

Feb. 17, 1970

G. W. CUNNINGHAM, JR.
CORONA CONTROL CIRCUIT FOR STEPPING XEROGRAPHIC
RECORDING APPARATUS

3,496,351

Filed March 2, 1966

2 Sheets-Sheet 1

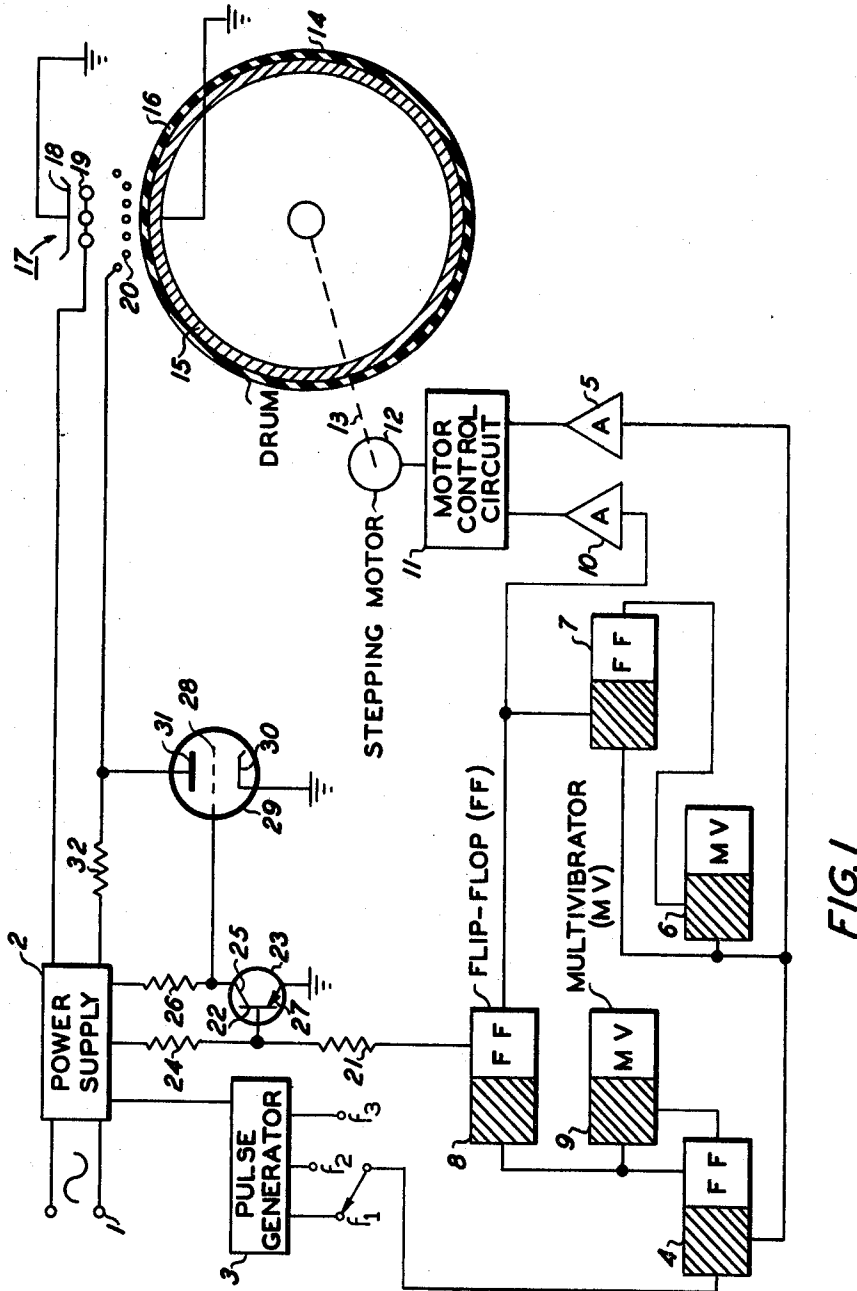


FIG. 1

INVENTOR.
GERALD W. CUNNINGHAM JR.

BY *Anthony J. Cunningham*
Paul W. Fink
ATTORNEYS

Feb. 17, 1970

G. W. CUNNINGHAM, JR.
CORONA CONTROL CIRCUIT FOR STEPPING XEROGRAPHIC
RECORDING APPARATUS

3,496,351

Filed March 2, 1966

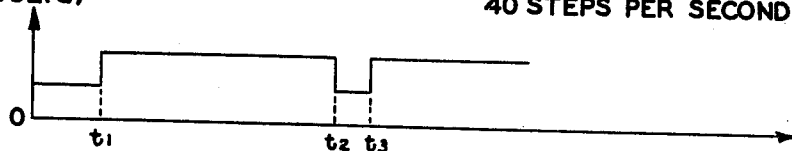
2 Sheets-Sheet 2

SCREEN POTENTIAL

(VOLTS)

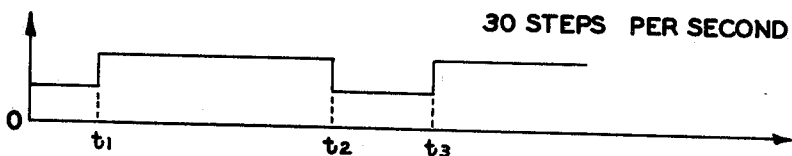
40 STEPS PER SECOND

FIG. 2A



30 STEPS PER SECOND

FIG. 2B



20 STEPS PER SECOND

FIG. 2C

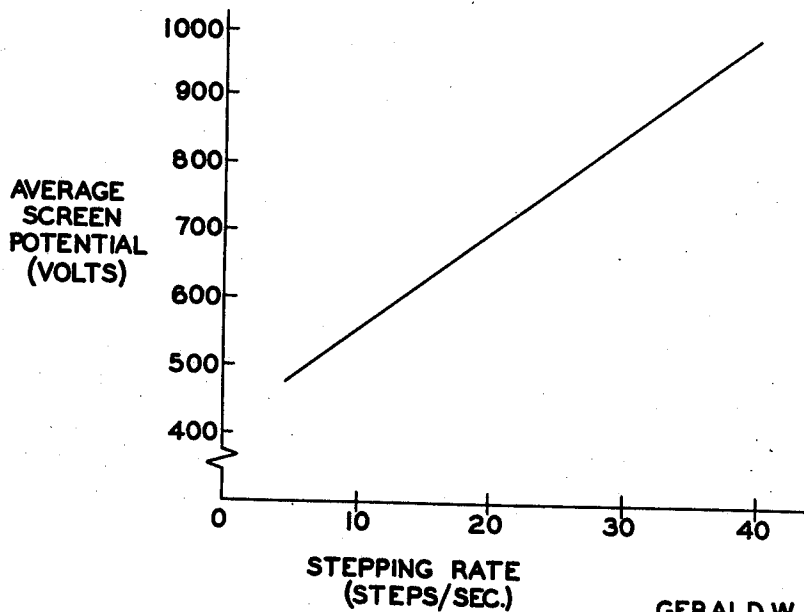
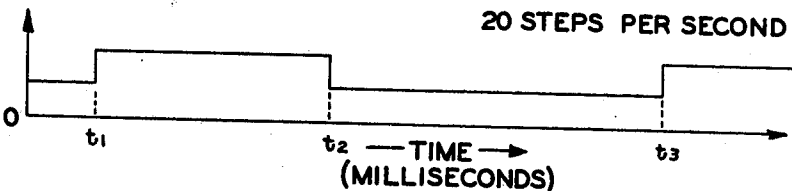


FIG. 3

INVENTOR.
GERALD W. CUNNINGHAM JR.

BY *Anthony D. Cunningham*
Paul W. Fitch
ATTORNEYS

1

3,496,351

CORONA CONTROL CIRCUIT FOR STEPPING XEROGRAPHIC RECORDING APPARATUS

Gerald W. Cunningham, Jr., Penfield, N.Y., assignor to Xerox Corporation, Rochester, N.Y., a corporation of New York

Filed Mar. 2, 1966, Ser. No. 531,266

Int. Cl. H01j 37/26; G03g

U.S. Cl. 250—49.5

10 Claims

ABSTRACT OF THE DISCLOSURE

A stepping xerographic recording apparatus wherein a corona control circuit maintains an average potential difference between the screen electrode and the coronode of a scorotron which is linearly proportional to the stepping rate of the xerographic plate member in the recording apparatus.

This invention relates in general to xerography and, in particular, to an improved control circuit for a xerographic reproducing apparatus.

More specifically, the invention relates to an improved control circuit for controlling the charging of a xerographic plate in a xerographic apparatus for use in producing reproductions in a step-by-step mode of operation.

In the process of xerography, a xerographic plate, comprising a layer of photoconductive insulating material on a conductive backing, is given a substantially uniform electrostatic charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. The exposure discharges the plate areas in accordance with the radiation intensity which reaches them and thereby creates an electrostatic latent image on the plate coating. The electrostatic latent image, thus formed on the plate, can then be utilized, as for example, by developing the image with a suitable toner material to render a visible image corresponding to the latent electrostatic image.

Since the disclosure of the basic concept of xerography, a variety of machines and devices have been proposed to incorporate such techniques in a manner to form copies xerographically on a commercial basis. In one type of commercially available automatic xerographic reproducing machines, the xerographic plate is formed in the shape of a drum which is rotated at a uniform speed through the various processing stations of the apparatus, including a charging station in which a uniform electrostatic charge is deposited on the photoconductive layer of the xerographic drum.

Now in order to extend the use of xerography into other fields of communications, such as its use in a communications printer or similar device, it may be desirable to project the image of a document to be reproduced onto a uniformly charged xerographic plate in piecemeal fashion. More specifically, a discrete portion of the document may be imaged on a corresponding area of the xerographic plate which is motionless during this exposure. In other words, the document may be imaged stepwise, for example, a line at a time, by suitable optical scanning device, while the xerographic plate is being moved in a step-by-step mode. Between steps, the plate is motionless and this period will hereinafter be referred to as dwell time. In this manner, successive portions of the document are scanned in a step-by-step manner to project step-by-step line scan images on successive portions of the xerographic plate to form a latent electrostatic image thereon. The successive previously exposed portions of the xerographic plate, having completed the exposure process, are advanced in the same step-by-step mode toward another position in the path to be taken

2

by the xerographic plate for further utilization, such as, for example, a developing operation to effect a visible image on the xerographic plate. This step-by-step mode of operation of the xerographic apparatus will hereinafter be referred to as stepping xerography.

One important process, to which the plate is subjected prior to the exposure operation, is the charging of the plate to a uniform charge potential. This operation is performed by a suitable charging device, such as a corona charging device, for example, a scorotron.

The scorotron may be of a type disclosed in U.S. Patent No. 2,777,957, issued to L. E. Walkup, Jan. 15, 1957, which generally consists of a plurality of control screen wires strung parallel to a conductive shield, and a plurality of coronode corona discharge wires arranged parallel to and between the screen wires and the conductive shield. Suitable potential is supplied from a source to the coronode wires which then emit corona current. When arranged for charging a xerographic plate, a portion of the corona passes through the control screen wires to be applied to the photoconductive surface of the plate, and excess corona is suppressed and drained off by the control screen wires. The magnitude of corona imparted from the scorotron is a function of both coronode potential and screen potential among other factors, such as coronode-plate spacing, coronode wire size, etc.

In a conventional xerographic apparatus, the xerographic plate is moved at a uniform speed relative to the scorotron or other corona generating device, whereby, for a uniform potential applied to the corona discharge wires and a constant voltage applied to the control screen of the scorotron, for example, a uniform potential will be applied to the xerographic plate. That is, for uniform movement between a xerographic plate and a corona charging unit, uniform charging of the xerographic plate will occur, all other factors affecting the charging process being equal.

However, in the case of stepping xerography, wherein the xerographic plate is advanced in step-by-step motion, a section or area of the plate is advanced to the charging station and then it remains motionless for a period of time. Thus, during both the period of time the plate is being advanced and during the period in which the plate is motionless, the dwell time, this area of the plate will be under the influence of the charging unit. The dwell time can vary depending on the stepping rate of the plate. Under this mode of operation, using a conventional corona charging device and a conventional charge control circuit for the corona charging device, a non-uniform electrostatic charge will be placed on the xerographic plate.

For example, if the charge control circuit is set whereby the corona charging device will apply a uniform charge to the xerographic plate while it is in motion, non-uniform charging will occur when the xerographic plate is motionless during the dwell time, resulting in an overall non-uniform charge being applied to the xerographic plate. Under this arrangement, the non-uniformity of charge would depend on the length of the dwell time or variation of the dwell time. The significance of the dwell time as a factor affecting the charging operation increases when this time is varied during the reproduction of one document or even between consecutive documents to be reproduced. This variance in dwell time is a result of varying the stepping rate of the xerographic plate. As the stepping rate is varied, the dwell time also varies. Since the charge on the plate varies in direct proportion to the time it is subject to the corona, the longer the dwell time, the higher becomes the charge on the plate. It is obvious that an unequal charge dis-

tribution on the plate is objectionable and excessive charging may occur which may fatigue the photoconductive material on the xerographic plate. Also, a grossly uneven charge distribution will result in an extreme variation in the latent electrostatic charge pattern which causes an undesirable variation in toner density when the latent electrostatic image is developed.

It is, therefore, an object of this invention to improve xerographic reproducing apparatus for use as a communication printer or similar device, the xerographic apparatus being capable of making copies on a line-by-line basis.

Another object of this invention is to improve control of the application of electrostatic charge from a corona generating device to a xerographic plate.

A still further object of this invention is to improve the control circuit for a corona charging device for use in charging the xerographic plate in a stepping xerographic apparatus whereby a uniform electrostatic charge is applied to the xerographic plate at any stepping rate of the xerographic plate.

These and other objects of the invention are accomplished by means of a control circuit which generates appropriate pulses to control the average potential difference between the coronode and the control screen of a scorotron thereby providing a uniform electrostatic charging of the xerographic plate.

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

FIG. 1 is a schematic illustration of a stepping xerographic apparatus and wiring diagram of the control circuit embodying the present invention for the xerographic apparatus;

FIGS. 2A, 2B, and 2C represent waveforms useful in understanding the scorotron control circuit of FIG. 1, and

FIG. 3 is a plotted curve showing the relationship between the average screen electrode potential of the scorotron and the stepping rate of the xerographic plate in accordance with the present invention.

Before a detailed description of the invention is given, it is noted that the flip-flops and multivibrators used in the circuit of FIG. 1 are actuated only by a positive pulse. By the term "positive pulse" it is meant a change in voltage levels from one level to a more positive level. An opposite change in voltage levels is referred to as a negative pulse. The cross hatched portion of the schematic symbol for these components is referred to as the set side, while the remaining portion is referred to as the reset side. As is well known in the art, a positive pulse to the input of the set side is said to set that component while with the exception of the multivibrators which are monostable, such an input to the reset side is said to reset that component. These components are in their reset condition before the operation of the circuit begins. Examples of suitable flip-flop and multivibrator design for utilization in the circuit of FIG. 1 are shown in Harmon Kardou's publication "Digital Logic," Catalog No. 515, at pages 11 and 12, respectively. However, it is to be understood that any conventional design may be used.

Now referring to FIG. 1, there is illustrated a schematic of a stepping xerographic apparatus and a control circuit for the apparatus. The control circuit has a conventional power supply 2 to which is applied alternating voltage from terminals 1. This power supply may comprise a conventional arrangement of transformers, rectifiers, filters, and voltage dividers to provide the necessary magnitudes of voltage of the proper polarity to various parts of the circuit which will be referred to in more detail hereinafter. Power supply 2 provides the power necessary to operate a conventional pulse generator 3 which generates a train of pulses at a frequency which corresponds to the desired stepping rate. This generator

may be of the type which can be adjusted to provide outputs having any frequency over a range of frequencies. This feature is shown symbolically by output taps f_1 , f_2 , and f_3 .

In order to better explain the novel features of the invention the operation of the circuit of FIG. 1 will be sub-divided into two areas of operation: (1) the control of the stepping motor, and (2) control of the charging device.

Referring now to the control of the stepping motor, it is seen that the pulse generator 3 provides an input to flip-flop 4 to set this component for each positive pulse in the pulse train. When flip-flop 4 is actuated to its set condition, the output from its reset side sets flip-flop 8 and multivibrator 9. The output of flip-flop 8 will be discussed in more detail hereinafter. The delay time of the monostable multivibrator 9 is determined by the time which is required to energize the stepping motor 12 in order to achieve the desired step.

The time delay in multivibrator 9 is dependent upon the inertia of the xerographic plate which is the load on the stepping motor, as well as the particular design of the motor itself. For example, a flat xerographic plate may require a longer motor energization time than would a cylindrical xerographic plate. However, once this time is established, the delay of multivibrator 9 is set accordingly.

Flip-flop 4 also provides an output from its set side to the set side of multivibrator 6 and flip-flop 7 in addition to the input of a conventional amplifier 5, which will be referred to as the power pulse amplifier since the pulse it amplifies provides the energization to the stepping motor 12 to effect rotation thereof. This power pulse is of an amplitude equal to the voltage level difference of the negative pulse from the set side of flip-flop 4 and of a duration equal to the time delay of multivibrator 9. Therefore, it is seen that when the time delay of multivibrator 9 has expired thereby resetting flip-flop 4, the power pulse to the input of amplifier 5 is terminated.

The positive pulse from the set side of flip-flop 4 which terminated the power pulse also sets multivibrator 6 and flip-flop 7. The output from the set side of flip-flop 7 provides an input to the reset side of flip-flop 8 and to amplifier 10. This amplifier is of conventional design as was amplifier 5 and is referred to as the brake pulse amplifier since it amplifies the pulse which provides the energization to the stepping motor to effect its braking after a predetermined arc of rotation. The negative pulse at the output of flip-flop 7 when that flip-flop is set forms the leading edge of a brake pulse which is supplied to the input of brake pulse amplifier 10. This brake pulse is then amplified and supplied to conventional motor control circuit 11 as is also the case with the amplified power pulse at the output of power pulse amplifier 5. The brake pulse is terminated when the time delay in monostable multivibrator 6 expires thereby providing from its set a side positive pulse which resets flip-flop 7.

The time delay of multivibrator 6, like that of multivibrator 9, is dependent upon the characteristics of stepping motor 12 and the inertia of its load.

At the instant of the termination of the brake pulse, the stepping motor 12 comes to rest and, accordingly, via suitable mechanical linkage (shown symbolically by broken line 13) between it and the xerographic plate 14, the xerographic plate 14 also becomes motionless after having traveled one step. In summary then it is clear that for each positive pulse in the train of pulses from pulse generator 3, a power pulse of a predetermined duration and a brake pulse of a specified duration are generated successively to energize stepping motor 12 and consequently its load, xerographic plate 14, to effect the movement of the plate through one step of a predetermined distance.

In the embodiment illustrated in FIG. 1, the xerographic plate 14 comprising a photoconductive material

5

16 on a grounded conductive support 15 is formed in the shape of a drum which is rotated by stepping motor 12. In addition to passing through a series of processing stations which, for purposes of clarity, are not illustrated in FIG. 1, the drum also passes a charging station. At the charging station there is positioned in closely spaced relation to and extending transversely across the path of motion of the peripheral surface of the drum a scorotron, generally designated 17, which is used to apply a charge potential to the drum.

Scorotron 17 comprises a conductive shield member 18 which is directly grounded, a plurality of corona emitting wires which make up the coronode 19, and a control screen electrode 20. Coronode 19 is connected to a source of suitable high positive potential supplied by power supply 2.

The second area of operation will now be described and it relates specifically to the control of scorotron 17 for applying a substantially uniform charge on the xerographic plate. Referring to flip-flop 8, it will be recalled that this flip-flop was set by the output from the reset side of flip-flop 4, which, in turn, was set by the positive pulse in the pulse train generated by pulse generator 3. When flip-flop 8 is set, the output from its reset side is a positive pulse of a duration which is determined by the time which elapses between the setting of flip-flop 4 and the resetting of flip-flop 7. It is understood that the resetting of flip-flop 7 resets flip-flop 8. This time interval is approximately equal to the total time duration of the power and brake pulses.

Transistor 23 has a base electrode 22 which is connected through resistor 24 to a source of suitable positive voltage at power supply 2, while the collector electrode 25 is connected through resistor 26 to a source of suitable negative voltage applied from power supply 2. The emitter 27 of transistor 23 is connected directly to ground. The reset side of flip-flop 8 is connected through resistor 21 to the base 22 of transistor 23. The bias potential applied to base 22 through resistor 24 from power supply 2 and the values of resistors 21 and 24 are such that transistor 23 is biased in the non-conducting region when flip-flop 8 is in its set condition. However, when flip-flop 8 is reset, transistor 23 is biased to conduct to such a degree that it acts substantially as a short circuit.

Therefore, when flip-flop 8 is in its set condition, transistor 23 is non-conducting. In this state, transistor 23 acts as an open circuit placing its collector bias applied from power supply 2 through resistor 26 on grid 28 of triode vacuum tube 29 by way of the direct collector-grid connection. This negative potential on grid 28 renders triode 29 non-conducting. This cut off biasing of triode 29 takes place during that period of time in which flip-flop 8 is set. This period corresponds to the movement of the motor and, accordingly, the movement of xerographic plate 14. It will be recognized that this period corresponds in time to the duration of the power and braking operations of the motor 12.

When the positive pulse from the reset side of flip-flop 8 returns to its lower voltage level when this flip-flop is reset, the bias on base 22 of transistor 23 is insufficient to maintain transistor 23 at cut-off and the transistor becomes conductive. As already mentioned, in its conductive state transistor 23 acts substantially as a short circuit, or as a closed switch, connecting its collector 25 to its emitter 27 which is at ground potential. This, in effect, places ground potential on grid 28 of triode 29 thereby biasing this tube in its conductive region. The period of this conductive condition of triode 29 corresponds to the dwell time of xerographic plate 14.

It is therefore seen that during the operation of the charging control circuit, triode vacuum tube 29 is in either of two operating modes: (1) a non-conducting mode, or (2) a conducting mode.

During corona emission in scorotron 17, control screen electrode 20 serves as a corona regulating electrode by

6

attracting positive ions from the corona emission. These positive ions are representative of excess corona current which is drained off by control screen electrode 20. During the non-conducting mode of triode 29, this excess corona current from coronode 19 is neutralized by electron flow in the scorotron control circuit previously described. With triode 29 effectively removed from the circuit, the positive ions on control screen 20 are neutralized by electron flow from positive anode bias potential supplied from power supply 2 across anode resistor 32 of triode 29 to the control screen electrode 20. This electron flow across resistor 32 creates a voltage drop across this resistor in such a manner as to add to the positive anode bias potential applied from power supply 2 to the anode 31 of triode 29. In this manner, the voltage present at control screen 20 is of a high value in excess of the anode bias potential from power supply 2. This excess is equal to the voltage drop across resistor 32 created by the neutralized electron flow.

During the conducting mode of triode 29, the excess corona current comprised of positive ions from coronode 19 are drained off by screen electrode 20, as was the case in the non-conducting mode. However, in this mode triode 29 is conducting. It is this source of electrons from cathode 30 of triode 29 which supplies the negative charge particles necessary to neutralize positive ions on control screen 20. Therefore, the only electron flow through resistor 32 in the anode circuit of triode 29 is that flow caused by the conduction of triode 29. Therefore, it is seen that the voltage at control screen 20 during the conducting mode of triode 29 is of a value which is equal to the anode bias potential supplied by power supply 2 to anode 31 less the voltage drop across the anode resistor 32. This control screen voltage is of a lower value than the control screen voltage during the non-conducting mode.

In effect then, during the conducting mode or during the dwell time of xerographic plate 14, the voltage on screen electrode 20 is of a low value. During the non-conducting mode or during the movement of xerographic plate 14, the control screen voltage is at a high value with respect to the voltage level on the control screen 20 during the conducting mode. Therefore, by using triode 29 as a gate, the average potential difference between screen electrode 20 and coronode 19 can be effectively controlled. This can be better seen by reference to FIGURES 2A, 2B, and 2C.

In reference to the waveforms of FIGURES 2A, 2B, and 2C, attention is now directed to FIGURE 2A showing the waveform of the average voltage on screen electrode 20. At time $t-1$, the stepping motor 12 is activated, thereby moving a new area of the xerographic plate 14 under the influence of scorotron 17. At this time flip-flop 8 is set thereby rendering transistor 23 conductive whereby triode 29 is biased in its non-conductive region, thereby placing a high positive voltage on screen electrode 20, for example, 1000 volts. At time $t-2$, this screen voltage returns to a lower voltage, for example, 450 volts, as a result of triode 29 beginning its conducting mode. Time $t-2$ also marks the instant in which the drum comes to rest and the dwell time of the area under scorotron 17 begins to run. This dwell time lasts until time $t-3$, at which time another power pulse is supplied to motor control circuit 11 of stepping motor 12 and triode 29 ceases conduction. The cycle just described then repeats itself.

It is seen in FIGURES 2B and 2C which represent the voltage on screen electrode 20 at stepping rates of 30 and 20 steps per second, respectively, that the dwell time represented by the periods $t-2$, $t-3$, increases as the stepping rate of the xerographic plate 14 decreases. However, it will also be noted that although the dwell time increases, the average screen electrode voltage decreases with decreasing step rate. This will be seen more graphically hereinafter.

It will be recalled that the charge on xerographic plate 14 varies in direct proportion to the dwell time of this plate, all other factors being equal. However, the expected increase in charge on the xerographic plate with increasing dwell time as shown in FIGURES 2B and 2C does not result. This is due to the fact that the average screen electrode potential actually decreases with increasing dwell time, because of the pulsing of screen electrode 20. This relationship is brought out more graphically in FIGURE 3.

FIGURE 3 shows a plotted curve of the average screen electrode potential as a function of stepping rate of the xerographic plate, with a coronode potential at a constant high positive value. It is seen from this curve that there is a linear proportion between the stepping rate of the xerographic plate and the average screen electrode potential. Therefore, as the stepping rate of the xerographic plate decreases and the dwell time increases, the average screen electrode potential decreases proportionally.

It is understood that in view of the constant coronode potential, whenever the average screen electrode potential is referred to, this statement applies with equal accuracy to the average potential difference between the coronode and the control screen electrode.

In summary then, it is seen that the corona control circuit allows the scorotron to maintain a substantially uniform charge on a xerographic plate independent of the stepping rate of this plate. By modifying the average screen electrode potential relative to the dwell time of the xerographic plate, the optimum charge on the plate is maintained and non-uniform or excessive charging is avoided.

Any motor which is capable of high speed incrementing may be used as stepping motor 12, such as the motor described in the article entitled, "Printed Circuit Motors for High-Speed Incrementing of Inertial and Dissipative Loads," which can be found in IEEE Transactions on Industrial Electronics, May 1963, page 28.

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 circuit of FIGURE 1 shows triode 29 in a shunt regulator mode with relation to the voltage on screen electrode 20, it must be realized too that a series regulating mode would be possible using the concept of this invention.

Another modification which would be realized from this description would be a system in which the scorotron 17 was adapted to move in steps over a fixed xerographic plate. It is obvious that in any situation where there is relative step motion between the source of corona and a xerographic plate to be charged, the concept of this invention would be readily adaptable.

It must also be noted that the motor 12 will always move through a definite arc or angle in the same amount of time, regardless of the stepping rate used. This is easily seen when it is remembered that the power and brake pulses are always of the same duration and magnitude, depending upon motor, load, etc. This is graphically shown in FIGS. 2A-C where t_1-t_2 corresponds to the stepping interval. This fixed relationship between period and length of motor travel for each step would permit the replacement of multivibrator 9 with a photodetector feedback system to generate the proper reset pulses for flip-flop 4. Such a system could detect the passage of a timing mark on stepping motor 12 and thus provide a timed reset pulse to this flip-flop.

Another modification of the present invention would be to use the control circuit to pulse the voltage on the coronode between suitable values while the control screen voltage remains constant.

It should be understood that from the description of the

circuit of FIGURE 1 that there are other arrangements for the flip-flops and multivibrators to afford the same result. For example, flip-flop 8 could be replaced by monostable multivibrator which is set directly by pulses from a suitable pulse generator operating at a frequency which corresponds to the step rate desired.

The intention of the applicant is therefore 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 stepping xerographic reproducing apparatus wherein a corona generating device having a shield member and a control screen electrode with a corona discharge electrode positioned therebetween is in closely spaced movable relation to a xerographic plate for applying a substantially uniform electrostatic charge to the xerographic plate, wherein the charging current to the xerographic plate is controlled by the potential difference between the control screen electrode and the corona discharge electrode and wherein, with regards to the motion of the corona generating device relative to the xerographic plate, there are dwell times between successive stepping intervals, a control circuit comprising:

(a) means for selectively generating one of a plurality of pulse trains having pulse repetition rates proportional to the repetition rates of a like plurality of stepping intervals; and

(b) gate means responsive to said pulse trains for providing a first potential difference between the corona discharge electrode and the control screen electrode during said stepping intervals and providing a second potential difference, lower than said first potential difference, between the corona discharge electrode and the control screen electrode during said dwell times,

whereby a substantially uniform electrostatic charge is applied to the xerographic plate from the corona generating device independent of the duration of said dwell times.

2. In a stepping xerographic reproducing apparatus wherein a corona generating device having a shield member and a control screen electrode, with a corona discharge electrode positioned therebetween, is in closely spaced movable relation to a xerographic plate for applying a substantially uniform electrostatic charge to the xerographic plate is controlled by the potential difference between the control screen electrode and the corona discharge electrode, and wherein, with regards to the motion of the corona generating device relative to the xerographic plate, there are dwell times between successive stepping intervals, a control circuit comprising:

(a) a source of pulses having a frequency corresponding to the repetition rate of said stepping intervals;

(b) a first source of potential;

(c) gate means responsive to said pulses to form a conductive path between said first source of potential and the control screen electrode during said dwell times;

(d) a second source of potential, said second source of potential being substantially higher than said first source of potential; and,

(e) resistive means connecting said second source of potential to the control screen electrode, whereby a substantially uniform electrostatic charge is applied to said xerographic plate from the corona generating device independent of the duration of said dwell time.

3. In a stepping xerographic reproducing apparatus wherein a corona generating device having a shield member and a control screen electrode, with a corona discharge electrode positioned therebetween, is in closely spaced movable relation to a xerographic plate for applying a substantially uniform electrostatic charge to the xerographic plate, wherein the charging current from said corona generating device to the xerographic plate is con-

trolled by the potential difference between the control screen electrode and the corona discharge electrode, and wherein, with regards to the motion of the corona generating device relative to the xerographic plate, there are dwell times between successive stepping intervals, a control circuit comprising:

- (a) means for selectively generating one of a plurality of pulse trains having pulse repetition rates proportional to the repetition rates of a like plurality of stepping intervals; and
 - (b) gate means responsive to said pulse trains for maintaining the average potential difference between the corona discharge electrode and the control screen electrode substantially uniform independent of the repetition rate of said stepping intervals,
- whereby a substantially uniform electrostatic charge is applied to the xerographic plate from the corona generating device.
4. In a stepping xerographic reproducing apparatus, wherein a corona generating device having a shield member and a control screen electrode, with a corona discharge electrode positioned therebetween, is in closely spaced movable relation to a xerographic plate for applying a substantially uniform electrostatic charge to the xerographic plate, wherein the charging current from said corona generating device to the xerographic plate is controlled by the potential difference between the control screen electrode and the corona discharge electrode whereby the control screen electrode drains off excess positive ions from the corona generated by the corona discharge electrode, and wherein there are dwell times between successive stepping intervals, a control circuit comprising:
- (a) means for providing a first source of electrons;
 - (b) means for providing a second source of electrons;
 - (c) voltage dropping means connecting said first source of electrons to the control screen electrode;
 - (d) means for selectively generating a series of pulses having a frequency proportional to the repetition rate of said stepping intervals; and
 - (e) gating means responsive to said pulses to connect said second source of electrons to the control screen electrode during said dwell times,
- whereby, during the stepping intervals, the positive ions on said screen electrode are neutralized by the electrons from said first source and from said second source during said dwell times to provide substantially uniform charging of the xerographic plate.
5. In a stepping xerographic reproducing apparatus wherein a corona generating device having a shield member and a control screen electrode, with a corona discharge electrode, positioned therebetween, is in closely spaced movable relation to a xerographic plate for applying a substantially uniform electrostatic charge to the xerographic plate, wherein the charging current from said corona generating device to the xerographic plate is controlled by the potential difference between the control screen electrode and the corona discharge electrode and wherein, with regards to the motion of the corona generating device relative to the xerographic plate, there are dwell times between successive stepping intervals, a control circuit comprising:
- (a) means for selectively generating a first series of pulses having a frequency proportional to the repetition rate of said stepping intervals;
 - (b) means responsive to said first series of pulses to generate a second series of pulses, the pulses of said second series having a width substantially equal to the duration of said stepping intervals;
 - (c) switch means having an output terminal and being responsive to said second series of pulses to be rendered open during said stepping intervals and closed during said dwell times; and
 - (d) means connecting said output terminal of said switch means to the control screen electrode,

whereby the potential difference between the control screen electrode and corona discharge electrode is regulated to provide a substantially uniform charging of the xerographic plate independent of the duration of said dwell times.

6. In a stepping xerographic apparatus the combination comprising:
- (a) a photoconductive member having two sides;
 - (b) a conductive base member affixed to one side of said photoconductive member;
 - (c) a first source of potential;
 - (d) a second source of potential;
 - (e) a corona generating device having a control screen electrode, a corona discharge electrode, and a conductive shield electrode, said device being cooperably juxtaposed relative to the other side of said photoconductive member;
 - (f) means connecting said first source to said corona discharge electrode;
 - (g) means connecting said second source to said control screen electrode;
 - (h) drive means for generating a step-by-step driving force;
 - (i) mechanical linkage means connected to said drive means for translating said driving force to effect relative step-by-step motion between said device and said photoconductive member, said step-by-step motion having dwell intervals between successive stepping intervals;
 - (j) pulse means having an output terminal for selectively generating a pulse train having a pulse repetition rate corresponding to the repetition rate of said stepping intervals;
 - (k) gate means having an input connected to said output terminal for maintaining the average potential difference between said control screen electrode and said corona discharge electrode substantially uniform independent of the repetition rate of said stepping intervals.
7. The combination recited in claim 6 wherein said gate means includes means for generating pulses in response to said pulse train, said pulses having a width substantially equal to the duration of said stepping intervals.
8. In a stepping xerographic apparatus the combination comprising:
- (a) a photoconductive member having two sides;
 - (b) a conductive base member affixed to one side of said photoconductive member;
 - (c) a first source of potential;
 - (d) a second source of potential;
 - (e) a corona generating device having a control screen electrode, a corona discharge electrode, and a conductive shield electrode, said device being cooperably juxtaposed relative to the other side of said photoconductive member;
 - (f) means connecting said first source to said corona discharge electrode;
 - (g) means connecting said second source to said control screen electrode;
 - (h) drive means for generating step-by-step driving force;
 - (i) mechanical linkage means connected to said drive means for translating said driving force to effect relative step-by-step motion between said device and said photoconductive member, said step-by-step motion having dwell intervals between successive stepping intervals;
 - (j) pulse means having an output terminal for selectively generating a pulse train having a pulse repetition rate corresponding to the repetition rate of said stepping intervals;
 - (k) gate means having an input connected to said output terminal for providing a first potential difference between said corona discharge electrode and

11

said control screen electrode during said stepping intervals, and a second potential difference, lower than said first potential difference, between said corona discharge electrode and said control screen electrode during said dwell intervals.

9. In a stepping xerographic apparatus, the combination comprising:

- (a) a photoconductive member having two sides;
- (b) a conductive base member affixed to one side of said photoconductive member;
- (c) drive means mechanically linked to said base member for moving same in a step-by-step manner having dwell intervals between successive stepping intervals;
- (d) a corona generating device having a control screen electrode, a corona discharge electrode, and a conductive shield electrode, said device being cooperably juxtaposed relative to the other side of said photoconductive member;
- (e) means having an output terminal for selectively generating a first series of pulses having a frequency corresponding to the repetition rate of said stepping intervals;
- (f) means having an input connected to said output terminal and responsive to said first series of pulses to generate a second series of pulses, the pulses of said second series having a width substantially equal to the duration of said stepping intervals; and
- (g) switch means having an output terminal and being responsive to said second series of pulses to be rendered open during said stepping intervals and closed during said dwell intervals;
- (h) means connecting the output terminal of said switch means to said control screen electrode.

12

10. A charging apparatus comprising:

- (a) a corona generating device having a control screen electrode, a corona discharge electrode, and conductive shield electrode;
- (b) a first source of voltage;
- (c) means connecting said corona discharge electrode to said first source of voltage;
- (d) voltage dropping means;
- (e) a second source of voltage having a value less than said first source of voltage;
- (f) means connecting said control screen electrode to said second source of voltage through said voltage dropping means;
- (g) a third source of voltage having a value lower than said second source of voltage;
- (h) means for selectively generating a series of pulses having a predetermined frequency; and,
- (i) gate means connected to said generating means and responsive to said pulses for selectively connecting said control screen electrode to said third source of voltage.

References Cited

UNITED STATES PATENTS

3,390,266	6/1968	Epping.	
2,890,343	6/1959	Bolton	250—49.5
3,146,688	9/1964	Clark et al.	95—1.7
3,335,274	8/1967	Codichini et al.	250—49.5

ARCHIE R. BORCHELT, Primary Examiner

S. C. SHEAR, Assistant Examiner

U.S. Cl. X.R.

95—1.7

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,496,351 Dated March 5, 1970

Inventor(s) Gerald W. Cunningham

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

Column 8, line 46, after "xerographic plate", the following phrase should be inserted --,wherein the charging current to the xerographic plate--

SIGNED AND
SEALED
JUL 7 1970

(SEAL)

Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents