Oct. 24, 1967 J. R. DAVIDSON ETAL 3,348,523

AUTOMATIC TONER CONTROL SYSTEM

Filed April 7, 1965 3 Sheets-Sheet 1

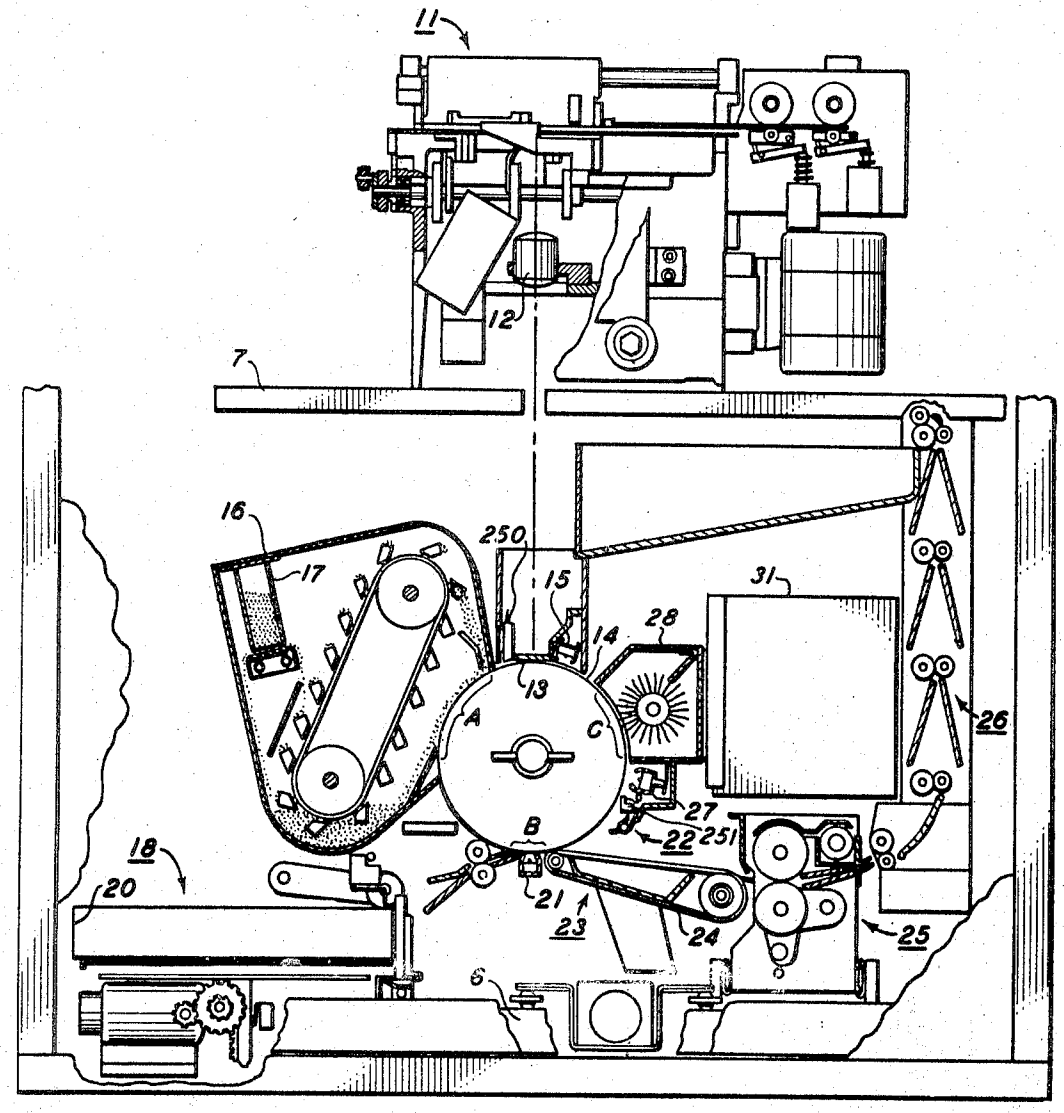


FIG. 1

INVENTORS
JAMES R. DAVIDSON
ROY M. PIERCE

BY James C. Schroeder
B. Chisana

ATTORNEYS

Oct. 24, 1967 J. R. DAVIDSON ETAL 3,348,523

AUTOMATIC TONER CONTROL SYSTEM

Filed April 7, 1965 3 Sheets-Sheet 2

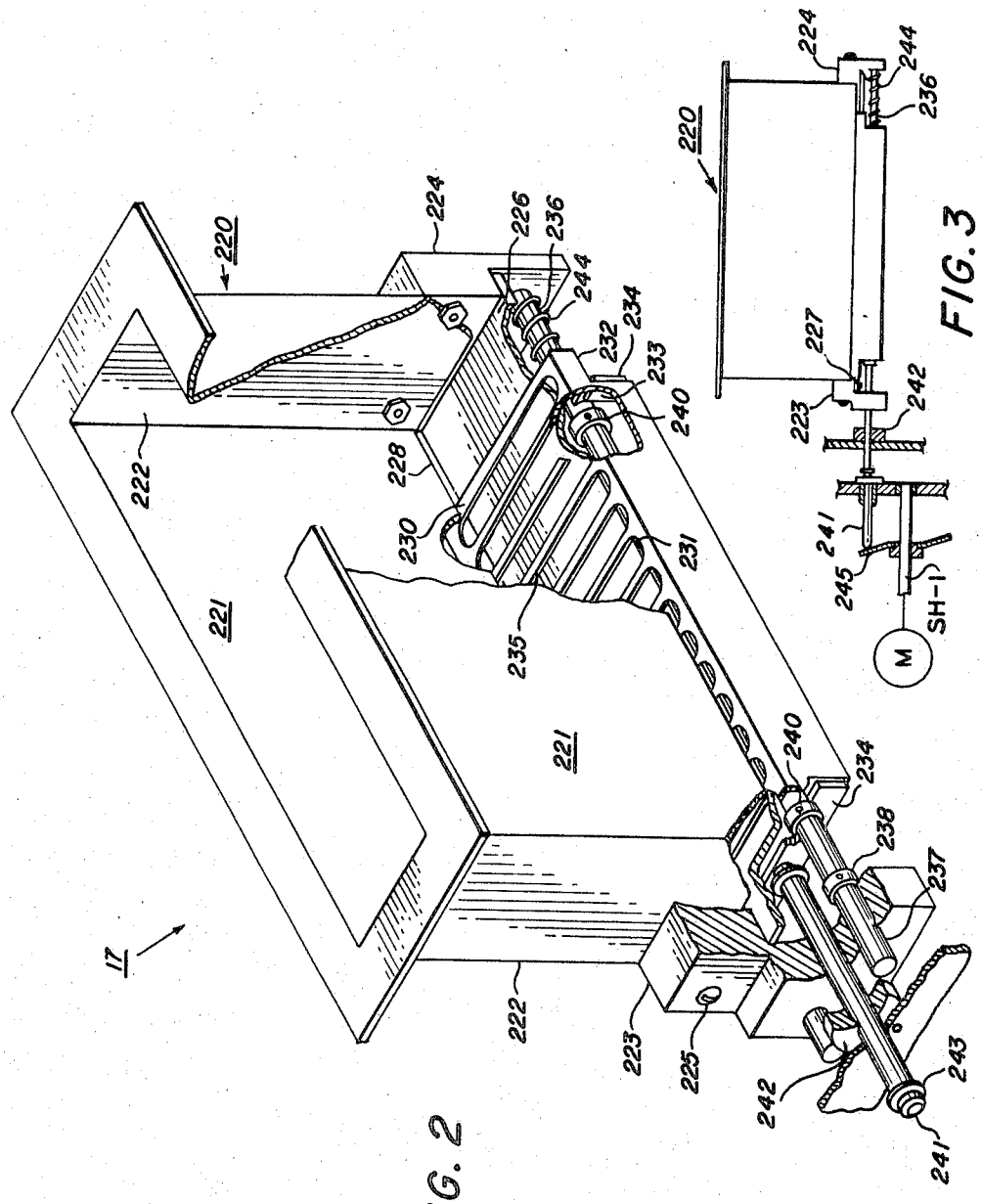


FIG. 2

FIG. 3

INVENTORS
JAMES R. DAVIDSON
ROY M. PIERCE

BY

ATTORNEYS

Oct. 24, 1967 J. R. DAVIDSON ETAL 3,348,523

AUTOMATIC TONER CONTROL SYSTEM

Filed April 7, 1965 3 Sheets-Sheet 3

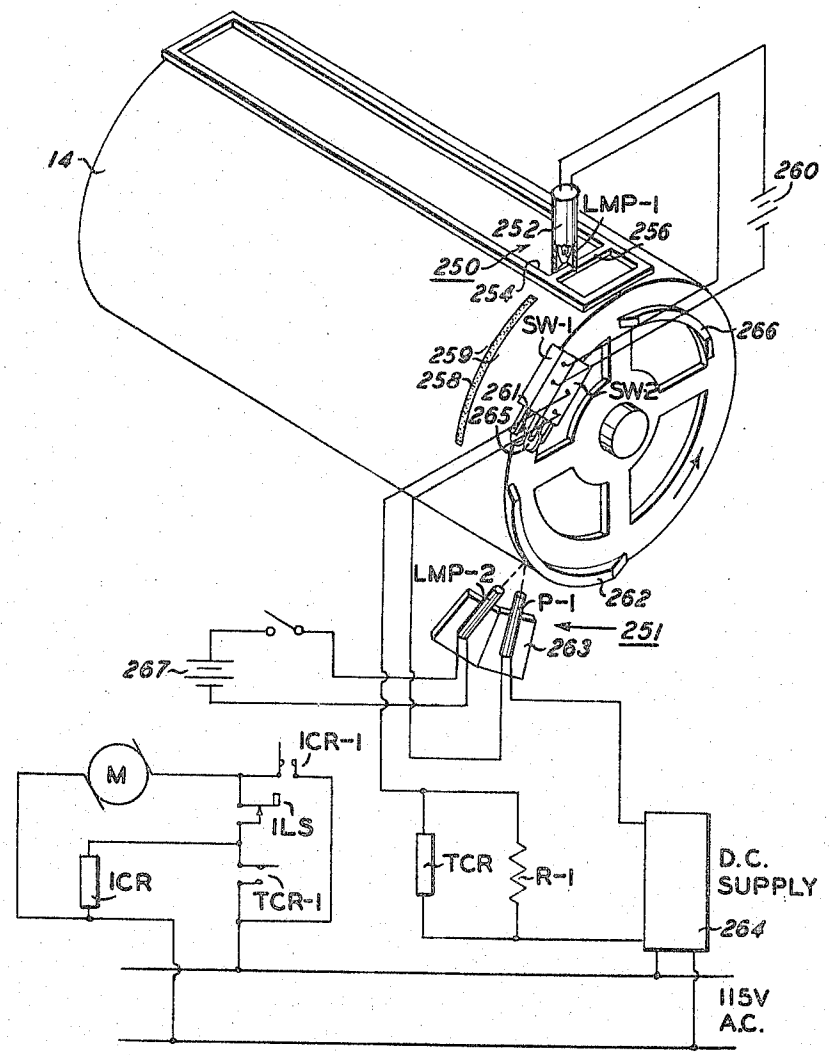


FIG. 4

INVENTORS
JAMES R. DAVIDSON
ROY M. PIERCE

BY

ATTORNEYS

United States Patent Office 3,348,523 Patented Oct. 24, 1967

3,348,523

AUTOMATIC TONER CONTROL SYSTEM

James R. Davidson, Rochester, and Roy M. Pierce, Webster, N.Y., assignors to Xerox Corporation, Rochester, N.Y., a corporation of New York

Filed Apr. 7, 1965, Ser. No. 446,356
2 Claims. (Cl. 118—7)

ABSTRACT OF THE DISCLOSURE

Apparatus for controlling the toner concentration in a developer mechanism in response to the quality of a control image developed thereby.

This invention relates to improvements in toner dispensing devices and, particularly, to improvements in the automatic control of these devices to facilitate the making of xerographic reproductions.

The present invention avoids the disadvantages of manual control for dispensing toner particles into the 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 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 constancy in image quality during xerographic processing.

These and other objects of the invention are attained by means of a control circuit utilized in conjunction with an improved toner dispensing device for dispensing toner into the developing apparatus in accordance with the density of a developed image upon the xerographic plate. Means are provided for producing an electrostatic image on the plate. This image is developed along with the image of a document being reproduced by the xerographic machine. A sensing device in the form of a photocell is also provided for receiving light rays reflected from the developed image and this serves to control conduction or current flow in a control circuit. A relay is arranged in the circuit and is adapted to connect a toner dispenser motor to a source of electrical power and a switching circuit which limits the energization of the motor to a predetermined cycle of operation.

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

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

FIG. 2 is an isometric view of a toner dispenser utilized with the xerographic machine;

FIG. 3 is a front view of the toner dispenser and its actuating mechanism; and FIG. 4 is a schematic illustration of a stripe marker and sensing device applied to a xerographic drum and the associated circuitry.

For a general understanding of the xerographic processing system in which the invention is incorporated, reference is had to FIG. 1 in which the various system components 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 the 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 to be described hereinafter for the purpose of scanning the minified data across a scanning light line. 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** includes a cylindrical member 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 card, 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 a latent electrostatic image in image 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, is 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 carrier 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 the developer housing sump. As toner powder images are formed, additional toner particles must be supplied to the developing material in proportion to the amount of toner deposited on the drum. For this purpose, a toner dispenser generally designated **17** is used to accurately meter toner to the developing material. Although any one of a number of well-known powder or granulated material dispensers may be used, the toner dispenser shown is of the type disclosed in Patent No. 3,062,109, issued to Mayo et al.

Positioned next and adjacent to the developing station is the image transfer station B which includes a sheet feeding mechanism adapted to feed sheets of paper successively to the developed image on the drum at the transfer station. This sheet feeding mechanism, generally designated **18**, includes a sheet source such as a tray **20** for a plurality of sheets of a suitable transfer material that is, typically, sheets of paper or the like, a separating roller adapted to feed the top sheet of the stack to feed rollers which direct the sheet material into contact with the rotating drum at a speed preferably slightly in excess of the rate of travel of the surface of the drum in coordination with the appearance of the developed image at the transfer station. In this manner, the sheet material is introduced between the feed rollers and is thereby brought into contact with the rotating drum at the correct time and position to register with the developed image. To effect proper registration of the sheet transfer material with the feed rollers and to direct the sheet transfer

material into contact with the drum, guides are positioned on opposite sides of the feed rollers.

The transfer of the xerographic powder image from the drum surface to the transfer material is effected by means of a corona transfer device **21** that is located at or immediately after the point of contact between the transfer material and the rotating drum. The corona transfer device **21** is substantially similar to the corona discharge device **15** in that it includes an array of one or more corona discharge electrodes that are energized from a suitable high potential source and extend transversely across the drum surface and are substantially enclosed within a shielding member.

In operation, the electrostatic field created by the corona discharge device is effective to tack the transfer material electrostatically to the drum surface, whereby the transfer material moves synchronously with the drum while in contact therewith. Simultaneously with the tacking action, the electrostatic field is effective to attract the toner particles comprising the xerographic powder image from the drum surface and cause them to adhere electrostatically to the surface of the transfer material.

Immediately subsequent to the image transfer station is positioned a transfer material stripping apparatus or paper pick-off mechanism, generally designated **22**, for removing the transfer material from the drum surface. This device includes a plurality of small diameter, multiple outlet conduits of a manifold that is supplied with pressurized aeriform fluid through the outlet condiuts into contact with the surface of the drum slightly in advance of the sheet material to strip the leading edge of the sheet material from the drum surface and to direct it onto a horizontal conveyor **23** having an endless conveyor **24** whereby the sheet material is carried to a fixing device in the form of a fuser assembly **25**, whereby the developed and transferred xerographic powder image on the sheet material is permanently fixed thereto.

After fusing, the finished copy is preferably discharged from the apparatus at a suitable point for collection externally of the apparatus. To accomplish this there is provided a vertical conveyor, generally designated **26**, by means of which the copy is delivered to a copy holder positioned in a suitable super-structure overhanging the rear portion of the desk top.

The next and final station in the device is a drum cleaning station C, having positioned therein a corona precleaning device similar to the corona charging device **15**, to impose an electrostatic charge on the drum and residual powder adherent thereto to aid in effecting removal of the powder, drum cleaning device adapted to remove any powder remaining on the xerographic drum after transfer and a source of light, not shown, whereby the xerographic drum is flooded with light to cause dissipation of any residual electrical charge remaining on the xerographic drum.

In general, the electrostatic charging of the xerographic drum in preparation for the exposure step and the electrostatic charging of the support surface to effect transfer are accomplished by means of corona generating devices whereby electrostatic charge on the order of 500 to 600 volts is applied to the respective surface, in each instance. Although any one of a number of types of corona generating devices may be used, a corona charging device of the type disclosed in Vyverberg Patent 2,936,725 is used for both the corona charging device **15** and the corona transfer device **21**, each of which is secured to suitable frame elements of the apparatus and connected to an electrical circuit described hereinafter.

Referring now to FIGS. 2 and 3, the toner dispenser **17** consists of a hopper or container **220** for the toner particles to be dispensed. Although the hopper or container **220** may be made in any size or shape, the hopper shown is formed as a rectangular open-ended box having vertical side walls **221** and end walls **222**, the upper ends of the walls being bent outward to form horizontal flanges by

means of which the hopper may be attached to the underside of top wall **201** of the developer housing as by welding, with the opening in top wall **201** of the developer housing in alignment with the opening in the hopper. At opposite ends of the hopper are positioned depending bearing blocks **223** and **224** for supporting the remaining elements of the toner dispenser, the bearing blocks being attached to end walls **222** by screws **225**.

The bottom of the hopper is partially closed by a dispensing plate **226** positioned in spaced vertical relation below the lower edges of the walls of the hopper. The dispensing plate **226** which is as wide as the hopper, is secured to the underside stepped portions of bearing blocks **223** and **224** by screws **227**. The dispensing plate **226** combines with the walls of the hopper **220** to provide a reservoir having narrow elongated outlet slits or passages **228** for the flow of toner particles.

To effect substantially uniform flow of toner particles through the outlets or passages **228**, there is provided a metering element, generally designated **230**, having a dispensing grid **231** positioned for reciprocating motion in the space between the dispensing plate **226** and the lower edges of the walls of the hopper **220**. The metering element **230**, as shown, has the dispensing grid **231** formed by a top wall having a series of transverse perforations or slots formed therein, and depending side walls **232**, the ends of which are bent inward at right angles to form flanges **233** to which support plates **234** are secured as by spot welding. For ease and economy in manufacturing the metering element is formed as a sheet metal stamping, the slots being formed relatively close to each other and to the transverse edges of the top wall so that after the slots are formed there remains only narrow strips of metal simulating wires **235**, the width of the metal remaining between slots being only sufficiently wide to prevent them from being bent out of shape in the stamping process.

The metering element **230** is supported by parallel guide rods **236** extending through holes formed in support plates **234**, the ends of the guide rods being journaled for reciprocating motion in apertures **237** formed in bearing blocks **223** and **224**. As seen in FIG. 2, the movement of the guide rods **236** to the left is limited by collars **238** adjustably secured thereto by suitable screws, while movement of the metering element **230** with respect to the guide rods **236** is prevented by a second set of collars **240** secured by set screws to the guide rods inboard of the support plates **234**.

For effecting movement of the metering element, a plunger rod **241** is journaled for reciprocating movement in a bearing block **242** secured to a side wall of the developer housing, the plunger extending at one end through a suitable aperture in the side wall to be actuated by a suitable power source, and at its opposite end the plunger rod extends through a suitable aperture in bearing block **223** into contact with the left-hand support plate **234**. To limit the movement of plunger rod **241**, retaining rings **243** are secured in suitable grooves at each end of the plunger rod. The return stroke of the metering element is effected by coiled springs **244** encircling the guide rods **236** and butting at opposite ends against the bearing block **224** and the right-hand support plate **234** to bias the metering element to the left.

As shown, the dispensing grid is positioned between the dispensing plate **226** and the lower edge of the walls of the hopper **220** in spaced relation to each other to permit free reciprocating movement of the grid. The space or clearance between each of the last-named elements may be varied during fabrication to accommodate the particle size of toner to be dispensed.

In the operation of the toner dispenser a supply of toner particles is placed within the hopper, the hopper grid and the dispensing plate forming a reservoir for the toner particles. Upon reciprocation of the grid by the plunger rod **241**, a metered quantity of toner particles will be permitted to cascade through the open grid work

of the grid from where they will fall to the reservoir portion of the conveyor housing **16**.

Since the toner dispenser **16** dispenses a uniform quantity of toner for a given strokelength of the metering element **230**, 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 unit of time. Thus, the dispensing rate may be varied by changing the length of stroke of the metering element **230**, which, for example, may be accomplished in its simplest form by adjustment of the right-hand collars **240** on the grid rods **236**.

Reciprocation of the plunger rod **241** is effected by means of wobble plate **245** secured to the end of a shaft SH–1 journaled in bearings mounted on frame plates **5** and **215**. The shaft is driven by suitable pulleys (not shown) connected to the shaft of a motor M. The contour of the wobble plate **245** is such that one complete revolution of the shaft SH–1 will actuate the rod **241** axially to reciprocate the dispensing grid once from one extreme position to the other.

In order to control the dispensing of toner from the toner dispenser **17**, there is shown in FIG. 4 the details of an automatic toner control system which ultimately imparts rotation to the wobble plate **245** 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 an exposure device which exposes a stripe near the edge of the drum after it is charged; a sensing device for generating a signal in accordance with the relative density of the developed stripe and; an electrical circuit for utilizing the signal for imparting rotation to the wobble plate of the toner dispenser.

As shown in FIG. 1, a stripe exposure or marking device **250** is mounted on the machine at a point between the charging device **15** and the developing mechanism **16**. Between the transfer station **21** and the pre-cleaning **27**, there is mounted a sensing head **251** which is adapted to project light onto the developed stripe and to sense the density of the toner comprising the stripe in accordance with the light reflected from the stripe.

The stripe marking device **250** comprises an exposure housing **252** positioned in close proximity to the drum adjacent one end and is formed with an exposure slit **254**. The exposure housing is provided with a narrow opaque strip of material **256** which extends across the exposure slit for separating the same into two open sectors. The sectors, in effect, are windows for permitting exposure of the drum therethrough by means of a small lamp LMP–1 mounted within the housing **252**. The windows are generally of equal area and, when the lamp is energized, allow the light rays therefrom to impinge the drum surface to expose and discharge those portions of the drum on either side of the strip **256**. The strip **256** and the windows in effect, function as a mask which results in the formation of a stripe **258** of unexposed drum surface between two exposed areas **259**, being produced when the lamp LMP–1 is energized. The lamp LMP–1 is connected to a battery **260** and to a switch SW–1 for controlling energization of the lamp. The switch SW–1 is provided with an actuator arm having a wheel **261** engagable with a cam **262** mounted on the end edge of the drum **14**. The switch SW–1 is normally opened and when the cam wheel or follower **261** engages the cam **262**, the switch is actuated to its closed position for energizing the lamp LMP–2 for exposing the areas **259** and thereby produce the image **258**.

For efficient operation of the automatic toner dispenser the stripe marking device is located near one of the extreme ends of the drum **14** remote from the adjacent edge for the copy image area that evolves from use of the drum in the xerographic machine. With this arrangement there is no interference between the exposure elements and the development of the resultant stripe pattern with the exposure elements for the xerographic processing of documents. The only common operative interaction between these two exposure devices is the use of the charging device **15**, the developer mechanism **16** for developing the respective images and, the cleaning device **28**.

After the stripes **258** have been developed in the developer mechanism **16** to form toner powder images of the stripes, the stripes are transported by normal rotation of the drum **14**, past the sensing device **251**. In traveling to this point, the toner powder images of the stripes being formed adjacent one end of the drum **14**, will be clear of the transfer station **21** and will not be transferred to a support material as is the case for the developed images of a document.

The sensing device **251** includes a support block **263** which may be mounted by any suitable means adjacent the surface of the drum. Within the holder **263** there is provided a lamp shield and lamp LMP–2 which extends into the shield and, when energized, is adapted to project light rays onto the developed stripe image **258** on the drum surface at an angle relative thereto.

The support block **263** also includes a photocell P–1 which is adapted to scan the light rays reflected from the drum surface and directed thereon by the light rays emanating from the lamp LMP–2. The relative positioning of the photocell is such that it will receive any light rays reflected from the area of the stripe **258**.

Electrically, the photocell P–1 is connected to one side of a D.C. power supply **264** and to a contact in a normally closed switch SW–2. As shown in FIG. 4, the switch SW–2 is provided with a switch actuator in the form of a cam wheel **265** which is adapted to cooperate with a cam **266** mounted along the end edge of the drum **14**. The cam **266** is similar to the cam **262**, being arcuate in form to conform to the curvature of the drum's circumference. When the cam follower **265** engages the cam **266**, the switch SW–2 is actuated to its closed condition and, conversely, when the cam moves away from the follower, during rotation of the drum, the switch is opened. The cams **262**, **266** are arranged about the circumference of the drum so that after an image **258** is produced by the action of the cam **262**, as described above, the cam **266** will cause the switch SW–2 to close when the central portion of the image **258** is passing the sensing head **251**.

The other contact of the switch SW–2 is connected to the other side of the D.C. source **264** by way of a parallel circuit comprising a relay coil TCR and a resistor R–1. In order to energize the relay TCR, the switch SW–1 must be closed and, the effective resistance of the photocell P–1 must be low enough so that when added to resistance of the parallel circuit will allow or make available sufficient current to energize the relay. This has the effect of rendering the relay TCR sensitive to the voltage drop across the resistor R–1. When the voltage drop is high, as will be produced when the voltage drop across the photocell is low, the current through the relay coil increases. The resistance for the resistor R–1 is chosen so that the relay will pull in when the photocell produces a predetermined voltage drop in accordance with the amount of light scanned by the photocell. In turn, the amount of light reaching the photocell will be determined by the density of the developed electrostatic image **258** as it is scanned by the photocell. In effect, the desired density of the developed image will determine the resistance valve of the resistor R–1 in order to cause energization of the relay in the event the density of the image drops below the desired density. To add flexibility to the system and to make the above determinations attainable, it is preferred that the resistor R–1 be variable. With this arrangement, a developed image having a predetermined desired density is brought into scanning view of the photocell. Next the variable resistor is adjusted until the relay becomes energized. This will establish the parameters for energizing the relay at the desired image density.

As previously stated, to provide the light rays that

must reach the photocell P–1 from the developed image **258**, the support block **263** has mounted thereat the light source LMP–2 connected to a suitable battery **267**. The light source is arranged at an angle relative to the axis of the photocell so that their respective axes intersect on the surface of the drum **14** and within the center of the image **258** when the same has been moved to be scanned by the photocell.

For each pulse of energization that is experienced by the relay TCR in the event the density of the developed stripe image is below a predetermined level, the relay will produce actuation of a normally open contact TCR–1 to its closed position to complete the circuit momentarily to a relay coil 1CR. This causes closing of the relay contact 1CR–1 for closing the circuit to the motor M and energization thereof. Mounted on the shaft SH–1 for rotation with the wobble plate **245** is a circular cam (not shown) adapted to actuate a normally closed limit switch 1LS to an open position once each revolution of the cam and wobble plate. Closing of the contact 1CR–1 also completes the circuit to the relay 1CR for holding the contact closed until the wobble plate makes one complete revolution. Upon this occurrance, the switch 1LS is opened momentarily to de-energize the relay 1CR and to open the power circuit to the motor M. Since a short duration pulse closed the contact TCR–1 for initiating the motor M operation, this contact will be opened before the switch 1LS is opened.

During normal operation of the automatic toner dispensing apparatus, the sensing head lamp LMP–2 is continuously energized for presenting light upon the stripe **258** and the clear areas between the ends of each stripe produced on the drum. However, only the light reflected from the central portion of the stripe is sensed by the photocell P–1 since the circuit to the photocell is opened by the switch SW–2 for all other positions of the stripe. The resistor R–1 is adjusted so that the voltage drop across it is low when the circuit to the photocell is open and high when a stripe is sensed and an undertoned image is present, whereby the voltage drop assumes a square waveform having high, flat peaks denoting the voltage drop when the stripes are sensed. It is the level of these high flat peaks that vary in accordance with the resistance of the photocell P–1 as it scans image areas. When the density of these areas is high, resulting in low reflectivity, the resistance of the cell P–1 will be high and the volatge drops across R–1 will be low and the wave-form thereof will have low level peaks. On the other hand, when the density is low causing higher reflectivity, the level of the voltage drop peaks across the resistor R–1 will be higher and, when it reaches a predetermined level, which serves as an indication of toner demand, the relay TCR will become energized for the length of time required to move the scanned image out of scanning position relative to the photocell. For each electrical pulse produced in this manner, the wobble plate **245** will rotate one complete revolution. As previously stated, one revolution of the plate **245** will actuate the dispensing grid **241** between its extreme position for dispensing toner into the developer housing.

As the density of the toner on subsequent stripes increases, the voltage drop across the resistor R–1 will lower, thereby terminating further actuation of the toner dispenser. The sensitivity of the sensing head can be varied by the parameters chosen for the resistor R–1 and the strength of the D.C. sources **260**, **264**, and **267**.

The toner dispenser **17** functions to sift toner material onto the developing material already present in the developer housing. In order to ensure uniform distribution of new toner to bring the toner density back to the desired level in a minimum of time, the toner dispenser extends horizontally substantially across the upwardly moving buckets which are in motion to cascade toner over the drum surface throughout its entire width.

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

While the invention has been described with reference to the structure disclosed herein, it is not confined to the details set forth, and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims. For example, instead of producing a stripe in the manner set forth above, a mask having a slot formed therein between the lamp LMP–1 and the drum surface may be utilized to produce a strip of exposed drum area. In this case, developer material of opposite polarity to that used in the above described arrangement must be used in order to acquire a toner developed stripe capable of being sensed by the sensing head.

What is claimed is:

1. In a xerographic apparatus of the type having a xerographic drum adapted to pass through a xerographic charging station and exposing station and including a developer mechanism arranged to produce a powdered image on the drum, a toner dispensing and control device including

a shielded light source positioned intermediate the charging and developer stations adjacent the edge of the drum at a position remote from the copy imaging area,

a mask positioned intermediate said shielded light and the drum and being adapted to produce a control latent electrostatic image on the remote area of the drum when said light is energized,

means to energize said shielded light periodically whereby a series of latent images are placed on the drum,

a container for the toner,

means for dispensing toner from said container into the developer mechanism for replenishing developer material therein,

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

a lamp arranged to illuminate a developed control image produced in said remote area,

a photoelectric device arranged to receive reflected light from the control image and connected in a circuit for establishing a current level therein when the density of the developed control falls below a predetermined value,

and means responsive to the current level in the circuit and associated with said actuator device for actuating the same to dispense toner into the developer mechanism when the current level attains a predetermined value.

2. The apparatus of claim **1** having means associated with the drum to intermittently energize said lamp source in response to a developed image brought into communication therewith.

References Cited

UNITED STATES PATENTS

2,956,487	5/1960	Giaimo	95—1.7
3,094,049	6/1963	Snelling	118—637 X
3,233,781	2/1966	Grubbs	118—9 X

CHARLES A. WILLMUTH, *Primary Examiner.*

PETER FELDMAN, *Assistant Examiner.*