Sept. 19, 1972 R. C. KAMOLA Re. 27,480

AUTOMATIC DEVELOPMENT CONTROLLER

Original Filed June 1, 1966 3 Sheets-Sheet 1

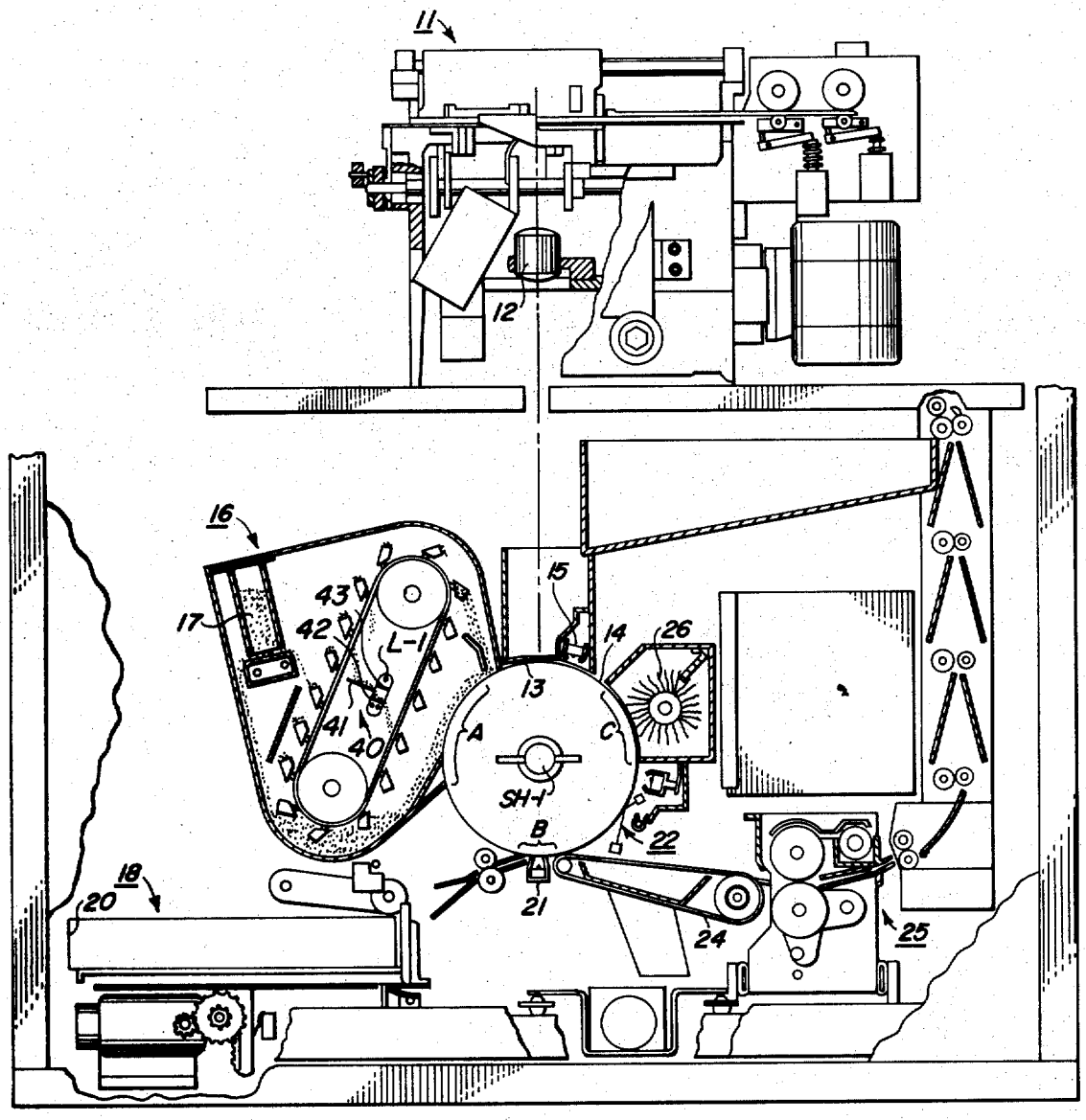


FIG. 1

INVENTOR.
ROMAN C. KAMOLA
BY B. A. Chesare
Spencer C. Schneider
ATTORNEYS

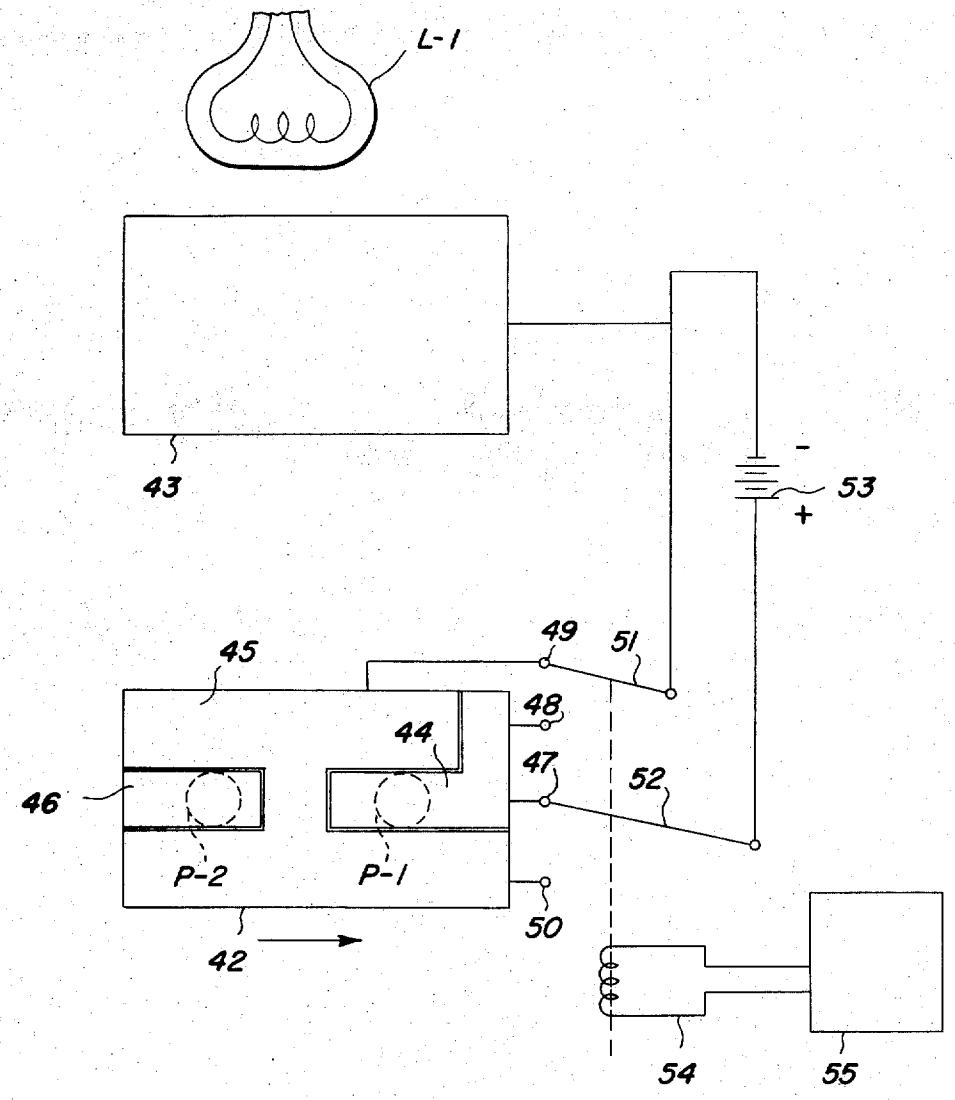


FIG. 2

INVENTOR.
ROMAN C. KAMOLA
BY D. A. Chisum
Norman P. Schneider
ATTORNEYS

AUTOMATIC DEVELOPMENT CONTROLLER

Original Filed June 1, 1966 3 Sheets-Sheet 3

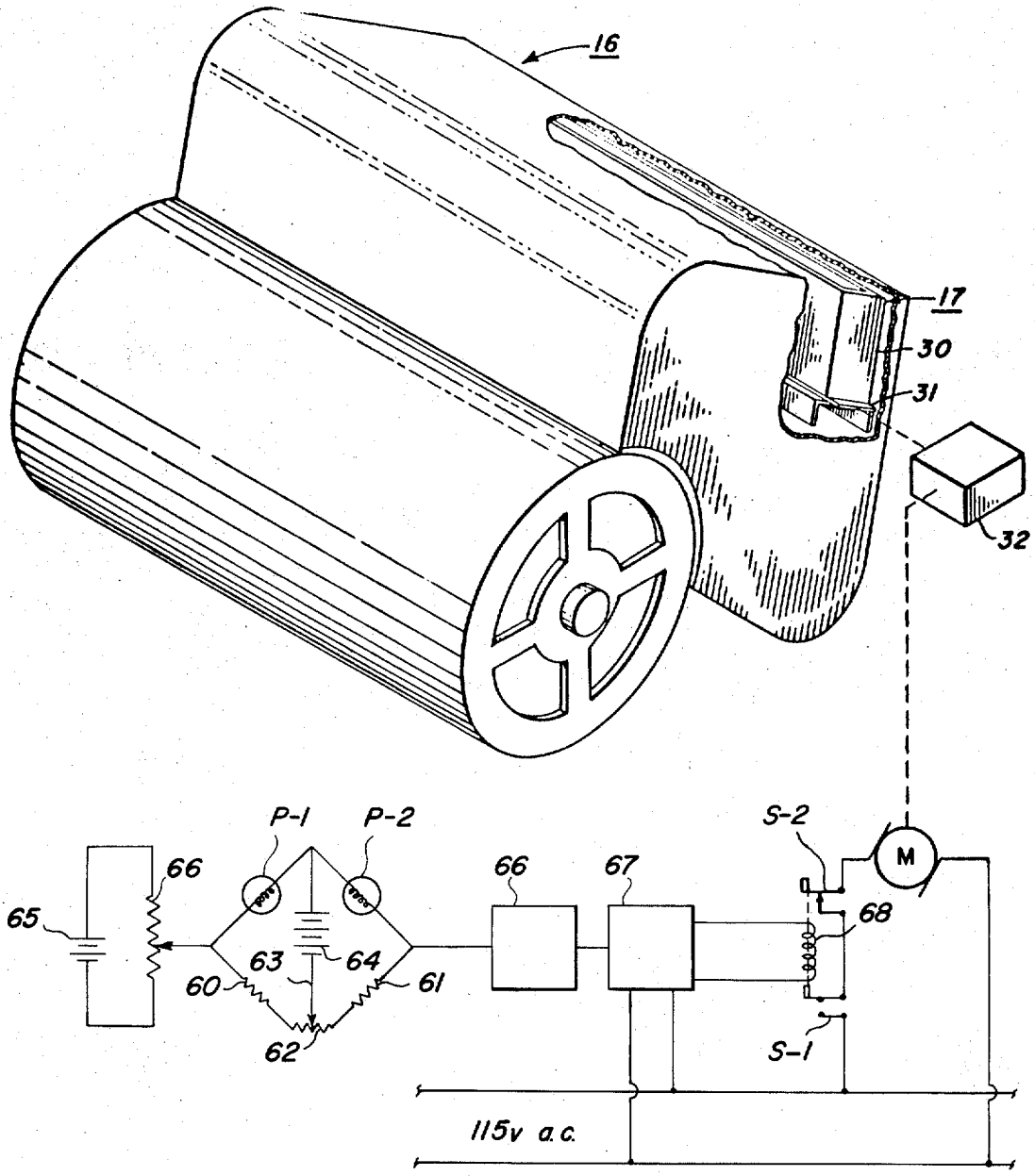


FIG. 3

INVENTOR.
ROMAN C. KAMOLA
BY
ATTORNEYS

United States Patent Office

Re. 27,480
Reissued Sept. 19, 1972

27,480

AUTOMATIC DEVELOPMENT CONTROLLER

Roman C. Kamola, North Rose, N.Y., assignor to Xerox Corporation, Rochester, N.Y.

Original No. 3,376,854, dated Apr. 9, 1968, Ser. No. 554,522, June 1, 1966. Application for reissue July 3, 1969, Ser. No. 846,986

Int. Cl. G03g *15/08*

U.S. Cl. 118—7 3 Claims

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

ABSTRACT OF THE DISCLOSURE

A toner concentration control system for a recording apparatus in which a sensor comprising two parallel spaced NESA glass plates through which developer material flows serves to generate signals to automatically control toner dispensing. The lower plate has a pattern which is held at a potential to attract toner. A light source and photocell on either side of the plate senses the toner deposit per unit of time in accordance with toner concentration. Another photocell is arranged as a leg of a bridge circuit which includes the first photocell such that when the latter senses a toner situation away from the desired density effect, an unbalance of the bridge occurs causing toner dispensing.

This invention relates to improvements in toner dispensing devices and particularly to improvements in the automatic control of these devices to maintain the image density constant during the making of xerographic reproductions.

The present invention avoids the disadvantages of manual control for dispensing toner particles into developing material used in xerographic processing equipment. This method of control is generally based upon guesswork by the operator who must continually observe the reproduction copy quality in order to maintain a reproduction run that is fairly constant in regard to image density. For automatic xerographic processing wherein the large production runs are frequent, an experienced operator must be in attendance to insure good control.

Therefore, the principal object of the invention is to control toner dispensing automatically in xerographic processing systems. A further object of the invention is to maintain consistency in image quality during xerographic processing. Another object of the invention is to determine and maintain the proper ratio of toner-to-carrier in xerographic developing material.

These and other objects of the invention are attained by means of a control circuit utilized in conjunction with a toner dispensing device for dispensing toner into a developing apparatus in accordance with the density of a developed image upon a xerographic plate. The amount of toner particles in the developing material is proportional to the amount that will deposit upon a surface that is charged with a voltage having a polarity opposite that upon the toner particles. This proportionality is utilized to control the amount of toner within the apparatus and, to this end, a sensor having a predetermined pattern on a charged surface is placed within the apparatus to receive some of the developing material falling thereon. A positive potential is placed upon the pattern (for systems wherein negative charged toner is used) and a negative charge is placed upon the area of the surface adjacent the pattern. This causes toner to be attracted to the pattern.

The amount of toner attracted to the pattern, for any paricular period of time, is related to the toner concentration in the developer apparatus. The sensor is connected in an electrical bridge circuit along with a compensating means for producing a signal, which when *the toner concentration is;* below a pre-set level [raises] *causes* a pulse to be generated for introducing toner particles into the machine toner dispensing system.

A preferred form of the invention is shown in the accompanying drawings in which:

FIG. 1 is a schematic sectional view of a typical xerographic machine embodying the principles of the invention;

FIG. 2 is a schematic illustration of toner sensor utilized in the machine shown in FIG. 1 and a charging circuit for the sensor; and

FIG. 3 is a schematic illustration of a toner dispensing arrangement with portions of the sensor applied to the associated circuitry.

For a general understanding of a typical xerographic processing system in which the invention may be incorporated, reference is had to FIG. 1 in which various components of a typical system are schematically illustrated. As in all xerographic systems, a light image of copy to be reproduced is projected onto the sensitized surface of a xerographic plate to form an electrostatic latent image thereon. Thereafter, the latent image is developed with an oppositely charged developing material to form a xerographic powder image, corresponding to the latent image, on the plate surface. The powder image is then electrostatically transferred to a support surface to which it may be fused by a fusing device, whereby the powder image is caused permanently to adhere to the support surface.

In the system disclosed herein, minified data cards are placed in a card magazine from which they are fed seriatim to a card carriage in a card handling apparatus, generally designated by reference character **11**. Suitable driving means are provided for the card carriage whereby it is caused to move the card past the optical axis of a light projecting system for the purpose of scanning the minified data across a scanning light. The illuminated card is projected downwardly by means of an objective lens assembly **12** and through a variable slit aperture assembly **13** and onto the surface of a xerographic plate in the form of a drum **14**.

The xerographic drum **14** is detachably secured to a shaft SH–1 mounted in suitable bearings in the frame of the machine and is driven in a counterclockwise direction by a motor at a constant rate that is proportional to the scan rate for the minified data car, whereby the peripheral rate of the drum surface is identical to the rate of movement of the reflected light image. The drum surface comprises a layer of photoconductive material on a conductive backing that is sensitized prior to exposure by means of a corona generating device **15**.

The exposure of the drum to the light image discharges the photoconductive layer in the areas struck by light, whereby there remains on the drum an electrostatic latent image in configuration corresponding to the light image projected from the minified data card. As the drum surface continues its movement, the electrostatic latent image passes through a developing station A in which there is positioned a developer apparatus including a casing or housing **16** having a lower or sump portion for accumulating developing material. A bucket-type conveyor having a suitable driving means may be used to carry the developing material to the upper part of the developer housing where it is cascaded down over a hopper chute onto the xerographic drum.

As the developing material is cascaded over the xerographic drum, toner particles are pulled away from the

arrier component of the developing material and deposited on the drum to form powder images, while the partially-denuded carrier particles pass off the drum into he developer housing sump. As toner powder images are ormed, additional toner particles must be supplied to the leveloping material in proportion to the amount of toner leposited on the drum. For this purpose, a toner dispenser generally designated **17** is used to accurately meter oner to the developing material. Although any one of a umber of well-known powder or granulated material lispensers may be used, the toner dispenser shown is of he type disclosed in Patent No. 3,062,109, issued to Mayo et al.

Positioned next and adjacent to the developing station s the image transfer station B which includes a sheet eeding mechanism adapted to feed sheets of paper successively to the developed image on the drum at the transer station. This sheet feeding mechanism, generally desgnated **18**, includes a sheet source such as tray **20** for a lurality of sheets of a suitable transfer material that is, ypically sheets of paper or the like, a separating roller dapted to feed the top sheet of the stack to feed rollers vhich direct the sheet material into contact with the rotatng drum at a speed preferably slightly in excess of the ate of travel of the surface of the drum in coordination vith the appearance of the developed image at the transer station. In this manner, the sheet material is introluced between the feed rollers and is thereby brought nto contact with the rotating drum at the correct time and osition to register with the developed image.

The transfer of the xerographic powder image from he drum surface to the transfer material is effected by neans of a corona transfer device **21** that is located at or mmediately after the point of contact between the transer material and the rotating drum. The corona transfer levice **21** is substantially similar to the corona discharge levice **15** in that it includes an array of one or more orona discharge electrodes that are energized from a uitable high potential source and extend transversely cross the drum surface and are substantially enclosed vithin a shielding member. In operation, the electrostatic ield created by the corona charging device **11** is effective o tack the transfer material **14** electrostatically to the lrum surface, whereby the transfer material moves synhronously with the drum while in contact therewith. imultaneously with the tacking action, the electrostatic ield is effective to attract the toner particles comprising he xerographic powder image from the drum surface and ause them to adhere electrostatically to the surface of he transfer material.

Subsequent to the image development station is posioned a transfer material stripping apparatus or paper ick-off mechanism, generally designated **22**, for removng the transfer material from the drum surface and, to lirect it onto a horizontal conveyor **23** having an endless onveyor **24**, whereby the sheet material is carried to a ixing device in the form of a fuser assembly **25**, whereby he developed and transferred xerographic powder image n the sheet material is permanently fixed thereto.

Referring now to FIG. 3, the toner dispenser **17** conists of a hopper or container **30** for the toner particles o be dispensed. Although the hopper or container **30** may e made in any size or shape, the hopper shown is formed s a rectangular open-ended box having vertical side nd end walls.

The bottom wall of the hopper **30** may comprise a sliding perforated plate **31** adapted for sliding movement ongitudinally of the hopper for metering the flow of toner rom the hopper. The toner thus dispensed is mixed with he developing material in the developer housing **16** to ecome almost immediately effective in the developing rocess. The metering provided by the plate **31** may be ontrolled by a mechanical device, generally indicated by he reference numeral **32**, such as a cam plate or linkage ystem which converts rotary motion to reciprocable

movement. Preferably, a single revolution of a rotary element in the device **32** will produce one reciprocable cycle of the plate **31**, thereby insuring the dispensing of predictable quantities of toner.

In the operation of the toner dispenser, a supply of toner particles is placed within the hopper, the hopper walls and the dispensing plate **31** forming a reservoir for the toner particles. Upon reciprocation of the plate **31** by the device **32**, a metered quantity of toner particles will be permitted to cascade through the openings in the plate where they will fall to the reservoir portion of the housing **16**.

Since the toner dispenser **17** dispenses a uniform quantity of toner for a given stroke length of the metering plate **31**, it is apparent that the quantity of toner delivered by the toner dispenser may be varied by either varying the length of stroke or by varying the number of strokes per actuation of the device **32**.

In order to control the dispensing of toner from the toner dispenser **17**, there is shown in FIG. 2 the details of an automatic toner control system which ultimately causes rotation of the rotary element in the device **32** in single revolution step-by-step operation in accordance with the density of the developed image on the drum **14**. Basically, the automatic toner dispensing system comprises a toner sensor **40** generally indicated by the reference number mounted within the developer housing **16** by suitable means which electrically insulates the sensor from surrounding structures and, a collecting plate **41** mounted above the sensor **40**. The plate **41** is arranged below the up-moving buckets **42** of the conveyor system for the developer **16** and is adapted to receive some developer material falling from each bucket. Suitable small holes formed in the buckets may be provided for this purpose. The plate **41** is positioned at an angle, approximately 20° relative to the vertical and arranged in such a way as to guide developer material falling thereon into the sensor **40**.

As shown in FIG. 2, the sensor **40** comprises a lower sensor plate **42** and an upper sensor plate **43** arranged parallel to the plate **42** slightly spaced therefrom (see FIG. 1). The lower plate **42** comprises a thin glass sheet having a thin transparent layer of a conductive oxide. Preferably, the plate **42** is formed of "NESA" glass, a trademark of the Pittsburgh Glass Company, which is generally tin-oxide coated glass that is transparent to white light.

A pattern **44** is formed on the plate **42** and is of rectangular shape being produced by scribing through the oxide layer in order to electrically separate the pattern **44** from the remaining portion **45** and has a rectangular shaped pattern **46** which has a width approximately equal to the width of the pattern **44** and in alignment therewith when viewing the plate **42** along the illustrated arrow. The pattern **46** is also formed by scribing through the oxide layer on the plate **42** however, whereas the pattern **44** is connected to an electrical circuit, as will be described hereinafter, the pattern **46** is free of any electrical influence at all times. As will be described hereinafter, the arrow is indicative of the direction of flow of developing material as it is applied to the sensor. The plate **43** is also formed of "NESA" glass, however, there are no patterns inscribed thereon.

In order to accumulate toner in an amount fairly indicative of the total amount of toner or, toner concentration, the lower plate **42** has applied thereto an electric potential of a polarity and amount to attract and retain toner particles for some predetermined unit of time. During this unit of time, the light transmission through this accumulated toner will be determined in terms of toner concentration for the developer mechanism. To this end, the pattern **44** of lower plate **42** is electrically connected to a first switch contact **47** and a second switch contact **48**. Similarly, the conductive portion **45** of the lower plate is connected to terminals **49** and **50**. The contacts are

part of a double pole single throw switch which includes a first switch arm **51** movable between the contacts **48** and **49** and a second switch arm **52** movable between the contacts **47** and **50**.

Each of the arms **51, 52** are connected to a pole of a source **53** of direct current and for illumination purposes. These connections are shown in FIG. 2 with the positive pole of source **53** being connected to the arm **52** thereby providing the pattern **44** with a positive potential and with the negative pole being connected to the arm **51** thereby providing the portion **45** with negative potential. This electrical configuration is merely illustrative and has been chosen for descriptive purposes because of the particular charge chosen for the toner particles, which in this illustration, is negative. The positioning then of the switch arm **51, 52** is such then that toner particles will be attracted to the pattern **44** and repelled from the portion **45**. To complete the circuit to the sensor elements, the upper plate **43** is also connected to the negative pole of the D.C. source **53**, or to that pole having a polarity similar to that of the toner particles.

In order to exhibit high sensitivity and rapid response time, the sensor **40** is adapted for intermittent sensing action and to this end, the switch arms **51, 52** are mechanically connected together and to the armature of a solenoid **54**. A switchable timing device **55** is connected to the solenoid for periodically energizing the same. As shown in FIG. **2**, with the switch arms **51, 52** positioned in contact with the contacts **49, 47**, respectively, toner particles as they cascaded through the sensor **40** will be attracted to the pattern **44**, during this attract cycle and repelled from the portion **45**, after a short unit of time has elapsed, say 10 seconds, the timer will energize the solenoid **54** for switching the arms **51, 52** against the contacts **48, 50**, respectively. During the attract cycle, toner will accumulate upon the pattern **44** and in an amount indicative of the amount of toner in the developing system. When the timer **55** has effected switching of the arms **51, 52** against the contacts **48, 50**, respectively, the polarity of the pattern **44** and the portion **45** are reversed whereupon the pattern **44** assumes a negative polarity and portion **45** of a positive potential. In this manner, the pattern **44** will repel the accumulated toner and new toner cascading down the inclined lower plate **42** during this cycle. With the polarity thus reversed, the pattern **44** is cleaned by the cascading developing material and thereby is conditioned during this clean cycle for another attract cycle. As will be described hereinafter, it is during the attract cycle that the light transmission through the pattern **44** is measured.

Throughout both the clean and attract cycles, the upper sensor plate **43** retains a negative potential, or that polarity which is similar to the polarity acquired triboelectically by the toner particles. As previously stated, for illustration purposes, the polarity is negative and, with the plate **43** being negative, toner particles are repelled by the plate and directed toward the lower plate **42**. In effect then, the upper plate remains fairly clean during operation of the toner sensor.

As shown in FIGS. 1 and 2, a first photocell P–**1** is arranged below and in alignment with the pattern **44** and a second photocell P–**2** is arranged below and in alignment with the clear pattern **46**. The photocells are positioned adjacent the lower surface of the plate **42** so that toner particles cascading through the sensor **40** will intercept light rays from a light source L–**1** positioned above the plate **[42]** *43* which shields the source from drifting toner. The relative positioning of the photocells is such that the cell P–**1** will receive the light rays through cascading developer streams, the accumulated toner on the pattern **44** and, the dust and other particles in the air between the plates **42** and **43** while the cell P–**2** will receive the light rays only through the developer stream and the dust and toner particles in the air. In effect then, the cell P–**2** is a compensating cell since it "sees" all that the cell P–**1** "sees" except for the accumulated toner.

Electrically, the photocells P–**1**, P–**2** form two legs of a bridge circuit which is illustrated schematically in FIG. 3. In the bridge circuit the effects of the developer stream and toner in the air between the sensor plates are subtractive so that the total effect across the bridge is due only to the light transmitted through the amount of toner deposited on the pattern **44**. The other two legs of the bridge circuit comprise two fixed resistors and portions of a variable resistor **62** having its wiper arm **63** connected to the negative terminal of a D.C. source **64**. To complete the bridge circuit, the junction between the photocells is connected to the positive terminal of the D.C. source. The power supply for the bridge circuit is derived *therefrom.* **[**from a**]** A suitable D.C. source **65** and potentiometer **66** which has its wiper arm connected between the resistor **60** and the photocell P–**1** *are utilized to control the sensitivity of the sensing circuit.*

The bridge unbalance output is led to a Schmitt trigger **66** connected to an amplifier **67** which is utilized to amplify the signal produced by the Schmitt trigger and to drive or energize a solenoid **68** having a normally open switch S–**1** connected in series with a normally closed switch S–**2**. The switches S–**1** and S–**2** are in series *with* **[**within**]** motor M and are connected to a suitable source of electrical power such as conventional house current. Upon energization of the solenoid **68**, the switch S–**1** closes to cause energization of the motor M. The shaft for the motor M or the mechanical device **32** may be provided with a cam arrangement (not shown) adapted to actuate the normally closed limit switch S–**2** to an open position for a major portion of each revolution of the shaft for motor M. With solenoid **68** being continuously energized during an undertoned condition of the image upon the drum **14**, the motor M will be intermittently energized to impart intermittent actuation of the mechanical device **32**.

During normal operation of the automatic toner dispensing apparatus, the sensor light source L–**1** is continuously energized for presenting light upon the plate **42**. This light is fairly evenly distributed upon the plate and the light transmitted through the pattern **44** and clear pattern **46** are sensed by the photocells P–**1**, P–**2**, respectively, and compared by the bridge circuit. The resistor **62** is adjusted so that there is a bridge balance with zero output between the results of the light impinging upon the cell P–**1** at the end of the attract cycle and the results of the light impinging upon the cell P–**2**. This balance will be determined by the desired density of the toner that accumulates on the pattern **44**. With a balanced condition of the bridge the Schmitt trigger will have zero output for the solenoid **68**. As the toner supply in the developer housing **16** deplets during normal xerographic processing, the density of the toner that accumulates on the pattern **44** will lessen. With a density lower than the predetermined level which was used to balance that bridge circuit, the bridge will swing out of balance and when differential current in the trunks of the bridge is sufficiently high, the Schmitt trigger, which in effect is a level detector will produce an electrical pulse causing a momentary energization of the solenoid and closing of the contacts S–**1**. For each electrical pulse produced in this manner, the motor shaft for motor M will rotate one complete revolution to actuate the dispensing toner into the developer housing.

As the density of the toner on the plate pattern **44** increases, the balance of the bridge circuit will become restored thereby terminating further actuation of the toner dispenser. The sensitivity of the sensing circuit can be varied by the parameters chosen for the resistors **60, 61** and **62** and the strength of the D.C. sources **64, 65**. These components will determine the output level of the bridge circuit and may be varied so that a high unbalance must be present before a level can be detected by the Schmitt trigger. This condition would evolve that it is desirable to

ave a relatively wide density range for xerographic reroductions. If high quality contrast is needed in the reroductions, then a very sensitive bridge balance is necesary whereby the slightest unbalance will demand toner ispensing and replenishment.

The toner dispenser **17** functions to sift toner material nto the developing material already present in the deeloper housing. In order to ensure uniform distribution f new toner to bring the toner-to-carrier relationship or atio back to the desired level in a minimum of time, the oner dispenser extends horizontally substantially across ie upwardly moving buckets which are in motion to casade toner over the drum surface throughout its entire idth.

Some of the newly dispensed toner may be caused to eposit on suitable baffle plates. To cause the particles to e mixed with the remaining developing material and iereby ensure adequate mixing of at least a portion of ie new toner, narrow slots may be formed in these plates hereby a portion of the material sliding down this plate caused to pass through the slots and over the surface f the developing material supply at the bottom of the ousing.

While the invention has been described with reference the structure disclosed herein, it is not confined to the etails set forth and this application is intended to cover ich modifications or changes as may come within the urposes of the improvements or the scope of the follow-ig claims. For example, other means for producing actution of the mechanism **32** or for that matter, dispensing y the dispenser **17**, the signals produced by the Schmitt igger **66** may be provided on the machine.

What is claimed is:

1. A toner dispensing control system for use in an elec-ostatic reproduction apparatus having an electrostatic hotosensitive plate and a developer mechanism adapted to pply electrostatically charged toner in developer material exposed electrostatic latent images on the plate thereby roducing powdered toner images thereon including,

a container for the toner;

means for dispensing toner from the container into the developer mechanism for replenishing the developing material with toner;

an actuator device associated with the said dispensing means for controlling the introduction of the toner into the developer mechanism;

sensing means associated with said developing mechanism and arranged to be applied to developer material therein, said sensing means including a transparent element having portions with distinct electrical properties and means for directing the flow of some developer material thereacross in a steady stream, a light source arranged to illuminate said portions and a light sensitive device arranged to receive light rays projecting through each of said portions to produce electrical outputs in accordance therewith, *and a second transparent element electrically biased with a polarity the same as the polarity of said toner arranged between the light source and the first mentioned transparent element whereby the stream of developer material will be directed between said element;*

means for comparing said outputs and producing a discrete signal indicative of a deviation in said outputs; and

means responsive to said signal and associated with said dispensing means for actuating the same to dispense toner into the developer mechanism.

[2. The toner dispensing control system in claim **1** herein said sensing means includes a second transparent lement electrically biased with a polarity the same as the olarity of said toner arranged between the light source nd the first mentioned transparent element whereby the stream of developer material will be directed between said elements.]

3. A toner dispensing control system for use in an electrostatic reproduction apparatus having an electrostatic photosensitive plate and a developer mechanism adapted to apply electrostatically charged toner in developer material to exposed electrostatic latent images on the plate thereby producing powdered toner images thereon including

a container for the toner,

means for dispensing toner from the container into the developer mechanism for replenishing the developing material with toner,

an actuator device associated with the said dispensing means for controlling the introduction of the toner into the developer mechanism,

sensing means associated with said developing mechanism and arranged to be applied to developer material therein, said sensing means including a transparent element and means for directing the flow of some developer material thereacross in a steady stream, a light source arranged to illuminate said transparent element and a light sensitive device arranged to receive light rays projecting through said transparent element to produce an electrical output in accordance therewith,

means for comparing said output with a predetermined value and producing a signal indicative of a deviation from said value,

means responsive to said signal and associated with said dispensing means for actuating the same to dispense toner into the developer mechanism,

said transparent element being formed with an electrically conductive control pattern and has an area that is free of electrical influence and positioned to be illuminated by said light source,

said pattern and said area being in alignment relative to the movement of the developer material across said transparent element,

a second light sensitive device arranged to receive light rays projecting through said area and associated with said means for comparing said output.

4. A toner dispensing control system for use in an electrostatic reproduction apparatus having an electrostatic photosensitive plate and a developer mechanism adapted to apply electrostatatically charged toner in developer material to exposed electrostatic latent images on the plate thereby producing powdered toner images thereon including

a container for the toner,

means for dispensing toner from the container into the developer mechanism for replenishing the developing material with toner,

an actuator device associated with the said dispensing means for controlling the introduction of the toner into the developer mechanism,

sensing means associated with said developing mechanism and arranged to be applied to developer material therein, said sensing means including a transparent element and means for directing the flow of some developer material thereacross in a steady stream, a light source arranged to illuminate said transparent element and a light sensitive device arranged to receive light rays projecting through said transparent element to produce an electrical output in accordance therewith,

means for comparing said output with a predetermined value and producing a signal indicative of a deviation from said value,

means responsive to said signal and associated with said dispensing means for actuating the same to dispense toner into the developer mechanism,

said transparent element being electrically conductive and being formed with a control pattern thereon, said control system including means for applying an electrical potential on the pattern of the opposite polarity as the charge on the toner and an electrical potential on other portions of the element of a polarity similar to that of the toner,

said means for applying an electrical potential including a switching means and a timer device connected to said control pattern and said other portions and adapted to reverse periodically the polarity of the electrical potential thereon.

References Cited

The following references, cited by the Examiner, are of record in the patented file of this patent or the original patent.

UNITED STATES PATENTS

3,399,652 9/1968 Gawron ---------- 118—63

PETER FELDMAN, Primary Examiner

U.S. Cl. X.R.

118—9, 637