United States Patent [19]

Maksymiak

[11] **3,727,065**

[45] **Apr. 10, 1973**

[54] **AUTOMATIC DEVELOPABILITY CONTROL SYSTEM**

[75] Inventor: **John Maksymiak,** Penfield, N.Y.

[73] Assignee: **Xerox Corporation,** Rochester, N.Y.

[22] Filed: **Oct. 17, 1969**

[21] Appl. No.: **867,208**

[52] **U.S. Cl.**..............**250/218,** 118/637, 222/DIG. 1, 356/207, 96/1 A

[51] **Int. Cl.**..............**G01n 21/26**

[58] **Field of Search**..............250/218, 223, 215; 356/207, 208; 222/DIG. 1; 118/637; 96/1 R, 1 A, 1 C

[56] **References Cited**

UNITED STATES PATENTS

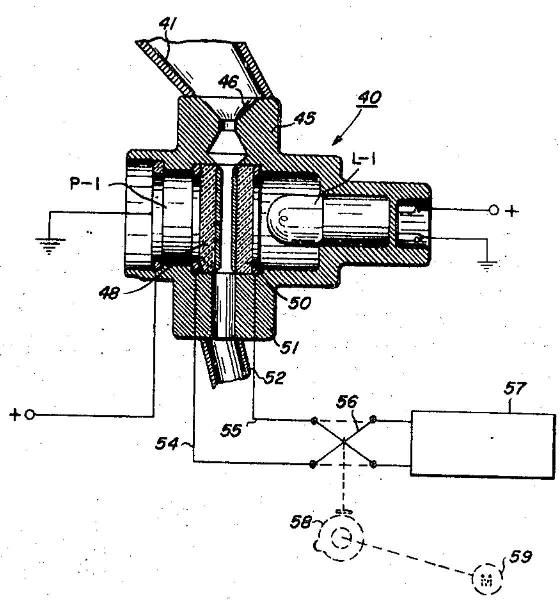
3,094,049	6/1963	Snelling	118/637 X
3,233,781	2/1966	Grubbs	118/637 X
3,376,854	4/1968	Kamola	250/218 X
3,399,652	9/1968	Gawron	250/218 X
3,430,606	3/1969	Pease et al.	250/218 X
3,526,338	9/1970	Goodrich et al.	222/1

Primary Examiner—Walter Stolwein
Attorney—James J. Ralabate, Norman E. Schrader and Bernard A. Chiama

[57] **ABSTRACT**

A developability control system for an electrostatic recording apparatus in which a sensor including two parallel spaced NESA glass plates through which developer material flows are connected in a circuit wherein each is electrically charged alternately for equal periods of time. While each plate is charged, it is adapted to attract toner. A light source on one side of the two plates and a photocell on the other side "-senses" the sum toner deposit on the two plates at all times thereby effecting a steady state control signal.

10 Claims, 5 Drawing Figures



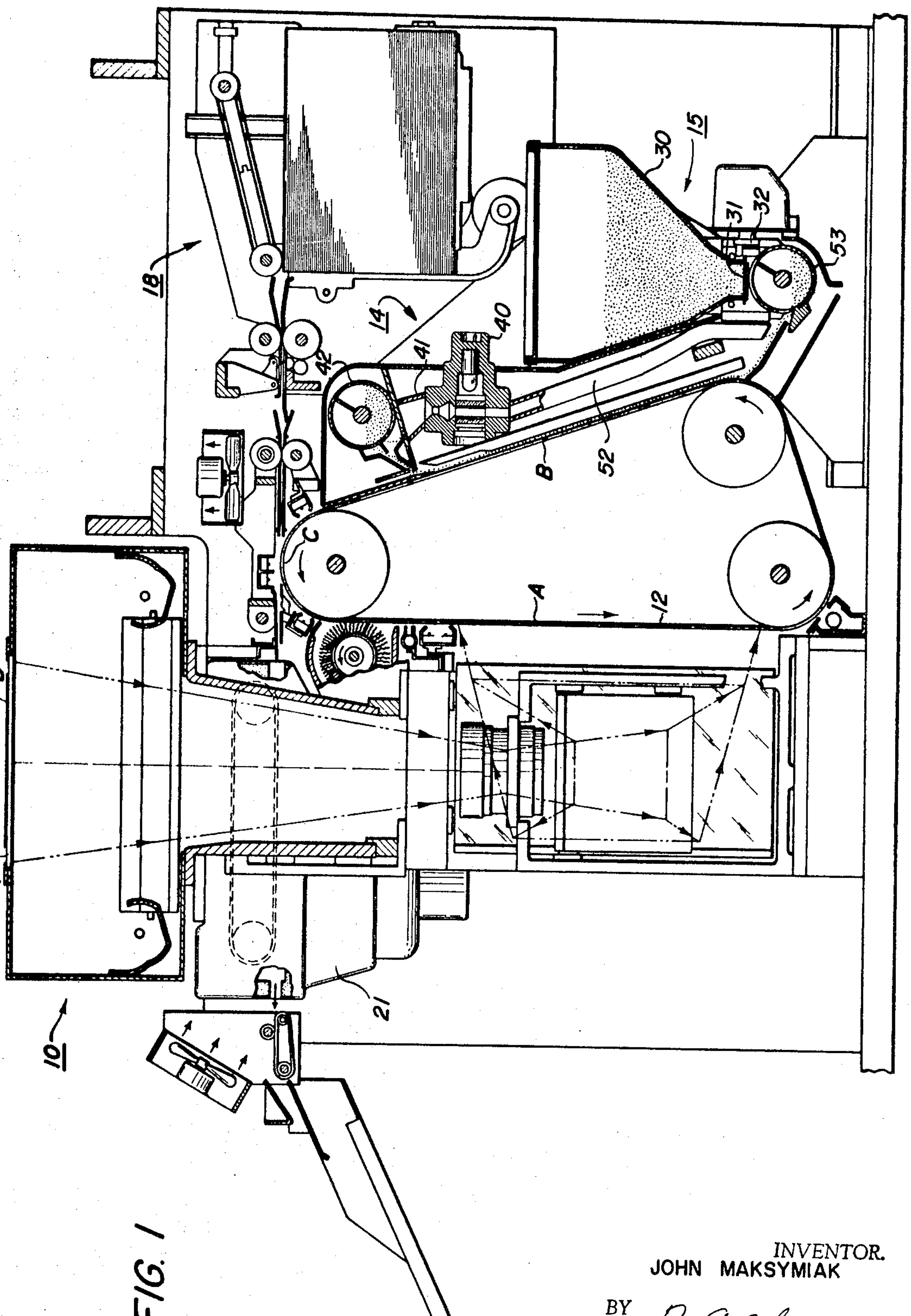


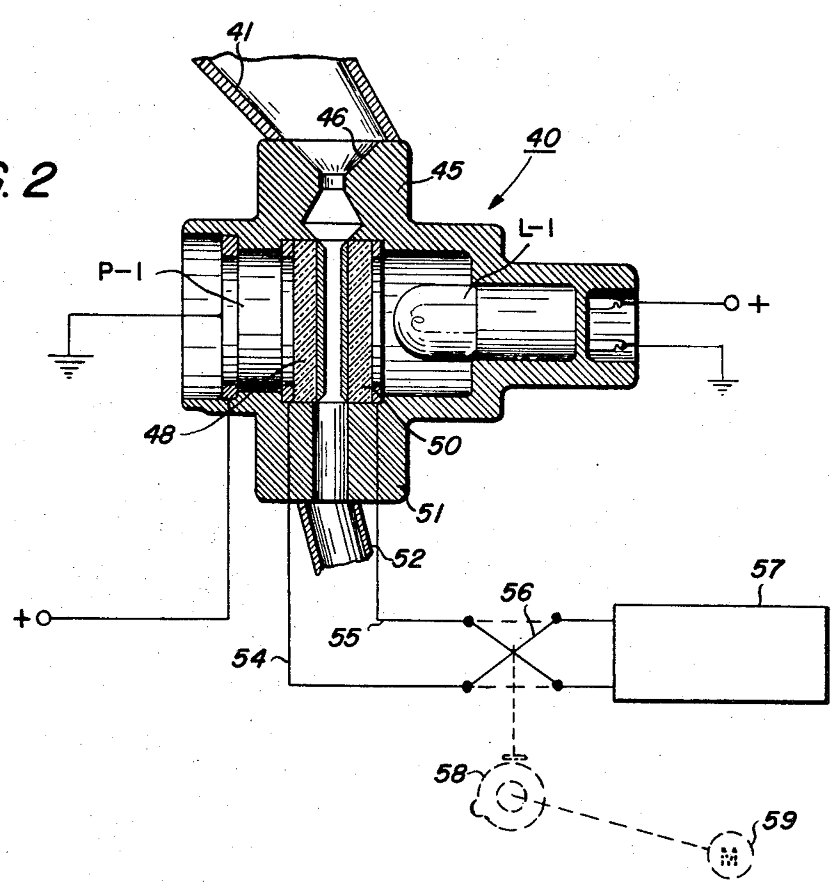
FIG. 1

INVENTOR.
JOHN MAKSYMIAK

BY B. A. Chiama

ATTORNEY

FIG. 2


41
46
40
45
L-1
P-1
+
48
50
51
52
57
56
+
55
54
58
59
M

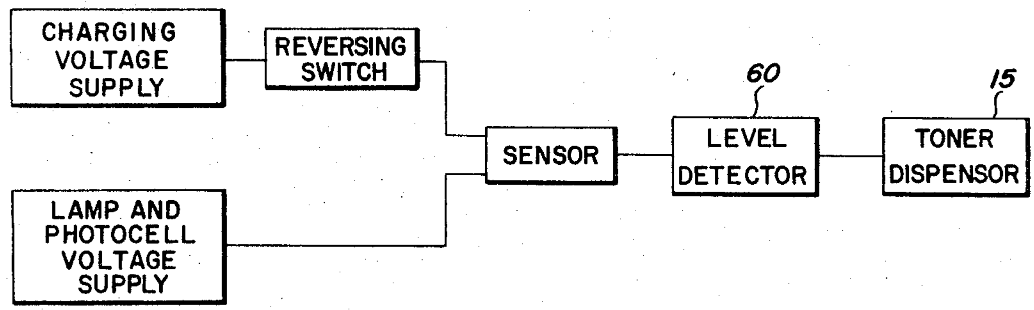

CHARGING VOLTAGE SUPPLY
REVERSING SWITCH
SENSOR
60
LEVEL DETECTOR
15
TONER DISPENSOR
LAMP AND PHOTOCELL VOLTAGE SUPPLY

FIG. 3

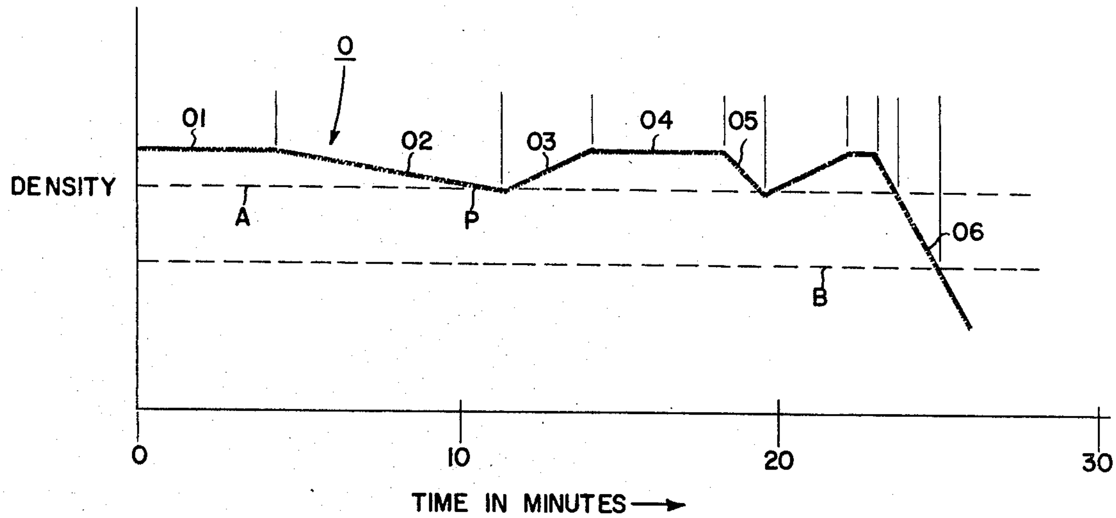

O
O1
O2
O3
O4
O5
DENSITY
A
P
O6
B
0
10
20
30
TIME IN MINUTES

FIG. 5

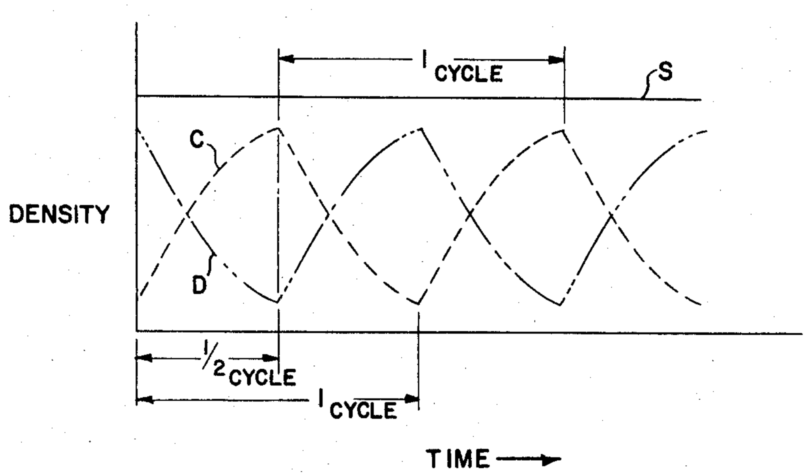

1 CYCLE
S
C
DENSITY
D
1/2 CYCLE
1 CYCLE
TIME

FIG. 4

AUTOMATIC DEVELOPABILITY CONTROL SYSTEM

This invention relates to improvements in sensors and controls for toner dispensing devices, and particularly to improvements in the automatic control of these devices to maintain the image density constant during the making of electrostatically produced reproductions.

Developability, as it pertains to apparatus utilized in graphic reproduction or copying, can be defined as the ability of the developer material used in the apparatus to develop to a specified density. A developability control system is one which controls the developed density of output copies of the apparatus. In the following description of the present invention, the characteristic of developing material which is to be controlled will be its ability to develop images to a defined density, or in other words the developability of the material. This ability of the material or its "developability" is often considered as related exclusively to the toner concentration of the material, that is, the ability to develop at defined density can be measured in terms of toner concentration and be returned to its optimum ability by adding toner by an amount determined by this measurement. Toner concentration, while the most important aspect in the ability to develop, is only one aspect. Temperature and humidity conditions also affect developability and there are many other factors, such as the state of compaction of the material, the electrical charges on the toner particles and the carrier beads, the state of attraction of toner particles to the carrier bead surface and for that matter, the carrier bead surface wear. For instance, two batches of developer material may have the same toner concentration, however, one batch located in a low humidity environment will involve developed density that is different from the developed density of the other batch located in a high humidity environment. In other words, the developability of the material will be different, even though toner concentration is the same. For the present description then rather than using "toner concentration" as the determining factor to be controlled, the all-inclusive term "developability" will be utilized and since this term is broader in scope, it will be understood that "developability" will enhance all that "toner concentration" connotes.

The present invention avoids the disadvantages of conventional density sensing devices for controlling the dispensing of toner particles into a developing apparatus used in electrostatic processing equipment. Generally, the density sensing methods which utilize the periodic collection of toner particles on a NESA glass plate with electrically isolated sections placed in a developing apparatus include the step of sensing light transmission through one area of the plate as a function of toner concentration. In effect the plate is "-developed" with the toner particles and, since a field is placed upon the plate for this purpose, the developing action results in edge development due to the electric field edge-effect. For automatic electrostatic processing wherein large high speed production runs are frequent, the resultant periodic peak senses are not efficient as a consistent developability indication means because of the sudden changes in toner content resulting from the high speed production of randomly presented originals having toner requirements ranging anywhere from heavy, solid area coverage to sparse line coverage.

Therefore, the principal object of the invention is to control dispensing in xerographic processing systems such arranged that toner particles will be added to developing material in amounts which are indicative of the optimum developability true toner concentration for any particular instant of time.

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 at all times the proper ratio of toner-to-carrier in xerographic developing material.

Another object of the invention is to utilize electroded development for collecting toner, and sensing its presence throughout the entire area of the sensing means thereby enhancing the accuracy of each sensing cycle.

Still another object of the invention is to utilize the electrode fields and developer motion to clean the toner on the plate opposite the plate that is being developed.

These and other objects of the invention are attained by means of a sensor and control means utilized in conjunction with a toner dispensing device for dispensing toner into a developing apparatus in accordance with the sensed density of toner alternately deposited on either of two attracting sensor elements. The amount of useful toner particles in the developing material can be determined by the amount that will be alternately deposited upon the plates, each being charged with a voltage to set up the proper field between the plates. This toner determination is utilized to control the amount of active toner within the apparatus. The sensor, having two surfaces each capable of carrying a charge placed thereon, is positioned within the apparatus to receive some of the developing material falling between the surfaces. Potentials are alternately placed upon the surfaces cyclically thereby reversing the electric field between the surfaces cyclically. This causes toner to be attracted to and cleaned from the surfaces cyclically. While one surface is provided with an attracting field, the other surface serves as a development electrode for the solid area development of the attracting surface since the electric field between the surfaces will be uniform. The amount of toner attracted to each surface when it is charged to attract toner for any particular period of time is related to or a function of the developability in the developer apparatus. The surfaces are connected in an electrical circuit which produces a steady state signal set for optimum condition and which, when deviated from a preset level, generates a control signal introducing toner particles into the machine toner dispensing system.

In other known toner concentration control devices which utilize development of a charged surface there are limitations which impede acceptable toner concentration determination. For example, in the U.S. Pat. No. 3,094,049 to Snelling wherein a conductive glass sensing surface is utilized, the charge on the sensing surface is not uniform due to the electric field edge-effect, resulting in toner development having greater concentration of toner along the edges of the sensing surface. This patented device does not utilize the sensing of the density of the accumulated toner, but rather the amount of light occluded from an area "-seen" by a photocell. Because of the resultant fringe development, the accumulation of toner for any sensing cycle is not as accurate indication of the toner concentration as may be needed for high speed, solid area reproduction.

In the U.S. Pat. No. 3,376,854 to Kamola there is disclosed a toner control device which also utilizes a conductive glass sensing surface. However, in this device, it is the density of toner accumulation that is sensed. There is also present the same problems regarding a non-uniform electric field across the surface due to the electric field edge-effect. Upon development of the surface, there is an uneven deposition of toner which is attracted to the edges of the surface while leaving a depletion of toner deposition in the center. Sensing of the toner density on this glass surface is confined to a relatively small area in the central portion of the surface wherein it is believed toner deposition is relatively uniform. One of the disadvantages here, of course, is that the area being sensed is relatively small, thereby minimizing the sensitivity that the sensing system is capable of acquiring. Another critical disadvantage is that there is slower response because of the longer time for toner to deposit in the center active area. The depletion of toner in the central portion of the surface also signifies a poor development utilization which cannot provide a good, accurate basis for toner density sensing which will be a good indication of toner concentration.

In U.S. Pat. No. 3,399,652, to Gawron, the reflectability of toner deposition on a charged surface is utilized to determine toner concentration. However, since the sensing plates in the patented device are charged with a single potential, it is questionable as to the magnitude and the distribution of the resulting field. Consequently, it is questionable as to the distribution of the toner particles on the sensing plates for measurement purposes. Since the patented device also utilizes a lens with a light source, it is more probable that light rays are focused on a small area on each of the disclosed fins thereby providing a small scan area.

These disadvantages are overcome by the present invention which utilizes an electroded development technique so that the electric field resulting from a charged sensing surface and a spaced surface that is either electrically grounded or has an opposite charge applied thereto is unidirectional and uniform. With this arrangement, upon development of the sensing surface by the toner particles being attracted thereto, the deposition of the toner is uniform throughout the sensing surface thereby insuring an adequate quantity of the particles for density determining purposes. In addition, the entire area thereof may be utilized for this density determination, thereby enhancing the sensitivity of the sensing system for providing more accurate determination of developability of the development material. The electroded sensor is simpler and more reliable than the sensors described in the Snelling and Kamola patents and simpler, more reliable and more sensitive than the fins in the Gawron probe.

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

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

FIG. 2 is a sectional view of a toner sensor utilized in the machine shown in FIG. 1;

FIG. 3 is a block diagram of the functional arrangement of a toner dispensing sensing and control system in which the present invention may be utilized;

FIG. 4 is a graphical illustration of the densities indicative of toner deposition on the sensing surfaces and, therefore, the toner concentration showing the steady-state conditions; and

FIG. 5 is a graphical illustration of the composite output as it would appear for a particular production run.

For a general understanding of a typical electrostatic 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 electrostatic systems such as a xerographic machine of the type illustrated, a light image of a document 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 comprising carrier beads and smaller toner particles triboelectrically adhering thereto 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 fixed by a fusing device whereby the powder image is caused permanently to adhere to the support surface.

The electrostatically attractable developing material commonly used in dry electrostatic printing comprises a pigmented resinous powder referred to here as "-toner" and a "carrier" of larger granular beads formed with glass, sand, polymer material or steel cores coated with a material removed in the triboelectric series from the toner so that a triboelectric charge is generated between the toner powder and the granular carrier. The carrier also provides mechanical control so that the toner can be readily handled and brought into contact with the exposed xerographic surface. The toner is then attracted to the electrostatic latent image from the carrier to produce a visable powder image on an insulating surface while the partially toner-depleted carrier beads are brought back into the developing system for the machine wherein it is mixed with developing material and a new supply of toner prior to reuse.

In the illustrated machine, an original D to be copied is placed upon a transparent support platen P fixedly arranged in an illumination assembly generally indicated by the reference numeral **10**. While upon the platen, an illumination system flashes light rays upon the original thereby producing image rays corresponding to the informational areas on the original. The image rays are projected by means of an optical system to an exposure station A for exposing the photosensitive surface of a moving xerographic plate in the form of a flexible photoconductive belt **12**.

The exposure of the belt surface to the light image discharges the photoconductive layer in the areas struck by light, whereby there remains on the belt a latent electrostatic image in image configuration corresponding to the light image projected from the original on the supporting platen. As the belt surface continues its movement, the electrostatic image passes through a working zone or developing station B in which there is positioned a developer assembly generally indicated by the reference numeral **14** and where the belt is maintained in a flat condition. The developer assembly **14** comprises horizontally and vertically conveying mechanisms which carry developing material to the upper part of the belt assembly whereat the material is dispensed and directed to cascade down over the upwardly moving inclined selenium belt **12** in order to provide development of the electrostatic image.

As the developing material is cascaded over the xerographic plate, toner particles in the development material are deposited on the belt surface to form powder images. As toner powder images are formed additional toner particles are supplied to the developing material in proportion to the amount of toner deposited on the belt during xerographic processing. For this purpose, a toner dispenser generally indicated by reference numeral **15** is used to accurately meter toner to the developer material in the developer assembly **14**.

The developed electrostatic image is transported by the belt **12** to a transfer station C whereat a sheet of copy paper is moved at a speed in synchronism with the moving belt in order to accomplish transfer of the developer image. There is provided at this station a suitable sheet transport mechanism adapted to transport sheets of paper from a paper handling mechanism generally indicated by the reference numeral **18** to the developed image on the belt at the station B.

After the sheet is stripped from the belt **12**, it is conveyed into a fuser assembly generally indicated by the reference numeral **21** wherein the developed and transferred xerographic powder image on the sheet material is permanently affixed thereto. After fusing, the finished copy is discharged from the apparatus at a suitable point for collection externally of the apparatus.

It is believed that the foregoing description is sufficient for the purposes of this application to show the general operation of an electrostatic copier using an illumination system constructed in accordance with the invention. For further details concerning the specific construction of the electrostatic copier, reference is made to copending application Ser. No. 731,934, filed May 24, 1968 in the name of Hewes et al now U.S. Pat. No. 3,661,452.

Referring now to FIGS. **1** and **2**, the toner dispenser **15** consists of a hopper or container **30** for the toner particles to be dispensed. Although the hopper or container **30** may be made in any size or shape, the hopper shown is formed as a rectangular open-ended box having tapering side and end walls.

The bottom wall of the hopper **30** may comprise a sliding perforated plate **31** adapted for sliding movement horizontally of the hopper for metering the flow of toner from the hopper. The toner thus dispensed is mixed with the developing material in the developer housing for the apparatus **14** to become almost immediately effective in the developing process. The metering provided by the plate **31** may be controlled by a mechanical device, generally indicated by the reference numeral **32**, such as a cam plate or linkage system which converts rotary motion of an electrical motor to reciprocable movement. Preferably, a single revolution of a rotary element in the device **32**, say, in the form of a motor shaft, will produce one reciprocable cycle of the plate **31**, thereby insuring the dispensing of predictable quantities of toner. Further details of the plate **31**, the linkage system and mechanical device **32** are not necessary to understand the present invention. A preferred form of these devices is illustrated and described in the copending application Ser. No. 731,966 filed on May 24, 1968 in the name of C. D. Wilson.

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 enter the apparatus **14**. Since the toner dispenser **15** 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 varying the number of strokes per actuation of the device **32**.

In order to control the dispensing of toner from the toner dispenser **15**, there is shown in FIG. **2** the details of an automatic control system which ultimately produces rotation of the rotary element in the device **32** in single revolution step-by-step operation in accordance with the demands of the control system as it determines the relationship of the toner concentration of the developing material with optimum toner conditions. Basically, the toner dispensing control system comprises a sensor generally indicated by the reference number **40** mounted within the developer assembly housing **14** by suitable means which electrically insulates the sensor from surrounding structures. Elongated baffle plates **41** are arranged below a horizontal conveyor **42** for the conveyor system for the developer system and are adapted to direct some of the developer material cascading from the conveyor **42** into the developer zone B. The plates **41** are positioned at angles relative to the vertical and arranged in such a way as to guide developer material falling therebetween into the sensor **40**.

The sensor **40** comprises a housing **45** attached to the lower edges of the plates **41**, and is formed with a funnel-shaped inlet opening **46** for presenting a circular flow orifice **47** through which entering development material may pass. The diameter of this orifice is such that the rate of flow of developing material through it remains constant. Within the housing **45** there is positioned a first sensor plate **48** arranged in a vertical plane and having a generally rectangular configuration. For practical purposes the plate may be of a size having approximately one-half inch for each side. A second sensor plate **50** is also arrange in the housing **45** parallel with the plate **48** and spaced therefrom a short distance. The plates **48**, **50** are formed of "NESA" glass, a trademark of the Pittsburgh Glass Company, which is generally tin oxide coated glass that is transparent to white light.

The spacing between the plates **48**, **50** may be on the order of one-tenth of an inch and is arranged below the flow orifice **47** in the inlet portion **46** of the housing **45**. Developing material flows by action of gravity through the flow orifice **47** and between the plates **48** and **50**, through the sensor **40** and out of the sensor by way of the outlet portion **51**. The material is then conveyed by a duct **52** connected between the outlet **51** and the lower conveyor **53** for the developing apparatus **14** in order to return the material back into the developing system for the machine.

Each of the plates **48, 50** is connected by a conductor **54, 55** respectively to a reversing switch **56** which, in turn, is connected electrically to a source **57** of direct current. The reversing switch **56** comprises a pair of micro-switches actuable by a rotatably cam **58** mounted on the shaft of a slow speed motor **59**. Preferably, the cam is driven with a speed of 60 revolutions per minute in order to effect a complete cycle of switch **56** actuation during each second of time. Each cycle of switch actuation provides one complete cycle of charging of the sensing plates **48, 50**, as will be discussed below. Instead of the switch **56**, the cam **58** and the motor **59**, other suitable means, such as an electronic switching circuit may be employed to acquire reverse cyclic charging of the plates **48, 50**.

During operation of the sensor **40**, an electric potential of a particular polarity and of a predetermined amount to attract and retain toner particles is applied alternately to the plates **48, 50**. As one of the plates is electrically charged to attract toner particles, the other has applied thereto a charge of a polarity which will repel toner particles therefrom during this time. As each of the plates are alternately charged positively and negatively, each plate during a cycle will attract toner for a short period of time and then immediately repel the same toner. As previously stated, each cycle has an expanse of time preferably on the order of one second whereby, for the first half cycle or for a duration of one-half second, toner particles are attracted and, for the second half of the cycle, toner particles are repelled. During the second half of each cycle wherein toner particles are repelled, the continuously flowing developing material moving between the plates will "-clean" the particular plate having the repelling charge thereon.

In the above description, it has been assumed that the toner particles are provided with negative charges so that when either of the plates **48, 50** has applied thereto a proper field, the toner particles will be attracted thereon. This electrical convention is merely illustrative and has been chosen only for descriptive purposes. The sensor plates function equally well with either positively or negatively charged toner with the same plate potential conditions.

The sensor **40** also includes a photocell **P–1** positioned in close proximity to the side of the sensor plate **48** away from the space between the sensor plates. A lamp **L–1** is also mounted in the sensor **40** and is arranged in close proximity to the side of the sensor plate **50** away from the spacing between sensor plates and in alignment with the plates and the photocell **P–1**. The relative positioning of the photocell and the lamp is such that the photocell will receive the light rays of the lamp through the cascading developer material stream between the sensor plates and the accumulated toner on first one and then the other for each "attract" – "-clean" cycle. The lamp is connected to a suitable source of electrical power to a control circuit for effecting the energization of the lamp during sensing operation, say for example, when the machine is turned "On".

Sensing control is accomplished by the present invention by continuously measuring the amount of toner particles that accumulates on both of the plates **48, 50** during multiple cycles of "attract" and "clean" actions. As previously indicated, a single sensing cycle includes the time when one of the plates **48, 50** attracts toner while the other repels it, and when the other plate attracts while the first attracting plate repels. Therefore, during a sensing cycle, each of the plates **48, 50** attracts toner particles for half the cycle time and each repels toner particles for the other half of the cycle. Cleaning may be accomplished if the plate which is not in the "attract" mode has a repelling field for the negative toner, as determined by the difference in potential between the two plates. For example, cleaning will occur if the "clean" plate has a potential at ground, or at a negative potential, or at a positive potential, but one which is less than that on the "attract" plate. If at a negative potential, cleaning will occur if the "clean" plate is less negative (that is, closer to zero) than the "attract" plate. As developing material cascades between the sensing plates, the material will clean away the toner particles previously attracted to that plate which is grounded.

The effect of this arrangement results in an output of the photocell that is effectively a steady state condition, that is, except for ripples, the output is maintained at a fixed quantity. In FIG. 4, the curve C illustrates the density of negatively charged toner buildup or cleaning relative to the sensing plate **48**, when the same is cyclically charged with "attract" or "clean" potentials. The curve D illustrates the density of the sensing plate **50** when this plate is cyclically charged with "attract" or "clean" potentials. As the plates **48, 50** are alternately charged with positive and negative potentials, the "attract" and "clean" operations for each plate result in the density acquiring high and low peaks, as evidenced by the shape of the curves C and D. Actually, the curves are of the same general shape and are approximately 180° out of phase with each other. As the plate **48** is charged positively, toner buildup increases while at the same time, toner previously built up on the plate **50**, is being cleaned off this plate. The summation of the densities due to the presence of toner on both plates at any one time is illustrated by the curve S, and this produces a summation signal in the photocell **P–1**. The curve S is shown as a straight line because of the similarities in its two component curves C and D. In practice, however, the curves C and D may differ slightly, resulting in a curve S which may possess a slight ripple. In any event, the curve S indicates the summation density of toner presence on the plates **48, 50** and the toner that is flowing between the plates but not adhering to either. For optimum conditions, the density will remain as the steady state condition having a fairly constant amplitude.

In other toner sensing devices, which employ only a single sensing plate or surface, only one of the curves C or D is available and the variations of density highs and lows usually require sophisticated electronics in order to produce effective "On-Off" conditions of toner addition.

The functional diagram in FIG. 3 illustrates the general operation to which the sensor **40** may be applied. Assuming the sensor **40** is provided with lamp and photocell voltages and that the charging voltage is disposed to be applied to either of the plates **48, 50**, the system is in condition for control operation. As the motor **59** is energized, say for example, as the reproduction machine is placed in its operating mode, the attract voltage is applied to the plates **48, 50** alternately, and the sensor **40** will then be in condition to control toner addition in the developing system for the machine. As toner in the developing system depletes during machine operation, the steady state output level of the photocell P–1 in the sensor is detected by a level detector circuit **60**, which may be preset with a predetermined threshold level, indicative of optimum toner content. A toner depletion will result in the lowering of the output level from the sensor in accordance with the depletion, and when this level attains an unacceptable value, such as dipping below the threshold level mentioned above, the resultant deviation in level value is sensed by the detector **60**. The detector **60** compares the sensor output level with the threshold level and produces a control signal to activate the toner dispenser **15** for adding more toner to the developing system. The dispenser adds toner in small amounts until the signal from the level detector **60** terminates.

In FIG. 5 the curve O illustrates the density conditions for a typical production run of the machine lasting approximately 25 minutes. The dotted line A illustrates the density experienced by the sensing plates **48, 50** at optimum toner content conditions and will be considered a sense line. At this line optimum developability conditions exist and below this level, toner must be added. The portion O_1 illustrates the situation wherein toner is not being removed with the machine in the operating condition, say for instance, when copies are not being produced. The downwardly sloping portion O_2 illustrates the gradual depletion of toner in the developing system during the production of copies comprising material in type or printed form or to what is generally considered as "line copy". It is noticed that the density slowly decreases in time as the production run continues toward completion. The positions of the various portions of the curve O such as portions O_1 and O_2 relative to the sense line A have been shown greatly exaggerated in FIG. 5 in order to better illustrate the different control actions of the toner control system. Actually, the portions of the curve O may be just off the level illustrated by the line A.

At the point P, the density level extends below the optimum density line A thereby resulting in the production of a corrective signal by the level detector **60** for causing the addition of more toner to the developing system. The portion O_3 of the curve indicates the result of this toner addition as the production run continues for line copy until the portion O_4 is reached wherein toner content is at its original level. The portion O_5 illustrates toner depletion for solid area coverage now being produced by the machine. It is noted that the depletion of toner for solid area production is quite rapid compared to the depletion of toner during long copy production. Again, as the toner depletion reaches the optimum level A, the toner dispenser is again actuated for adding toner to the system.

In the event the toner supply has been exhausted during machine operation, the level detector **60** will continuously produce an "add" signal. However, toner cannot be added to the system and its depletion, as noted by the portion O_6, will continue downwardly. At the level B, a suitable signal device may be incorporated into the machine in order to warn the operator of this toner depletion condition. If necessary, a machine shut-off signal may be produced in order to cause machine shutdown if this is more desirable than a warning signal.

From the foregoing it will be apparent that the sensor **40** is, in effect, a miniature cascade developing device wherein the development of either of the plates **48, 50** is enhanced by the other plate serving as a development electrode. Development is effected by means of an electrode field and not by fringe fields which occur when a single surface is employed without the influence of a parallel spaced surface having a charge for producing an electric field therebetween. The development then on each of the plates **48, 50** is complete; that is, the distribution of toner throughout the plate is uniform. In other words, the entire sensing surface is essentially utilized for development thus providing a larger relative area from which density may be measured which in turn allows better density averaging. The photocell P–1 may then be applied to the entire sensing surface area instead of merely the conventional small area utilized for scanning or sensing, and thus incorporates better control sensitivity into the control system.

While the invention has been described with reference to the structure disclosed, it is not confined to the details set forth; but is intended to cover such modifications, or changes as may come within the scope of the following claims.

What is claimed is:

1. A device for sensing electrostatically charged particles in a mixture of particulate material, including

a pair of spaced apart surfaces each being capable oF carrying an electrical charge adapted to attract the charged particles,

means for producing relative movement between at least some portions of the mixture and said surfaces and with the portions therebetween,

means for alternately producing an attracting charge on one of the surfaces and then the other surface for each of a series of sensing cycles, and

means for detecting the particles attracted to the surfaces during said series of cycles.

2. A device for sensing electrostatically charged particles in a mixture of particulate material, including

a pair of spaced apart surfaces each being capable of carrying an electrical charge when in an electric field for attracting the charged particles,

means for producing relative movement between at least some portions of the mixture and said surfaces and with the portions therebetween,

energizing means for producing an electric field between said surfaces, said energizing means being adapted to reverse the direction of said electric field alternately for each of a series of sensing cycles, and

means for detecting the particles attracted to the surfaces during said series of cycles.

3. A device for sensing electrostatically charged particles in a mixture of particulate material, including a pair of spaced apart surfaces each being capable of carrying an electrical charge adapted to attract the charged particles and an electrical charge adapted to repel the particles,

means for producing relative movement between the surfaces and some of the mixture with the latter therebetween, means for simultaneously producing an attracting charge on one of the surfaces and repelling charge on the other and then to reverse these charge relationships for each of a series of sensing cycles, and

means for detecting the particles attracted to the surfaces during said series of cycles.

4. An apparatus for maintaining the developability of developing material, including

a sensing surface adapted to carry a toner attracting charge,

means for producing an attracting charge on said surface, said attracting charge being capable of developing the surface with a quantity of toner related to a desired predetermined level of developability of the material,

means for forming a unidirectional electric field with said surface when said surface has an attracting charge thereon thereby effecting solid area development of the surface,

said surface being arranged to be applied to the developing material with movement relative thereto in order to permit attraction of the toner upon said surface, and

means for detecting the toner attracted to said surface.

5. The apparatus of claim 4 wherein said means for forming an electric field includes a development electrode spaced generally parallel to said surface.

6. A device for sensing electrostatically charged particles in a mixture of particulate material, including

a sensing surface capable of carrying an electrical charge adapted to attract the charged particles,

energizing means for producing an attracting charge on said surface,

means for producing relative movement between at least some portions of the mixture and said surface,

means arranged in cooperation with the charge on said surface for applying a uniform electric field over substantially all of said surface thereby effecting uniform deposition of the attracted particles on said surface, and

means for detecting the particles on said surface as a function of the developability of the particles in the mixture.

7. A device for sensing electrostatically charged particles in a mixture of particulate material, including

a sensing surface capable of carrying an electrical charge adapted to attract the charged particles,

energizing means for producing an attracting charge on said surface,

means for producing relative movement between at least some portions of the mixture and said surface,

means cooperable with said energizing means for applying a uniform electric field over substantially all of said surface thereby effecting uniform deposition of the attracted particles on said surface, and

means for detecting the particles on said surface as a function of the developability of the particles in the mixture.

8. A device for sensing electrostatically charged particles in a mixture of particulate material, including

a sensing surface capable of carrying an electrical charge adapted to attract the charged particles,

means for producing relative movement between at least some portions of the mixture and said surface,

means for producing an attracting charge on said surface and applying a uniform electric field over substantially all of said surface thereby effecting uniform deposition of the attracted particles on said surface, and

means for detecting the particles on said surface as a function of the developability of the particles in the mixture.

9. A device for sensing electrostatically charged particles in a mixture of particulate material, including

a sensing surface capable of carrying an electrical charge adapted to attract the charged particles,

energIzing means for producing an attracting charge on said surfaces,

means for producing relative movement between at least some portions of the mixture and said surface,

means cooperable with said energizing means for applying a uniform electric field over substantially all of said surface thereby effecting uniform deposition of the attracted particles on said surface, and

means for determining the presence of the charged particles as the same are being attracted to the surface.

10. A device for determining the proportional relationship of electrostatically charged particles in a mixture of particulate material, including

a pair of spaced apart surfaces each being capable of carrying an electrical charge,

means for producing movement of the material between said surfaces and in contact therewith,

means for alternately and simultaneously producing an attracting charge on one of the surfaces and a cleaning charge on the other surface for each of a series of sensing cycles, and,

means for detecting the sum of particle deposit on the surfaces at all times during said series of sensing cycles.

* * * * *