Nov. 6, 1962 J. J. CODICHINI 3,062,956

XEROGRAPHIC CHARGING APPARATUS

Filed April 4, 1960 2 Sheets-Sheet 1

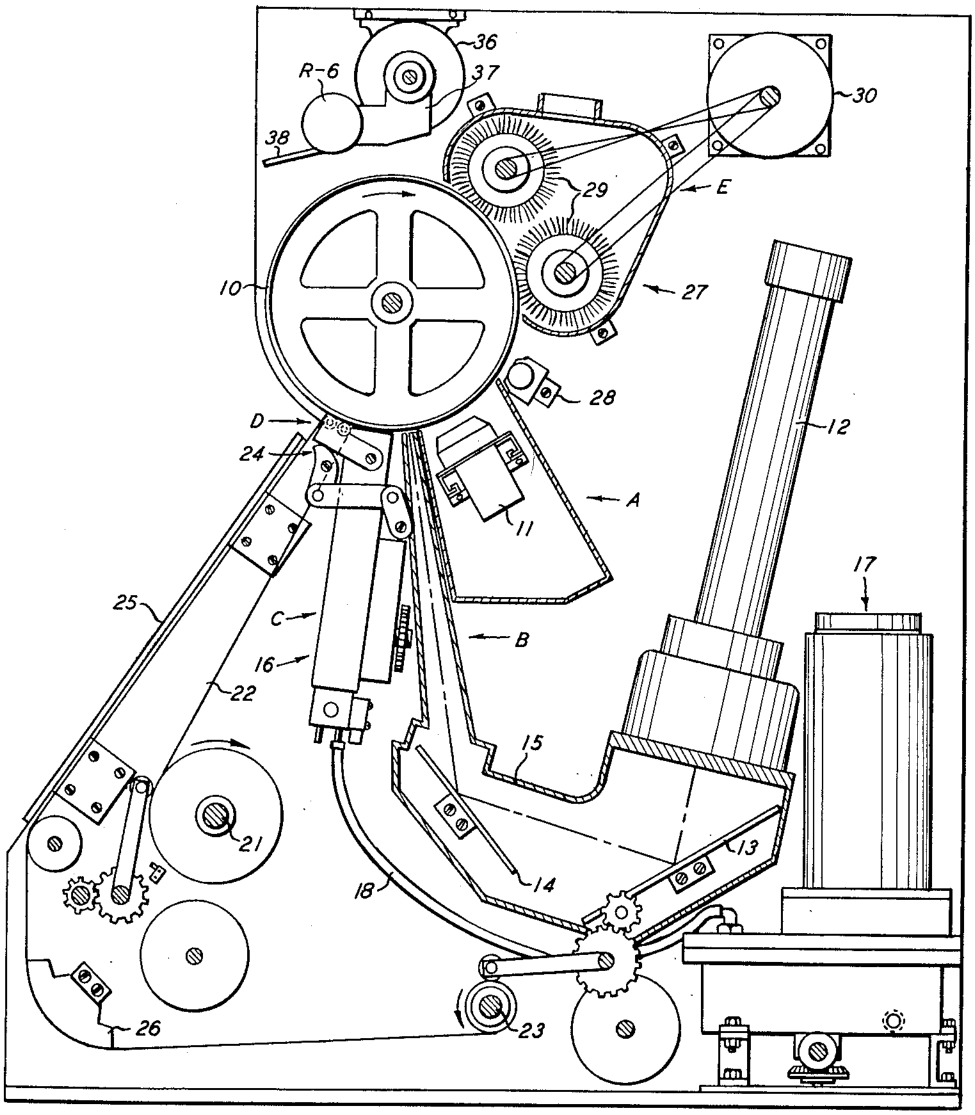

FIG. 1

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XEROGRAPHIC CHARGING APPARATUS

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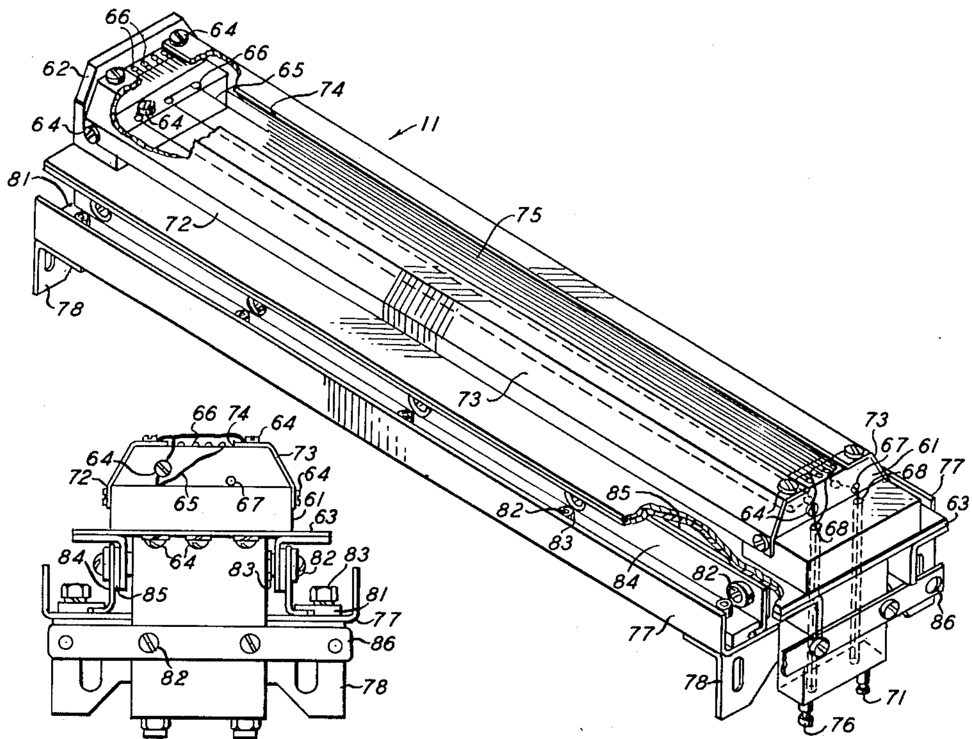

FIG. 2

FIG. 3

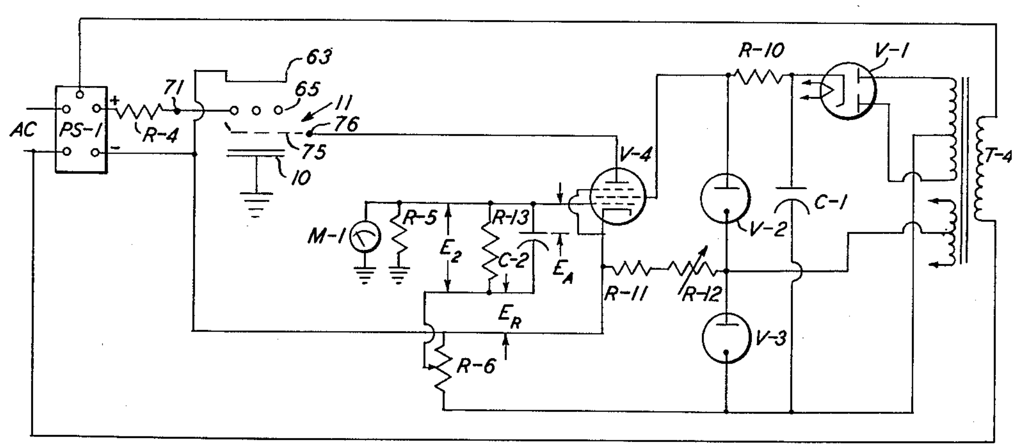

FIG. 4

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XEROGRAPHIC CHARGING APPARATUS

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3 Claims. (Cl. 250—49.5)

This invention relates to the field of xerography and, particularly, to an improved electric circuit to control a corona generating device for applying electrostatic charge on a xerographic plate.

In the art of xerography, for example, as disclosed in Carlson Patent 2,297,691, a xerographic plate, comprising a photoconductive insulating material on a conductive backing, is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. This exposure discharges the plate areas in accordance with the radiation intensity which reaches them and thereby creates an electrostatic latent image on or in the plate coating which may then be developed with an electroscopic material which clings to the plate electrostatically in a pattern corresponding to the electrostatic image. Thereafter, the developed xerographic image is usually transferred to a support material to which it may be fixed by any suitable means.

By present techniques, the charging of the xerographic plate in preparation for the exposure step is accomplished by means of a corona generating device whereby electrostatic charge on the order of 500 to 600 volts is applied to the xerographic plate. A form of corona generating device for this purpose is disclosed in Walkup Patent 2,777,957, issued January 15, 1957, wherein a plurality of parallel wires are connected in series to a high voltage source and are supported in a conductive shield that is arranged in closely spaced relation to the surface to be charged. When the wires are energized, corona is generated along the surface of the wires and ions are caused to be deposited on the adjacent photoconductive surface. Suitable means are usually provided to effect relative movement of the surface to be charged and the corona generating device. A biased wire shield placed between the corona wires and the xerographic plate permits energizing the corona wires to a potential well above the corona threshold potential thereof without causing damage to the xerographic plate because the excess of corona current over that required for proper charging of the plate is drained off by the biased sheld.

As is well known, the corona threshold potential and the corona current from an energized wire are functions of the wire diameter, i.e., the corona threshold increases and the corona current for any given potential decreases as the wire diameter is increased. Variations in the potential applied to corona wires of a given diameter will cause relatively large changes in corona current with corresponding variations in the charging rate. In addition, the corona threshold potential and corona current are also affected directly by deposits of dust that may accumulate on the wire and by variations of movement and ironized conditions of the air sheath surrounding the wire. Thus when operating at the corona threshold, minute differences in wire diameter, slight accumulations of dust on the wire, and variations in air current or in air pressure drastically affect the corona generating potential of the wire and cause a non-uniform electrostatic charge to be deposited on the xerographic plate.

In the art of xerography it has been established that consistent high quality reproductions can best be effected when a uniform potential is applied to a xerographic plate to prepare the plate for the exposure step. If the

xerographic plate is not charged to a sufficient potential, the electrostatic latent image obtained upon exposure will be relatively weak and the resulting deposition of a developer material thereon will be correspondingly small and if the xerographic plate is overcharged the converse will occur, and if overcharged sufficiently the photoconductive layer of the xerographic plate may be permanently damaged.

Since the contrast value, comparable to the contrast values obtainable from silver halide papers, of the electrostatic latent image is related directly to the potential charge on the xerographic plate before exposure, it is apparent that if the plate is not uniformly charged over its entire area, the contrast value of the electrostatic latent image obtained upon exposure will vary in different areas on the plate, and a streaky effect will be visible on the image when developed.

It is therefore the principal object of this invention to improve the electrical circuit of a corona generating device whereby a uniform electrostatic charge may be deposited on a xerographic plate.

A further object of this invention is to improve scorotron control circuits for use in automatic xerographic machines wherein it is desirable to continuously charge a xerographic plate to a uniform potential, regardless of variations in the supply line voltage or changes in the surrounding atmospheric conditions.

These and other objects of the invention are attained by means of a scorotron consisting of a back-up plate, coronode wires extending parallel to the back-up plate to charge a xerographic plate by corona discharge, and a screen or shield partially enclosing the coronode wires whereby the potential applied to the xerographic plate may be varied by changing the screen or shield potential. To ensure a constant charging current, the charging circuit connected to the scorotron contains a current stabilizer and a regulated direct current power supply.

For a better understanding of the invention as well as other objects and features thereof, reference is had to the following detailed description of the invention to be read in connection with the accompanying drawings, wherein:

FIG. 1 illustrates schematically a preferred embodiment of a xerographic reproducing apparatus adapted for continuous and automatic operation, and incorporating a corona generating apparatus in accordance with the invention;

FIG. 2 is a persepctive view, partly broken away to show structural details, of a preferred scorotron charging apparatus;

FIG. 3 is an end view of the scorotron charging apparatus; and

FIG. 4 is a schematic electrical wiring diagram of a preferred control circuit for the scorotron of FIG 2.

Referring now to the drawings there is disclosed a preferred embodiment of a variable speed xerographic processor for producing continuous tone images using a corona generating device of the invention. Specifically, the apparatus shown is a close-access xerographic recorder for use in an aircraft to produce permanent continuous tone images on a transfer material from suitable infrared or radar images of the objects to be reproduced while at the same time permitting members of the aircraft to view these images within a relatively short period of time.

As shown in FIG 1 the variable speed xerographic apparatus comprises a xerographic plate including a photoconductive layer or radiation-receiving surface on a conductive backing and formed in the shape of a drum, generally designated **10**, which is mounted on a shaft journalled in a suitable frame to rotate in the direction indicated by the arrow to cause the drum surface sequentially to pass a plurality of xerographic processing stations.

For driving the drum at a variable speed there is provided a suitably mounted motor 36 connected to a conventional variable speed drive 37, the output shaft of which is connected in a suitable manner (not shown) to drive the drum. The output speed of the variable speed drive is controlled by means of shaft 38 to vary the speed of the drum as desired, for example, to vary the speed of the drum in relation to changes in the ground speed of an aircraft in which the apparatus is mounted.

For the purpose of the present disclosure, the several xerographic processing stations in the path of movement of the drum surface may be described functionally, as follows:

A charging station, at which a uniform electrostatic charge is deposited on the photoconductive layer of the xerographic drum;

An exposure station, at which a light or radiation pattern of copy to be reproduced is projected onto the drum surface to dissipate the drum charge in the exposed areas thereof and thereby form a latent electrostatic image of the copy to be reproduced;

A developing station, at which a xerographic developing material including toner particles having an electrostatic charge opposite to that of the electrostatic latent image are cascaded over the drum surface, whereby the toner particles adhere to the electrostatic latent image to form a xerographic powder image in the configuration of the copy to be reproduced;

A transfer station, at which the xerographic powder image is electrostatically transferred from the drum surface to a transfer material or support surface; and

A drum cleaning and discharge station, at which the drum surface is brushed to remove residual toner particles remaining thereon after image transfer, and at which the drum surface is exposed to a relatively bright light source to effect substantially complete discharge of any residual electrostatic charge remaining thereon.

The charging station is preferably located as indicated by reference character A. In general, the charging apparatus includes a corona discharge device 11 which consists of an array of one or more corona discharge electrodes that extend transversely across the drum surface and are energized from a high potential source and are substantially enclosed within a shielding member.

Next subsequent thereto in the path of motion of the xerographic drum is an exposure station B. This exposure station may be one of a number of types of mechanisms or members to expose the charged xerographic drum to a radiation image, which then causes a release of the charge on the drum in proportion to the radiation from the copy onto the surface of the drum. As shown, the exposure mechanism includes a cathode ray tube 12 connected to a suitable electronic circuit, not shown or described since it forms no part of the instant invention. Images projected by the cathode ray tube onto the image mirror 13 are reflected onto object mirror 14 for projection onto the xerographic drum, the entire projection system being enclosed in a suitable exposure housing 15 to exclude extraneous light.

Adjacent to the exposure station is a developing station C in which there is positioned a development mechanism, such as development electrode 16 which is mounted to maintain a uniform close spacing between its upper surface and the surface of the xerographic plate to form a development zone therebetween. The development electrode 16 is supplied with a powder cloud by powder cloud generator 17 through conduit 18. Neither the development electrode 16 nor the powder cloud generator 17 are described in detail herein since they form no part of the subject invention.

Positioned next and adjacent to the developing station is the image transfer station D which includes a web feeding mechanism to feed a web of paper or other suitable transfer material to the drum and a transfer mechanism to effect transfer of a developed xerographic powder image from the drum onto the transfer material. The sheet feeding mechanism includes a supply roll 21 for a web of transfer material 22 which is fed up and over a transfer mechanism 24 into transfer contact with the drum and then down under a viewing platen 25 across a fusing apparatus, such as heat fuser 26 whereby the developed and transferred xerographic powder image on the transfer material is permanently fixed thereto from whence it is wound onto take-up roll 23.

The next and final station in the device is a drum cleaning station E, having positioned therein a plate cleaner 27 adapted to remove any powder remaining on the xerographic plate after transfer by means of brushes 29 driven by motor 30 and a light source 28 adapted to flood the xerographic plate with light to cause dissipation of any residual electrical charge remaining on the xerographic plate.

Suitable control means are used to actuate the drum, development electrode, powder cloud generator, web feed mechanism and the plate cleaning device.

It is believed that the foregoing description is sufficient for the purposes of this application to show the general operation of the xerographic apparatus. For further details concerning its specific construction, reference is made to copendng application Serial No. 19,951, filed concurrently herewith in the names of John T. Bickmore, Joseph J. Codichini, and Charles L. Huber on April 4, 1960.

Charging Apparatus

Referring now to the subject matter of the invention, the electrostatic charging of the xerographic plate in preparation for the exposure step is accomplished by means of a corona generating device whereby an electrostatic charge is applied to the plate surface as it moves relative to the charging device. The potential applied to the plate is dependent upon the particular print contrast desired. Higher print contrasts require higher initial plate potentials.

To effect charging of the plate there is provided a corona generating device and a charging circuit to supply electrical power to the corona generating device.

Although any suitable corona generating device may be used, a scorotron as shown in FIG. 2 is used in the preferred embodiment of the invention. The scorotron consists of a back-up plate, wires called the coronode, and screen wires. The coronode wires, by corona discharge, charge the photoconductive surface of the xerographic plate. The potential applied to the plate surface can be varied by changing the screen potential.

To insure a constant charging current during operation at any given contrast setting, the charging circuit contains a current stabilizer and a regulated direct current power supply. The current stabilizer is a device for controlling charging current by automatically adjusting the screen potential when a current change is sensed.

Specifically, the corona generating device 11 consists of two terminal blocks 62 and 62 made of suitable insulating material connected to opposite ends of grid bar or back-up plate 63 by suitable means such as screws 64. Terminal block 62 is mounted on one end of grid bar 63 while terminal block 61 extends through a suitable aperture (not shown) formed in the opposite end of the grid bar 63. Stretched between and attached by means of studs 66 to the stepped portions of the terminal blocks are a plurality of fine high voltage coronode wires or wires 65 of continuous length. One end of the continuous length wire is secured by a screw 64 to terminal block 62, the wire then extending between the terminal blocks parallel to grid bar 63 to form three strands of wires, the opposite end of the wire ending at terminal block 61 where the wire extends through apertures 67 and 68 therein and is connected to binding post 71 threaded into the bottom end of terminal block 61.

To control or suppress the effective charging potential of wires **65** there is provided a pair of side walls **72** secured by means of screws **64** to opposite sides of the terminal blocks, each of the side walls having converging portions **73** each arranged at an angle of approximately 45° to the side wall and a top portion partly extending over the top of the terminal blocks. The top portions of the side walls are spaced apart to afford a corona discharge opening **74** extending parallel and above the wires **65**.

The corona discharge opening **74** is partly screened by grid wires **75** of continuous length electrically connected to side walls **72**, the grid wires extending between the terminal blocks to which they are secured by means of studs **66** in the top of these blocks. One end of the wire forming screen or grid wires **75** is connected by a screw **64** to the end of terminal block **61** and then connected to the side walls **72** from whence the wire is wound on the studs of the terminal blocks to form as shown eight strands of wires of continuous length, the opposite end of the wires extending through a second aperture **68** in terminal block **61** to be connected to a second binding post **76**. The side walls and grid wires form a control shield around the coronode wires to suppress the effective charging potential of the coronode wires.

Both the wires **65** and **75** are made of any suitable non-corrosive material such as stainless steel having a uniform exterior. In the embodiment of the charging device shown the diameter of wires **65** is approximately three-and-one-half thousandths of an inch and the diameter of wires **75** is approximately ten thousandths of an inch, it being apparent that other size wire can be used.

For supporting the charging device there is provided a U-shaped slide support **77** having attached on its bottom side, as seen in FIG. 2, at opposite ends thereof a pair of flanged mounting plates **78** which extend laterally across the support whereby the charging device can be suitably attached to a frame element of the xerographic apparatus. The support **77** has attached to its upper surface a pair of grid slide bars **81** which extend the length of the slide grid and are positioned at opposite sides thereof, by means of screws **82** and nuts **83**.

The undercut portions of the grid slide bars **81** are positioned to face inward and parallel to each other to form a modified T-slot to slidably receive the slide brackets **84** secured along with insulating bars **85** to the depending side portions of grid bar **63** by means of screws **82** and nuts **83**.

To prevent longitudinal movement of the charging device a support plate **86** adapted for connection in a suitable manner to a frame element of the machine is secured to the outer face of terminal block **61**.

A clearer understanding of the operation of the charging apparatus and of its electrical controlling circuit can best be obtained by reference to the schematic wiring diagram of FIG. 4. The corona generating device **11** is shown in this figure as being positioned above a xerographic plate **10** suitably grounded. Coronode wires **65** are connected to a power source PS–1 in the potential range of approximately 6,000 to 11,000 volts. As the coronode wires **65** are energized by this high potential power source, corona emission or ion flow from the coronodes occurs, causing a charging current to flow from the coronodes to the xerographic plate. Corona emission for a given size wire is affected by changes in the applied potential, by deposits of dust that may accumulate on the wire and by variations of movement and ionized conditions of the air sheath surrounding the coronode. The latter condition becomes acute when the apparatus is used in an aircraft which normally operates at varying altitudes since as the air becomes less dense as the altitude increases the corona emission will increase.

It has been found as disclosed in Walkup Patent 2,777,957 that by the introduction of an electrode, such as a conductive shield or grid between the source of corona emission or ions and the xerographic plate to which the ions are flowing that the flow of ions or charging current can be suppressed. By using a conductive shield or grid acting as a control electrode, a portion of the ions released by the coronode wires is imparted through the control electrode to the xerographic plate, the remaining ions released being suppressed and drained off by the control electrode.

The magnitude of the charging current then becomes a function of both the rate of corona emission from the coronodes and the potential applied to the control electrode.

To control the charging current there is provided a current stabilizer circuit shown in FIG. 4 in connection with the scorotron potential charging circuit.

In the circuit a conventional high voltage power supply PS–1 is connected to a source of alternating current, such as a commercial outlet of 110 volts, 60 cycle alternating current. The potential of this power supply depends to a certain extent on the diameter of the coronode wires, and with wires of conventional size, for suitable durability, it is preferred to have this power supply capable of generating a potential of between 6,000 to 8,000 volts. The binding post **71**, to which the coronode wires **65** are attached, is connected by a suitable conductor in series with resistors R–4 to the positive output terminal of the high voltage power supply and the grid bar **63** is connected to the negative terminal of the high voltage power supply.

The primary of a multiple step-up transformer T–4 is also connected to the source of alternating current. Opposite ends of the high voltage secondary winding of transformer T–4 are connected to the anodes of a full-wave rectifier V–1. Rectifier V–1 in parallel with capacitor C–1 forms a rectifying circuit so that direct current is supplied to the voltage regulator tube V–3 and to voltage regulator tube V–2 in series with resistor R–10. Tube V3 is a voltage reference tube which supplies a reference voltage E_R in series with the cathode of control tube V–4, for example, a high gain pentode. The output of the control tube V–4 is applied to the screen **75**, the conductor line from the control tube being connected to terminal post **76** of the scorotron **11**.

The charging current is set to the value, as indicated on meter M–1 connected in parallel to resistor R–5, depending upon the particular print contrast desired, by adjustment of potentiometer R–12 which is connected in series with resistor R–11 and rheostat R–6, this setting being made at a predetermined drum speed.

In operation, any change of current through resistor R–13 (charging current from coronodes to the xerographic plate) which is in parallel with capacitor C–2, produces a change in the applied voltage to the grid of control tube V–4. The result is a change in tube resistance which produces a change in screen potential.

The voltage drop across R–13 is proportional to the charging current and is compared to the reference voltage E_R. As shown, the difference voltage (E_2—E_R) is used as the input signal to the control tube. This difference voltage is designated as E_a in the figure.

With this circuit, as a decrease in charging current occurs, the resistance of control tube V–4 increases thereby increasing the screen voltage to permit the charging current to increase back to its desired value and, of course, the converse is true as the charging current increases above a desired value.

As previously described, the charging current is set to a desired value for a given drum speed. However with a fixed reference voltage as the drum speed increases, the current will remain constant and therefore the voltage at the drum will decrease and as the drum speed decreases, the voltage at the drum will increase. With a linear relationship existing in this circuit between reference voltage E_r and charging current, by using a linear potentiometer R–6 control can be established such that charging current is proportional to the angular rotation of the potentiometer. Therefore, to control the charging current at a desired value at various drum speed, potentiometer R–6 as shown in FIG. 1 is mounted adjacent to the variable speed drive 37 for operation by control shaft 38 to which it is mechanically linked in a suitable manner. Thus as control shaft 38 is actuated to effect operation of the variable speed drive to change drum speed, the rheostat R–6 will be adjusted to maintain the desired charging current as the drum speed is varied.

Resistor R–13 should have a large value of resistance in order that the unit will operate as a stiff control since for a given change of charging current the change in voltage applied to control tube V–4 is proportional to the resistance value of resistor R–13.

With the control circuit of the invention the charging current can be maintained at a constant value and is not influenced by any of the normal variables such as geometry of the scorotron, voltage variations, dirty wires, atmospheric changes, etc., which ordinarily affect charging current.

By maintaining the charging current constant, high quality reproductions having the desired contrast value can be made continuously and automatically.

While the invention has been described with reference to the circuit disclosed herein, it is not confined to the details set forth since it is apparent that certain electrical equivalent components may be substituted for the components of the preferred circuit without departing from the scope of the invention. Thus, for example, although the number of turns of wire used in the preferred embodiment for the coronode 65 and screen 75 are 3 and 8, respectively, it is apparent that any number of turns of wire may be used for these elements depending upon the results desired. This application is therefore intended to cover such modifications or changes as may come within the purposes of the invention as defined by the following claims.

What is claimed is:

1. In a xerographic reproducing apparatus wherein a corona generating device having a back-up plate and screen wires, with at least one corona discharge wire positioned therebetween is mounted in closely spaced movable relation to a xerographic plate for applying an electrostatic charge onto the xerographic plate, and wherein the charging current to the xerographic plate is controlled by changing the potential applied to the screen wires, an increase in screen potential effecting an increase in charging current and a decrease in screen potential effecting a decrease in charging current;

a control circuit for the corona generating device including a high voltage direct current source, the corona discharge wire being connected to a terminal of one polarity of said high voltage direct current source,

means to generate a regulated direct current potential,

a control tube having a cathode, an anode and a grid,

said cathode being connected in series between said means to generate a regulated direct current potential and the terminal of opposite polarity of said high voltage direct current source whereby a controlled voltage is applied to said cathode,

said anode being electrically connected to said screen wires,

an electrical connection between the xerographic plate and said grid,

a resistor connected in series between the xerographic plate and the terminal of opposite polarity of said high voltage direct current source whereby the charging current through said xerographic plate flows through said resistor,

the variations in the charging current, as sensed by said resistor, causing variations in the voltage applied between the grid and cathode of said tube which amplifies this voltage change thereby changing the voltage applied to the screen wires to correct for initial charging current change.

2. In a xerographic reproducing apparatus wherein a corona generating device having a back-up plate and screen wires, with at least one corona discharge wire positioned therebetween is mounted in closely spaced movable relation to a xerographic plate for applying an electrostatic charge onto the xerographic plate, and wherein the charging current to the xerographic plate is controlled by changing the potential applied to the screen wires, an increase in screen potential effecting an increase in charging current and a decrease in screen potential effecting a decrease in charging current;

a control circuit for the corona generating device including a high voltage direct current source, the corona discharge wire being connected to the positive terminal of said high voltage direct current source,

means to generate a regulated direct current potential,

a control tube having a cathode, an anode and a grid,

said cathode being connected in series between said means to generate a regulated direct current potential and the negative terminal of said high voltage direct current source whereby a controlled voltage is applied to said cathode,

said anode being electrically connected to said screen wires,

an electrical connection between the xerographic plate and said grid,

a resistor connected in series between the xerographic plate and the negative terminal of said high voltage direct current source whereby the charging current through said xerographic plate flows through said resistor,

the variations in the charging current, as sensed by said resistor, causing variations in the voltage applied between the grid and cathode of said control tube which amplifies this voltage change thereby changing the voltage applied to the screen wires to correct for initial charging current change,

and said means to generate a regulated direct current potential including a rheostat whereby the value of the reference voltage applied to said cathode may be varied to regulate the initial charging current.

3. In a xerographic reproducing apparatus wherein a corona generating device having a back-up plate and screen wires, with at least one corona discharge wire positioned therebetween is mounted in closely spaced movable relation to a xerographic plate for applying an electrostatic charge onto the xerographic plate, wherein the charging current to the xerographic plate is controlled by changing the potential applied to the screen wires, an increase in screen potential effecting an increase in charging current and a decrease in screen potential effecting a decrease in charging current, and wherein the xerographic plate is driven by means of a variable speed drive controlled by means of a speed adjusting shaft;

a control circuit for the corona generating device including a high voltage direct current source, the corona discharge wire being connected to the positive terminal of said high voltage direct current source,

means to generate a regulated direct current potential,

a control tube having a cathode, an anode and a grid,

said cathode being connected in series between said means to generate a regulated direct current potential and the negative terminal of said high voltage direct current source whereby a controlled voltage is applied to said cathode,

said anode being electrically connected to said screen wires,

an electrical connection between the xerographic plate and said grid,

a resistor connected in series between the xerographic plate and the negative terminal of said high voltage direct current source whereby the charging current through said xerographic plate flows through said resistor,

the variations in the charging current, as sensed by said resistor, causing variations in the voltage applied between the grid and cathode of said control tube which amplifies this voltage change thereby changing the voltage applied to the screen wires to correct for initial charging current change,

and said means to generate a regulated direct current potential including a linear rheostat connected to the speed adjusting shaft whereby the value of the reference voltage applied to said cathode may be varied as the speed of the xerographic plate is varied to regulate the initial charging current as a function of the xerographic plate speed.

No references cited.