

[54] A. C. CORONA CHARGING APPARATUS
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[51] Int. Cl. G03g 15/00
[58] Field of Search 250/49.5 ZC, 49.5 GC;
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3,164,074 1/1965 Francis 250/49.5 ZC
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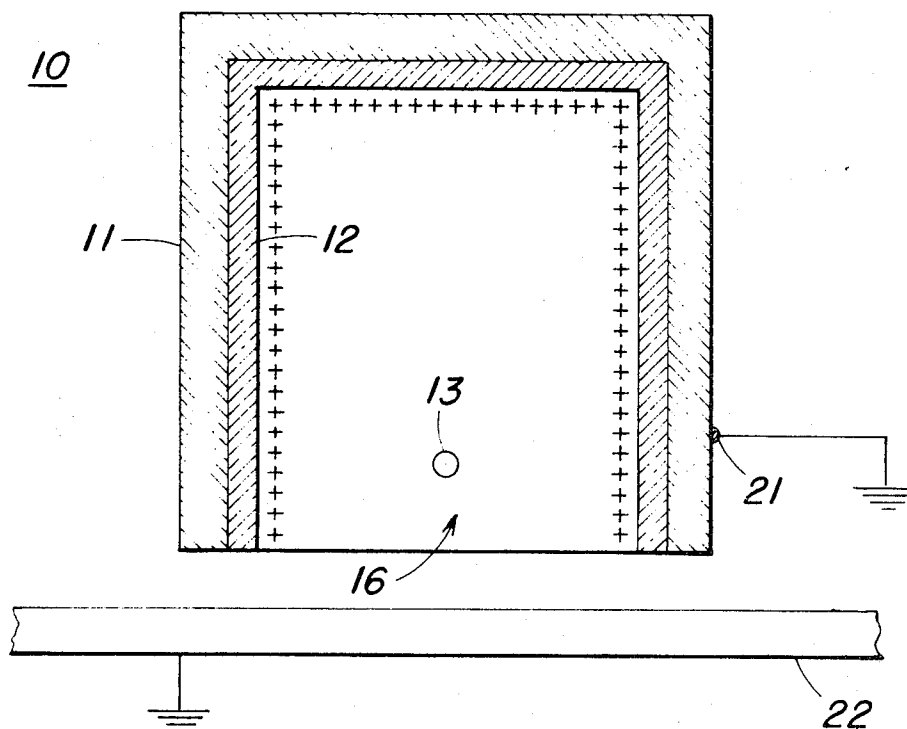
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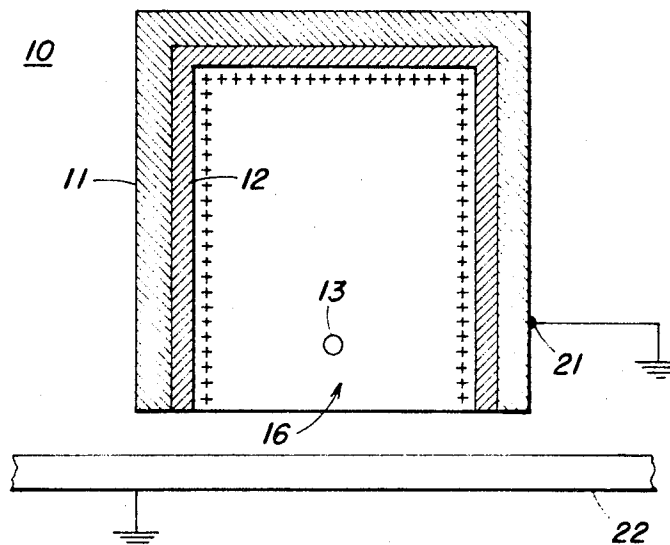
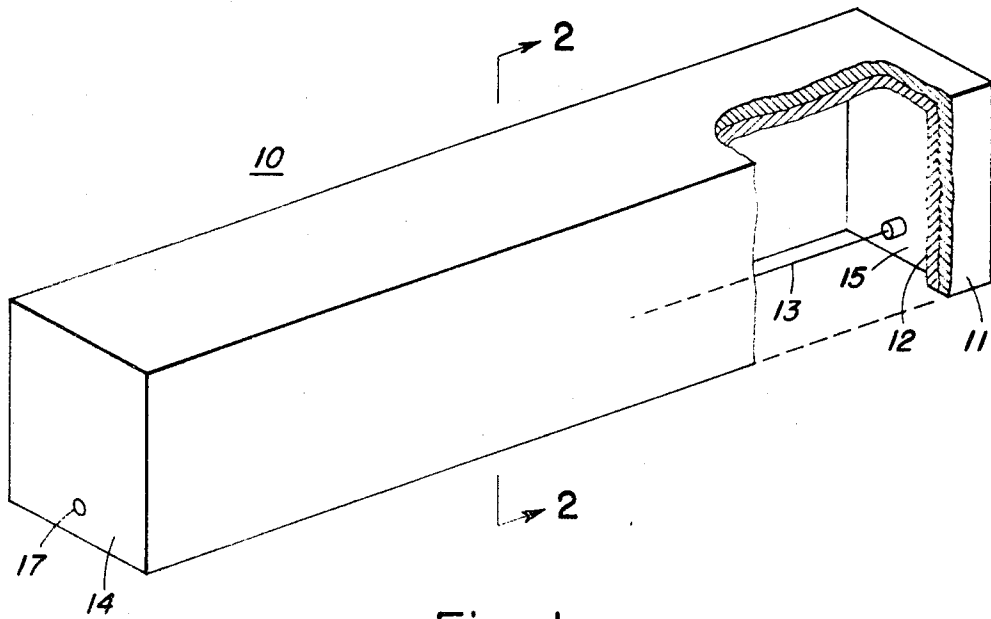
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ABSTRACT

A method of increasing the current flow from an a.c. corona charging apparatus and the apparatus therefor are provided in accordance with the teachings of the present invention. According to one embodiment of this invention a.c. corona charging apparatus is provided with a corona discharge electrode and a dielectric shield disposed in partially surrounding relationship with respect to said corona discharge electrode. Conductive means is mounted on the external surface of said dielectric shield such that said conductive shield is contiguous with and collateral with said dielectric shield. The conductive means is adapted to be supplied with a reference potential such that when a corona generating a.c. voltage is applied to said corona discharge electrode an a.c. corona current is produced having a magnitude significantly in excess of that heretofore obtainable.

7 Claims, 4 Drawing Figures





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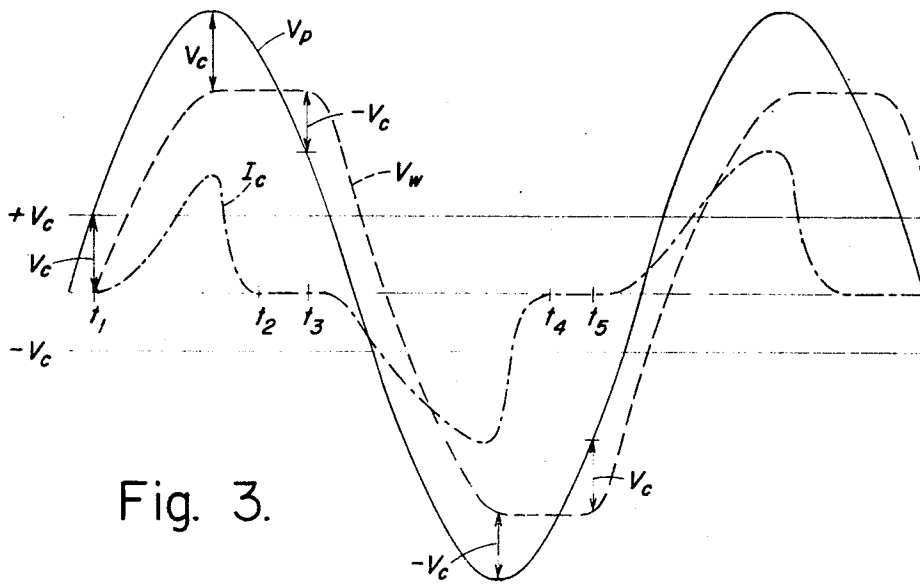


Fig. 3.

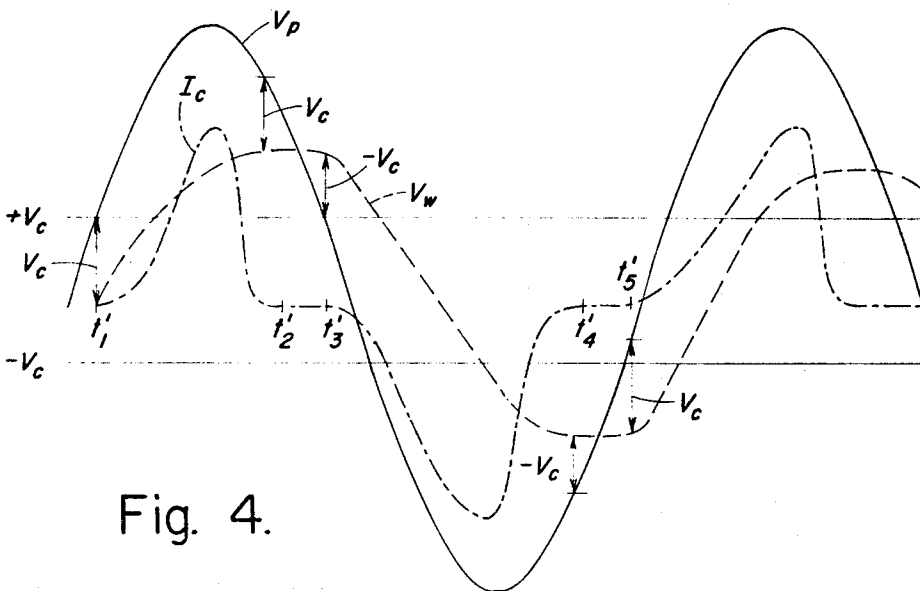


Fig. 4.

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A. C. CORONA CHARGING APPARATUS

This invention relates to a.c. corona charging apparatus devices and in particular, to a method of and apparatus for increasing the corona current flow from a.c. corona charging apparatus having a dielectric shield.

In the electrophotographic reproducing art, it is necessary to deposit a uniform layer of electrostatic charges on the surface of a photoreceptor such that the electrostatic charges may be selectively dissipated in accordance with modulated radiation imaged thereon to form an electrostatic latent image of an original document. The electrostatic latent image will then be developed and the developed image may be transferred to a support surface to form a final copy of the original document. If the photoreceptor comprises a conventional reusable electrophotographic member, the photoreceptor may be cleaned and prepared for subsequent operations thereon. The foregoing has been described in detail in U. S. Pat. No. 2,297,691 which issued to Chester F. Carlson.

The prior art has suggested various techniques and devices for applying a uniform electrostatic charge on the surface of a photoreceptor. Some of these techniques include: an alpha-emitting radioactive source for ionizing the air by emitting alpha particles; a conductive rubber roller having a potential applied thereto, which roller can be rolled over the photoreceptor; a charged insulator placed in contact with the photoreceptor whereby charges may be transferred from the insulator to the photoreceptor; and a corona discharge device of the type described in U. S. Pat. No. 2,777,957 which issued to L. E. Walkup. Although each of the foregoing is applicable in specialized uses it is preferred to deposit the uniform electrostatic charge on the surface of a photoreceptor by employing a corona discharge. A particular type of corona discharge device that has been readily included in conventional electrophotographic reproducing apparatus and is described in detail in U. S. Pat. No. 2,836,725 which issued R. G. Vyverberg and assigned to Xerox Corporation. Corona charging apparatus is usually comprised of a corona discharge electrode, such as a corona wire, surrounded by a conductive shield. The corona discharge electrode is adapted to be supplied with a d.c. voltage of sufficient magnitude to create a corona current flow from the electrode to the surface of a photoreceptor in spaced registration therefrom. The geometry of typical corona charging apparatus admits of various configurations as disclosed in U. S. Pat. No. 2,879,395 which issued to L. E. Walkup and assigned to Xerox Corporation.

Although corona charging apparatus is advantageously utilized to deposit a uniform layer of electrostatic charge on the surface of a photoreceptor various other applications thereof have been adopted. Typical of these applications are electrostatic transfer of a developed image to a support surface, removal of background toner particles from a developed electrostatic latent image, and pre-cleaning a photoreceptor by neutralizing the charge on toner particles adhering to the surface of the photoreceptor after transfer of the developed image to a support surface. An attendant disadvantage of corona charging apparatus developed by the prior art for use in electrophotographic reproducing devices is the accumulation of dust particles and toner particles on and about the interior of corona charging

apparatus to such an extent that the corona current generated thereby substantially decreases as the density of particle accumulation increases. Accordingly, self-cleaning corotrons have been developed which employ corona winds inherently generated by corona charging apparatus as a means to clean the corona discharge electrode and the interior walls of the surrounding shield. Detailed descriptions of such devices may be found in U. S. Pat. No. 3,324,291 which issued to F. W. Hudson on June 6, 1967 and assigned to Xerox Corporation and in U. S. Pat. No. 3,471,695 which issued to F. W. Hudson et al. on Oct. 7, 1969 and assigned to Xerox Corporation.

An alternative embodiment of corona charging apparatus self-cleaning comprises an a.c. corona charging apparatus wherein the corona discharge electrode thereof is supplied with a corona generating a.c. voltage. As is understood by those of ordinary skill in the art the creation of a corona current is predominantly determined by the potential difference between the corona discharge electrode and the partially surrounding shield. Accordingly, if the shield is comprised of a metal shield supplied with a reference potential such as ground potential, a positive corona current will be generated when the difference between the a.c. voltage applied to the corona discharge electrode and the reference potential supplied to the metal shield exceeds the positive corona threshold voltage; and a negative corona current will be generated when the difference between the a.c. voltage applied to the corona discharge electrode and the reference potential supplied to the metal shield exceeds the negative corona threshold. In theory then, a maximum a.c. corona current is generated for the embodiment of an a.c. corona charging apparatus including a grounded metal shield. Unfortunately the grounded shield a.c. corona charging apparatus suffers from the disadvantage that toner particles or dirt particles which accumulate on the inner walls of the metal shield and are not effectively removed therefrom produce deleterious effects. More specifically, these particles are comprised of dielectric material which store the charged ions communicated thereto from the corona discharge electrode during corona discharge. As charge buildup on these particles occurs, a voltage is induced on the contaminated inner wall of the surrounding shield resulting in a nonuniform potential difference between the corona discharge electrode and the shield. Hence, the a.c. corona current is subject to variations due to the discontinuities in the aforementioned potential difference.

A suggested improvement over the grounded metal shield a.c. corona charging apparatus is comprised of an a.c. corona charging apparatus having an insulating or dielectric shield constructed of a plastic material such as Teflon or Mylar. The accumulation of dielectric particles on the inner surface of the dielectric shield has no appreciable effect upon the a.c. corona current. This advantageous characteristic is however, achieved at the loss of magnitude of the a.c. corona current. The loss in corona current is brought about by the rapid increase of voltage induced on the inner surface of the dielectric shield, thereby limiting the potential difference between the corona discharge electrode and the dielectric shield to an undesirable range. In fact the rate of increase in the voltage induced on the inner surface of the dielectric shield closely approximates the rate of increase of the corona generating a.c. voltage

applied to the corona discharge electrode. This may be explained by recognizing that the voltage induced on the shield is directly proportional to the charge thereon and inversely proportional to the capacitance between the inner surface of the shield and ambient ground potential. Thus as the charge stored on the shield increases, the voltage induced on the inner surface thereof increases, and if the capacitance between the inner surface of the shield and ambient ground is a low value, a small buildup of charge induces a large voltage. Ambient ground potential is equivalent to one plate of a parallel plate capacitor spaced a sufficient distance from the inner surface of the dielectric shield, which inner surface may be considered to be the other plate of the parallel plate capacitor, such that the capacitance therebetween is a low value. Consequently, a small value of a.c. corona current induces a large voltage on the inner surface of the dielectric shield such that the potential difference between the corona discharge electrode and the surface of the dielectric shield is much less than the potential difference between the corona discharge electrode and the surface of a grounded metal shield, thereby maintaining the corona current of the former corona charging apparatus at an undesirably lower magnitude than the corona current of the latter corotron.

Therefore it is an object of the present invention to provide a method of and apparatus for increasing the corona current of a.c. corona charging apparatus.

It is another object of the present invention to provide self-cleaning corona charging apparatus having an improved corona current output.

It is a further object of this invention to provide a method of and apparatus for increasing the corona current generated by a corona discharge device, which device is relatively unaffected by the accumulation of foreign particles thereon.

Various other objects and advantages of the invention will become clear from the following detailed description of an exemplary embodiment thereof and the novel features will be particularly pointed in connection with the appended claims.

In accordance with this invention, a method of increasing the current flow from the corona discharge electrode of an a.c. corona charging apparatus, and the apparatus therefor, is provided wherein conductive means is disposed about the external surface of a partially surrounding dielectric shield, which conductive means is collateral with said dielectric shield; a reference potential is applied to said conductive means; and a corona generating a.c. voltage is supplied to the corona discharge electrode of said corona charging apparatus.

The invention will be more clearly understood by reference to the following detailed description of an exemplary embodiment thereof in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of a.c. corona charging apparatus in accordance with the present invention;

FIG. 2 is a sectional view taken along lines 2—2 of FIG. 1;

FIG. 3 is a graphical representation of waveforms generated by apparatus of the prior art; and

FIG. 4 is a graphical representation of the waveforms generated by the apparatus of the present invention.

Referring now to the drawings wherein like reference numerals are used throughout, and in particular to FIG.

1, there is illustrated a perspective view of an a.c. corona discharge device in accordance with the present invention which comprises a corona discharge device 10 including a shield of dielectric material 12, a layer of conductive material 11, insulating end plates 14 and 15, and a corona discharge electrode 13. The shield of dielectric material 12 is disposed in partially surrounding relationship with respect to the corona discharge electrode 13 and admits of rectangular cross section. The dielectric material may be comprised of Teflon, Mylar, Lucite, Plexiglas, Lexan or the like. As is illustrated in FIG. 1, and in more detail in FIG. 2, the dielectric shield 12 is formed of a pair of parallel side walls maintained in spaced apart relationship by an upper interconnecting wall. The dielectric shield 12 may be of unitary construction and defines an opening 16 at the lower portion thereof. The longitudinal dimension of dielectric shield 12 is coextensive with the longitudinal dimension of corona discharge electrode 13. The thickness of the dielectric shield 12 is determined by the dielectric strength of the material used, the frequency of the corona generating a.c. voltage, and the diameter of the toner particles that might adhere to the walls of the dielectric shield. Satisfactory experiments have been conducted with a dielectric shield having a thickness of one mil, and a reasonable range of thickness is between 0.25 and 10 mils. The dielectric material tends to break down below 0.25 mils and, as will soon be described, many of the advantages obtained by the present invention are minimized if the thickness of the dielectric material is substantially in excess of 10 mils.

A layer of conductive material 11 is mounted on the external surface of the dielectric shield 12 so as to be contiguous and collateral with said dielectric shield. The conductive material 11 may comprise a unitary structure such as a foil sheet or the conductive material 11 may comprise a conductive paint, strips of conductive material, a wire grid network or the like. The thickness of the conductive material 11 is not critical per se as will soon be understood from the forthcoming description, and therefore, may provide the structural rigidity for the corona discharge device of the present invention. Although not illustrated herein, the upper interconnecting wall of the dielectric shield 12 and the corresponding portion of the contiguous conductive material 11 may be provided with elongated openings substantially parallel to the corona discharge electrode 13 to act as an exit orifice for the flow of corona air currents inherently generated by the corona discharge device 10 as described in aforementioned U. S. Pat. Nos. 3,324,291 and 3,471,695.

The corona discharge electrode 13 is mounted within insulating end portions 14 and 15 disposed at opposite ends of the shield structure comprised of the dielectric shield 12 and the contiguous layer of conductive material 11. Suitable connecting means 17 are provided on the end portions 14 and 15 for connecting the corona discharge electrode 13 to a suitable source of corona generating a.c. voltage, not shown. The corona discharge electrode 13 may comprise one or a plurality of fine wires elongatedly disposed between the opposite end portions 14 and 15. A typical wire that may be utilized is a 3.5 mil diameter platinum alloy wire, well known to those of ordinary skill in the art.

As illustrated in the sectional view of FIG. 2, the conductive material 11 may be provided with suitable con-

necting means 21 for applying a reference potential such as a d.c. voltage or, if desired, ground potential to the conductive material 11. The corona discharge device thus formed is disposed in spaced registration from the surface of a photoreceptor 22 in such manner that relative motion may be provided between the corona discharge device and the photoreceptor.

The operation of the corona discharge device 10 in accordance with the present invention will now be described in conjunction with FIGS. 3 and 4. An a.c. corona current will be generated from the corona discharge electrode 13 when the a.c. voltage applied thereto exceeds the corona threshold voltage. For purposes of explanation it will be assumed that the a.c. voltage applied to the corona discharge electrode 13 is sinusoidal and the frequency thereof is 60 Hz. However it should be understood that other frequencies may be utilized and in fact the corona discharge device 10 of the present invention has been satisfactorily operated with frequencies on the order of 600 Hz. During each position half cycle, a positive corona current flows from the corona discharge electrode 13 to the surface of the photoreceptor means 22 and during each negative half cycle a negative corona current flows from the corona discharge electrode 13 to the surface of the photoreceptor means 22. Corona current additionally flows from the electrode 13 to the walls of the dielectric shield 12. Inasmuch as the shield 12 is comprised of dielectric material, the flow of corona current thereto will result in a buildup of charge on the inner surface of the walls of shield 12. Consequently, a voltage will be induced on the inner surface of the shield 12. When the voltage induced on the walls of shield 12 obtains a value such that the potential difference between the voltage applied to the electrode 13 and the induced voltage is equal to or less than the corona threshold voltage, the corona emission of the electrode 13 will terminate. Stated otherwise, the electric field intensity near the surface of the corona discharge electrode 13 is determined by the potential difference between the voltage applied to the electrode 13 and a voltage induced on the walls of shield 12. A greater electric field intensity produces a greater corona current. The present invention increases the corona current flow from the corona discharge electrode 13 by maintaining a higher electric field intensity at the surface of the corona discharge electrode 13 than has been heretofore thought possible in corona discharge devices having a dielectric shield.

The interior surface of the dielectric shield 12 comprises one plate of a grounded parallel plate capacitor, the other plate being comprised of the grounded conductive material 11. As is understood, the capacitance of this grounded parallel plate capacitor is a function of the thickness of the dielectric shield 12 and the dielectric constant thereof. The voltage induced on the inner surface of the dielectric shield 12 is determined by the capacitance of the aforementioned grounded parallel plate capacitor and may be represented as $V_w = Q/C$, where V_w is the voltage induced on the inner surface of the wall of the dielectric shield, Q is the instantaneous charge stored on the inner surface of the wall of the dielectric shield 12, and C is the capacitance of the grounded parallel plate capacitor. If the capacitance of the grounded parallel plate capacitor is large, it is understood that a substantial amount of charge must be stored on the inner surface of the wall of the

dielectric shield 12 before the induced voltage V_w is sufficient to cause termination of the corona current. Conversely, if the capacitance of the grounded parallel plate capacitor is small, a relatively small amount of stored charge will result in an induced voltage V_w whereby the corona current will be terminated. Thus, the provision of continuous conductive material 11 supplied with a reference potential such as ground potential tends to increase the magnitude during each half cycle, of the a.c. corona current emitted by the corona discharge electrode 13. It is apparent that the flow of corona current to the surface of photoreceptor 22 will result in a buildup of charge thereon which tends to decrease the potential difference between the voltage applied to corona discharge electrode 13 and the voltage induced on the photoreceptor 22 whereby the corona current flow is decreased. However, it may be assumed that the photoreceptor 22 is transported at a rate sufficient to inhibit the charge retained on the surface thereof to reach a critical value which substantially affects the corona current.

The increase in corona current flow in accordance with the present invention may best be appreciated by comparing the operation of the corona discharge device 10 illustrated herein with the operation of prior art corona discharge devices. A typical prior art a.c. corona discharge device includes a shield such as dielectric shield 12 of the present invention that is not provided with a metallic layer contiguous therewith. When, at time t_1 , the a.c. voltage V_p applied to the corona discharge electrode of the prior art device increases to a value exceeding the corona threshold voltage V_c , the electric field intensity at the surface of the corona discharge electrode is of sufficient magnitude such that corona emission occurs and a corona current I_c begins to flow. The corona current flows to the surface of a photoreceptor and in addition, a corona current path is established between the corona discharge electrode and the inner surface of the walls of the dielectric shield. Consequently, the charge stored on the inner surface of the walls of the dielectric shield increases and an increasing voltage is induced on the shield. The inner surface of the surface of the wall of the dielectric shield comprises one plate of a grounded parallel plate capacitor, the other plate being comprised of the ambient or virtual ground potential in the vicinity of the dielectric shield. Ambient ground may be represented by a grounded plate disposed externally of the dielectric shield and parallel to and substantially spaced from the inner surface of the wall of the shield. As is understood, the large separation between the plates of the grounded parallel plate capacitor thus formed results in a low capacitance thereof. Hence the voltage induced on the shield may be represented as $V_w = (1/C) \int I_c dt$ where V_w is the voltage induced on the shield, I_c is the corona current, and C is the capacitance of the grounded parallel plate capacitor. It may be observed from FIG. 3 that a small increase in the corona current results in a correspondingly small increase in the charge stored in the inner surface of the wall of the dielectric shield because of the small capacitance of the grounded parallel plate capacitor, but a large increase in the induced voltage on the walls of the shield. In fact, the voltage V_w induced on the walls of the shield changes at a rate that is approximately equal to the rate of change of the a.c. voltage V_p applied to the corona discharge electrode.

The voltage V_w induced on the walls of the shield rapidly increases to a value such that the potential difference between the a.c. voltage V_p supplied to the corona discharge electrode and the voltage V_w is equal to the corona threshold voltage V_c . This occurs in approximate coincidence with the positive peak voltage of the a.c. voltage V_p . Hence as V_p decreases the potential difference between V_p and V_w will be less than the corona threshold voltage V_c . Because corona discharges exhibit a hysteresis effect, corona current I_c continues to flow until time t_2 , at which time the corona current I_c is terminated. Termination of the corona current I_c prevents further buildup of charge on the inner surface of the walls of the dielectric and accordingly, V_w retains its peak magnitude until time t_3 . At this time the potential difference between the a.c. voltage V_p applied to the corona discharge electrode and the peak voltage V_w stored on the walls of the shield is equal to the negative corona threshold voltage $-V_c$. Consequently, the electric field intensity at the surface of the corona discharge electrode is of sufficient magnitude to create a corona emission and negative corona current I_c begins to flow. The negative corona current produces a buildup of negative charge on the shield thereby inducing an increasingly negative voltage V_w on the inner surface of the walls of the shield. Since the capacitance of the grounded parallel plate capacitor comprised of the inner surface of the walls of the shield and ambient ground potential is of a low value the voltage V_w decreases at a rate that approximates the rate of change of voltage V_p . When the a.c. voltage V_p obtains its negative peak value, the potential difference between the voltage V_p and the voltage V_w is equal to the negative corona threshold voltage $-V_c$. As the a.c. voltage V_p tends to increase the potential difference between V_p and V_w falls below the negative corona threshold voltage. The hysteresis effect, however, enables the corona current I_c to flow until time t_4 when the corona current I_c terminates. The voltage V_w induced on the inner surface of the wall of the dielectric shield retains its negative peak value until time t_5 whereupon the potential difference between the a.c. voltage V_p and V_w is equal to the corona threshold voltage V_c . Consequently corona current I_c begins to flow and the foregoing cycle is repeated.

Referring now to FIG. 4, it is observed that the corona discharge device 10 of the present invention operates in a manner similar to that just described, however significant improvements are noted. The inner surface of the walls of dielectric shield 12 and the layer of grounded conductive material 11 contiguous therewith comprise first and second plates of a parallel plate capacitor. The separation of the parallel plates, which is equal to the thickness of the dielectric shield 12 is sufficiently small so that the capacitance is large. Consequently, the rate of increase of the voltage V_w induced on the inner surface of the walls of the shield 12 from time t'_1 to time t'_2 is less than the rate of change of the a.c. voltage V_p applied to the corona discharge electrode 13. Hence the potential difference between V_p and V_w in FIG. 4 during the interval t'_1 to t'_2 is greater than the potential difference between V_p and V_w in FIG. 3 during the corresponding interval t_1 to t_2 , resulting in a corona current I_c of greater magnitude. In addition, it is seen that in the present invention the positive half cycle of corona current I_c is terminated at a time t'_2 which is later than the time t_2 at which the positive

half cycle of corona current of the prior art is terminated. Similarly the magnitude and duration of the negative half cycle of the corona current I_c in accordance with the present invention is greater than the magnitude and duration of the negative half cycle of corona current I_c of the prior art. The increased corona current flow of the present invention is attributed to the increase in capacitance from the inner surface of the wall of dielectric shield 12 to ground. Thus, a large increase in the corona current is required for a correspondingly large increase in the induced voltage V_w on the walls of the shield in accordance with the equation $V_w = (\int I_c dt / C)$. Another advantage of the present invention is that the magnitude of the corona generating a.c. voltage applied to the corona discharge electrode 13 need not be as great as heretofore required in order to obtain a corona current of equivalent magnitude.

The average d.c. value of the corona current emitted from the corona discharge electrode 13 may be determined by applying a d.c. reference potential of constant magnitude to contact 21 of conductive material 11. This modification of the corona discharge device of the present invention is desirable if the corona discharge device is to be utilized to deposit a uniform layer of electrostatic charge of a given polarity on the surface of the photoreceptor 22. The geometry of the corona discharge device 10 of the present invention has been illustrated herein as exhibiting a rectangular cross section. Typical dimensions are a width of seven-eighths inches, a height of five-eighths inches and a length of 10 inches. The corona discharge device, as illustrated in FIG. 2, may be positioned 0.1 inch above the surface of the photoreceptor 22, and corona discharge electrode 13 may be spaced 0.25 inch from the surface of the photoreceptor 22. The present invention, however, is not limited to the aforementioned configuration and readily admits of various shapes such as those disclosed in U.S. Pat. No. 2,879,395 which issued to L. E. Walkup on Mar. 24, 1959 and assigned to Xerox Corporation. Thus the present invention exhibits desirable characteristics of corona discharge devices having a grounded metallic shield, i.e., increased corona current flow, and desirable characteristics of corona discharge devices having a dielectric shield, i.e., the operation thereof is relatively unaffected by the accumulation of toner particles or dust particles.

While the invention has been particularly shown and described with reference to a specific embodiment thereof, it will be obvious to those skilled in the art that the foregoing and various other changes and modifications in form and details may be made without departing from the spirit and scope of the invention. It is therefore intended that the appended claims be interpreted as including all such changes and modifications.

What is claimed is:

1. A method of increasing the current flow from the corona discharge electrode of an a.c. corona charging apparatus having a dielectric shield partially surrounding said corona discharge electrode and a surface, comprising the steps of:

providing a conductive layer in contact with the external surface of said dielectric shield, said conductive layer being collateral with said dielectric shield;

applying a reference potential to said conductive layer; and

supplying said corona discharge electrode with a corona generating a.c. voltage.

2. The method of claim 1 wherein said step of applying a reference potential to said conductive layer comprises applying ground potential to said conductive layer.

3. The method of claim 1 wherein said step of applying a reference potential to said conductive layer comprises applying a d.c. voltage exhibiting a constant magnitude to said conductive layer.

4. An a.c. corona discharge device, comprising:

an elongated corona discharge electrode;

a dielectric shield disposed in partially surrounding relationship with respect to said elongated corona discharge electrode, said dielectric shield being co-extensive with said elongated corona discharge electrode;

a layer of conductive material in contact with the external surface of said dielectric shield, said conductive means being collateral with said dielectric shield;

means for applying a reference potential to said conductive means; and

means for supplying said elongated corona discharge electrode with a corona generating a.c. voltage.

5. Apparatus for applying an a.c. corona current to a surface, comprising:

corona discharge electrode means supported in spaced registration from said surface;

a dielectric shield disposed in partially surrounding relationship with respect to said corona discharge electrode means such that a corona current path is defined between said corona discharge electrode means and said surface, the interior surface of said dielectric shield comprising the first plate of a parallel plate capacitor;

conductive means in contact with the exterior surface of said dielectric shield and collateral there-

with, said conductive means comprising the second plate of a parallel plate capacitor;

means for applying a reference voltage to said conductive means; and

means for applying a corona generating a.c. voltage to said corona discharge electrode means.

6. Apparatus for applying an a.c. corona current to a surface, comprising:

corona discharge electrode means;

parallel plate capacitance means disposed in partially surrounding relationship with respect to said corona discharge electrode means, said parallel plate capacitance means including a first plate comprised of the interior surface of a dielectric shield and a second plate comprised of conductive means in contact with the exterior surface of said dielectric shield;

means for applying a reference voltage to said conductive means; and

means for applying a corona generating a.c. voltage to said corona discharge electrode means whereby an a.c. corona current is generated when the difference between the corona generating a.c. voltage applied to said corona discharge electrode means and the voltage induced on the first plate of said parallel plate capacitance means exceeds the corona threshold voltage.

7. The apparatus of claim 6 wherein the separation between said first and second plates of said parallel plate capacitance means is from about 0.25 to 10 mils whereby the capacitance of said parallel plate capacitance means is such that the rate of change of the voltage induced on the first plate of said parallel plate capacitance means is less than the rate of change of the corona generating a.c. voltage applied to said corona discharge electrode means.

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