

United States Patent

Schmidlin

[15] 3,684,364

[45] Aug. 15, 1972

[54] **LIFT OFF ELECTRODE**

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[73] Assignee: Xerox Corporation, Rochester, N. Y.

[22] Filed: June 24, 1971

[21] Appl. No.: 156,257

[52] U.S. Cl. 355/3, 96/1, 250/49.5 ZC,
317/262 A

[51] Int. Cl. G03g 15/02

[58] Field of Search ...355/3, 4, 10, 17; 250/49.5 ZC;
317/262 A; 96/1, 1.2, 1.3

[56] **References Cited**

UNITED STATES PATENTS

3,527,941 9/1970 Culhane et al.....355/3 X

FOREIGN PATENTS OR APPLICATIONS

274,131 4/1965 Australia 355/17

Primary Examiner—Samuel S. Matthews

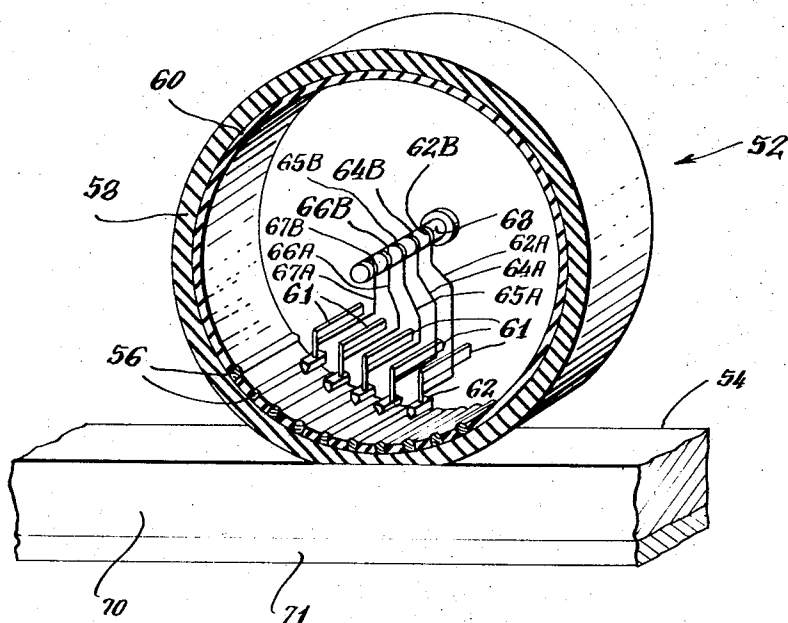
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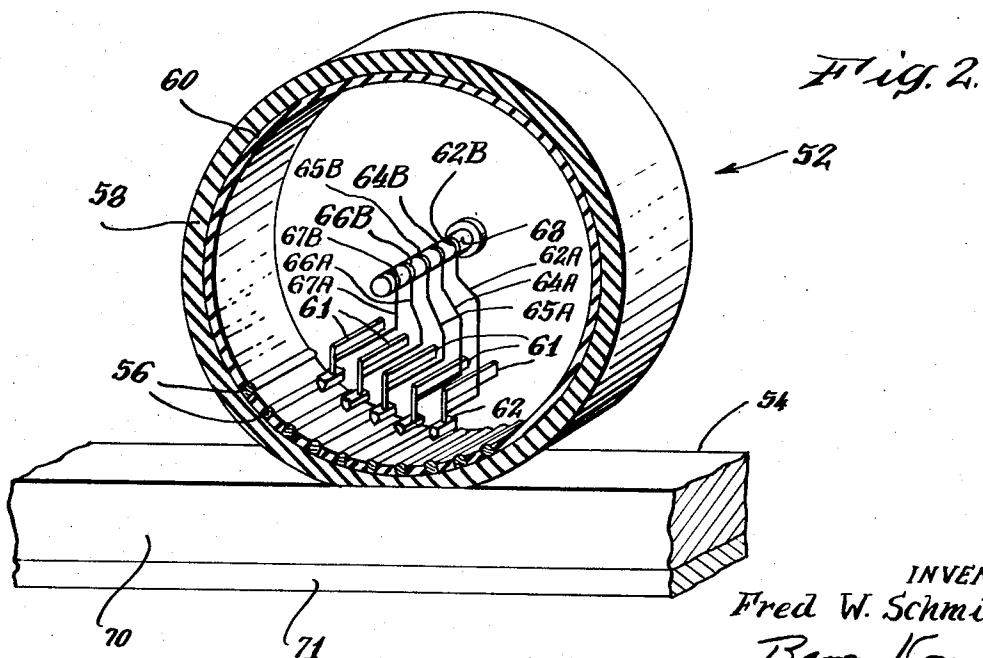
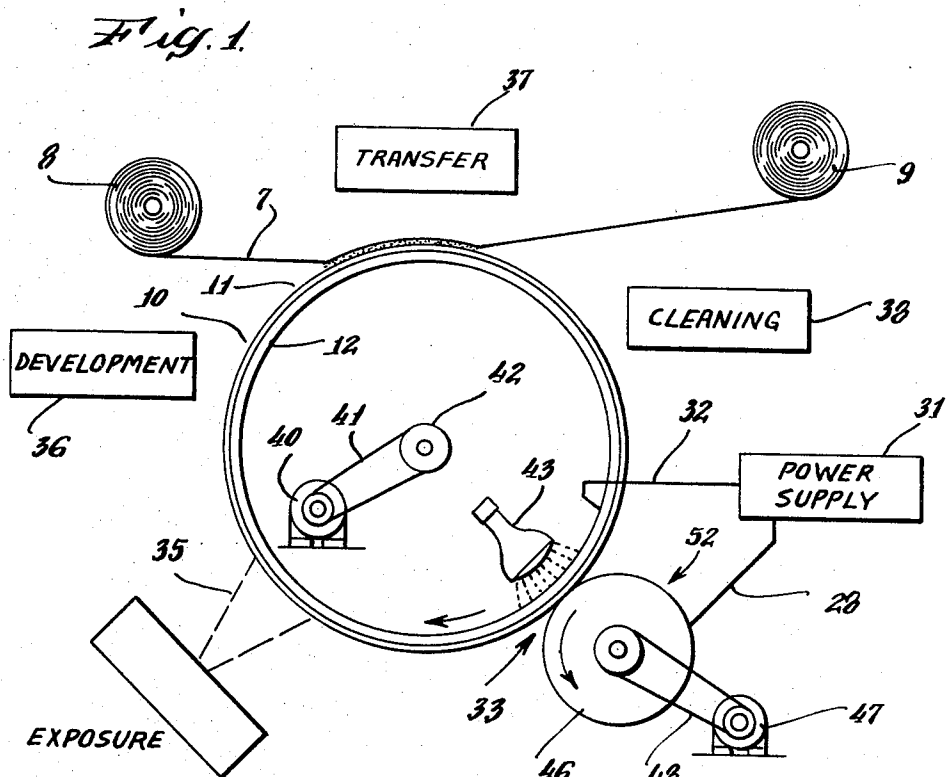
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[57] **ABSTRACT**

The problem of electric breakdown in air at the initial and final contact points of a roller electrode with a reproductive surface is solved by providing a graded potential to the roller electrode over the area of contact. By selecting appropriate low level potentials for the initial and final contact points, air breakdown is avoided. The graded potential can be provided to the roller by means of a plurality of sliding contacts and resistively interconnected electrodes arranged about the circumference of the roller extending sufficiently through the roller to provide the requisite field to the reproducing surface beneath.

11 Claims, 7 Drawing Figures

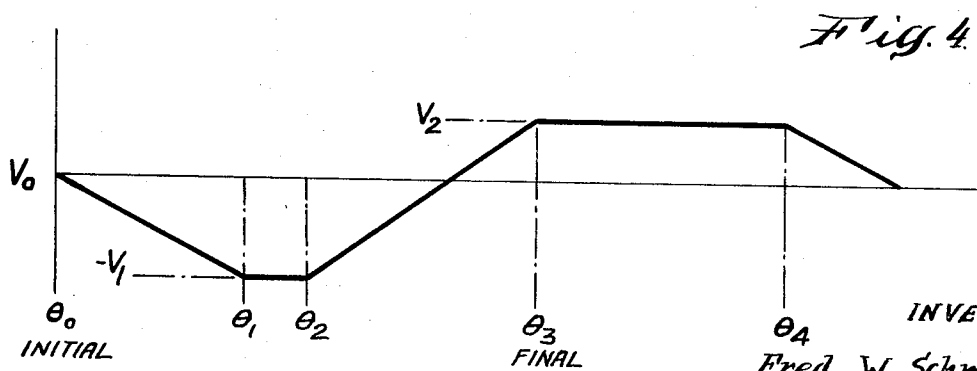
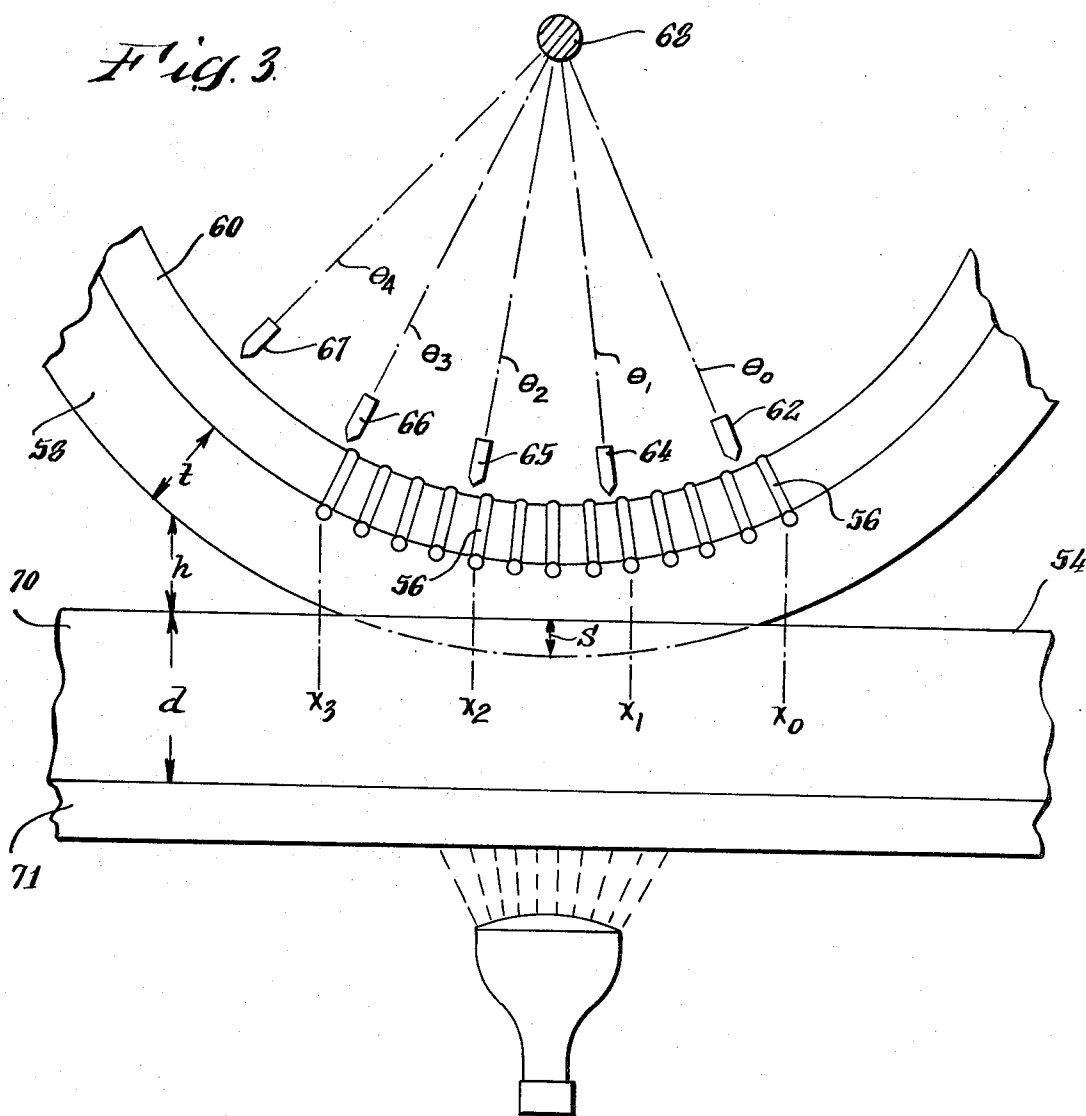




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Fig. 5.

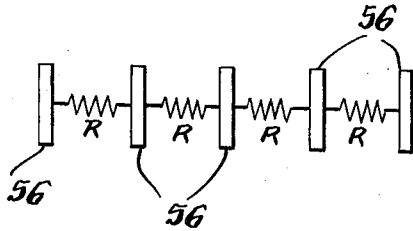


Fig. 6.

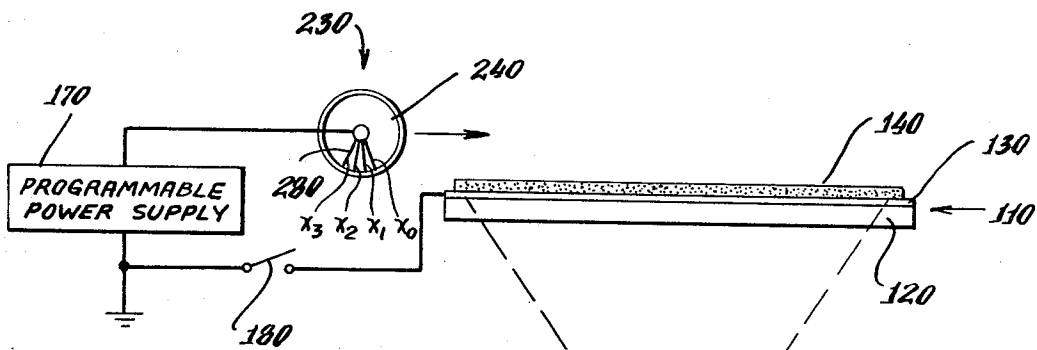
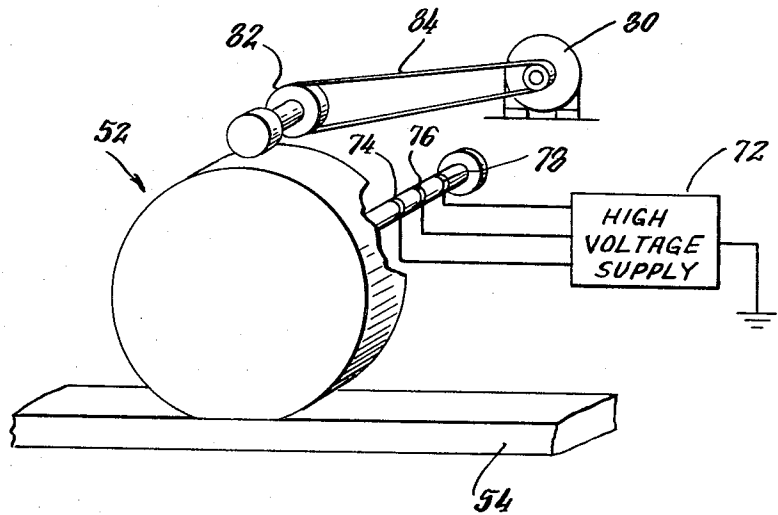
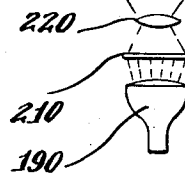


Fig. 7.



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LIFT OFF ELECTRODE

This invention relates to field applications in reproduction devices and particularly to a novel device for eliminating electric breakdown in air at the leading and trailing edges of a field applicator.

According to the invention of C. F. Carlson as described in U.S. Pat. No. 2,297,691, there is provided a process for preparing electrophotographic pictures wherein a uniform electrostatic charge is applied to the surface of a photoconductive insulating body. This charge is selectively dissipated by exposure to a pattern of light and shadow. This exposure and its consequent dissipation of electric charge results in an electrostatic latent image which can later be developed or made visible by treatment with an electroscopic material which adheres to the electrostatic charge pattern and which, optionally, may be transferred to a second surface to form an electrophotographic print or picture. If desired, other methods of utilization of the electrostatic latent image are available and the basic invention has wide applications in many fields of use.

For the application of the electrostatic charge or charge potential to the photoconductive insulating body of Carlson's invention, there have been proposed and tried have means, methods and apparatus. One of these, frictional electrification, is subject to certain difficulties in control and reproducibility. Another method of operation employs, for charging the photoconductive insulating layer, a form of corona discharge wherein an adjacent electrode comprising one or more fine conductive bodies maintained at a high electric potential causes deposition of an electric charge on the adjacent surface of the photoconductive body. This means of charging, however, is subject to the disadvantage, among others, of requiring high voltages generally in the order of several thousand volts.

The present invention relates to means and apparatus for the application of electric charge between contiguous surfaces. More specifically, the invention relates to induction of charge onto a surface of a contiguous member, or applying a high field between two members while in close proximity, and reducing said field while the two members approach or recede from each other. For example, the invention finds particular application to placing an electric charge or potential on a photoconductive insulating body overlying a conductive backing member whereby there may be imparted to such member an electric charge or voltage in the order of magnitude now employed in electrostaticography and whereby such voltage may be achieved without the need for sources of exceptionally high electric potential.

In electrostaticographic reproductive devices it is necessary to charge a suitable photoconductive or reproductive surface with a charging potential prior to the formation thereon of light image. IT is advantageous in various forms of such reproductive devices to induce such charges by means of approach and retraction of an electrode carrying a potential of sufficient magnitude to induce the required charge. Typical examples of such forms of charging include induction charging and TESI, an acronym for Transfer of ElectroStatic Images. In each of the foregoing, the induction of charges onto the surface of a contiguous member may be effected by roller electrodes employed

for placing the requisite charge on the reproductive surface.

In photoelectrophoretic imaging, it is necessary to apply a field of sufficient magnitude to an ink layer to produce images upon exposure to a light source.

The difficulty encountered when employing the foregoing field application forms in induction charging or in photoelectrophoretic imaging is the possibility of loss of field due to electric breakdown in air at the initial and final contact points formed between the roller surface and the reproducing surface. It is therefore important that the field application process avoids any form of breakdown or charge transfer during operation. It is also important that the field application device operates to induce a uniform charge over the complete area without the formation of any non-uniform charge areas caused by irregularities in the charging device, breakdown effects are clearly undesirable.

It is a prime object of this invention to provide a novel field applicator construction which will provide a field to a reproductive surface without electric breakdown in air at the initial and final contact points of the applicator and surface.

It is a further object of the present invention to provide a novel construction for a field applicator that will avoid charge transfer during induction charging.

It is a still further object of the present invention to provide a novel construction for a field applicator that will provide a uniform charge over the contiguous charging area without transfer of charge or electric breakdown in adjacent airgaps.

The foregoing objects are achieved by providing a field applicator of the roller electrode form with a programmed or graded potential for developing a voltage profile of desired relative magnitude over the contact area. More specifically, a construction is employed wherein an electrostaticographic reproducing device is provided with a reproducing surface such as a photoconductive layer supported on a substrate, or as in photoelectrophoretic devices a thin layer of finely divided photosensitive particles dispersed in an insulating liquid carrier and coated on an injection electrode. The reproducing surface cooperates contiguously with a roller electrode for applying a charge to the surface. The roller applies a charge to the surface by virtue of continuous contact with the reproducing surface over a predetermined arc portion of the roller circumference. A potential is applied to the roller surface such as to provide a plurality of potential levels over the arc surface portion of the roller contacting the reproducing surface. The levels are designed or programmed to form a graded potential over the arc portion with the potential profile characteristic of low potential at points proximate the point of initial and final contact of the arc portion, and high potential intermediate said points. By providing fixed arms and sliding contacts, the graded potential can remain fixed over the contacting arc area while the roller itself continues to rotate over the reproducing surface.

The foregoing objects and brief description as well as further features and advantages of the invention will become more apparent from the following detailed description and appended drawings, wherein:

FIG. 1 is a schematic illustration of a typical contiguous charging apparatus;

FIG. 2 is a perspective view of a roller electrode and reproducing surface;

FIG. 3 shows a detailed cross section of a roller electrode configuration for providing a graded potential;

FIG. 4 is a diagram of a graded potential waveform profile which can be supplied to the roller surface;

FIG. 5 shows a detail of FIG. 2 for supplying a graded potential; and

FIG. 6 shows one manner of driving the roller and supplying the graded potential thereto.

FIG. 7 shows the use of the invention in conjunction with photoelectrophoretic imaging.

Referring to FIG. 1, an automatic type of electrostatographic machine utilizing induction charging is illustrated with a contiguous charging mechanism.

The plate 10 comprising a photoconductive insulating layer 11 and a conductive backing member 12 is in this embodiment in the shape of a rotary drum. Positioned along the circumference of the drum are various xerographic process stations. These various stations include the charging station generally designated 33, exposure station generally designated 35, a development station designated 36, a transfer station 37, and a cleaning station 38. The drum 10 is driven by motor 40 in the direction indicated through belt drive 41 connected at axle 42 of drum 10. Thus, the process begins at charging station 33, at this station, an electrostatic charge is induced on the surface of photoconductive insulating layer 11, thereby sensitizing the plate. The drum rotation carries the sensitized portion of the plate to exposure station 35 where an image of light and shadow is projected to the surface of photoconductive insulating layer 11 and is converted into an electric charge pattern by selectively dissipating electrostatic charge in areas where light or other activating radiation strikes the surface of the sensitive photoconductive insulating layer. Next, the plate is carried to development station 36 whereat particles carrying electrostatic charge are contacted against the surface of the photoconductive insulating layer 11 and deposit in with the electrostatic field of force which exists between the charges on the surface of photoconductive insulating layer 11 and the electrostatically charged particles. The drum 10 is then rotated to transfer station 37 whereat the developed particle image created at development station 36 is transferred to a sheet or web of material 7 fed from supply spool 8 to takeup roll 9 and optionally fixed thereon. Following transfer at transfer station 37, the drum is rotated to cleaning station 38 whereat any particles remaining on the surface of photoconductive insulating layer 11 after transfer are removed. In conventional induction charging, following cleaning any charge pattern remaining on the surface of the photoconductive insulating layer 11 may be dissipated through the use of uniform illumination of the surface form a lamp such as an ordinary incandescent lamp or fluorescent lamp or through the use of other techniques generally known to the art. In conjunction with the present invention, the newly induced charge smother any residual charge, and the lamp 43 serves a different function.

Charging station 33 in this embodiment includes a roller electrode 52, shown in detail in FIG. 2. Electrode 52 is driven by motor 47 through drive belt 48 and the drum rotates in the direction indicated to move an electrically insulating surface 46 thereof at a linear speed

equal to the linear speed of photoconductive insulating layer 11 of drum 10. Power supply 31, in the embodiment described in connection with FIG. 1, is adapted to supply an array of voltages to electrode 52 through the leads 28 and 32 to produce a programmed voltage profile. The lamp 43 is positioned so as to shine on the photoconductor 11 while it is in contact with roller 52. In this manner, lamp 43 renders the photoconductor 11 in a conductive state. It is noted that either the substrate 12 or the roller electrode must be at least partially transparent to permit illumination. The former is preferred, and as illustrated, the lamp 43 is beneath the substrate 11. A potential applied between a conductive member of the electrode 52 and backing member 12 will then cause induced charge to come to the surface of the photoconductive insulating layer 11 by traversing the photoconductor layer from the conductive backing 12. Since a uniform charge is induced independent of any residual charge, the erase function of the lamp 43 is no longer needed.

When the insulating surface 46 is between a conductive member of the electrode 52 and drum 10 and a potential is applied, the surface of the insulator attains an intermediate potential between the potential placed on the electrode 52 and the potential placed on backing member 12, and an electric field exists between the facing insulating surfaces. To insure that the roller electrode provides a sufficient field to the photoconductive insulator without causing charge transfer or electrical breakdown in air at points proximate the initial and final contact of the roller and surface, a graded potential is provided with an appropriate profile. Referring to FIG. 2, the operation of the invention in conjunction with induction charging is illustrated. A roller electrode 52 is shown in contiguous contact with an electrostatographic reproducing surface 54, having a photoconductive layer 70 supported on a substrate 71 as described above. The electrode is shown in cross section to illustrate a plurality of conducting elements 56 distributed about the circumference of the roller 52, arranged parallel to the long axis of the cylinder and separated sufficiently to be electrically isolated from one another. The cylindrical roller is coated with a pressure deformable outer insulating layer 58 such as a soft rubber or the like, and an inner layer 60 of a relatively stiff material such as a hard rubber of the like. As illustrated, a plurality of sliding contacts, 62, 64, 65, 66 and 67 are fixedly mounted as by suitable supports 61 within the cylindrical roller 52 and are connected via suitable electrical conductors 62A, 64A, 65A, 66A and 67A to contacts or commutation rings 62B, 64B, 65B, 66B and 67B mounted on the shaft 68. Alternatively, individual conductors can be directly connected from the contacts to the supply.

The roller 52 applies a field to the photoconductor 70. In operation, the roller 52 is pressed into contact with the surface 54 of photoconductor 70 such that a flat area is created, as shown in greater detail in FIG. 3, wherein an additional contact 64 is shown. The amount of compression S of the deformable insulative layer 58 determines both an arc portion of the roller circumference, which is the width of the contact area X_3-X_0 , and the distance between the surface 54 and the conductor elements 56 embedded in the inner layer 60.

The latter distance can be expressed mathematically, wherein t is the uncompressed thickness of the insulative layer 58, and R is the radius of the roller, by $t-s$ wherein $s = (X_3 - X_0)^2 / 8R$. To insure uniform charging, the gap between conductors need only be small relative to the magnitude of $t-s$, or for example of the ratio of approximately 1 to 3.

Further, the compressed area width $X_3 - X_0$ should be sufficient to provide the desired profile over the charging surface without producing excessive fields.

As described hereinabove, the graded potential is applied by supplying proper valued voltage levels to each desired conductor element position by means of separate supply voltage levels to each of the contacts 62B, 64B, 65B, 66B and 67B through the shaft 68. The sliding contacts 62, 64, 65, 66 and 67 remain in fixed position while the conductor elements 56 and the surrounding roller layers 58 and 60 rotate. In this manner, a voltage profile of proper levels is created at a space fixed point above a predetermined arc portion of said roller circumference defining the charging area.

To avoid the appearance of excessive electric fields across large air gaps, it is thus only necessary to program or otherwise provide applied voltage such that at the initial point X_0 and at the final point X_3 (clockwise rotation of the roller relative to the surface is assumed in FIGS. 3 and 4 for purposes of clarity and convenient illustration), the conductors at those points, as well as points proximate thereto such as at adjacent conductors, are brought to approximately the final surface potential of the photoconductor layer 70 of the surface 54. The contacts defined by the positions at $X_3 - X_0$ need not coincide with the edges of the compressed area, but may be placed outside that area by a gap g , wherein $g = h$. Thus, $(X_3 - X_0) \geq S$ is acceptable providing that breakdown levels are not exceeded. Breakdown is a function of the applied potential across an air gap and below a minimum level, breakdown cannot occur. Referring again to FIG. 3, five sliding contacts 62, 64, 65, 66 and 67 are illustrated at angular positions $\theta_0, \theta_1, \theta_2, \theta_3, \theta_4$; θ_0 representing the initial or touch down point, and θ_3 the final or lift off point. If it is, by way of example, desired to induce a charge such as to produce a final surface potential of V_0 , then a potential profile can be applied to the angular positions as shown in FIG. 4. As shown in FIG. 4, to induce a surface potential of V_0 , a potential of $V_2 \approx V_0$ is applied at position θ_3 , and a potential of $-V_1$ as determined by the relationship $-V_1 = -V_0 \cdot \epsilon_p / \epsilon_i \cdot (t-s)/d$ is applied at position θ_1 , wherein ϵ_p is the permittivity of the photoconductive layer 70, ϵ_i is the permittivity of the insulative layer 58, and d is the thickness of the photoconductive layer 70. The potential is returned to ground over a distance at least equal to that of the width $X_3 - X_0$ of the compressed area. By way of illustration, for a roller electrode with a radius $R = 12$ cm, and $S = 100$ microns; the compressed area $X_3 - X_0 = 1$ cm.

The graded potential can obviously be formed in any desired pattern or configuration. The conductor elements 56 can be interconnected by resistive elements R , as shown in FIG. 5, to provide a desired profile with fewer sliding contacts.

If the electrodes are to be resistively separated internally, for example by making the inner hard rubber partially conductive, or by a third material between the conductors, two conditions must be satisfied:

1. The dielectric relaxation time must be less than the time required for an electrode to move out where a gap first appears, and

2. The joule heat must not be excessive.

The foregoing conditions are compatible for a substantial resistivity range of the order of 3×10^6 to 3×10^9 ohm-centimeters.

Alternatively, a larger number of sliding contacts can be provided, each with a desired potential level. Discontinuity in the areas between conductive elements are minimized or entirely avoided by a potential fringing effect coupled with a high density of conductive elements. Further, the photoinduced conductivity of the reproducing surface 54, resulting from illumination by lamp 43, serves to dissipate local charge levels created by the potential applied, thereby smoothing the charge over the area of contact between roller electrode and surface.

With respect to providing voltage levels to sliding contacts, the shaft 68, shown in FIG. 2, may contain a plurality of conductors each coupled to an appropriate series of external electrical contacts isolated from one another, both on the interior and exterior of the roller 52. As shown in FIG. 6, potential is provided by the leads of a suitable voltage supply 72 which contacts respective contacts 74, 76, 78 for providing the supply to the internal sliding contact connectors. The shaft can be fixed mounted, the roller 52 itself rotatable around the shaft by means of an external drive motor or the like 80, coupled to a drive pulley 82 by a belt 84. Other means for supplying the potential can be provided. For example, the contacts 62B, 64B, 65B, 66B, 67B, 74, 76, 78 can be of the slip ring type with the voltage supply connections made thereto by means of brushes or the like, and the roller drive mechanism 80 employed to drive both shaft and roller.

In the case of the induction charging roller, charge transfer can be avoided by chemically passivating the outer surface of the insulative layer 58 so that charges become more deeply trapped on the surface of the photoconductor layer 70 than can possibly become trapped on the surface of the insulative layer 58. This assists in preventing transfer of charge from the photoconductor to the insulator. Further undesirable charge transfer can be prevented by increasing the levels of the applied potential V_2 relative to the potential V_0 necessary to maintain proper charge levels.

The invention is easily applied to photoelectrophoretic processing. Referring to FIG. 7, there is seen a transparent electrode generally designated 110 which, by way of example, is composed of a layer of optically transparent glass 120 overcoated with a thin optically transparent layer 130 of tin oxide commercially available under the name NESA glass. This electrode shall hereafter be referred to as the injecting electrode. Coated on the surface of the injecting electrode is a thin layer of finely divided photosensitive particles dispersed in an insulating liquid carrier. During this initial part of the description of the invention, the term "photosensitive" may be thought of as any particle which, once attracted to the injecting electrode will migrate away from it under the influence of an applied electric field when it is exposed to actinic electromagnetic radiation; however, a detailed theoretical explanation of the apparent mechanism of operation of the invention is given below. The liquid suspension 140

may also contain a sensitizer and/or a binder for the pigment particles which is at least partially soluble in the suspending or carrier liquid as will be explained in greater detail hereinafter. Above the liquid suspension 140 is a second electrode 230 which is connected to one side of a programmable supply 170 such as an array of potential sources 170 through multiple of switches such as 180. The opposite side of potential source 170 is connected to the injecting electrode so that when switch 180 is closed an electric field is applied across the liquid suspension 140 from electrodes 110 and 230. An image projector made up of a light source 190, a transparency 210, and a lens 220 is provided to expose the dispersion 140 to a light image of the original transparency 210 to be reproduced. It should be noted at this point that the injecting electrode need not necessarily be optically transparent but that instead electrode 230 may be optically transparent and exposure may be made through it from above as seen in FIG. 7.

The pigment suspension is exposed to the image to be reproduced while potential is applied across the blocking and injecting electrodes by closing switch 180. In the FIG. 7 embodiment of the invention, the roller electrode 230 is caused to roll across the top surface of the injecting electrode with switch 180 closed during the period of image exposure. This light exposure causes exposed pigment particles originally attracted to the injecting electrode to migrate through the liquid and adhere to the surface of the roller electrode 230, leaving behind a pigment image on the injecting electrode surface which is a duplicate of the original transparency 210. This pigment image may then be fixed in place as, for example, by placing a lamination over its top surface or by virtue of a dissolved binder material in the carrier liquid such as paraffin wax or other suitable binders that come out of solution as the carrier liquid evaporates. A 3-6 percent by weight of paraffin binder in the carrier has been found to produce good results. The carrier liquid itself may be molten paraffin wax or other suitable binder in a liquid state which is self-fixing upon cooling and return to the solid state. In the alternative, the pigment image remaining on the injecting electrode may be transferred to another surface and fixed thereon. As explained in greater detail below, the system can produce either monochromatic or multichromatic images depending upon the type and number of pigments suspended in the carrier liquid and the color of light to which the suspension is exposed in the process.

As shown in FIG. 7, the roller electrode 230 is designed in accordance with the invention to provide a graded potential along the surface of the liquid suspension 140. This is accomplished in the manner described heretofore in conjunction with induction charging. The roller electrode is provided with a series of internal sliding contacts 280 fixedly mounted within the cylindrical roller 230. The contacts apply spatially fixed potentials at positions X_0, X_1, X_2, X_3 . As continuous rolling contact is made with the surface of the liquid suspension 140, a resultant electric field is applied across the suspension. By maintaining the potential at each point X_0, X_1, X_2, X_3 below the breakdown voltage of each effective "electrical thickness" of the series of air gap insulator gap and surface gap between the respective

electrodes, proper levels may be maintained. Thus, at lift off and touchdown points, X_0, X_3 , the potential levels will be relatively low, whereas at contact areas between X_1 and X_2 , the potential can be higher. For example, referring to FIG. 3, for air at atmospheric pressure and small gaps (in the neighborhood of 100 microns) the breakdown field E_b may be approximated with the general relationship:

$$E_b = 6.2h + 312$$

where h is the air gap in microns and the field is definable in terms of volts per micron. This relationship is derived as an analytic approximation of measured characteristics of the apparent spark breakdown gradient of air for plane-parallel electrodes at 760 mm Hg and at 20° C., at the low end of the gap range. See "Gaseous Conductors Theory and Engineering Applications" by J. D. Cobine, Dover Publications, N.Y. 1941, page 173, FIG. 7.16. The actual field strength over a length Y is approximately:

$$E_h = V_h/Y = V_h/h + b$$

where

$$b = d \cdot \epsilon_0/\epsilon_p + t \cdot \epsilon_0/\epsilon_i$$

and is the effective "electrical thickness" in series with the gap h , across which the potential is V_h . In the above formula, d is the thickness of the ink layer or photoconductor; ϵ_p is the permittivity of the ink or photoconductor; t is the thickness of the insulator or roller electrode; and ϵ_i is the permittivity of the insulator or roller electrode. The factor ϵ_0 is the permittivity of air and conversion of the d and t lengths to equivalent electrical thicknesses permits combination with the h length. Thus, breakdown can be prevented at any y where

$$V_y < 213 + 6.2(b+h).$$

If in a typical photoelectrophoretic device h is set at $\sqrt{200b}$ and $b=10$, for example, breakdown is prevented if $V_y < 650$ volts. Thus, the contact area X_1, X_2 can be set at, for example 1,500 volts, and the voltage over the minor air gap space at touch down and lift off set at 650 volts to insure proper operation without breakdown.

Other methods of producing electric fields between approaching and receding electrodes can be adapted to incorporate the concept of the present invention. For example, polychrome photoelectrophoretic processing employing roller electrodes can be adapted to provide profiled or graded voltage levels. An example of photoelectrophoretic polychrome imaging systems is shown in the U.S. Pat. Nos. 3,384,565, and 3,384,488, both to Tulagin et al. In such systems, high electric fields normally appear in regions just prior to initial (touch down) and final (lift off) contact points of the arc portion of the roller contacting the reproducing surface, and by using the programmable electrode as described herein, break-down or charge transfer can be avoided. Variations in the use of a deformable insulating layer may be employed, along with the concept of programming potential application points over the contact area to eliminate high electric fields over the air gaps at touch down and lift off.

Although this invention has been described as carried out in specific embodiments thereof, it is obvious

that many variations of the invention can be employed, as with equivalent forms of electrostatic charging, and it is not intended that the scope be limited thereby but is rather intended to broadly include all variations within the spirit of the invention as defined herein.

What is claimed is:

1. In an electrostatographic reproducing device including a reproducing surface having a photoconductive layer supported upon a substrate, means for applying an electric field across said layer, comprising first and second electrodes arranged on either side of said layer, one of said electrodes being a roller electrode having a defined circumference and applying said field across said layer by continuously contacting said layer over a major portion of a predetermined arc portion of said roller circumference, potential means for providing said roller electrode with a graded potential over said predetermined arc portion of said roller circumference said graded potential having the characteristic of potential levels relative to said surface at points proximate air gaps formed at the point of initial and final contact of said predetermined arc position of said roller circumference with said reproducing surface, said potential levels insufficient to cause electrical breakdown over said air gaps, and high potential levels intermediate said points over the area of contact between said arc position and said surface.

2. The combination of claim 1 wherein said roller includes a plurality of conductive elements distributed about the circumference of said roller, a plurality of sliding contacts each adapted to be conductively coupled to a conductive element positioned in contact therewith, said sliding contacts fixedly mounted within said roller, said potential means supplying said potential levels over the plurality of sliding contacts, said sliding contacts defining an area corresponding to said predetermined arc portion.

3. The combination of claim 2 wherein said roller includes an inner layer including said conductive elements and a pressure deformable outer layer urged into contact with said reproducing surface layer with sufficient pressure to provide a substantially flat contact between said outer layer and said reproducing surface and to reduce the distance between said conductive elements and said reproducing surface.

4. In an electrostatographic reproducing device including a reproducing surface having a photoconductive layer supported on a substrate, means for applying an electric field across said layer, comprising first and second electrodes arranged on either side of said layer, one of said electrodes being at least partially transparent, said first electrode being a roller electrode having a defined circumference and applying said field across said layer by continually contacting said layer over a major portion of a predetermined arc portion of said roller circumference, potential means for providing said roller electrode with a potential over said predetermined arc portion of said roller circumference, said potential means providing a plurality of potential levels, means applying each of said potential levels to separated portions of said predetermined arc portion of said roller circumference to form a graded potential over said predetermined arc portion, said graded potential having the characteristic of low potential levels relative to said surface at points proximate air

gaps formed at the point of initial and final contact of said predetermined arc position of said roller circumference with said reproducing surface, said potential levels insufficient to cause electrical breakdown over said air gaps, and high potential levels intermediate said points over the area of contact between said arc position and said surface, and means for exposing said layer portion during said contact to a source of illumination through said transparent electrode.

5. The combination of claim 4 wherein said second electrode comprises said substrate in a drum shape, said layer coating the exterior of said drum, said drum circumference including a charging station, exposure station, development station, transfer station, and cleaning station, said first electrode contacting said layer at said charging station.

6. The combination of claim 4 wherein said roller includes a plurality of conductive elements distributed about the circumference of said roller, a plurality of sliding contacts each adapted to be conductively coupled to a conductive element positioned in contact therewith, said sliding contacts fixedly mounted within said roller, said potential means supplying said potential levels over the plurality of sliding contacts, said sliding contacts defining an area corresponding to said predetermined arc portion.

7. The combination of claim 4 wherein said roller includes an inner layer including said conductive elements and pressure deformable outer layer urged into contact with said reproducing surface layer with sufficient pressure to provide a substantially flat contact between said outer layer and said reproducing surface and to reduce the distance between said conductive elements and said reproducing surface.

8. In an electrostatographic reproducing device including a reproducing surface having a layer of finely divided electrically photosensitive particles dispersed in a substantially insulating liquid carrier supported upon a substrate, means for applying an electric field across said layer, comprising first and second electrodes arranged on either side of said layer, one of said electrodes being at least partially transparent, said first electrode being a roller electrode having a defined circumference and applying said field across said layer by continually contacting said layer over a major portion of a predetermined arc portion of said roller circumference, potential means for providing said roller electrode with a potential over said predetermined arc portion of said roller circumference, said potential means providing a plurality of potential levels, means applying each of said potential levels to separated portions of said predetermined arc portion of said roller circumference to form a graded potential over said predetermined arc portion, said graded potential having the characteristic of low potential levels relative to said surface at points proximate air gaps formed at the point of initial and final contact of said predetermined arc position of said roller circumference with said reproducing surface, said potential levels insufficient to cause electrical breakdown over said air gaps, and high potential levels intermediate said points over the area of contact between said arc position and said surface, and means for exposing said layer portion during said contact to a source of illumination in image configuration through said transparent electrode, whereby an image is formed.

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9. The combination of claim 8 wherein said source of illumination is a light source positioned opposite said substrate, said substrate is formed of a transparent material, and said exposure means includes means for projecting an image to be reproduced toward said transparent substrate, for exposing said photosensitive particles to said image.

10. The combination of claim 9 wherein said roller includes a plurality of conductive elements distributed about the circumference of said roller, a plurality of sliding contacts each adapted to be conductively coupled to a conductive element positioned in contact therewith, said sliding contacts fixedly mounted within

said roller, said potential means supplying said potential levels over the plurality of sliding contacts, said sliding contacts defining an area corresponding to said predetermined arc portion.

5. 11. The combination of claim 10 wherein said roller includes an inner layer including said conductive elements and a pressure deformable outer layer urged into contact with said reproducing surface layer with sufficient pressure to provide a substantially flat contact between said outer layer and said reproducing surface and to reduce the distance between said conductive elements and said reproducing surface.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,684,364

Dated August 15, 1972

Inventor(s) Fred W. Schmidlin

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

Column 1, line 27, "have" should be --various--.

Column 1, line 59, the "T" in "IT" should be --t--.

Column 3, line 41, after "in" insert --accordance--.

Column 3, line 57, "form" should be --from--.

Column 8, line 37, in the formula, "213" should be --312--.

Signed and sealed this 29th day of May 1973.

(SEAL)

Attest;

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,684,364 Dated August 15, 1972

Inventor(s) Fred W. Schmidlin

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

Column 1, line 27, "have" should be --various--.

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