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[54] **AUTOMATIC POTENTIAL CONTROL SYSTEM FOR ELECTROPHOTOGRAPHY APPARATUS**  
 17 Claims, 3 Drawing Figs.

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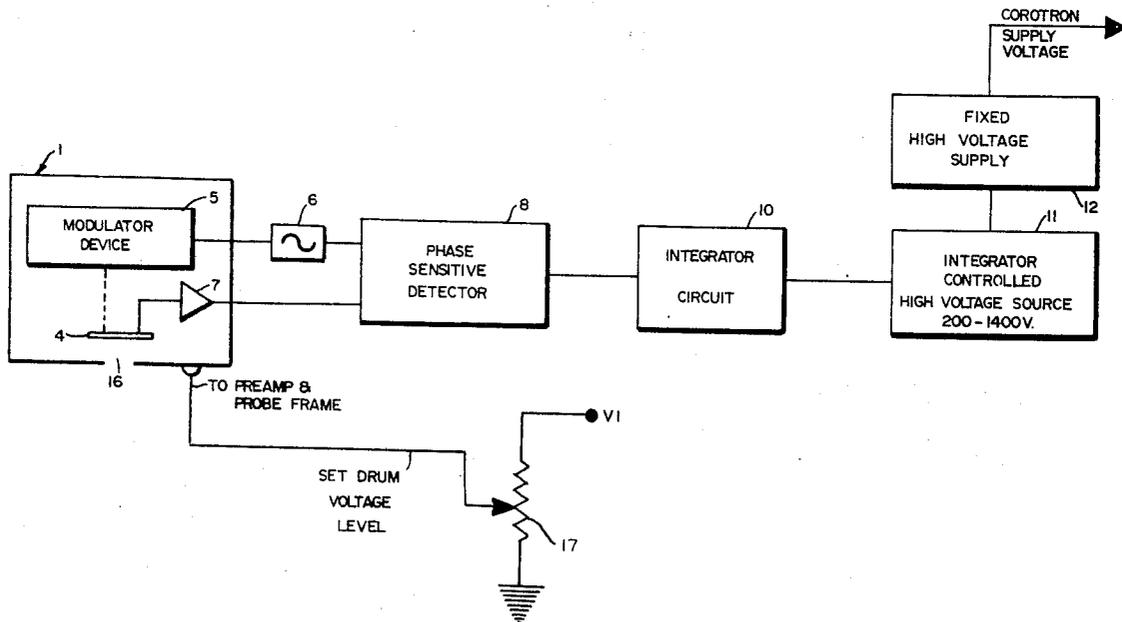
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 4; 250/49.5; 323/19, 22, 100; 324/32

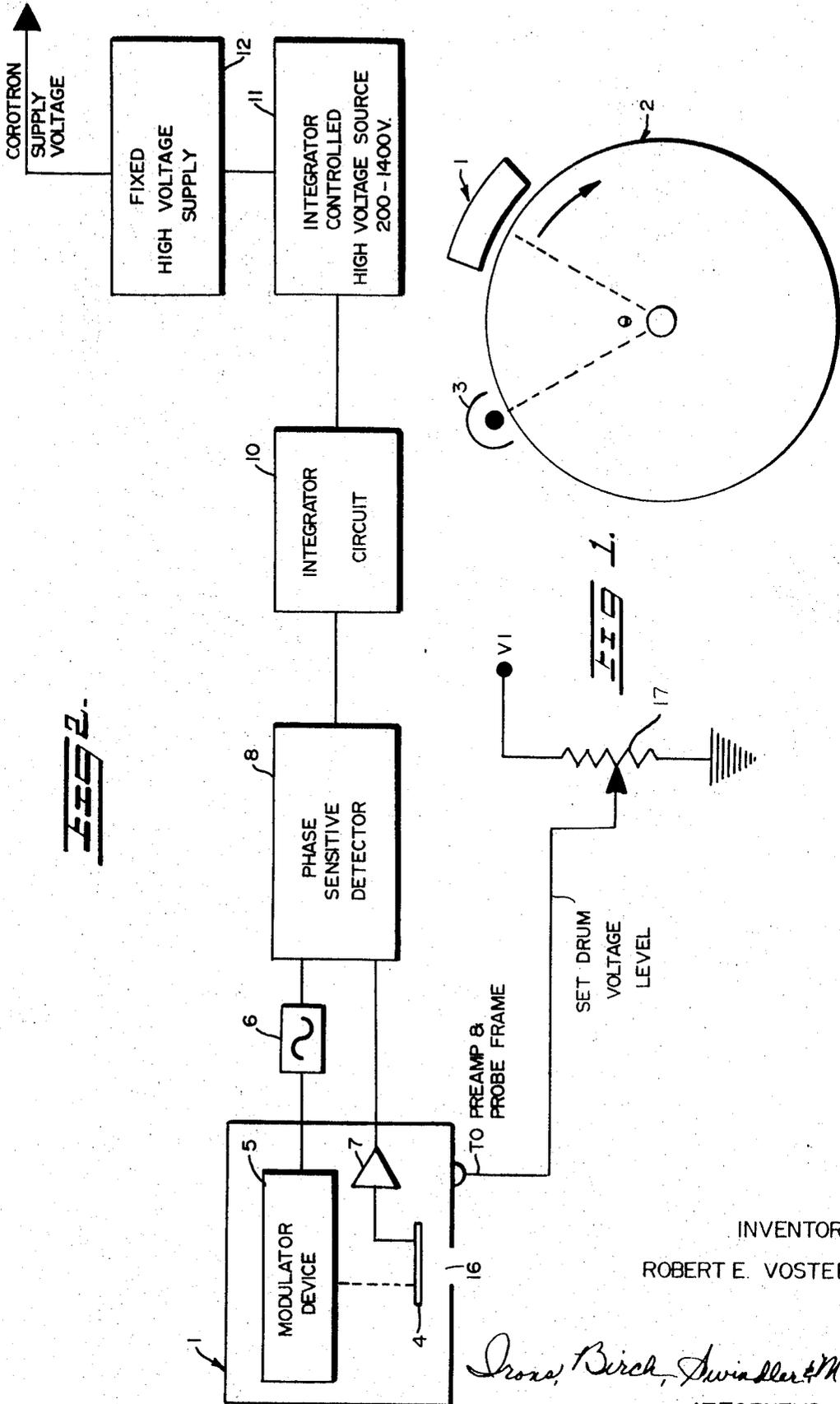
**ABSTRACT:** An automatic potential control system for use with electrophotography apparatus having a corona generator to maintain a surface at a preset fixed potential value. A detector is electrostatically coupled to the surface and produces a control signal indicative of the magnitude and polarity of the potential difference of the surface relative to the preset fixed potential. Integrator means are connected to the output of the detector and control a high voltage supply to supply a corresponding input voltage to the corona generator to cause the latter to charge the surface to the preset fixed potential value.

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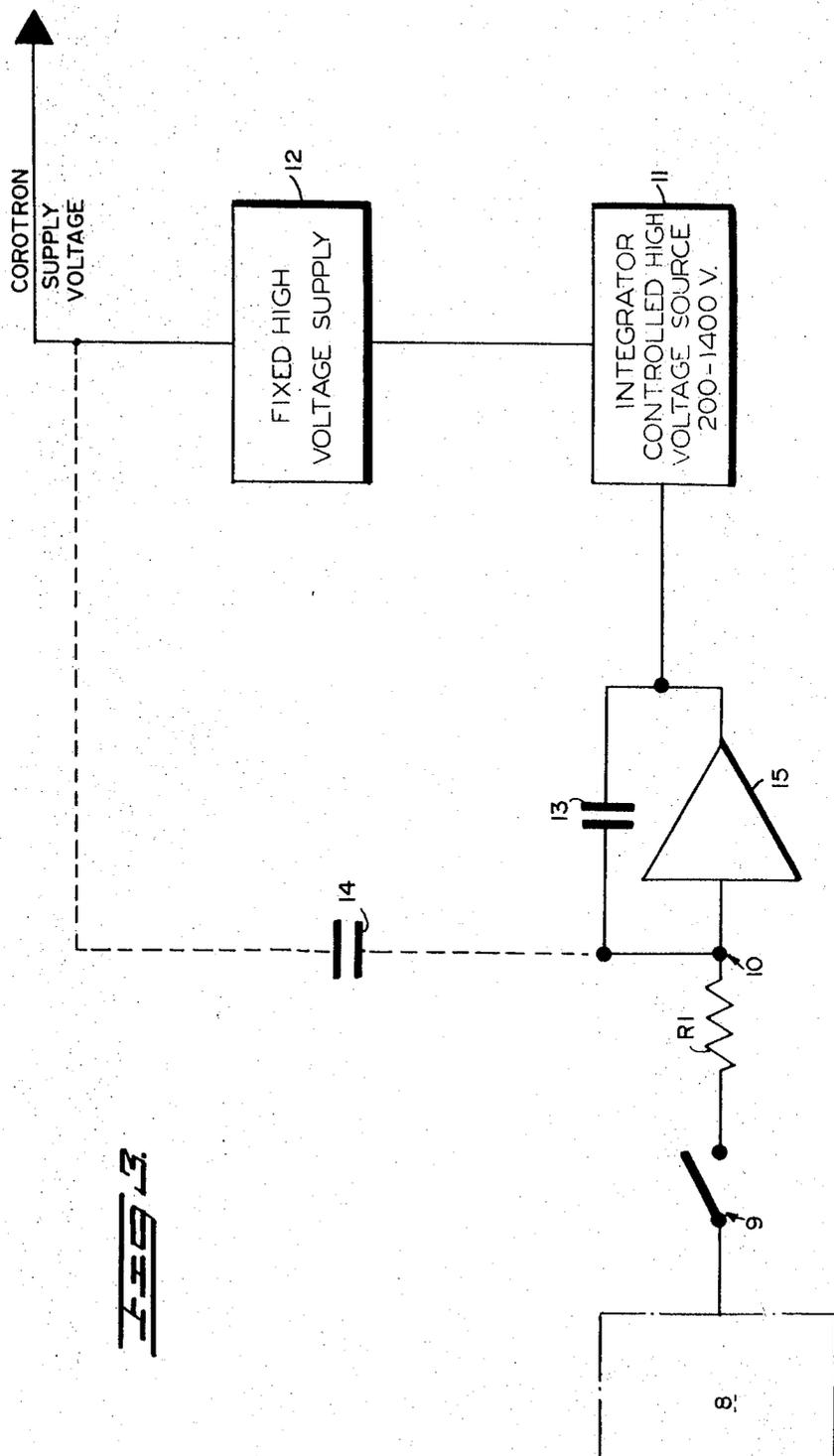
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**FIG. 2**

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## AUTOMATIC POTENTIAL CONTROL SYSTEM FOR ELECTROPHOTOGRAPHY APPARATUS

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The invention relates to an automatic surface potential control system. It has particular use in electrophotography, and more particularly, in xerography.

#### 2. Description of the Prior Art

In electrophotography in general and xerography in particular, a reproducible copy can be produced if a constant voltage is accepted on the photosensitive surface immediately prior to imaging. The surface is usually charged by a linear charge generator commonly called a corotron, and the relative velocity between the corotron and the surface-to-be-charged determines the resultant surface charge density. This surface charge density and the thickness and makeup of the dielectric of the surface-to-be-charged determines the voltage on the surface immediately prior to imaging.

It is well known that the current-per-unit length from the corotron, which is basically a corona generator, is a function of:

1. Corotron-to-surface spacing,
2. Applied corotron voltage,
3. Ambient pressure,
4. Ambient temperature,
5. Ambient relative humidity.

The above enumerated factors can vary with time thereby producing a variable photoreceptor voltage. The thickness, dielectric constant, and dielectric leakage of the photoreceptor can vary from receptor to receptor and as a function of time.

### SUMMARY OF THE INVENTION

This and other disadvantages of the prior art are cured by the present invention which provides for regulation for the photoreceptor voltage to enable the production of a more reproducible photocopy.

The invention discloses the use of a detector to derive an indication of the magnitude and polarity of the surface potential difference relative to the preset fixed potential. A corona generator is employed to charge the surface to a preset fixed value which is adjustable. In the embodiment shown, the detector is angularly spaced in the forward direction relative to the corona generator, with respect to rotation of a drum surface, such that significant airborne corona charge does not exist between the drum surface and the detector.

The detector is electrostatically coupled to the surface and produces a control signal indicative of the magnitude and polarity of the potential difference of the surface relative to the preset fixed potential. Integrator means are connected to the detector and control a high voltage supply to supply a corresponding voltage to the corona generator to cause the latter to maintain the surface at the preset fixed value.

Switch means may be connected between the output of the detector and the input of the integrator means to restrict the input to the integrator means to those times when a valid sample is being measured by the detector. Additional capacitance means may be connected between the input of the integrating means the output of the high voltage supply, and the relative capacitance values of the integrating means and the additional capacitance means can be selected such that the system can correct relatively faster variations between the actual and preset fixed surface potential values.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block circuit diagram of the automatic potential control system according to the invention;

FIG. 2 is a block diagram showing use of the invention with a rotating drum;

FIG. 3 is a circuit diagram illustrating a modification of the invention shown in FIG. 1.

### DETAILED DESCRIPTION OF THE INVENTION

FIG. 2 shows the principle of operation of the invention as applied to a xerographic drum potential control system. Detector probe 1 is an electrostatic modulator positioned in close proximity to xerographic drum 2 which rotates in the direction indicated. The detector probe may, for example, be one of the types used in the electrostatic modulators described in applicant's copending Pat. applications Ser. Nos. 567,973, filed July 26, 1966; 759,913, filed Sept. 16, 1968; and 767,147, filed Oct. 14, 1968. These respectively employ a rotating disc modulator, a vibrating capacitor modulator, and a tuning fork modulator. Other types of electrostatic modulators may also be used.

Detector probe 1 is positioned in forward direction relative to corotron 3, with respect to the direction of rotation of drum 2. Corotron 3 comprises a corona generator angularly displaced from detector probe 1 by angle  $\theta$ , which is sufficiently large such that no significant airborne corona charge exists between detector probe 1 and drum 2. The detector probe is spaced approximately one-eighth of an inch from the surface of the drum.

With reference to FIG. 1, the frame of detector probe 1 and its associated electronic circuitry are connected to an adjustable reference potential designated set drum voltage level. The reference potential level is determined by the setting of potentiometer 17 in conjunction with reference voltage source V1.

The detector probes described in the above-identified patent applications basically comprise a sensitive electrode which, with reference to FIG. 1, is designated by identification numeral 4. The configuration of detector probe 1 shown in FIG. 2 is meant to be a generic representation of detector probes of electrostatic modulators that may be exemplarily used according to the invention. These have a modulator device 5 operative in conjunction with sensitive electrode 4 to cause an AC voltage having a magnitude determined by the DC difference potential between the unknown drum potential and the reference potential to be produced on sensitive electrode 4. The phase of the described AC voltage relative to that of signals supplied by reference oscillator 6 is determined by the DC polarity of this potential difference. The AC voltage produced at sensitive electrode 4 is fed to preamplifier 7.

The operation of the electrostatic modulator generically shown in FIG. 2 is as follows. The detector probe and particularly sensitive electrode 4 is positioned in electrostatic coupling relationship with the surface of drum 2 to produce a detector signal at the sensitive electrode indicative of the magnitude and polarity of the actual surface potential of the drum. Sensitive electrode 4 is exposed to the surface of the drum through window 16 of the probe housing frame. Reference oscillator 6 produces reference signals at a predetermined frequency which causes modulator device 5 to vary the coupling relationship and thereby produce modulated detector signals having a carrier frequency equal to the predetermined frequency. The modulated detector signals are applied to preamplifier 7.

Reference oscillator 6 is also connected to one input of phase sensitive detector 8 and the output of preamplifier 7 is connected to the other input of phase sensitive detector 8. The latter therefore receives reference signals from oscillator 6 and modulated detector signals, at fixed phase relationship with respect to the reference signals, from preamplifier 7. After demodulation, an output signal indicative of the magnitude and polarity of the actual surface potential difference of drum 2 relative to the preset fixed potential is provided at the output of phase sensitive detector 8.

As described in some of the above-identified applications, individual isolation transformers may be interposed between reference oscillator 6 and phase sensitive detector 8 and also between the preamplifier 7 and the phase sensitive detector 8. There would normally be a common power supply for reference oscillator 6 and preamplifier 7 but reference oscilla-

tor 6 may operate relative to ground potential with its associated isolation transformer feeding modulator device 5. The set drum voltage level is connected to the frame of the preamplifier and probe, as shown in FIG. 1, thus establishing the preset fixed potential.

The output of the phase sensitive detector is a DC signal having a magnitude which is linearly related to the AC input thereto. It has a polarity that reverses with phase reversal of the input signal thereto. The output of the phase sensitive detector is connected to integrating circuit 10 which drives integrator controlled high voltage source 11. The latter drives a floating, fixed high voltage supply 12, which may be supplied by the xerography machine being utilized.

The operation of the described system may be illustrated by assuming exemplary values. However, the invention is not limited to such values and a wide range of other values would also be suitable.

A typical range of corotron supply voltage required to drive a given corotron under an exemplary range of (a) corotron-to-drum spacings, (b) ambient temperature, (c) pressure and (d) relative humidity, while maintaining a constant drum voltage might be 54000 to 66000 volts. If a minimum integrator controlled high voltage source output of 200 volts is assumed, a fixed high voltage supply source 12 of 5200 volts should be connected in series with the controlled source 11.

Further, assume a set drum voltage level of 600 volts and an actual drum surface voltage of 590 volts. With the drum voltage being 10 volts less than the set level, a corresponding AC voltage would be produced at sensitive electrode 4 and this would be amplified by preamplifier 7. The output of the preamplifier would be demodulated by phase sensitive detector 8, and the demodulated output thereof would be fed through to integrating circuit 10. The output of the latter would thereby increase and cause a corresponding increase in the output of integrator controlled high voltage source 11 and consequently total corotron supply voltage. The corotron supply voltage applied to the input of the corotron, and thereby the corotron current, would thereby increase.

The increase in corotron current causes a corresponding increase in the drum surface charge density and thus an increase in the drum surface potential. The system shown in FIGS. 1 and 2 would stabilize when the actual drum potential equals the set level, and would automatically function to maintain this condition.

FIG. 3 shows one type of integrating circuit that may be used. It consists of amplifier 15 connected to function as an operational amplifier having feedback capacitor 13 and input resistor R1. The capacitance of capacitor 13 must be chosen in consideration of the geometry and speed of rotation of the drum in order to optimize speed-of-response of the system. The system would be unstable and oscillatory if capacitor 13 is too small, and the speed-of-response would be excessively slow if capacitor 13 is too large.

The circuit may be modified by connecting capacitor 14 between the input of amplifier 15 and the output corotron supply voltage and reducing the value of capacitor 13 relative to the value thereof in the absence of capacitor 14. The system would then be rendered capable of responding to faster changes in "fixed" voltage supply 12, assuming integrator controlled high voltage source 11 has a corresponding speed-of-response capability.

By interposing switch 9 between the output of phase sensitive detector 8 and the input of integrator circuit 10, the integrator input can be restricted to those times when a valid sample is being measured by detector probe 1. This provides discontinuous sampling that might be required when plates or sheets, as opposed to drums, are being used in conjunction with the invention.

Thus the invention is not limited to use with drum 2, but may also be used in conjunction with plates and sheets. The integrator circuit 10 memorizes the result of the immediate preceding sample, and may thereby serve as an initial condition for correcting subsequent samples.

Fixed high voltage supply 12 can vary slowly without adversely influencing the performance of the system provided (a) the rate-of-change of the "fixed" voltage is less than the maximum rate-of-change capability of the controller, and (b) the maximum change of the "fixed" voltage of the drum is within the capability of integrator controlled high voltage source 11 to supply in addition to that previously specified.

The high voltage portion of the circuit of FIGS. 1 and 3 consists of a fixed high voltage supply 12 series connected to integrator controlled high voltage source 11. A single controllable supply, controlled by the low voltage integrator output, may be substituted for elements 11 and 12, if desired, for purposes of economy or simplicity of design.

I claim:

1. An automatic potential control system for use with electrophotography apparatus having a corona generator to maintain a surface at a preset fixed potential comprising:

a detector electrostatically coupled to the surface to produce a control signal indicative of the magnitude and polarity of the potential difference of the surface relative to the preset fixed potential;

integrator means connected to the output of the detector, and a high voltage supply connected to the output of the integrator means and controlled by the latter to supply a corresponding voltage to the corona generator to cause the latter to maintain the surface at the preset fixed potential.

2. An automatic potential control system as recited in claim 1 further comprising:

an integrator controlled high voltage source interposed between the output of the integrator means and a series connected fixed high voltage supply.

3. An automatic potential control system as recited in claim 1 further comprising:

switch means connected between the output of the detector and the input of the integrating means to cause the input of the latter to be restricted to those times when a valid sample is being measured by the detector.

4. An automatic potential control system as recited in claim 1 wherein the integrating means comprises first capacitance means.

5. An automatic potential control system as recited in claim 4 further comprising:

second capacitance means connected between the input of the integrating means and the output of the high voltage supply, the relative capacitance values of the first and second capacitance means being selected such that the system can correct relatively fast variations between the actual and preset fixed surface potential values.

6. An automatic potential control system as recited in claim 5 further comprising:

an integrator controlled high voltage source interposed between the output of the integrator means and a series connected fixed high voltage supply.

7. An automatic potential control system as recited in claim 6 further comprising:

switch means connected between the output of the detector and the input of the integrating means to cause the input of the latter to be restricted to those times when a valid sample is being measured by the detector.

8. An automatic potential control system as recited in claim 1 wherein the integrating network comprises an amplifier connected as an operational amplifier having associated feedback capacitance means connected between its output and input, and input resistance means.

9. An automatic potential control system as recited in claim 8 further comprising:

additional capacitance means connected between the input of the amplifier and the output of the high voltage supply, the relative capacitance values of the feedback and additional capacitance means being selected such that the system can correct relatively fast variations between the actual and preset fixed surface potential values.

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10. An automatic potential control system as recited in claim 9 further comprising:

switch means connected between the output of the detector and the input resistance means to cause the input of the integrating means to be restricted to those times when a valid sample is being measured by the detector.

11. An automatic potential control system as recited in claim 1 wherein the surface being measured is in the form of a rotating drum, the detector being positioned in forward direction relative to the corona generator, with respect to the direction of rotation of the drum, by a predetermined angular distance which is sufficient to prevent the existence of any significant airborne corona charge between the detector and the surface of the drum.

12. An automatic potential control system as recited in claim 11 further comprising:

an integrator controlled high voltage source interposed between the output of the in generator means and a series connected fixed high voltage supply.

13. An automatic potential control system as recited in claim 11 further comprising:

switch means connected between the output of the detector and the input of the integrating means to cause the input of the latter to be restricted to those times when a valid

sample is being measured by the detector.

14. An automatic potential control system as recited in claim 11 wherein the integrating means comprises first capacitance means.

15. An automatic potential control system as recited in claim 14 further comprising:

second capacitance means connected between the input of the integrating means and the output of the high voltage supply, the relative capacitance values of the first and second capacitance means being selected such that the system can correct relatively fast variations between the actual and preset fixed drum potential values.

16. An automatic potential control system as recited in claim 15 further comprising:

an integrator controlled high voltage source interposed between the output of the integrator means and a series connected fixed high voltage supply.

17. An automatic potential control system as recited in claim 16 further comprising:

switch means connected between the output of the detector and the input of the integrating means to cause the input of the latter to be restricted to those times when a valid sample is being measured by the detector.

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