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3,332,396

XEROGRAPHIC DEVELOPING APPARATUS WITH CONTROLLED CORONA MEANS

Filed Dec. 9, 1963

2 Sheets-Sheet 1

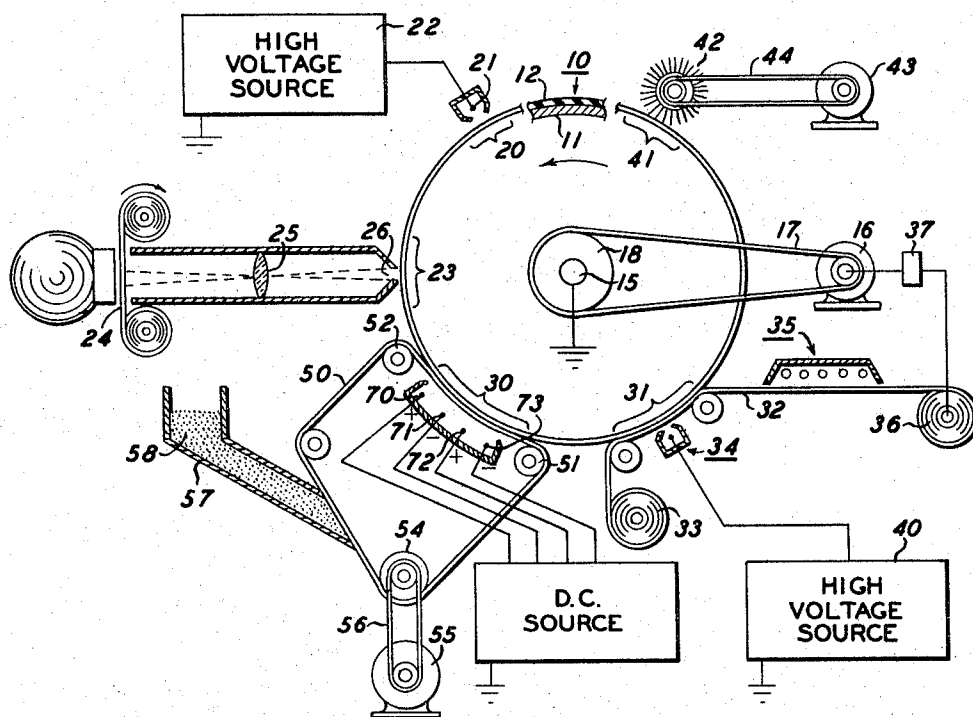


FIG. 1

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2 Sheets-Sheet 2

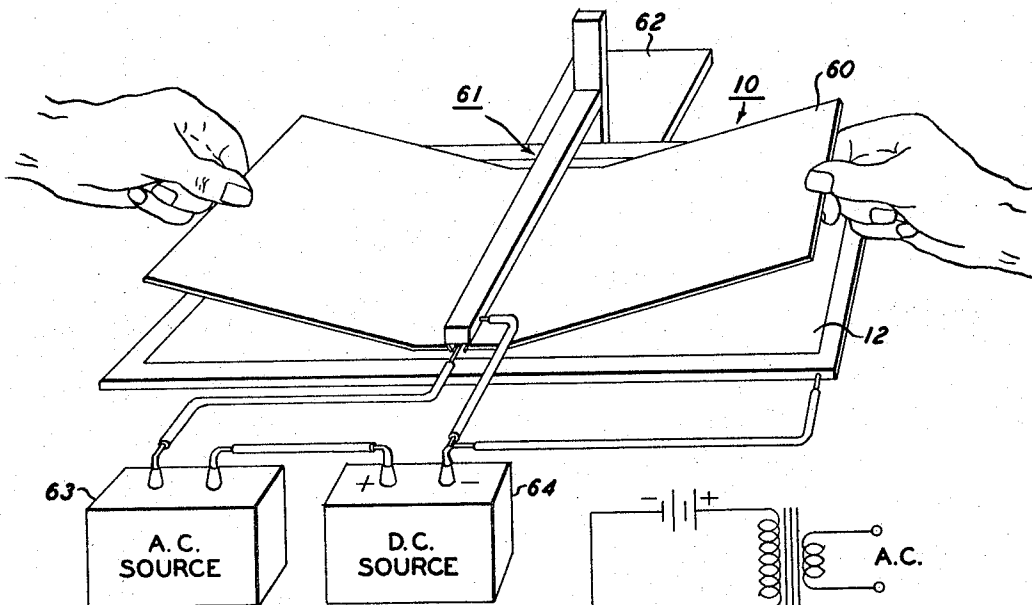


FIG. 2

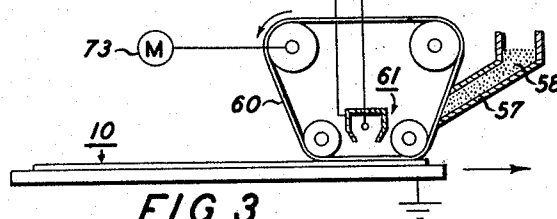


FIG. 3

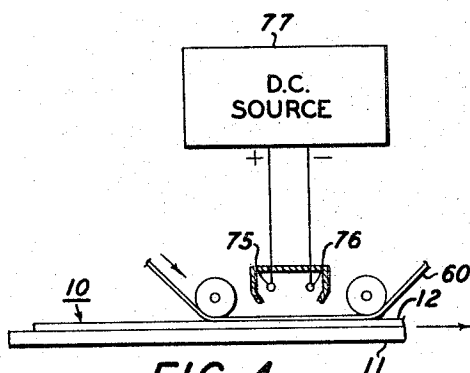


FIG. 4

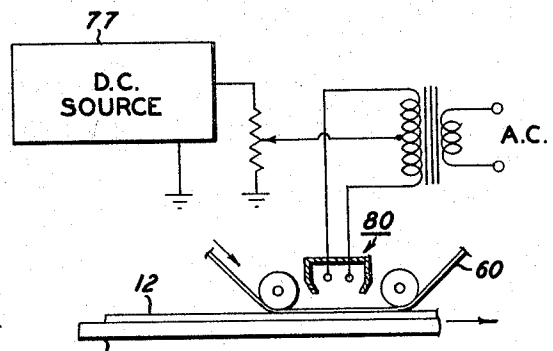


FIG. 5

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XEROGRAPHIC DEVELOPING APPARATUS WITH CONTROLLED CORONA MEANS

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3 Claims. (Cl. 118—637)

This invention relates to xerography and particularly to improvements for developing electrostatic latent images.

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 convention projection techniques. This exposure discharges the plate areas in accordance with the radiation intensity that reaches it, 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 image may be fixed by any suitable means to the surface on which it has been developed or may be transferred to a secondary support surface to which it may be fixed or utilized by means known in the art.

Whatever method is employed for forming electrostatic images, they are usually made visible by developing. Various developing systems are well known and include cascade, brush development, magnetic brush, powder cloud, and liquid development, to name a few. In connection with these various development systems it is known that a conductive control electrode as, for example, disclosed in U.S. Patents 2,808,023, 2,777,418, 2,573,881 and others is highly effective in influencing electrostatic gradients to develop images having varying charge gradients and having relatively large solid image areas. At the same time, when developing images generally devoid of solid areas and consisting primarily of line copy images, superior results are generally obtainable without the electrode in place.

Another developing method, as disclosed in Mayo U.S. Patent 2,895,847 employs a support member such as a web, sheet or other member termed a "donor" which carries a releasable layer of electroscopic marking particles to be presented into close contact with an image-bearing plate for deposit in conformity with the electrostatic image to be developed. With donor development, the electrical properties of the donor member are a factor for developing in response to the area characteristics of the latent image. That is, electrically insulating donors respond best with line copy while electrically conductive donors respond best with solid areas in a manner comparable to the control electrode. Accordingly, prior attempts to provide development flexibility on a practical basis for development of any kind of image such as solid area versus line copy, with the system of Mayo has not met with success. This has resulted in limitations on the usual copying system since material to be reproduced cannot be copied in random order.

In connection with the donor type development, it has recently been discovered that by applying a controlled corona bias to a donor member characterized by appropriate electrical resistance while in contact with a plate being developed, that the donor functions to effect results similar to a control electrode described above. That is, by applying a corona bias to the rear surface of the

donor member when presenting developer into contact with an electrostatic latent image, it becomes much more effective than an insulating or highly resistive unbiased donor for developing images having relatively large solid areas as well as the various gradations of charge commonly associated with continuous tone images. At the same time, when developing images generally devoid of solid areas and gradations in tones and consisting primarily of line copy images, substantially greater image exposure latitude can still be obtained by developing with the donor in its inherently more resistive state without the benefit of the corona bias applied thereagainst.

Now in accordance with the instant invention, there is provided novel method and apparatus adapted to afford control over development properties in accordance with the area characteristics of the latent image to be developed. Specifically, control is achieved by employing a donor member having electrical resistivity able to support charge at its top surface for a time compatible with the speed at which the donor is moved. At the same time a corona discharge is applied against the back side of its presentation area to maintain equal potential as it moves through areas of varying fields against the plate surface. This affords an expedient and inexpensive solution to overcome the difficulties encountered heretofore while at the same time, enhancing the latitude and versatility of these various development systems.

It is, therefore, an object of the invention to provide novel control for development of xerographic images.

It is a further object of the invention to provide novel method and apparatus for controlling the electrical field effecting development in a xerographic development system.

It is a still further object of the invention to provide novel method and apparatus for effecting increased development versatility of a xerographic donor type development system.

These and other objects of the invention are achieved in accordance with the embodiments of the invention which are exemplified by the following drawings in which:

FIG. 1 is a schematic illustration of a continuously operative automatic xerographic apparatus incorporating an embodiment of the invention;

FIG. 2 is an embodiment of the invention as adapted partially for hand operation;

FIG. 3 is an embodiment of the invention adapted for automatic operation; and

FIGS. 4 and 5 are variations of the embodiments of FIG. 3.

For a general understanding of the invention, reference is generally made to all figures in which there is included a xerographic plate 10 comprising a supporting substrate 11 supporting a layer of photoconductive insulating material 12. Support member 11 is generally and preferably an electrical conductor or a supported electrically conductive layer in contact with photoconductive insulating layer 12. It may thus comprise, in accordance with conventional xerographic usage, such material as aluminum, brass, or other metals, metalized paper or paper with a relatively high moisture content, glass with a transparent or other conductive coating, or like known layer. Photoconductive insulating layer 12 may comprise various photoconductive insulating materials known to be useful in the art of xerography. Such materials preferably include vitreous layers such as selenium, sulfur or anthracene or other organic photoconductors as well as dispersions or photoconductive pigments such as zinc oxide and various resins or other electrically insulating binder materials. Layer 12 is generally characterized as being a good electrical insulator capable of maintaining a surface charge in the dark, but becoming substantially more con-

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ductive when illuminated by visible light, X-rays, or other forms of activating radiation. For illustrative purposes only, layer 12 may be considered to be a layer of vitreous selenium 20 to 50 microns in thickness. Vitreous selenium layers are more fully described in Bixby U.S. Patent 2,970,906.

Referring now specifically to FIG. 1, there is illustrated a continuous xerographic machine adapted to form a xerographic reproduction of copy onto a paper sheet, web or the like. The apparatus includes a xerographic plate 10, in the form of a cylindrical drum, which comprises the photoconductive insulating peripheral surface on a conductive substrate as above. The drum is mounted on an axle 15, journaled for rotation, and driven by a motor 16 through belt 17 connected to pulley 18 secured to the shaft or axle 15.

Position adjacent to the path of motion of the surface of the drum 10 is a charging station 20 comprising, for example a positive polarity corona discharge electrode 21 consisting of a fine wire suitably connected to a high voltage source 22 of potential high enough to cause a corona discharge from the electrode onto the surface of drum 10. Subsequent to the charging station 20 in the direction of rotation of the drum, is an exposure station 23 generally comprising suitable means for imposing a radiation pattern reflected or projected from an original copy 24 onto the surface of the xerographic drum. To effect exposure, the exposure station is shown to include a projection lens 25 or other exposure mechanism as is conventional in the art, preferably operating with slit projection methods to focus the moving image at the exposure slit 26.

Next subsequent to the exposure station is a developing station, generally designated 30, as will be further described below for rendering the latent image visible. Beyond the developing station is a transfer station 31 adapted to transfer a developed image from the surface of the drum to a transfer web 32 that is advanced from supply roll 33 into contact with the surface of the xerographic drum at a point beneath a transfer electrode 34. After transfer, the web desirably continues through a fusing or fixing device 35 onto a take-up roll 36 being driven through a slip-clutch arrangement 37 from motor 16. Desirably, electrode 34 has its corona discharge electrode operably connected to a high voltage source 40 whereby a powder image developed on the surface of the drum is transferred to the web surface. Fusing device 35 primarily fixes the transferred powder image onto the web to yield a xerographic print.

After transfer, the xerographic drum 10 continues to rotate past a cleaning station 41 in which residual powder on the drum surface is removed. This may include, for example, a rotating brush 42 driven by a rotor 43 through a belt 44 whereby the brush bristles bear against the surface of the drum to remove residual developer therefrom. Optionally, further charging means, illumination means or the like, may effect electrical or controlled operations.

Operative at the developing station 30 is a donor member 50 in a form of an endless web, as will be further described, adapted to pass over a pair of insulating rollers 51 and 52 between which developer on the donor member comes into firm surface contact against the surface of the rotating xerographic drum 10. Movement of the donor web is effected by means of a drive roller 54 being driven by a motor 55 operating through a belt 56, preferably to drive the web in the same direction as the surface rotation of the xerographic drum. The speeds of the donor member and drum may be substantially the same or the donor member can travel at surface speeds as high as 5 to 10 times as fast as the peripheral speed of the drum to effect a skidding or sliding action thereagainst. Thus, there is maintained between donor member 50 and drum 10 a continuous contact. When a sliding action is used there is achieved a dual purpose of ensur-

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ing an extremely quick contact between all points of the surface of the drum and the donor member, while further bringing to each point of the drum surface a substantially greater quantity of developer material than is carried by any one point on the surface of the donor member.

Adjacent to one portion of the path of motion of the developer donor member 50 is a powder loading station which may, for example, comprise a developer hopper 57 containing a quantity of developer powder 58 which may be a form of two-component developer mixture as disclosed in Walkup and Wise U.S. Patent 2,638,416. The hopper opens against the donor member, whereby the web passes in contact with the developer supply and is coated uniformly with the toner powder component of the mixture as the web passes upwardly against the developer. Other web loading mechanisms and developer compositions, may, of course, be employed including dusting, brushing or the like as is known in the art.

The specific improvement of the invention will now be described. An understanding of the operability hereof is helpful in that it should be initially apparent and understood that the donor web in presenting developer to the xerographic plate passes through regions of high and low potential emanating from the charged and uncharged areas of the plate constituting the latent image. The fields associated with the charge pattern extend above the plate surface a distance through which the donor member passes and decreases in magnitude increasingly with distance therefrom. In order that the donor member function in accordance with the invention, it must first be characterized by sufficient strength and durability to be employed for continuous recycling, as were illustrated, and in addition should preferably comprise an electrical insulator or at least possessed of sufficiently high electrical resistance of approximately 10^{12} ohm cm. or greater. This is not to be considered an absolute limitation, since the resistivity requirement will become less of about 10^{11} ohm cm. and below with reduced time periods of contact between the particular incremental area of the donor and the xerographic plate. Hence, the use of donor films of too low resistivity permits excessive penetration of charge from the corona discharge source, as will be understood into the donor web within the time of contact. That is, as a too low resistivity donor advances from charged to uncharged areas of the electrostatic latent image, the charges induced into the bulk of the web causes excessive deposition of toner in these uncharged areas. At the same time, however, for development speeds giving shorter contact times, materials of lower resistivity may be used. Found suitable for this purpose are such materials as a fluorinated-vinyl carbon material marketed as Teflon, polyethylene terephthalate marketed as Mylar, and polyethylene.

In carrying out the method of the invention, a neutral corona bias is applied from corona generating device against the back non-developer bearing surface of the donor member in areas thereof corresponding substantially to the development zone in contact with the xerographic plate. By this means, as the donor web advances through the regions of high and low plate potential the applied neutral bias, it is believed, serves to suppress fields above the donor and produce the effect of a grounding plane closely spaced thereto. Accordingly, it being the objective to develop areas of charge only, the donor member must have the inherent electrical properties described above and the corona device must be able to dissipate charge at the top surface of the donor in a time compatible with the speed at which the donor is moving. By way of example, to at most deposit negligible amounts of developer with a distance about one mm. from the trailing edge of a solid area image with a donor web moving relatively at 50 mm. per second, the donor surface potential should be reduced with a discharge time constant of about $\frac{1}{50}$ sec. or 20 milliseconds. In order to effect the equal potential in the field above the development zone, it may be ac-

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complished in different ways as exemplified by the different figures of the drawings.

Referring first to FIG. 2, there is illustrated a xerographic plate 10 on which an electrostatic latent image has been previously formed and against which a donor member here designated 60, is adapted to be hand-drawn with the developer side in contact against the plate surface. Supported extending from a stand 62 immediately above the donor in the development zone is a corona generating device 61 secured and adapted to be connected to A.C.-D.C. sources 63 and 64 in the manner shown. To be most effective, generating device 61 is mounted as close to the donor surface as feasible being on the order of approximately 1/8" above the surface thereof. When it is desired to beneficially utilize the corona discharge for maximum benefit, as where solid charge areas of image are to be developed, the corona generating potentials are applied to device 61 as by means of a switch not shown. This potential varies somewhat depending on the corona threshold of either polarity for a particular wire electrode diameter. This typically occurs for positive corona at 3000 and 3600 for 2 mil and 3.5 mil wire respectively. The threshold of the same wires for negative corona is approximately 2800 and 3300 volts.

Because of the threshold differences between polarities, an A.C. connection to the wire electrode will inherently produce more negative than positive corona discharge such that the D.C. applied in the circuit thereof serves to equalize the output of both polarities. By this means a neutral or zero voltage results on the backside of the donor member as it is drawn through the development zone. As discussed above, the exact operating conditions will, of course, vary as a function of the relative speeds between donor and xerographic plate as well as particular electrical properties of the donor member being employed. For example, it was found that with a 3 mil thickness baryta paper at relatively dry humidity conditions and toned uniformly with developer, an A.C. supply of 4545 volts with a D.C. supply of positive 410 volts applied to the corona generator spaced approximately 1/8 inch above the paper surface produce excellent solid area development at relative speeds of 2 to 24 inches per second. Optimum development results were produced at approximately 4 inches per second. As the relative speed increased, development quality became increasingly reduced in plate areas extending away from the immediate vicinity of the corona discharge. At 6 inches per second the area of a stationary plate as in FIG. 2 immediately under the corona generator for about 3 inches in each direction gave excellent results while those areas at a distance exceeding 3 inches showed prominent dropoff in quality. As the relative speed increased beyond 6 inches per second the decrease in quality became more prominent at reduced distances from the vicinity of the corona discharge device.

To achieve the A.C.-D.C. bias control in accordance with FIG. 1, two (or more in even multiples) corona generating electrodes here designated 70, 71, 72 and 73 are arranged closely adjacent to each other and staggered as to polarity of corona discharge closely spaced to the rear side of the donor member in contact with the xerographic drum. In this arrangement with the separate but equal in output generators, it is important that good mixing of positive and negative corona discharge be effected against the donor. Accordingly, it becomes necessary to position the generators further than 1/8 inch from the donor. At the same time, for best performance, the generators should be almost contiguous to each other. Each generating device in FIG. 1 is charged to emit a substantially equal output of corona of its respective polarity.

FIG. 3 is shown to have similar type electrical connections to the corona generating device 61 as described in connection with FIG. 2 above. FIG. 2 illustrates a partially hand-operated device while FIG. 3 is adapted for automatic operation with the donor web 60 adapted to be driven by motor 73 while the xerographic plate is simul-

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taneously advanced in the same general direction as the web.

FIG. 4 illustrates a variation in which multiple corona generating devices 75 and 76 are each energized with corona generating potential from a D.C. source 77 to achieve an equal potential result similar to that described in connection with FIG. 1.

FIG. 5 illustrates a different type of corona generator designated 80 representing a two-wire corona generator, as for example disclosed in Mott U.S. Patent 3,076,092 in which a D.C. bias is imposed on the center tap of a secondary transformer coil supplying A.C. to alternate electrodes of the corona generator.

By the above description there has been disclosed novel method and apparatus for controlling development characteristics when using a donor type developer support presenting developer to a latent image on a xerographic plate. Since the particular arrangement of corona generator or generators can be energized at the discretion of the operator, they accord wide versatility in development in that the generators need not be energized when developing line copy, such that the donor member functions with its inherent insulating characteristics preferable for line copy development. Likewise, during development of images possessed of wide solid areas the corona generator or generators are energized to produce the control electrode effect. Thus, by generating A.C.-D.C. corona discharge, against the backside of a donor member effecting development, it becomes possible to effect results of a ground electrode in enhancing solid area development of xerographic images. Whereas specific forms of corona generating devices and arrangements have been shown, the invention is not intended to be limited thereto but is intended to include any of corona generating devices known in the art which alone or in combination can produce the A.C.-D.C. neutralization plane effective in producing the results described above. It is essential that the development zone, being the contact area of donor and plate, be substantially blanketed with corona discharge. The number of generator units necessary therefore, to achieve the blanket effect will vary as a function of the area of development zone.

Further, whereas the invention has been described primarily for use with direct development, i.e., developing charge areas on the xerographic plate, by applying a bias approximately equaling the charged areas, and using a developer charged to the same polarity as the charged areas on the xerographic plate, uncharged rather than charged areas will be developed. This latter variation is particularly useful where the original exposure was, for example, from a negative and reversal or indirect development is desired. Likewise, the uncharged areas may contain solid areas requiring the control electrode effect to obtain good quality development.

Since many changes could 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 and specification shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. An electrostatic latent image developing means comprising:

- (a) means for supporting an insulating member bearing an electrostatic latent image;
- (b) web means supporting on the first surface thereof a layer of powdered electroscopic developing materials;
- (c) means to advance said first surface against the surface of said insulating member;
- (d) corona emitting means comprising a plurality of corona generating electrodes arranged adjacent to each other with alternate electrodes emitting opposite polarity corona of substantially the same quantity output, said corona emitting means spaced adja-

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cent and at least $\frac{1}{8}$ inch from the second surface of said web at the area of contact between said first surface and said insulating member; and

- (e) a potential source electrically connected to said corona emitting means supplying corona generating potential to said corona emitting means.

2. An electrostatic latent image developing means comprising:

- (a) means for supporting an insulating member bearing an electrostatic latent image;
 (b) web means supporting on the first surface thereof a layer of powdered electroscopic developing material;
 (c) means to advance said first surface against the surface of said insulating member;
 (d) corona emitting means adjacent the second surface of said web at the area of contact between said first surface and said insulating member, said corona emitting means comprising at least one electrode to which is supplied A.C. potential to cause alternately positive and negative corona emission and positive D.C. potential to cause the quantities of positive and negative emission to be substantially equal; and

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- (e) a potential source electrically connected to said corona emitting means supplying corona generating potential to said corona emitting means.

3. The electrostatic latent image developing means according to claim 2 wherein said corona emitting means is spaced approximately $\frac{1}{8}$ inch above said second surface of said web.

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