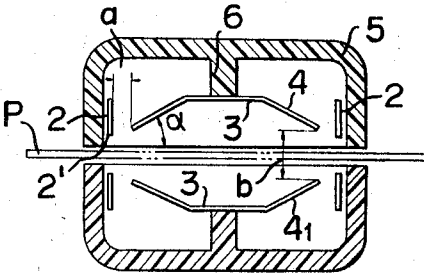


FIG. 10

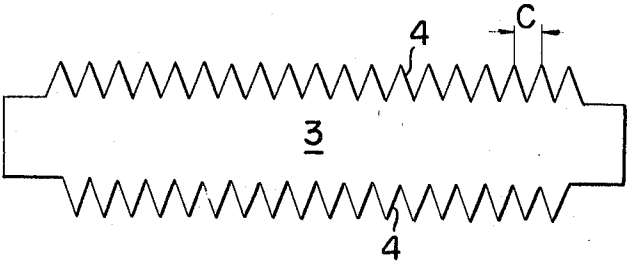
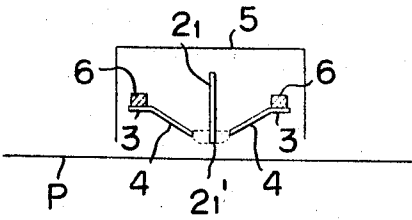


FIG. 9



CORONA DISCHARGING DEVICE FOR ELECTROPHOTOGRAPHIC PROCESS

This invention relates to improvements in corona dischargers for electrophotographic use.

Conventional discharge electrodes of corona dischargers for charging photosensitive members in electrophotography include fine metal wires such as tungsten filaments, or needle-form electrodes. In the former case, the metal wire is, in general, as fine as from 6/100 to 8/100 mm. in diameter, and is frequently broken during handling or in use whereupon the high-voltage output may be short circuited, destroying the electric source, or a dangerous condition may occur.

In the latter case, the end of the needle-form electrode is directed toward the photosensitive member surface, and the electrostatic field is of high intensity in the vicinity of the needle end. As a result, on the surface of the negative needle-form electrode secondary electron discharge by positive ion is predominant while travel of single electrons caused only by negative ions is inhibited. Thus, a plasma state is inevitably formed in which positive charge and negative charge are present in a mixed state. Electrostatic charge of polarity opposite to that of the electrode is thus concentrated on the photosensitive member surface and the possibility of generating a locally high dielectric field is increased, and thereby corona discharge sometimes evolves into a spark discharge or streamer. Accordingly, the photosensitive member may be damaged or such excess current may flow as to destroy the high-voltage electric source. Even if spark discharge does not occur, there are the disadvantages that uniform development is not obtained, and that half-tone is not obtained.

An object of this invention is to overcome the above-described disadvantages in a corona discharger employing needle-form electrodes. In accordance with this invention, the ends of the needle-form electrodes are directed not toward the photosensitive member, but toward the shield member or shield plate.

The term "needle-form electrode" as used throughout the specification and the appended claims is intended to mean an electrode in the form of a projected member having an elongated body tapering to a corona discharge point, such as, for example, needle, sawtooth, cone and the like.

In accordance with the invention, the main discharge is carried out between the needle-form electrode and the shield member in a direction almost parallel to the photosensitive surface, and therefore the local electric field is directed towards the shield member. In other words, a corona of polarity opposite to that of the needle-form electrode, i.e. the locally strong corona, is directed to the shield member so that the circumferential electric field of the main discharge acts on the surface of the photosensitive member. Thereby, a uniform and soft electric field is applied to the photosensitive member surface, the charged zone is widened, and remarkably excellent charging can be carried out. The term "circumferential" refers not only to the outer portion of the electric field, but also to portions thereof exclusive of the central portion of the main discharge in the electric field.

In further accordance with this invention, a plurality of needle-form electrodes are commonly supported by a conductor, with the needle-form electrodes alternately arranged to discharge in respectively opposite directions. Irregularity in amount of charge deposited on the photosensitive member surface is thus prevented.

It is an object of this invention to provide an improved corona discharger having needle-form electrodes for electrophotographic use.

It is another object of this invention to provide a corona discharger having needle-form electrodes which provides a uniform, wide and soft electric field on a photosensitive member surface.

It is a further object of this invention to provide a corona discharger having needle-form electrodes which facilitates the formation of half-tone image.

For a better understanding of the invention as well as other objects and further features thereof, reference is had to the following detailed description thereof to be read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a diagram showing a first state of discharging of a corona discharger of this invention;

FIG. 2 is a diagram showing a subsequent state of the charging operation of a corona discharger of this invention;

FIG. 3 is a schematic diagram of an embodiment of a corona discharger according to this invention;

FIG. 4 is a diagram showing an arrangement of needle-form electrodes of this invention;

FIG. 5 is a front view of an embodiment of this invention where needle-form electrodes are provided on a supporting conductive rod;

FIG. 6 shows an outline of various kinds of charging devices in accordance with the invention;

FIG. 7 is a schematic diagram explaining the principle of an aspect of this invention;

FIGS. 8 and 9 are schematic drawings of embodiments of this invention;

FIG. 10 shows a sawtooth-type electrode.

Referring to FIG. 1, 1 is a needle-form electrode; 2 is a shield plate or shield wire; 3 is a photosensitive member.

When direct current voltage is applied to needle-form electrode 1, electric field F is generated from the end of needle-form electrode 1 toward shield plate 2, and photosensitive member 3 is charged by circumferential electric field F_x in the primary stage of charging operation as is shown in FIG. 1. In the latter stage of the charging operation the photosensitive surface bears charge and electric field F_x is eliminated as is shown in FIG. 2.

When electrodes 1_1 and 1_2 are directed in the respectively opposite directions from a common or discontinuous electrode supporting conductor 4 as is shown in FIG. 3, irregularity in charging of photosensitive surface 1 is effectively eliminated. For this purpose electrodes 1_1 and 1_2 are arranged as shown in FIG. 4.

As an alternate manner in which the needle-form electrodes may be provided, a hole or groove 5 is formed in supporting conductor 4 in a slant direction as is shown in FIG. 5, and one electrode is inserted to form the two electrodes 1_1 and 1_2 . The end of the needle may be shaped in conical form or in the form of knife edge.

The needle-form electrode may be arranged in such a way that its direction, i.e., the direction of the axis of its elongated body, is at an angle θ with the photosensitive surface as shown by $1_1'$ in FIG. 3. It is preferable to adjust the angle θ from 20° to 40°, preferably about 30°.

This invention may be applied to various kinds of charging devices. In case of single corona dischargers shown in FIG. 6, a to c , remarkably excellent electrostatic charging is obtained when a copper wire of 1 mm. in diameter is used as needle-form electrode 1, aluminum plate is used as shield plate 2, the distance between the end of the needle and the shield plate is from 8 to 10 mm., the interval between the needle-form electrodes is 20 mm., and the distance between the end of the needle-form electrode and the photosensitive surface is about 12 mm., high voltage of (−) 2.5 kv. is applied to the electrode supporting conductor, and high voltage of (+) 2.5 kv. is applied to the shield plate.

According to another aspect of this invention, the needle-form electrode is particularly arranged in such a manner that the extension of the axis of the electrode elongated body crosses the material to be charged at an acute angle, preferably an angle ranging from 20° to 40° and the end of the shield member positioned nearest the material to be charged lies substantially on the extension of the axis of the electrode elongated body.

Referring to FIG. 7, needle-form electrode 4 is placed in such a manner that the extension of axis X of the electrode elongated body crosses shield plate 2 at edge $2'$ of shield plate 2 and crosses the material to be charged, for example, a

photosensitive plate P at an angle α . When the end of the electrode is in edgewise form, corona is easily generated.

Referring to the upper half of FIG. 8 and to FIG. 9, electrode base plate 3 is mounted on support 6 in a housing of the charging device, end 2' or 2₁' facing photosensitive plate P of shield plate 2 or 2₁, substantially lies on the extension of the axis of the electrode, and such extension of the axis of the elongated body of electrode 4 or 4₁ crosses photosensitive plate P at an angle α ranging from about 20° to 40° when the shield plate 2 or 2₁ is positioned in such a manner that it is at right angle with photosensitive plate P. When the device is so arranged, the plasma having disadvantageous effects, as mentioned above, and (+) ions existing in the vicinity thereof are attracted onto shield plate 2 or 2₁, and only the ion group existing around the above-mentioned (+) ions has an effect on photosensitive plate P to enhance the charging efficiency.

FIG. 8 also shows a structure in which the device of this invention is used as a double corona discharger. Needle-form electrodes 4 and 4₁ are provided with respectively different polarities and are of sawtooth type. Sawtooth electrodes 4 and 4₁ are integrally formed on the both sides of base plate 3 (e.g. as shown in FIG. 10). In the above structure, the following dimensions result in an excellent charging:

α = angle between the axis of the electrode elongated body and the surface of P = 30°

a = distance between the pointed end of the electrode and the shield plate = 12 mm.

b = distance between the pointed ends of electrodes of different polarity = 14 mm.

c = distance between the pointed ends of electrodes of the same polarity = 5 mm.

Referring again to FIG. 9, shield plate 2₁ is placed at the center, and needle-form electrodes 4 and 4₁ are symmetrically placed on both side of the shield plate. Each of needle-form electrodes 4 and 4₁ are arranged at only one side of each base plate 3.

Referring to FIG. 10, the sawtooth-type electrode consists of base plate 3 and sawteeth 4. The sawteeth on both sides are alternately projected. This type of sawtooth electrode plate can be easily made by using a press, and therefore they can be obtained at low cost with high accuracy of dimensions by mass production.

The corona charging devices of this invention are free from disadvantages, such as breaking of wire and short circuit often occurring in conventional fine charging wire coronas. There is no fear of irregular charging and an excellent halftone can be obtained since locally strong charging is not involved. Furthermore, there are such advantages that the charging efficiency is high, the capacity required of high-voltage electric sources is low, dielectric breakdown of the photosensitive member is avoided and durability of the charging device is improved.

We claim:

1. Apparatus for use in imparting charge to the surface of a chargeable member comprising a conductive element having an end juxtaposed with said chargeable member surface, and an electrode providing corona discharge directed onto both said conductive element and said chargeable member surface and comprising an elongated body tapering to a corona discharge point, the longitudinal axis of said electrode body both intersecting a plane containing said conductive element and forming an acute angle with a plane containing said chargeable member surface.

2. The apparatus claimed in claim 1 wherein said electrode body longitudinal axis intersects said plane containing said conductive element substantially perpendicularly.

3. The apparatus claimed in claim 1 wherein said longitudinal axis of said electrode body intersects said plane containing said conductive element substantially at said conductive element end.

4. The apparatus claimed in claim 1 including in addition a conductor supporting said electrode, a further electrode supported by said conductor and comprising an elongated body tapering to a corona discharge point, and a further conductive element disposed on an opposite side of said support conductor from said first-mentioned conductive element and having an end juxtaposed with said surface, said further electrode providing corona discharge directed onto both said further conductive element and said member surface, the longitudinal axis of said second electrode body both intersecting a plane containing said further conductive element and forming an acute angle with said plane containing said chargeable member surface.

5. The apparatus claimed in claim 4 wherein said electrode and further electrode comprise sawteeth formed integrally with said support conductor.

6. The apparatus claimed in claim 4 wherein said electrode and further electrode comprise portions of a single electrode member supported in a transverse aperture in said support conductor.

7. The apparatus claimed in claim 1 including a further electrode disposed on an opposite side of said conductive element from said first-mentioned electrode and providing corona discharge onto both said conductive element and said member surface, said further electrode comprising an elongated body tapering to a corona discharge point, the longitudinal axis of said further electrode body both intersecting a plane containing said conductive element and forming an acute angle of from 0° to 40° with said plane containing said chargeable member surface.

8. The apparatus claimed in claim 4 wherein said electrode and further electrode are displaced from one another along said support conductor.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,581,149 Dated May 25, 1971

Inventor(s) Hiroshi Tanaka et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Item [73], Title page, "Canon Camera Kabashiki Kaisha" should read --Canon Kabushiki Kaisha--.

Signed and sealed this 9th day of November 1971.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents