

April 5, 1966

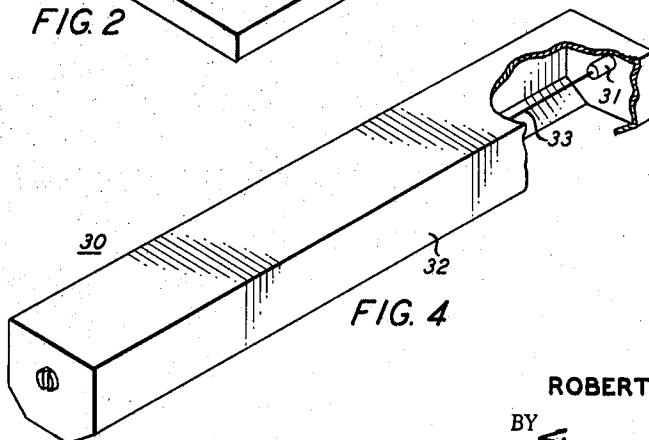
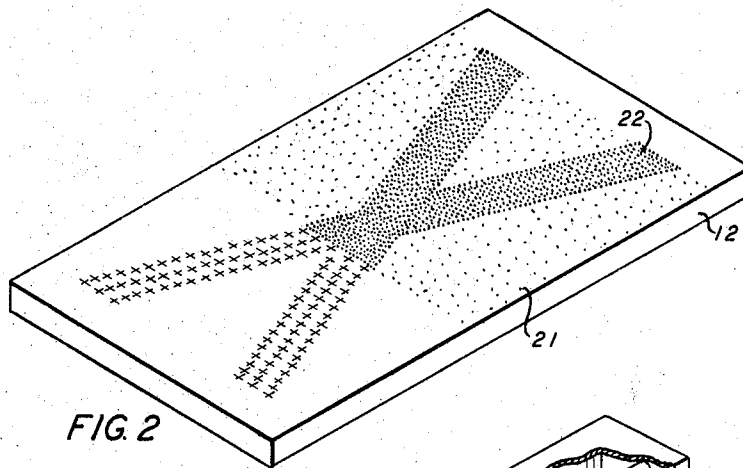
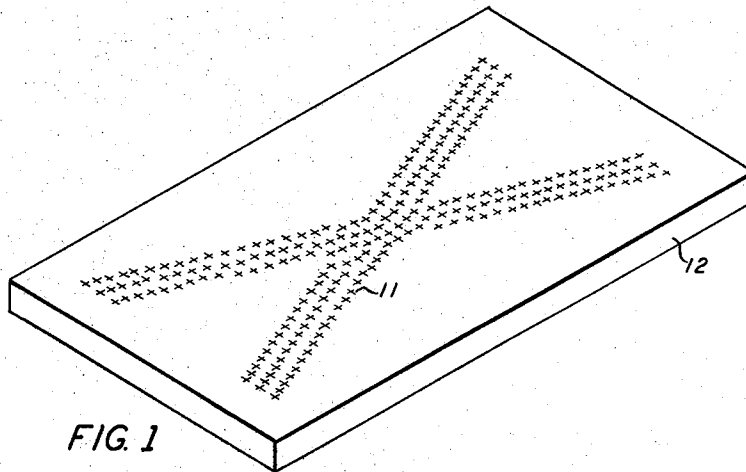
R. W. GUNDLACH

3,244,083

XEROGRAPHIC DEVICE

Filed Oct. 23, 1962

4 Sheets-Sheet 1



INVENTOR
ROBERT W. GUNDLACH

BY *Stanley Z. Role*

ATTORNEY

April 5, 1966

R. W. GUNDLACH

3,244,083

XEROGRAPHIC DEVICE

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4 Sheets-Sheet 2

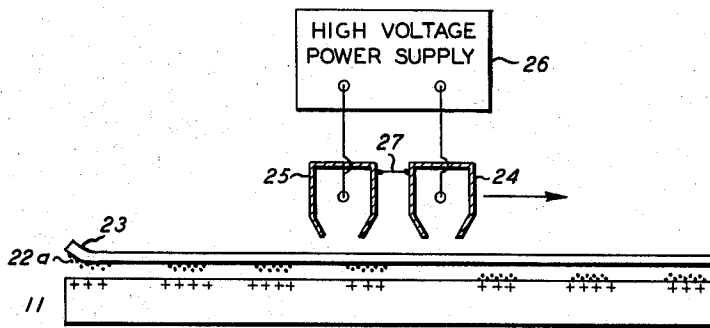


FIG. 3

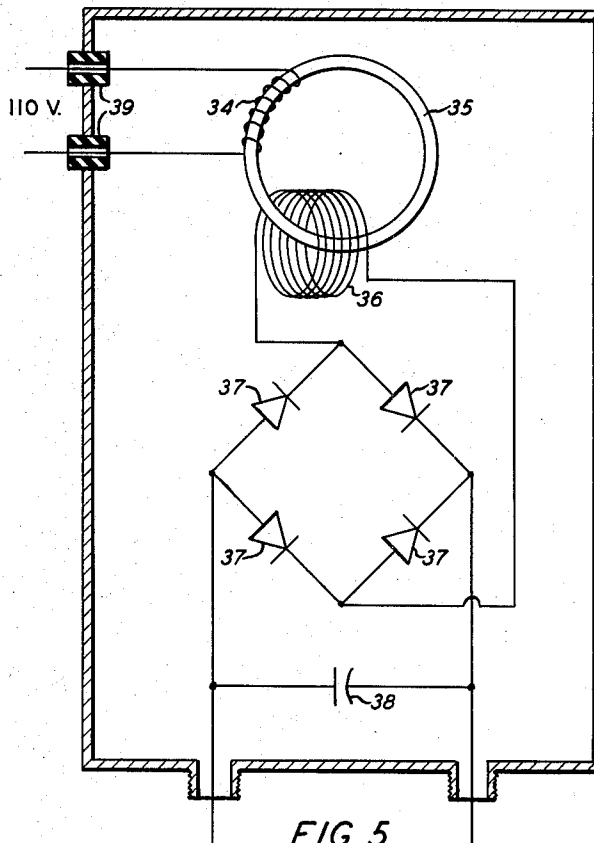


FIG. 5

INVENTOR.
ROBERT W. GUNDLACH

BY

Stanley Z. Lee

ATTORNEY

April 5, 1966

R. W. GUNDLACH

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4 Sheets-Sheet 3

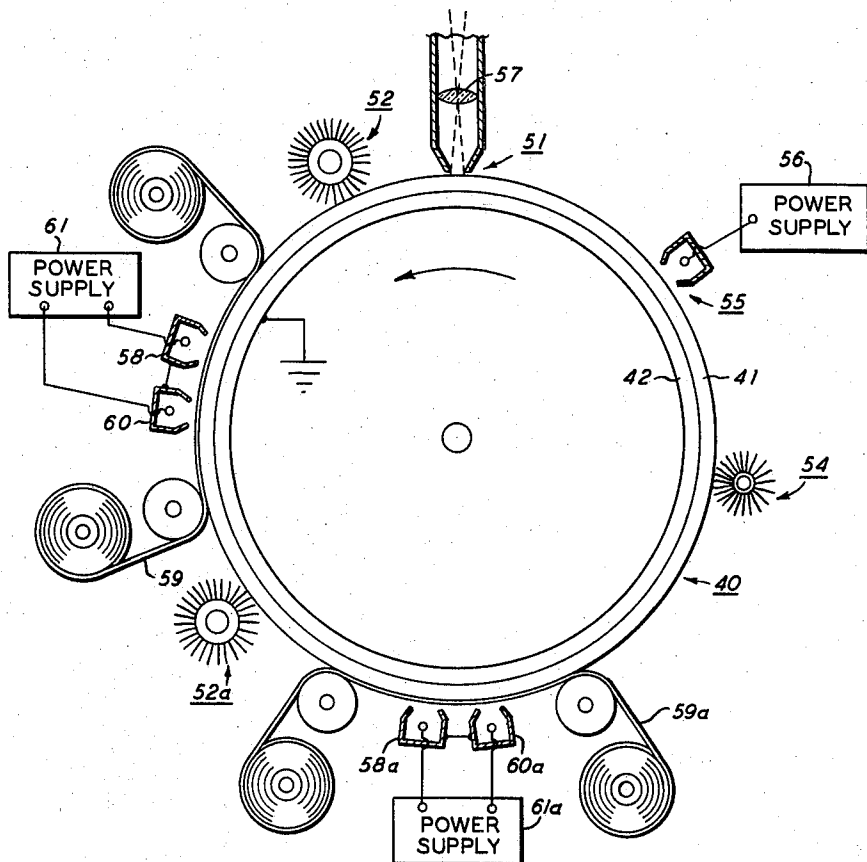


FIG. 6

INVENTOR
ROBERT W. GUNDLACH
BY
Stanley Z. Cole
ATTORNEY

April 5, 1966

R. W. GUNDLACH

3,244,083

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4 Sheets-Sheet 4

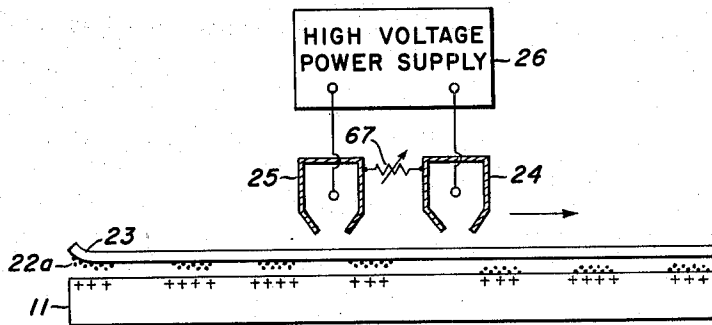


FIG. 7

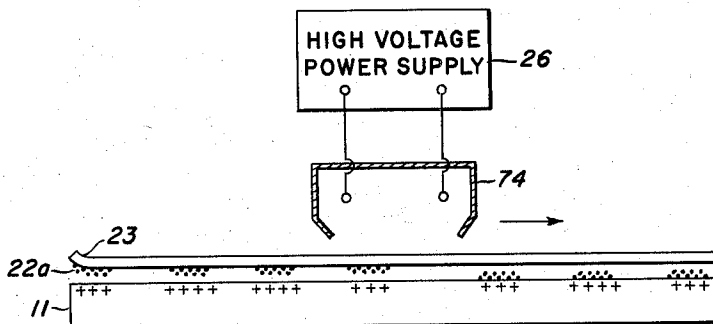


FIG. 8

INVENTOR.
ROBERT W. GUNDLACH

BY

Charles M. Brackhoff

ATTORNEY

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3,244,083

XEROGRAPHIC DEVICE

Robert W. Gundlach, Victor, N.Y., assignor to Xerox Corporation, Rochester, N.Y., a corporation of New York

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6 Claims. (Cl. 95—1.7)

This invention relates to xerography and, in particular, to a novel method and apparatus for separating a toner image from an insulating surface while preserving the electrostatic charge pattern on which it is developed.

Xerography is a well-known method of image recording in which a latent electrostatic charge pattern formed on a sufficiently non-conductive material is visualized by an appropriate development process. The developed image is usually transferred to any suitable image transfer material such as paper, especially when a reusable plate is employed in the formation of the electrostatic charge pattern.

The latent electrostatic charge pattern may be formed in various ways. One well-known technique involves as a first step deposition of a uniform electrical charge on a xerographic plate comprising a photoconductive layer overlying a conductive backing. This first step is carried out in the dark, or in light to which the photoconductive layer is insensitive, by means of a corona discharge device such as that disclosed in Walkup U.S. Patent 2,777,957. Exposure of the charged plate to an optical image selectively dissipates the charge in light-struck areas, thus producing an electrostatic charge pattern conforming to the optical image.

One of several known development techniques may be employed to render the electrostatic charge pattern visible. For instance, the charge pattern may be dusted with an oppositely charged pigmented resin powder, termed toner. As already indicated, it may be preferred that the toner image be transferred to image transfer material thus freeing the xerographic plate for further use. Electrostatic transfer techniques have been successfully employed for this purpose. Accordingly, an image transfer web, such as a sheet of paper or plastic, may be laid over the developed image and an electrical charge applied to the upper surface as by means of a corona discharge device already mentioned. The charge deposited on the web establishes an electrostatic field which draws the charged toner particles from the plates and attaches them to the transfer web. The transfer web may then be separated from the plate such as by peeling.

During separation, electrostatic field in the air gap between the transfer web and plate remains essentially constant so that the electrical potential rises as the spacing increases. The lines of force which hold the toner particles in place are accordingly stretched. When the spacing has so increased that the electrical potential reaches a critical point with respect to the atmospheric conditions, air breakdown or sparking occurs in the air gap. This phenomenon results in distortion of the electrostatic charge pattern and in diminution of electrical contrast. In conventional xerography, in which only one transfer is made from a developed image, this sparking is of no consequence. However, it must be avoided if the electrostatic charge pattern is to be preserved for subsequent development and transfer steps.

One method of electrostatic image preservation is disclosed in Byrne U.S. Patent 2,951,443, and comprises separating the developed image from the insulating surface while applying a uniform and constant electrical potential to the image transfer web by means of a conductive member such as a roller. However, it is frequently difficult to determine exactly what potential

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should be applied to the conductive member to accomplish neutralization of the transfer charge. The transfer charge may vary because of power supply fluctuations, spacing between corona discharge transfer device and image web, etc., and sparking may not be prevented if the applied potential is insufficient to neutralize the transfer charge or if the transfer charge is "over-neutralized."

The instant invention is directed to preventing air breakdown or sparking by insuring that a neutralizing charge of correct magnitude is applied to the transfer web. This is accomplished by means of a second corona discharge device operated in conjunction with the transfer corona discharge device. By operating the two devices electrically connected in accordance with this invention, transfer charge neutralization may be effected so that spark-free transfer can be conveniently attained.

Accordingly, it is a principal object of this invention to provide novel means to preserve an electrostatic charge pattern in its original condition without distortion during the separation step in the xerographic process.

Other and further objects of this invention are made apparent by the following description in which:

FIGURE 1 illustrates an electrostatic charge pattern on a non-conductive plate;

FIGURE 2 illustrates development of the plate carrying an electrostatic charge pattern;

FIGURE 3 illustrates transfer-separation according to the present invention;

FIGURE 4 illustrates a corona discharge device suitable for use in the present invention;

FIGURE 5 shows a preferred power supply for use in the present invention;

FIGURE 6 is a diagrammatic view of a continuous machine for production of multiple copies according to the present invention;

FIG. 7 illustrates an embodiment wherein the transfer-separation corona devices are connected by a variable resistor; and

FIG. 8 illustrates an embodiment wherein the shields of the corona devices comprise an integral structure.

Illustrated in FIGURE 1 is an electrostatic charge pattern 11 on the surface of insulating plate 12. The electrostatic charge pattern 11 is designated by plus marks and, for purposes of this description, is assumed to be of positive polarity. However, it is to be understood that the charge pattern may be of either positive or negative polarity and may consist of gradations of potential or charge or may be, as illustrated, areas of charge interspaced by areas of substantially no charge. The particular charge pattern illustrated in FIGURE 1 may be regarded as a line copy pattern consisting of representative areas of charge and absence of charge which desirably can be printed in areas of black on a white surface. Insulating plate 12 must be at least sufficiently non-conductive to support an electrostatic charge during the instant process. The conventional xerographic plate is suitable for this purpose but it is not suggested that this invention is limited thereto.

In FIGURE 2 there is illustrated development of electrostatic charge pattern 11 by the technique generally known in the art as "cascade development." In cascade development, which is described in Walkup U.S. Patent 2,618,551, a mixture of particles 21 is presented to the surface bearing the charge pattern. The particles are generally frictionally electrostatically charged and the electrostatic fields of force which exist between the charges on the particles and the charges on the surface of the plate cause particle deposition in conformity with the electrostatic charge pattern resulting in toner image 22.

The developer generally used in cascade development comprises a dry mixture of fine toner particles electrostatically adhering to larger particles generally referred to

as carrier particles. The carrier particles will part with the finer toner particles as the developer mixture passes over and in contact with the electric field of influence of the electrostatic charge pattern. During development, developer is passed across the plate surface either once or a number of times and the toner particles deposit on the charge pattern to form a visible toner image.

It is to be realized that other known xerographic development techniques may be used. Accordingly, it is intended to include within the scope of this invention separation of toner images produced by other known xerographic developing techniques including, but not limited to, loop development, powder cloud development, brush development, magnetic development, and the like. Specifically, it is noted that where a rigid plate member is being used, cascade development is generally preferred to produce line copy images and powder cloud development is generally preferred to produce continuous tone images.

Transfer-separation comprising the present invention is illustrated in FIGURE 3. Particles comprising toner image 22 are shown adhering to insulating plate 12 in conformity with electrostatic charge pattern 11 indicated by the plus marks. Transfer web 23, which is shown in light contact with insulating plate 12, may comprise any suitable material such as paper, plastic, or the like. As transfer corona device 24 is moved relative to insulating plate 12 in the direction shown by the arrow, its positive corona discharge overcomes the attractive forces of electrostatic charge pattern 11, thus causing toner image 22 to be transferred onto transfer web 23. Transferred toner image 22a is shown adhering to those portions of transfer web 23 which have been subjected to the corona discharge from transfer corona device 24. Separation corona device 25 emits corona discharge opposite in polarity to that of transfer corona device 24 and is also moved relative to transfer web 23 and insulating plate 12 in the direction indicated by the arrow. Separation corona device 25 causes neutralization of the charge produced by transfer corona device 24 permitting the separation of transfer web 23 from insulating plate 12 without the occurrence of air breakdown or sparking. As a result electrostatic charge pattern 11 remains intact after the separation step permitting its reuse in the development process for the formation of additional toner images. Separation corona device 25 need not necessarily be positioned immediately adjacent to transfer corona device 24, as appearing in FIGURE 3. However, the corona devices would generally be closely positioned to minimize the physical space occupied by these elements.

FIGURE 4 shows one of the general types of corona discharge devices suitable for operation in conjunction with the present invention. It is referred to as a corotron and is described in greater detail in Vyverberg U.S. Patent 2,836,725. The corotron assembly, designated generally by reference character 30, comprises two insulating terminal blocks 31 positioned at either end of the assembly and joined together by a conductive shield 32. Corona wire 33 is a fine conductive strand mounted on the insulating terminal blocks and runs lengthwise of the assembly from one block to the other beneath shield 32. Corona wire 33 forms the corona discharge electrode and may be conductively connected to a high voltage power source.

It is to be realized that when separation of the transfer web from the insulating plate surface takes place without transfer charge neutralization, such as that provided by separation corona device 25 shown in FIGURE 3, the capacitance between the transfer web and the surface of the insulating plate decreases as the gap between the two increases. As capacitance decreases, since the charge on each surface is not varied, the potential increases at a rapid rate during separation. Usually a point is reached at which the potential becomes sufficiently great to bring about an electric air breakdown between the surfaces resulting in distortion of the image pattern

on the insulating plate surface. Therefore, separation corona device 25, by effecting the neutralization of transfer charge, maintains the field-space relationship below critical stress conditions. Little or no positive charge remains on the transfer web 23 but the transferred toner image 22a is held on the web by physical forces and the small remaining positive transfer charge. Sparking or other electric air breakdown phenomena are prevented and the electrostatic charge pattern is maintained on the insulating plate surface in its original condition.

As already indicated, the neutralization charge must be of correct magnitude in order to be effective. If the ionic emission from separation corona device 25 is either insufficient or too great, conditions conducive to air breakdown will persist. Of course, neutralization of the transfer charge could be accomplished by using two separately powered corona discharge devices for transfer and separation. These devices would have to be carefully adjusted so that the neutralization charge would be of equal magnitude, but opposite polarity, to that of the transfer charge. As a practical matter, variations in operating conditions mentioned earlier make such critical adjustments extremely difficult if not impossible.

Apparatus according to the present invention is inherently self-regulating so that exactly the same amount of charge is deposited on the transfer web by each corona device. By forcing the oppositely charged emission from separation corona device 25 to be automatically equal to the emission from transfer corona device 24, complete neutralization of the transfer web is effected. The present invention achieves this result, variations in operating conditions notwithstanding.

Reference is again made to FIGURE 3 to show how the neutralization charge is effectively regulated in accordance with the present invention. Transfer corona device 24 and separation corona device 25 are both electrically connected to oppositely poled terminals of power supply 26, which is described in greater detail in connection with FIGURE 5. For purposes of this description, the corona wire of transfer corona device 24 is shown connected to the positive side of power supply 26 and the corona wire of separation corona device 25 is shown connected to the negative side although this relation can be reversed. The power supply 26 is electrically insulated or isolated from ground as are each of the corona discharge devices. The respective shields of the two corona devices are electrically connected by means of wire 27 although it is to be understood that this electrical connection may be optionally attained through a fixed or variable resistor 67, as illustrated in FIG. 7, or by operating the corona devices with their shields in direct contact, or by forming both such shields as an integral structure 74, as schematically illustrated in FIG. 8. The other components shown in FIGS. 7 and 8 are the same as those of FIG. 3 and are designated by the same reference characters. If a resistor were used for this electrical connection, it might, if desired, be used to controllably reduce corona emission from the two corona devices.

Since, except for the corona emission contact, the elements mentioned are electrically isolated from their environment, it may be seen that the amount of current leaving one corona device must be equal and opposite to that entering the other corona device. With the elements connected as shown in FIGURE 3, voltages will automatically adjust to provide equal emission from the two corona devices. Accordingly, the amount of charge deposited by the corona devices must be equal, resulting in complete neutralization of charge on the transfer web.

The necessary electrical isolation in the apparatus can be attained by careful attention to conventional principles of good engineering. The corona devices should be supported on high quality insulators and connected to the power supply by well insulated conductors. The power supply may be of the conventional transformer rectifier type, but should incorporate a well insulated

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transformer free of corona. It is especially advantageous to use the type of transformer in which the high voltage secondary winding is physically separated from the core and primary winding. Good insulating should be used throughout the power supply and rectifier filament transformers, if used, should have well insulated secondary windings. Filter condensers, if employed, should be connected across the high voltage transformer rather than to ground, unless they are of exceptionally low leakage. If a power supply meeting this description is not available, power supply 26 may alternatively comprise a conventional power supply mounted on good insulators and powered by a well insulated high voltage isolation transformer which may be of the 1:2 type. Various other means for providing high voltage power sources isolated from ground are known and may be employed. Also, power supply 26 may be replaced by several individual power supplies provided each is suitably insulated.

FIGURE 5 depicts the essential elements of a preferred high voltage power supply for use in this invention. A primary winding 34 is wound on a toroidal iron core 35. High voltage secondary coil 36 is interlinked with the core but is physically separate from the core and primary winding. A set of rectifiers 37 transform the high voltage alternating current to direct current on the order of 10,000 to 15,000 volts. A filter condenser 38 may be connected across the rectifier output terminal. The entire high voltage assembly is connected to high voltage feed through bushings 39 which may be the sole mechanical support therefor. Thus, complete electrical isolation exists between the high voltage circuit and all low voltage elements such as the mechanical structure of the power supply, the primary winding, or the like.

As illustrated in FIGURE 6, the present invention may be suitably applied to a continuously operating machine designed to produce a plurality of copies from a single electrostatic charge pattern. A xerographic drum 40 comprising a photo-conductive insulating layer 41 overlying a conductive backing 42 is suitably mounted to rotate in the direction indicated by the arrow. The drum is disposed and adapted to pass successively through a charging station 50 and exposure station 51, a first development station 52, a first transfer-separation station 53, a second development station 52a, and a second transfer-separation station 53a and a cleaning station 54.

The charging, exposing, developing, and cleaning stations are conventional in the art of xerography. Thus, for example, the charging station may be of the type described in connection with FIGURE 4 comprising a corona wire 55 operably connected to power supply 56. The exposure station 51 may include a projection lens 57 or other means of imposing a pattern of light and shadow to be recorded on the surface of xerographic drum 40. First developing station 52 and second developing station 52a may comprise suitable means or methods for applying an electroscopic powder or material to the xerographic drum and may, for example, comprise a fur brush.

In accordance with the present invention, transfer-separation station 53 comprises a pair of corotrons electrically connected to the same power supply 61 in the manner described in connection with FIGURE 3. Transfer corotron 58 is positioned and disposed to effect the electrostatic transfer of the electroscopically adhering toner image from the surface of xerographic drum 40 to the surface of transfer web 59. Separation corotron 60 is positioned and disposed to deposit an electrostatic charge to neutralize that deposited by transfer corotron 58. The electrostatic fields of force at the area of separation are thereby maintained below air breakdown potential so that separation of the transfer web from the surface of the xerographic drum may be effected without destruction of the electrostatic charge pattern. The electrostatic charge pattern is again visualized in this embodiment at second development station 52a after which transfer

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of the toner image may again be effected at second transfer-separation station 53a.

Although FIGURE 6 illustrates an embodiment of the present invention designed to produce only two copies from an electrostatic charge pattern, this embodiment may be easily modified to produce a larger number of copies. A plurality of such development and transfer-separation stations may be alternately positioned around the xerographic drum for additional copies of the charge pattern. Or, mechanical arrangements may be embodied to allow continuous cycling while the charging means and the exposure means are maintained in an inoperative position to allow production of a predetermined number of copies.

Although this invention has been described with reference to the specific structures disclosed in this application, it is not intended that this invention be limited by those specific embodiments. Rather it is intended that the claims apply broadly within the spirit and scope of this invention.

What is claimed is:

1. Self-regulating apparatus to successively deposit on a chargeable surface of an image transfer web a first electrostatic charge and a second electrostatic charge of equal magnitude and opposite polarity to said first electrostatic charge, comprising in combination:

(a) a first corona discharge device comprising corona wire positioned within a conductive shield;

(b) a second corona discharge device comprising corona wire positioned within a conductive shield; and,

(c) an electrically isolated high voltage power supply; said corona wires of said corona discharge devices being respectively connected to oppositely poled terminals of said power supply, said conductive shields being electrically connected, said combination of said corona discharge devices and said power supply being electrically isolated from its environment, and said corona discharge devices being disposed so that successive areas of said web are brought into operative proximity with said first corona discharge device and said second corona discharge device respectively.

2. Apparatus according to claim 1 wherein said conductive shields are electrically connected by means of a variable resistor to controllably reduce corona emission of said corona discharge devices.

3. Apparatus according to claim 1 wherein said conductive shields of said corona discharge devices comprise an integral structure.

4. Apparatus to produce a plurality of duplicate copies from an original comprising:

(a) a xerographic plate in the form of a drum comprising a photoconductive layer overlying a grounded conductive backing;

(b) means to form an electrostatic charge pattern on said xerographic plate conforming to said original;

(c) developing means to form a visible toner image comprising electrically charged powder;

(d) guide means to bring a surface of an image transfer web into contact with said toner image;

(e) self-regulating transfer-separation means comprising a first shielded corona electrode to deposit an electrostatic charge on the non-contacting surface of said web to effect transfer of said powder to the contacting side of said web and a second shielded corona electrode to deposit a neutralizing charge on the non-contacting surface of said web, said corona electrodes being connected to oppositely poled terminals of a high voltage power supply, the respective shields of said electrodes being electrically connected, and said transfer-separation means being electrically isolated from its environment; and,

(f) means to move successive portions of said plate first into operative relation with said electrostatic

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charge pattern forming means and then into operative relation with a plurality of combinations comprising in sequence said developing means, said guide means and said transfer-separation means.

5. Apparatus to produce a plurality of duplicate copies from an original comprising:

- (a) a xerographic plate in the form of a drum comprising a photoconductive layer overlying an electrically grounded conductive backing;
- (b) means to form an electrostatic charge pattern on said xerographic plate conforming to said original;
- (c) developing means to form a visible toner image comprising electrically charged powder; and,
- (d) electrically isolated self-regulating transfer-separation means comprising a first shielded corona electrode to deposit on the surface of an image receiving web opposite to that surface of said web brought into contact with said toner image to effect transfer of said toner image to the contacting surface of said web, a second shielded corona electrode to deposit a neutralizing charge on the non-contacting surface of said web, and an electrically isolated high voltage power supply, said corona electrodes being connected to oppositely poled terminals of said high voltage power supply and respective shields of said electrodes being electrically connected.

6. In xerographic apparatus for successively applying to a chargeable surface a first electrostatic charge of one polarity and a second electrostatic charge of equal magnitude and of opposite polarity to that of said first elec-

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trostatic charge, said apparatus including a power supply, a first shielded corona discharge electrode and a second shielded corona discharge electrode, the improvement comprising in combination:

- a first corona discharge electrode partly surrounded by an electrically conductive shield;
- a second corona discharge electrode partly surrounded by an electrically conductive shield;
- a power supply including a transformer having a high voltage secondary winding physically separate from the primary winding;
- means to connect said electrodes to opposite poles of said power supply; and,
- means to electrically connect the conductive shields partly surrounding said electrodes.

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EVON C. BLUNK, *Primary Examiner*.

30 WILLIAM D. MARTIN, *Examiner*.