

June 6, 1967

F. W. HUDSON
CORONA GENERATING DEVICE WITH MEANS TO CAUSE AIR FLOW
THERE THROUGH TO MAINTAIN THE PARTS FREE
OF DUST ACCUMULATION

3,324,291

Filed July 6, 1964

2 Sheets-Sheet 1

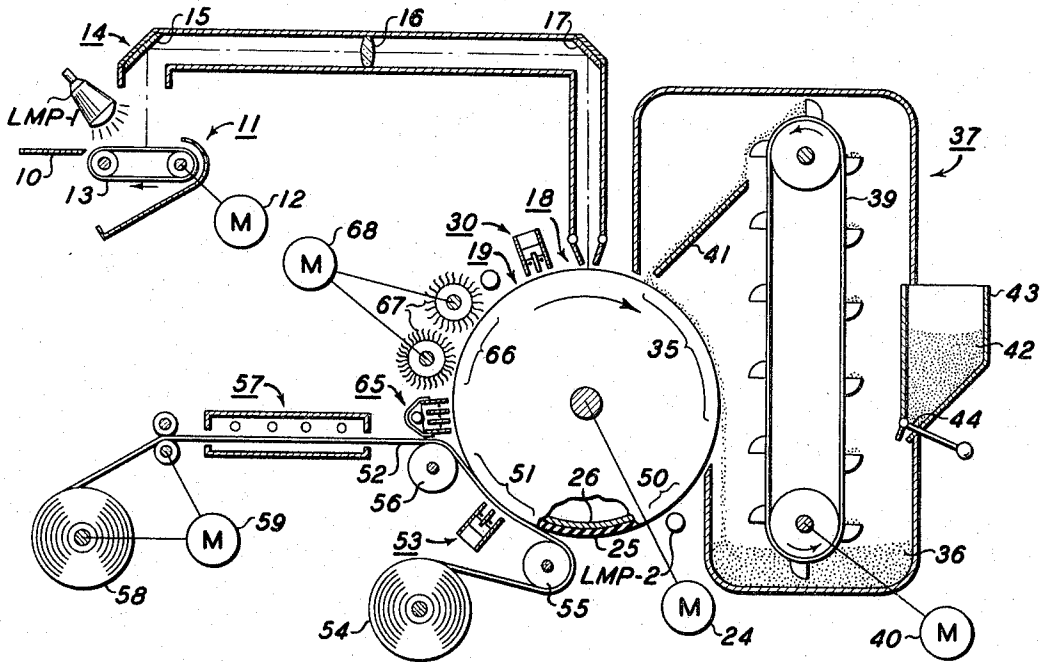


FIG. 1

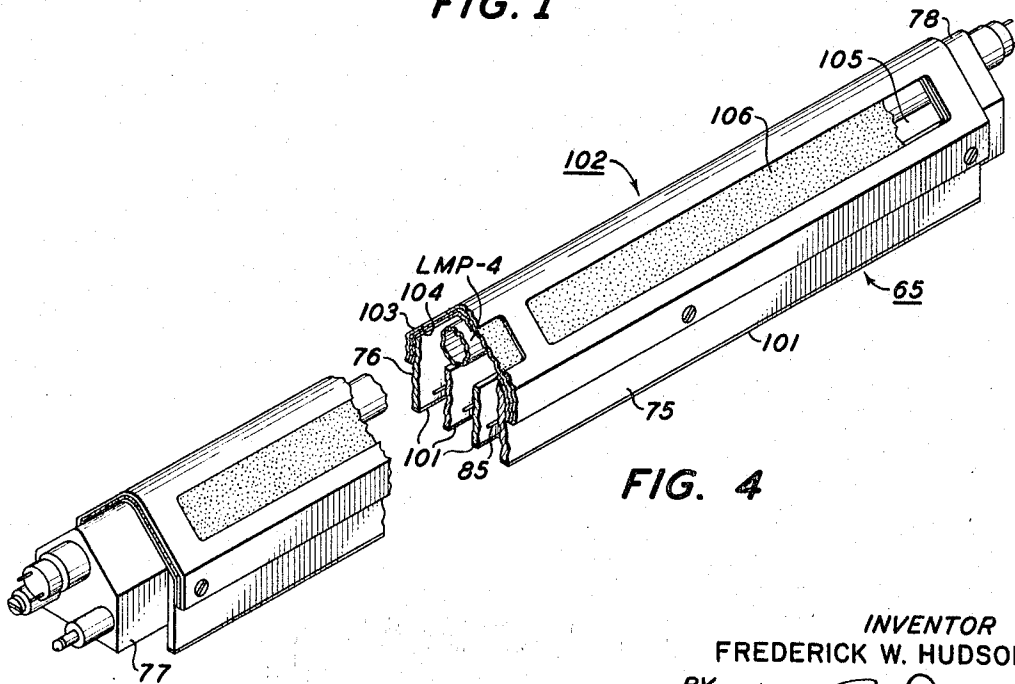


FIG. 4

INVENTOR
FREDERICK W. HUDSON
BY *Stanley Z. Role*
Samuel Rubini
ATTORNEYS

June 6, 1967

F. W. HUDSON

3,324,291

CORONA GENERATING DEVICE WITH MEANS TO CAUSE AIR FLOW
THERE THROUGH TO MAINTAIN THE PARTS FREE
OF DUST ACCUMULATION

Filed July 6, 1964

2 Sheets-Sheet 2

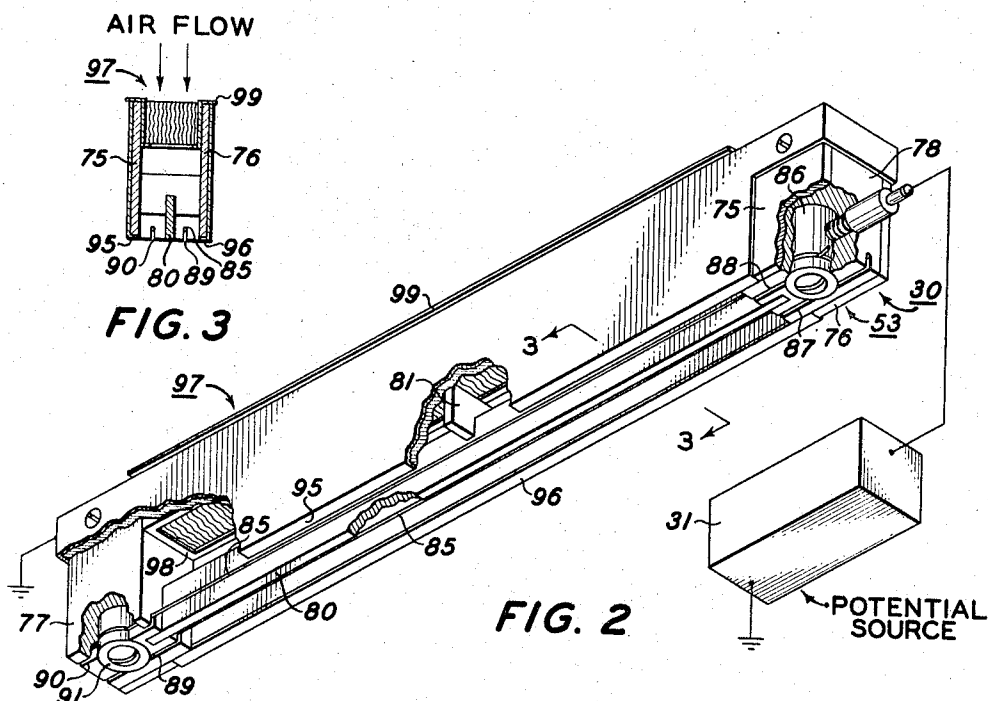
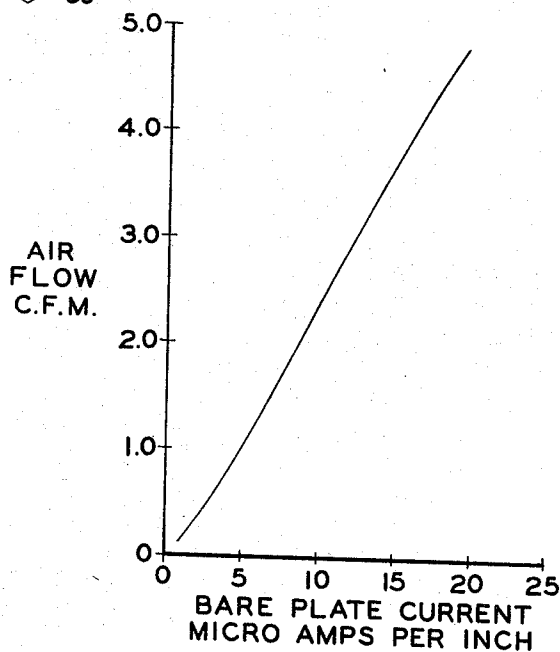


FIG. 5

INVENTOR
FREDERICK W. HUDSON

BY *Stanley Z. Cole*
Daniel Rubin
ATTORNEYS

1

3,324,291

CORONA GENERATING DEVICE WITH MEANS TO CAUSE AIR FLOW THERETHROUGH TO MAINTAIN THE PARTS FREE OF DUST ACCUMULATION

Frederick W. Hudson, West Henrietta, N.Y., assignor to Xerox Corporation, Rochester, N.Y., a corporation of New York

Filed July 6, 1964, Ser. No. 380,259

11 Claims. (Cl. 250—49.5)

This invention relates to xerography and particularly to an improved corona generating device for applying an electrostatic charge onto a recipient surface.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued Oct. 6, 1942, a xerographic plate comprising a layer of photoconductive insulating material on a conductive backing is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. This exposure discharges the plate areas in accordance with the radiation intensity that reaches them, and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is effected with an electrostatically charged, finely-divided material such as an electroscopic powder that is brought into surface contact with the photoconductive layer and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image. Thereafter, the developed xerographic powder image is usually transferred to a support surface to which it may be fixed by any suitable means.

In automatic equipment employing the principles of xerography, it is common to employ a xerographic plate in the form of a cylindrical drum which is continuously rotated through a cycle of sequential operations including charging, exposure, developing and transfer. During the cycle copy is reproduced onto a support surface and after transfer, the plate is cleaned before reuse. It is usual to charge the xerographic plate with corona of positive polarity by means of a corona generating device having an electrode which when supplied with potential above the corona threshold produces an emission of corona ions that deposit uniformly onto the plate surface. Typical of the corona generating device employed heretofore are those described in Walkup Patent U.S. 2,777,957 and in Vyverberg Patent U.S. 2,836,725, each constructed generally of an electrode wire or wires supported relatively close to the surface to be charged. A grounded metallic shield generally surrounds the electrode except for an opening through which charge is emitted and is adapted to attract surplus emission emanating therefrom.

Inherent in xerographic apparatus of the type described above is the continuous presence of dust generated by the operations and generally comprising particulate quantities of stray electroscopic powder. With prolonged continuous operation, it has been found that the dust accumulates on and about the interior of the corona generator to such an extent that the charging efficiency thereof decreases substantially as the density of dust accumulation increases. This has required frequent cleaning and maintenance. For example, in order to maintain the entire apparatus operating effectively it has been necessary heretofore to completely clean the corona generator

2

after approximately every 10,000 reproductions made. With millions of copies being generated yearly, the costs of servicing has represented a significant economic overhead. At the same time, in order to ensure uninterrupted operation within a plausible programmed maintenance schedule, it has been found necessary to operate these prior corona generating devices at a potential substantially above the threshold potential, being a much higher potential than is otherwise required for corona emission. Still further, in addition to the problem associated with cleanliness it has long been known that the consumption of corona collected by the surrounding shield has been far in excess of that applied onto a recipient surface to be charged. It has been established that with some corona generators the shield or other surrounding elements consume as much as 84% of the total charging current while only the remaining 16% is effective in applying a charge in the manner intended onto a receiving surface such as a xerographic plate.

Now in accordance with the instant invention, there has been discovered a novel corona generating apparatus that is substantially self-cleaning as to be capable of operating consistently more efficiently for prolonged periods far greater than heretofore. At the same time, the unit is increasingly efficient in its dissemination of corona emission in a manner whereby a predominant percentage of charging current is utilized in the application of charge to the recipient surface in contrast to the shield. This is achieved in accordance with the corona generating device of the invention that produces a directionally controlled air pumping action for maintaining the unit substantially free of dust deposits while utilizing a compact arrangement that is effective in more efficiently disseminating the corona discharge.

It is therefore an object of the invention to provide a novel corona generating device for applying electrostatic charge onto a recipient surface.

It is a further object of the invention to provide a corona generating device having enhanced performance and increased operating efficiency whereby a substantially greater proportion of total current is utilized effectively in applying charge onto a recipient surface.

It is a further object of the invention to provide a corona generating device which is inherently self-cleaning in minimizing dust accumulation within the unit whereby to maintain a prolonged consistency of charging efficiency as to require reduced maintenance than heretofore.

It is a still further object of the invention to provide a corona generating device for use in an automatic xerographic machine that is substantially more economical to operate than similar units of the prior art type.

Further objects and features of the invention will become apparent on reading the following description in connection with the drawings wherein:

FIG. 1 is a schematic illustration of an automatic xerographic apparatus embodying the corona generator device of the invention;

FIG. 2 is an isometric view of one embodiment of the corona generating device of the invention;

FIG. 3 is a sectional view taken substantially along the lines 3—3 of FIG. 2;

FIG. 4 is an isometric view of a variation of the embodiment illustrated in FIG. 2; and

3

FIG. 5 is a graph illustrating a characteristic relation of generated air flow as a function of charging current applied to the electrode wire.

For a general understanding of the xerographic processing system in which the invention is incorporated, reference is had to FIG. 1 in which the various system components are schematically illustrated. As in all xerographic systems based on the concept disclosed in the above-cited Carlson patent, a radiation light image of copy to be reproduced is projected onto the sensitized surface of a xerographic plate to form electrostatic image thereon. Thereafter, the latent image is usually developed with an oppositely charged developing material to form a xerographic powder image corresponding to the latent image on the plate surface. The powder image is then electrostatically transferred to a support surface to which it may be fused by any suitable form of fusing device, whereby the powder image is caused permanently to adhere to the support surface.

The xerographic apparatus described herein typically may be of the type described in Cerasani et al. Patent U.S. 3,076,392. In the apparatus referred to, copies to be reproduced, which usually are positive in form, are placed on a support tray 10 from which they are fed onto a suitable transport mechanism designated 11. Suitable drive means are provided for the transport mechanism from motor 12 to endless belts 13 whereby the copy is moved past the optical axis of projection system 14 and is illuminated by projection lamp LMP-1. The image of the copy is reflected by mirror 15 through an objective lens 16 and then is reflected by mirror 17 downwardly through a variable slit aperture assembly 18 and onto the surface of the xerographic plate in the form of drum 19.

Xerographic drum 19 includes a cylindrical member mounted in suitable bearings in the frame of the machine and is driven in a clockwise direction by a motor 24 at a constant rate that is proportional to the transport rate of the copy, whereby the peripheral rate of the drum surface is identical to the rate of movement of the reflected light image. The drum surface comprises a layer of photoconductive material 25 such as vitreous selenium, on a conductive backing 26 such as aluminum. The photoconductive material is sensitized prior to exposure by means of a corona generating device 30, in accordance with the invention as will be described more fully below, and which is energized from a suitable high potential source 31 (FIG. 2).

Exposure of the drum to the light image discharges the photoconductive layer in the areas struck by light, whereby there remains on the drum a latent electrostatic image in image configuration corresponding to the light image projected from the copy. As the drum surface continues its movement, the electrostatic latent image passes through a developing station 35 at which a two-component developing material 36, which may be of the type disclosed in Walkup patent, U.S. 2,638,416, is cascaded over the drum surface by means of developing apparatus 37. In the developing apparatus, developing material is carried upward by conveyor 39 driven by suitable drive means from motor 40 and is released onto chute 41 wherefrom it is cascaded down over the drum surface. Toner component 42 of the developer, which is consumed in developing, is stored in dispenser 43 and is released in amounts controlled by gate 44.

After developing, the xerographic powder image passes a discharge station 50 at which the drum surface is illuminated by a lamp LMP-2, whereby residual charges on the non-image areas of the drum surface are completely discharged. Thereafter, the powder image passes through an image transfer station 51 at which the powder image is electrostatically transferred to a support surface web 52 by means of a second corona generating device 53 similar to corona generator 30 as will be hereinafter described.

4

The support surface to which the powder image is transferred may be of any convenient type such as paper and is obtained from a supply roll 54 to pass over guide rolls 55 and 56 and over suitable tensioning rolls being directed into surface contact with the drum in the immediate vicinity of transfer corona generating device 53. After transfer, the support surface is separated from the drum and is guided through a suitable heat fusing apparatus 57 whereby the powder image is permanently affixed to the support surface. Thereafter, the support surface is fed over a further system of guide and tensioning rolls and onto a take-up roll 58 that is driven by motor 59.

Following separation of the support surface from the drum, a corona generating device 65, likewise constructed in accordance with the invention hereof as will be further described below, directs negative electrostatic charge to the residual powder image on the drum surface and simultaneously applies additional illumination for discharging residual charges thereon prior to being cleaned. The drum surface then passes through a cleaning station 66 at which the surface is brushed by cleaning brushes 67, rotated by a motor 68, whereby residual developing material remaining on the drum is removed. Suitable light traps are provided in the system to prevent any light rays from reaching the drum surface, other than the projected image, during the period of drum travel immediately prior to sensitization by corona generating device 30 until after the drum surface is completely passed through the developing station 35.

Referring now specifically to FIGS. 2 and 3, a corona generating device constructed in accordance with a first embodiment of the invention is illustrated and shown connected to a potential source 31. The unit is generally comprised of a frame comprising a pair of electrically insulating walls 75 and 76 secured in spaced apart substantially parallel relation by means of electrically insulating end blocks 77 and 78. Intermediate, extending substantially parallel between the side walls, is a center bar 80 secured at opposite ends in the end blocks and likewise comprising an electrically insulating material. The lower edge of bar 80 is generally parallel and coplanar with the lower edges of the sidewalls. Cradle 81 provides a center support for bar 80. Suitable materials for the insulating frame members comprise rigid plastic acrylic resins marketed as Lucite or Plexiglas or other suitable dielectrics including a polycarbonate resin marketed as Lexan or the like as is known in the art.

An electrode corona emitting wire 85, usually on the order of 2 to 5 mils in diameter extends from a terminal post 86 connected to potential source 31. The position of the wire relative to the frame is defined at the terminal end by slots 87 and 88 grooved or milled in the lower surface of end block 78. From there, the wire extends to the opposite end block 77 between the sidewalls and the center bar 80 into corresponding grooved slots 89 and 90 in the end block 77 whereat it is looped about plug 91. The grooves supporting the electrodes are milled or cut to a depth to maintain the electrode wires close to the lower surface of the frame for effecting maximum charge application when supported in the xerographic apparatus. At the same time, they are supported within the frame sufficiently to afford protection against breakage from an inadvertent encounter with foreign objects during handling and assembly thereof. A slot depth of about $\frac{3}{16}$ " above the lower plane of the frame has been found about optimum for this purpose.

In order to emit corona emission from the electrode outward from the bottom section of the frame, towards a recipient surface, there is provided a source of reference potential in the form of conductive strips 95 and 96 which may be a conductive paint, metal foil or the like secured along the bottom edges of sidewalls 75 and 76. In the embodiment shown, the strips form part of a continuous foil sheet extending about the sidewalls 75 and around the end blocks and receive a ground connec-

5

tion when installed in operative position in the apparatus such as that described above. The field provided by the conductive strips serves also to prevent sparking as might otherwise occur from the electrodes when closely spaced to a photoconductive surface 25, i.e., sparking which might inadvertently occur, occurs instead between the electrode and the grounding strips. Whereas a ground plane has been described and is utilized in the preferred embodiment hereof, it is to be understood that a reference potential on the order of up to about 5,000 volts could be connected to the conductive strips in order to modify the current flow between the shield and the recipient surface. The flow of corona with this structural arrangement is found to be generally suppressed or repelled by the insulating members of the frame as to effect an ion flow substantially unidirectional from the electrode wires toward the recipient surface. Some relatively small proportion of flow is collected by the conductive strips.

As is known in the art, corona emission has associated therewith corona winds comprised of ionized air molecules which acquire velocities such that their momentum carry the ions to the xerographic plate, for example, against retarding air currents. It has been found that with unidirectional flow these winds create a vacuum behind the wires and an air pressure at the plate surface. The vacuum created thereby has been discovered to be sufficient to induce an air pumping action of substantial magnitude as may be understood by referring to the graph of FIG. 5. The graph has plotted the correlation of air flow in cubic feet per minute without filter resistance for varying charging currents based on an air flow area of about 0.023 square feet and a close spacing to the recipient surface. This air flow is utilized in the embodiments herein to provide a cleansing action by preventing the accumulation or deposition of dust in or about the unit.

To ensure that the air entering the unit is itself generally free of dust or dirt particles likely to accumulate, there is provided an opening defined by the outer walls and end blocks in the top central portion of the frame in which is contained a filter unit 97. The filter unit consists of a rectangular frame 98 sized to fit the opening provided and having a lip section 99 extending about its perimeter for resting on the top surfaces of side walls. The central core 100 of the filter comprises a disposable or washable type commercially available filtering media such as Aerosolve 85 or Aerosolve 95 marketed by the American Air Filter Company of Louisville, Ky., offering a minimum resistance to air flow. As shown in FIG. 3, the filter media is of paper pleated within the frame to maximize surface area. By this means as air is induced through the filter toward and past the electrode members, all wall surfaces therein receive a continuous air pressure cleaning action from the velocity of the filtered air. This air flow has been found not only to remove dirt or dust accumulated therein, but also repels dust or dirt in the atmosphere from entering the underside of the generating unit counter to the direction of corona emission. For best results, filter units having a filtering efficiency of about 99% when measured by the standard D.O.P. smoke test are preferred. Optionally, additional filtered or dust free air can be furnished from a pressurized source for traversing the unit when desired. Also where the air intake to the unit, in contrast to the electrodes, extends into a relatively dust-free atmosphere, the filter units can optionally be eliminated. With the xerographic embodiment described, this occurs as the air intake extends increasingly remote from the vicinity of the xerographic drum.

The lamp located in the cyclic path immediately preceding the cleaning station 66 has likewise in the prior art been subjected to heavy contamination of dust particles as to substantially reduce the illumination therefrom and require frequent maintenance at about every 1000 cycles. It has been found that by incorporating a lamp in the corona generating unit of the invention that the cleaning effect provided by the air pumping action

6

of the corona generator can likewise maintain the lamp similarly free of dust particles as to result in a consistently high output efficiency thereof.

Referring therefore specifically to FIG. 4, there is illustrated a second embodiment of corona generating device 65 in which a lamp designated LMP-4 is supported above the electrode wires 85. This generating unit includes similar sidewalls 75 and 76 and end blocks 77 and 78 as corona generating unit 30 described above in connection with FIGS. 2 and 3. The unit illustrated here includes three runs of electrode wire 85, the center one of which is separated from the adjacent outer wires by two intermediate bars 80 and otherwise is adapted to operate similarly as described above. A grounding or other potential plane to which corona emission is attracted is provided in the form of conductive strips or paint 101 similar to 95 described above and extending attached lengthwise along the bottom edge of the respective members.

In order to accommodate the lamp there is provided a dome shaped shield 102 comprised of two separate overlying and mating sections 103 and 104 having identically situated openings 105 defined therethrough. Between the mating sections, at least in the area of the openings, is secured a filter paper 106 which provides a filtering passage for air induced through the openings 105. With this arrangement, the lamp LMP-4 is positioned in the path of air flow and is maintained clean similarly by the air pumping action of the generating unit. By this means, a high lamp efficiency is maintained concomitantly with a high corona generating efficiency.

By the above description, there has been disclosed a novel corona generating apparatus having a high current efficiency by virtue of its inherent capability of operating insensitive to dust and toner accumulation as has occurred heretofore in prior art devices. With the arrangement described, the unit has been found to disseminate as much as five times the current flow to the recipient surface as to the grounded shield surfaces provided. Because of the inherent ability to consistently maintain high efficiency, the unit is capable of being operated closer to the corona threshold than heretofore which typically occurs in 2 and 3.5 mil wire at approximately 3,000 volts and 3,600 volts respectively for positive corona discharge. Maintenance utilizing a corona generator of the type described has been reduced from an approximately former every 10,000 cycles of copy to in excess of 20,000 cycles and above. At the same time, where the unit includes a lamp, lamp cleaning has been extended from the former 1000 cycles to 10,000 cycles and above. Hence, not only does the increased efficiency of current consumption afford more economical operation to the consumer, but the decreased maintenance by virtue of the increased time span between service calls for good apparatus operation results likewise in a significant economic saving.

The unit is compact occupying substantially less space than prior units and for example an embodiment such as that shown in FIG. 2 may very well have a total dimension of 1" wide x 2" high of length suitable for the particular requirement. Since the unit is substantially smaller physically than prior type units, it is possible in a compact apparatus to use multiple charging units which enhance the application of charge uniformity as to effect higher and more uniform corona current densities on the recipient surface. Whereas, two or three electrode wires per unit have been shown, this is not to be considered a limitation since any suitable number of wires can be utilized in accordance with the particular requirements of the conditions under which it is to be employed. Further, whereas the ground shield has been illustrated in combination with the frame, it should be understood that where sparking is not a problem, it is possible that the recipient surface itself, such as a photoconductive layer can comprise the ground field toward which the ions are attracted.

Since many changes can be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A corona generating device for the emission of corona discharge comprising in combination:

- (a) a frame including at least a pair of electrically insulating walls secured together in spaced apart relation;
- (b) a corona discharge electrode extending generally lengthwise between the walls of said frame;
- (c) means for connecting said electrode to a source of corona generating potential;
- (d) means defining a reference field spaced from said electrode for effecting directional flow of corona discharge generally towards said field to exterior of said frame whereby a vacuum is induced by said discharge within said frame in the vicinity of said electrode; and,
- (e) means defining an air entrance opening in said frame generally opposite said electrode from said field defining means and communicating with the vacuum area thereof whereby a continuous quantity of air induced by said vacuum flows into said entrance through said frame past said electrode for maintaining the parts thereof substantially free of dust accumulation.

2. A corona generating device for applying electrostatic charge onto the surface of a chargeable member comprising in combination:

- (a) a frame including at least a pair of electrically insulating walls secured together in spaced apart relation;
- (b) support means to support said frame closely spaced to the surface of a member to be charged;
- (c) a corona discharge electrode extending generally lengthwise between the walls of said frame;
- (d) means for connecting said electrode to a source of corona generating potential;
- (e) means defining a reference field spaced from said electrode for effecting directional flow of corona discharge generally towards said field to exterior of said frame whereby a vacuum is induced by said discharge within said frame in the vicinity of said electrode; and,
- (f) means defining an air entrance opening in said frame generally opposite said electrode from said field defining means and communicating with the vacuum area thereof whereby a continuous quantity of air induced by said vacuum flows into said entrance through said frame past said electrode for maintaining the parts thereof substantially free of dust accumulation.

3. Apparatus according to claim 2 in which said reference field is defined by a layer of conductive material secured extending along the edges of said frame walls adjacent said electrode.

4. A corona generating device for the emission of corona discharge comprising in combination:

- (a) a frame including at least a pair of electrically insulating walls secured together in spaced apart relation;
- (b) a corona discharge electrode extending generally lengthwise between the walls of said frame;
- (c) means for connecting said electrode to a source of corona generating potential;
- (d) means defining a reference field spaced from said electrode for effecting directional flow of corona discharge generally towards said field to exterior of said frame whereby a vacuum is induced by said discharge within said frame in the vicinity of said electrode;
- (e) means defining an air entrance opening in said frame generally opposite said electrode from said

field defining means and communicating with the vacuum area thereof; and,

- (f) an air filter media supported between the entrance of said defined opening and said vacuum area whereby a continuous quantity of filtered air induced by said vacuum flows through said frame past said electrode for maintaining the parts thereof substantially free of dust accumulation.

5. A corona generating device for applying electrostatic charge onto the surface of a chargeable member comprising in combination:

- (a) a frame including at least a pair of electrically insulating walls secured together in spaced apart relation;
- (b) support means to support said frame closely spaced to the surface of a member to be charged;
- (c) a corona discharge electrode extending generally lengthwise between the walls of said frame;
- (d) means for connecting said electrode to a source of corona generating potential;
- (e) means defining a reference field spaced from said electrode for effecting directional flow of corona discharge generally towards said field to exterior of said frame whereby a vacuum is induced by said discharge within said frame in the vicinity of said electrode;
- (f) means defining an air entrance opening in said frame generally opposite said electrode from said field defining means and communicating with the vacuum area thereof; and,
- (g) an air filter media supported between the entrance of said defined opening and said vacuum area whereby a continuous quantity of filtered air induced by said vacuum flows through said frame past said electrode for maintaining the parts thereof substantially free of dust accumulation.

6. Apparatus according to claim 5 in which said reference field is defined by a layer of conductive material secured extending along the edges of said frame walls adjacent said electrode.

7. Apparatus according to claim 6 in which said conductive material comprises a conductive paint.

8. Apparatus according to claim 6 in which said conductive material comprises a conductive foil.

9. Apparatus according to claim 5 including a lamp supported within said frame in the path of said air flow for emitting illumination onto said chargeable surface concomitantly with the application of charge thereto.

10. In a xerographic apparatus including a xerographic drum comprising a photoconductive layer on a conductive substrate, and means to continuously rotate said drum sequentially past a plurality of processing stations, a corona generating device for applying electrostatic charge onto the surface of said drum and comprising in combination:

- (a) a frame including at least a pair of electrically insulating walls secured together in spaced apart relation;
- (b) support means to support said frame closely spaced to the photoconductive surface of said drum;
- (c) a corona discharge electrode extending generally lengthwise between the walls of said frame;
- (d) means for connecting said electrode to a source of corona generating potential;
- (e) means defining a reference field spaced from said electrode for effecting directional flow of corona discharge generally towards said field to exterior of said frame whereby a vacuum is induced by said discharge within said frame in the vicinity of said electrode;
- (f) means defining an air entrance opening in said frame generally opposite said electrode from said field defining means and communicating with the vacuum area thereof; and,

9

(g) an air filter media supported between the entrance of said defined opening and said vacuum area whereby a continuous quantity of filtered air induced by said vacuum flows through said frame past said electrode for maintaining the parts thereof substantially free of dust accumulation.

11. Apparatus according to claim 10 in which said reference field is defined by a layer of conductive material secured extending along the edges of said frame walls opposite said xerographic drum.

10

10

References Cited

UNITED STATES PATENTS

2,777,957	1/1957	Walkup	-----	250—49.5
3,038,073	6/1962	Johnson	-----	250—49.5
3,117,501	1/1964	Oliphant	-----	95—1.7

RALPH G. NILSON, *Primary Examiner*.

W. F. LINDQUIST, *Assistant Examiner*.