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Silverberg

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[54] **AC COROTRON**

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[52] **U.S. Cl.** .... **317/2 F**
[51] **Int. Cl.** **H05f 3/00,** H01t 19/04
[58] **Field of Search** .... 317/2 F, 4, 262 A

[56] **References Cited**

UNITED STATES PATENTS

3,396,308	8/1968	Whitmore	317/2 F
2,897,395	3/1959	Walkup	317/262 A
3,376,208	4/1968	Wood	317/262 A

Primary Examiner—L. T. Hix
Attorney—James J. Ralabate et al.

[57] **ABSTRACT**

An improved a.c. corotron for neutralizing the charge on a charge receiving surface is provided according to the teachings of the present invention. The a.c. corotron, which includes an electrode and a shield partially surrounding the electrode is adapted to be driven by an a.c. source connectable between the electrode and the shield. According to one embodiment of the invention an impedance is connected intermediate the electrode and the a.c. source to tend to equalize the magnitude of the a.c. potential applied to the electrode during the intervals in the operation of the a.c. corotron in which positive and negative ion current flows. This reduces the magnitude of any offset voltage which may ultimately remain on the charge receiving surface.

4 Claims, 5 Drawing Figures

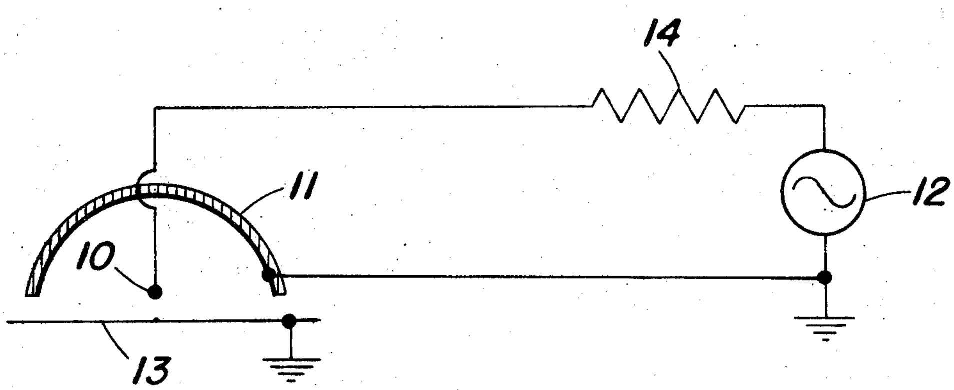


Fig. 1.

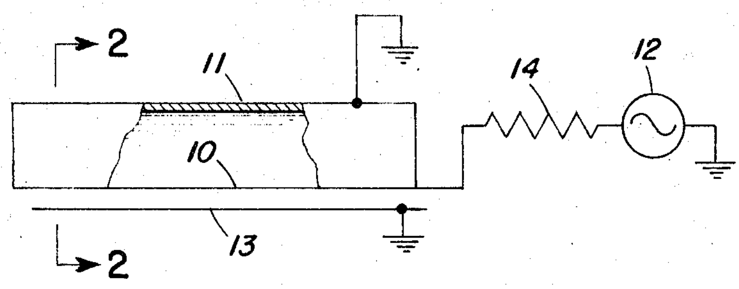
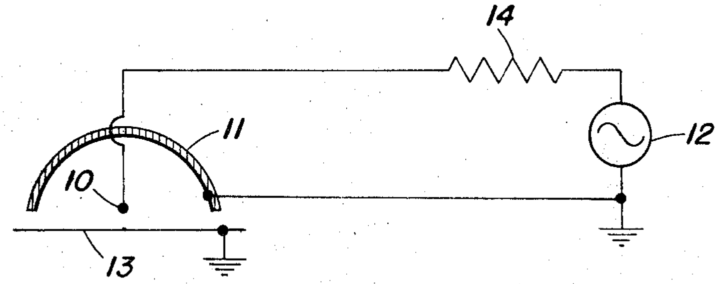


Fig. 2.



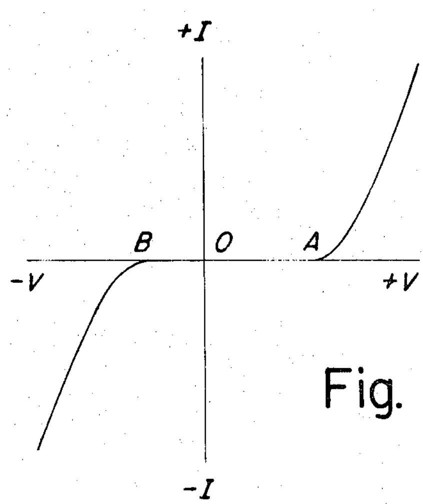


Fig. 3.

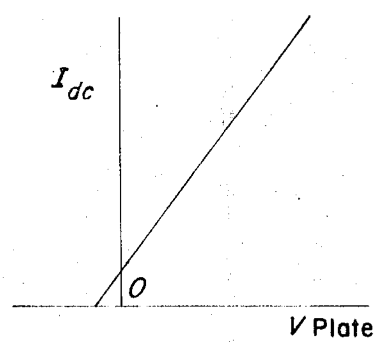
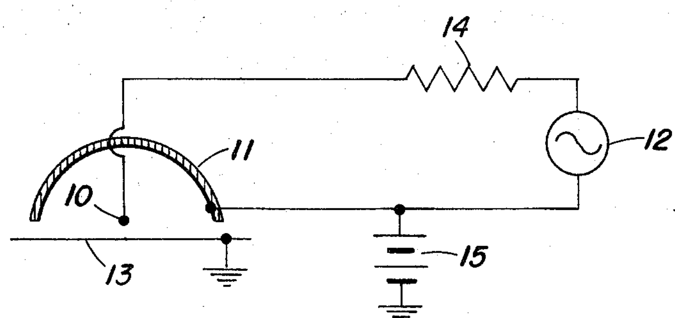


Fig. 4.

Fig. 5.



AC COROTRON

This invention relates to an a.c. corotron utilizing an a.c. voltage for energizing an electrode to produce corona thereat to neutralize an electrostatic charge on a charge receiving surface disposed in proximity thereof, and more specifically to an impedance means embodied in such corotron for controlling the relative magnitudes of positive and negative peak values of the electrode energizing voltage to thereby reduce the magnitude of any offset voltage which may remain on the charge receiving surface.

Electrographic reproduction of the type disclosed in the U. S. Pat. No. 2,297,691, issued to Chester F. Carlson has heretofore been disclosed wherein a uniform layer of electrostatic charge is deposited on the surface of a suitable photoreceptor for selective dissipation in response to modulated radiation imaged thereon to form an electrostatic latent image of an original document. This image is thereafter developed and transferred to a support surface to form a final copy of the document. Also, various devices have been disclosed which deposit a uniform electrostatic charge on the surface of the photoreceptor such as the corona discharge devices disclosed in U.S. Pat. No. 2,777,957 issued to Walkup.

A corona discharge device of a type contemplated herein comprises an elongted corona discharge electrode and a conductive shield partially enveloping the electrode on a lengthwise axis thereof and connected to a reference potential, whereby a charge receiving surface is subject to an electrostatic charge. An a.c. voltage is applied to the electrode for producing thereat a corona discharge which serves to neutralize an electrostatic charge on a surface. It is recognized that, when supplied with an a.c. voltage of sufficient magnitude, a negative corona discharge current is initiated at a lower threshold voltage than the positive corona discharge current. Consequently, more negative ions flow to a charge receiving surface during a given cycle than positive ions. Hence, after neutralization, a negative offset voltage of finite magnitude may remain on the charge receiving surface. This offset voltage impairs the operation of the electrophotographic reproducing device in such manner that low quality images of the reproduced documents result.

The present invention, therefore, contemplates an improved corotron for controlling the instantaneous relative magnitudes of positive and negative peak values of a.c. voltage energizing the corona discharge electrode on a reduce the magnitude of offset voltage remaining on a charge receiving surface.

It is accordingly a principal object of the present invention to provide an improved corotron for use in electrophotographic reproducing apparatus.

Another object is to minimize the magnitude of an unwanted electrostatic charge occurring on a charge receiving surface by an a.c. a corotron.

A further object is to provide an improved corotron for enhancing the quality of images of documents reproduced in an electrophotographic reproducing device.

Additional objects and advantages of the invention are apparent from the following description.

In combination with a prior-art type of corotron (corona discharge device) embodying an elongated wireform corona discharge electrode, and a conductive

shield partially enveloping the electrode along a longitudinal axis thereof and referenced to a potential both the electrode and the shield being disposed in proximity an to a charge receiving surface to be neutralized, voltage wherein an a.c. is supplied to the electrode to produce a corona discharge thereat whereafter an unwanted finite magnitude of offset voltage remains, a specific embodiment of the present invention comprising a resistive impedance interposed between the electrode and a means for supplying an a.c. voltage to the electrode for controlling the instantaneous relative magnitudes of positive and negative peak values of the a.c. voltage whereby the magnitude of the offset voltage remaining on the charge receiving surface is reduced. In this embodiment the positive peak value is made larger than the negative peak value.

A further embodiment concerns the use of a supply of d.c. potential between the reference potential and a point common to the shield and a.c. source for charging the shield surface to a d.c. potential of preassigned polarity and magnitude. Otherwise, the modification operates substantially in the manner of the specific embodiment as hereinbefore mentioned.

The invention is readily understood from the following description taken together with the accompanying drawing in which:

FIG. 1 is a side elevational view of a conventional corona discharge device energized with an a.c. voltage and including a specific embodiment of the invention;

FIG. 2 is essentially a cross-sectional view of a mechanical portion taken along line 2—2 in FIG. 2;

FIGS. 3 and 4 are curves illustrating circuit action obtainable in FIGS. 1 and 2; and

FIG. 5 is a modification of the circuit portion of FIGS. 1 and 2.

FIGS. 1 and 2 illustrate a conventional corotron (corona discharge device) embodying an elongated wire-type electrode 10 partially enveloped by a substantially half-round conductive shield 11 and suitably supported at opposite ends thereof, not shown. This electrode is disposed on a center line which is close to and equidistant from both opposite lengthwise edges of the shield. This shield is connected to a reference ground potential. A supply of a.c. voltage 12 is connected between the electrode and the reference ground potential to produce corona discharge at the electrode. A charge receiving surface 13 is spaced from an open end of the shield in proximity of the electrode to receive corona current therefrom. For the purpose of this description the charge receiving surface 13 is assumed to be a suitable photoreceptor, and may have other applications depending on a particular use of the corona discharge device in given electrophotographic reproducing apparatus.

A conventional use of the apparatus schematically illustrated in FIGS. 1 and 2 is to neutralize an electrostatic charge effective on the photoreceptor surface. Since the major portion of ion current produced at the corona discharge of the electrode flows to the shield, the voltage effective on the electrode at any instant of time is substantially determined by the voltage-ion current relationship between the electrode and the shield. Referring to FIG. 3, it is seen therein that the voltage-ion current relationship between the electrode and shield is asymmetrical with respect to the polarity of the applied voltage at source 12. That is to say, the positive voltage threshold OA is larger than the negative voltage threshold OB.

The result of such asymmetry is that when the alternating current voltage applied to electrode **10** is passed equipotentially about ground, the negative ion current pulses applied to both the shield and the photoreceptor surface are greater in amplitude and duration than the amplitude of the positive ion current pulses applied to both the shield and the photoreceptor surface. As a consequence of the larger amplitude and duration, negative current pulses cause an unwanted offset voltage of finite magnitude to remain on the photoreceptor surface.

In accordance with the present invention, an impedance **14** positioned in series between the electrode and the ungrounded terminal of the a.c. in FIGS. **1** and **2** serves to reduce the magnitude of the above-noted offset voltage remaining on the photoreceptor in the following manner. It is to be noted that the impedance may be of a type which is preferably, but not necessarily, capable of transmitting direct current. It is seen, therefore, that the impedance may be a resistive type.

A high impedance presents a load to the corotron having an effect thereon which may be analyzed by superimposing a corresponding load line onto the graphical representation of FIG. **3**. The load line intersects the positive voltage-ion current curve at a positive current value that is substantially equal to the negative current value at which the negative voltage-ion current curve is intersected. However, because of the asymmetry of FIG. **3**, the positive voltage exceeds the negative voltage at the points of intersection. Hence, the impedance cause the corona discharge to provide substantially equal magnitudes of positive and negative ion current flow to the photoreceptor, by increasing the positive peak voltages with respect to the negative peak voltages supplied by the a.c. supply to the electrode. Stated otherwise, the amplitude of the negative ion current pulses delivered to both the shield and the photoreceptor surface are reduced to a value which is substantially equal to the magnitude of the positive ion current pulses delivered to both the shield and the photoreceptor surface. This substantially reduces the magnitude of the unwanted offset voltage remaining on the photoreceptor surface to a small or approximately zero value.

Since the operational positive and negative peak voltages previously mentioned are determined by the corona characteristics of ambient air proximate to the corotron illustrated in FIGS. **1** and **2**, while the voltage-ion current relationship between the electrode and shield is substantially identical with that shown in FIG. **3**, any ambient air changes which affect the relative and absolute values of the positive voltage-ion current and the negative voltage-ion current are automatically compensated for.

It is to be noted that the magnitudes of the positive and negative ion current pulses effective between the electrode and shield are primarily a function of the voltage differences therebetween. This assumes that at least a small finite amount of ion current is flowing between the electrode and shield. If the potential of the photoreceptor surface admits of a given magnitude and polarity, one of the positive and negative ion current pulses is slightly increased in magnitude while the other is slightly decreased in magnitude. This enables the a.c. corotron to deliver a net value of direct current to the photoreceptor surface in response to a charge on said surface. That is to say, the voltage difference between the electrode and the surface permits the delivery of a net value of direct current to the photoreceptor surface as illustrated in FIG. **4**. It is desired that the plot of d.c. corona current (I_{dc}) and electrode voltage (V_{plate}) in FIG. **4** intersect at origin O and exhibit maximum slope; hwoever, the small negative offset voltage that remains after neutralization of the surface results from the delivery of net negative d.c. current as just described.

FIG. **5** is a modification of FIGS. **1** and **2** in that a supply **15** of d.c. potential has a positive terminal connected to shield **11** and the other terminal of a.c. source **12** and a negative terminal to the reference potential. This supply charges the shield surface to a voltage of preassigned polarity and magnitude, the latter being substantially equal to the terminal voltage of supply **15**. In this manner, the aforedescribed offset voltage may be completely reduced to zero if the voltage provided by supply **15** is equal to the offset voltage. Otherwise, the operation of FIG. **5** is identical with that of FIGS. **1** and **2** as hereinbefore described. It should be recognized that the photoreceptor surface may be charged to a desired value substantially equal to the magnitude and polarity of supply **15**.

One example of parameters used in FIGS. **1, 2** and **5** comprise: shield **11** having an internal diameter of ⅝ inches; electrode **10** having a diameter of 3 mils and a length of 10 inches, which is approximately coextensive with the length of shield **11**; an operating voltage of 7 kilovolts zero to peak, and a frequency of 60 HZ for source **12** for inducing a corona current of the order of 35 microamps per inch of the electrode; a series resistor on the order of 10 megohms; and a voltage of 50 volts for supply **15** in FIG. **5**. It has been experimentally ascertained that a net corona current of 5 microamps per inch is delivered to the photoreceptor surface if said surface exhibits a potential of +1000 volts.

A modification of the embodiments illustrated in FIGS. **1, 2** and **5**, although not shown, contemplates the use of a conventional a.c. transformer to couple the a.c. voltage produced by source **12** to the electrode **10**. It may be appreciated that impedance **14** may, therefore, be connected in series with source **12** in the primary circuit of the transformer. One of ordinary skill in the art will recognize that the effective impedance thus connected in series with the electrode is a function of the turn ratio of the primary and secondary coils of the transformer. Accordingly, the turns ratio may be selected such that a higher impedance is reflected into the secondary circuit. This well-known intrinsic property of transformers may be advantageously exploited by utilizing a low impedance exhibiting preferable power dissipation characteristics in the primary circuit while achieving the desired results that may be obtained from using a high impedance connected in series with the electrode. Similarly, a precise commercially available low voltage variable impedance may be connected in the primary circuit to attain results not readily derived from impedances series connected to the electrode because precise, high voltage variable impedances are not readily found in the market place.

It is understood that the invention herein is described in specific respects for the purpose of this description. It is also understood that such respects are merely illustrative of an application of the invention as hereinbefore described. Other arrangements may be derived by those skilled in the art without departing from the spirit and scope of the invention as evidenced by the appended claims.

What is claimed is:

1. Corotron apparatus for nuetralizing a charge receiving surface comprising in combination;

an elongated electrode;

a shield partially surrounding said electrode, said shield being maintained at a reference potential;

impedance means coupled to said electrode for equalizing the relative magnitudes of positive and negative voltage applied to the coronode when ion current flows from the electrode; and

means for supplying an a.c. voltage to said electrode to effect a corona discharge thereat, said last named means being connected intermediate said impedance means and a reference potential and said charge receiving surface being maintained in a fixed relationship with respect to said reference potential.

2. Corotron apparatus as defined in claim 1 wherein said reference potential is maintained at ground potential.

3. Corotron apparatus as defined in claim 1 wherein said impedance means is a resistor.

4. Corotron apparatus for charging a charge receiving surface comprising in combination;

an elongated electrode;

a shield partially surrounding said electrode;

impedance means coupled to said electrode for equalizing the relative magnitudes of positive and negative voltage applied to the electrode when ion current flows therefrom;

first means for supplying an a.c. voltage to said electrode to effect corona discharge thereat, said first means being connected intermediate said impedance means and a reference potential; and

second means for supplying a d.c. potential to said shield, said second means being connected intermediate said shield and said reference potential for charging said charge receiving surface to a potential of the same polarity as said d.c. potential, said charge receiving surface being maintained in a fixed relationship with respect to said reference potential.

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