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E. A. WEILER ET AL

3,376,853

ELECTROSTATIC TONER CONTROL

Filed April 29, 1966

2 Sheets-Sheet 1

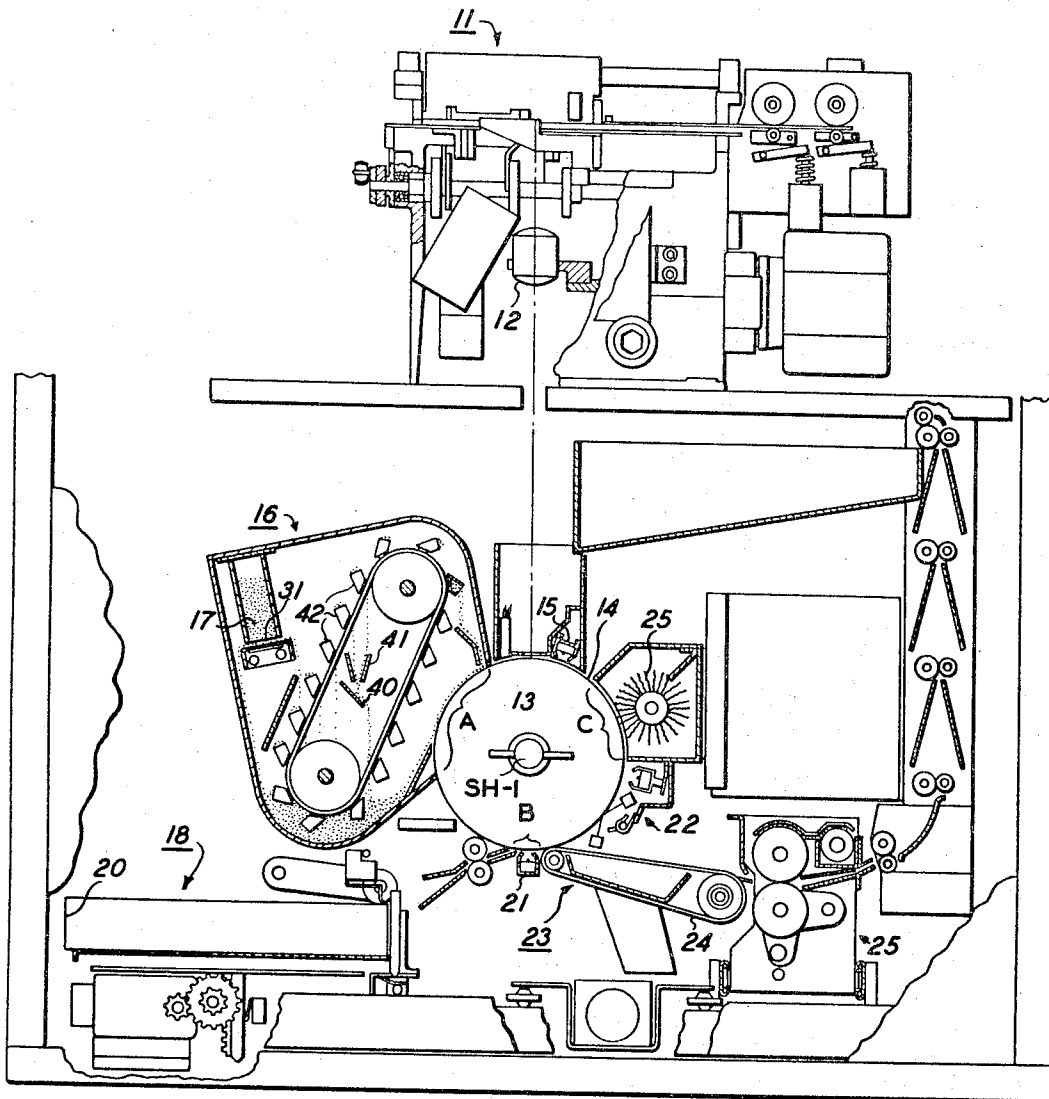


FIG. 1

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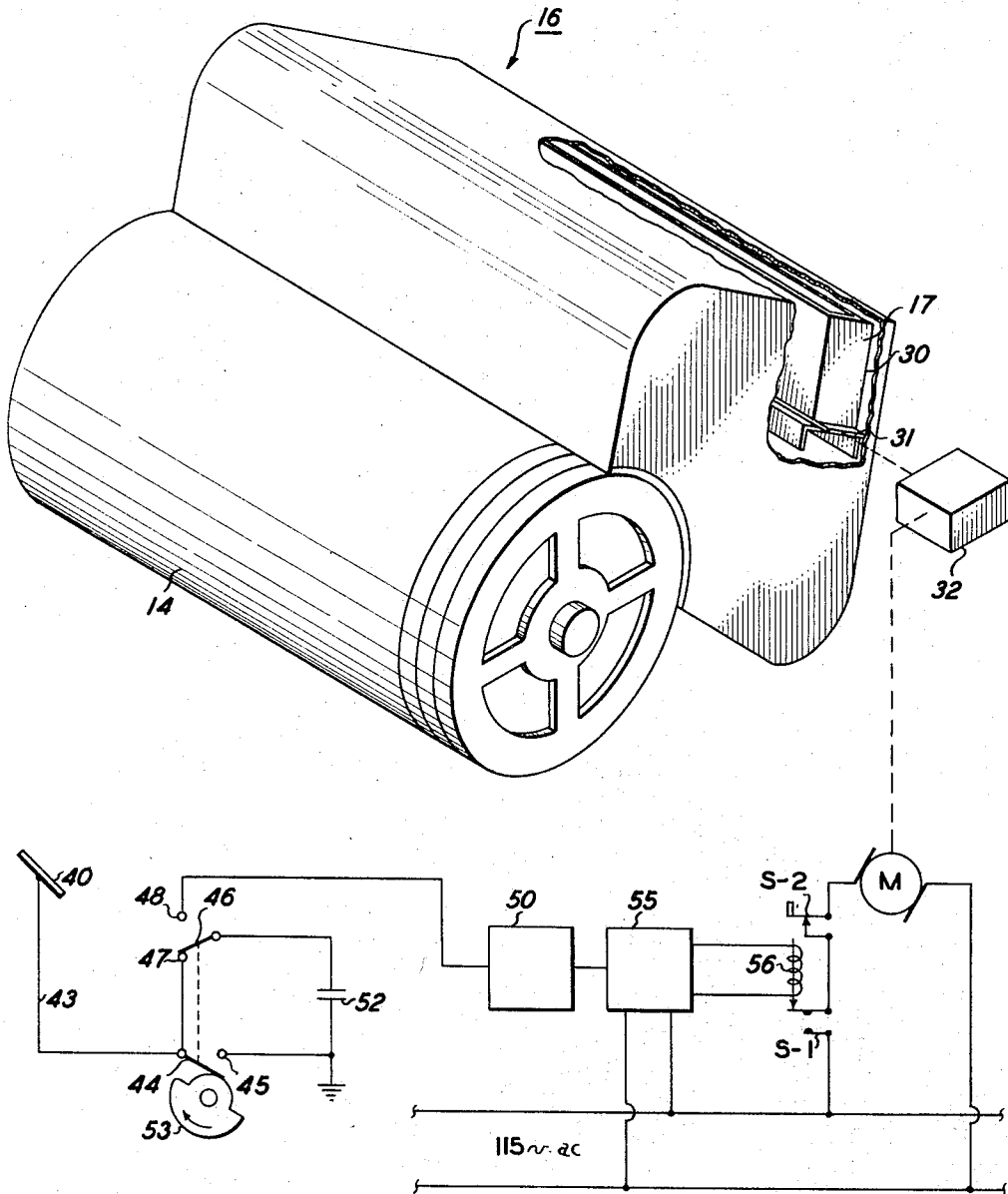


FIG. 2

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ELECTROSTATIC TONER CONTROL

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4 Claims. (Cl. 118—637)

ABSTRACT OF THE DISCLOSURE

A toner concentration control system for a recording apparatus in which a conductive plate within a developer housing is used to sense the amount of toner in the housing. A steady stream of developer material is directed across the plate which accumulates a charge induced thereon in proportion to the amount of toner. This induced charge is utilized to charge a capacitor which, when it attains a predetermined charged value, causes actuation of a toner dispenser mechanism.

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 guess-work 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 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 of electrostatic charge within the apparatus or, in other words, the ability of the toner particles to charge a surface. This proportionality is utilized to control the amount of toner within the apparatus and, to this end, a conductor plate is placed within the apparatus to receive some of the developing material falling thereon. The plate will be charged by the toner particles and this charge is utilized to charge a capacitor. The discharge of which serves to produce a control signal. The capacitor is arranged in a circuit such that if the amplitude of the signal is below a pre-set level, a pulse is generated for causing introduction of toner particles into the machine 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; and

FIG. 2 is a schematic illustration of a toner dispens-

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ing arrangement and a sensing device 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 serially 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 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 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 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 anyone 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 suc-

cessively to the developed image on the drum at the transfer station. This sheet feeding mechanism, generally designated 18, includes a sheet source such as 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.

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 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.

The next and final station in the device is a drum cleaning station C, having positioned therein a corona pre-cleaning 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 and, a drum cleaning device in the form of a rotary brush 26 adapted to remove any powder 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 to 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 2,836,725 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 a suitable electrical circuit.

Referring now to FIG. 2, the toner dispenser 17 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 vertical side and end walls.

The bottom wall of the hopper 30 may comprise a sliding perforated plate 31 adapted for sliding movement longitudinally 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 16 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 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 imparts rotation to 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 conductor plate 40 mounted within the developer housing 16 by suitable means which electrically insulates the plate from surrounding structures and, a dispensing bin or housing 41 mounted above the plate 40. The bin 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 40 is at an angle, approximately 45° relative to the vertical and arranged below the bin 41 in such way as to receive developer material falling therefrom.

As shown in FIG. 2, the plate 40 is electrically connected by a conductor 43 to a switch arm 44 of a single pole, single throw switch having its other contact 45 electrically connected to ground. The switch arm 44 is mechanically coupled to a switch arm 46 of a double pole, single throw switch which includes a contact 47 connected to the switch arm 44 and a contact 48 electrically connected to a signal sensor 50.

Between the contacts 45 and 46 there is connected a capacitor 52 of relatively large capacity and which has a charging time of approximately 8 seconds or, at least, equal to the time for the drum 14 to make one complete revolution. The switch arm 44 and consequently, the arm 46 is mechanically actuated between their respective controlling positions by a rotating cam 53 mechanically connected to the shaft SH-1 for the drum 14. With this arrangement, the cam 53 will rotate at the same speed as the drum and will actuate the two switches for each rotation thereof. As shown in FIG. 2, when the switch 44, 45 is open, the arm 46 is in engagement with the contact 47 and, when the cam actuates the arm 44 against the contact 45, the arm 46 will be actuated away from the contact 47 and into engagement with the contact 48. Instead of the switch arrangement described above, a double pole, double throw switch may also be utilized as long as the electrical connections thereto are equivalent to those illustrated.

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Electrically, the signal sensor 50 is connected to an amplifier 55 which is utilized to amplify the signal produced by the sensor 50 and to drive or energize a solenoid 56 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 a motor M and are connected to a suitable source of electrical power such as conventional house current. Upon energization of the solenoid 56, 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 the motor M. With the solenoid 56 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 conductor plate 40 receives a portion of the developing material carried upwardly by the buckets just prior to cascading over the adjacent drum surface. A charge, opposite in polarity to the particular toner used in the developing material is induced in the plate 40 and is quantitatively proportional to the amount of toner in the system. If the latent image is under-toned, the supply of toner in the developer housing is low, which condition will manifest itself by a corresponding reduction of the charge accumulated on the plate 40 from a pre-set amount programmed into the apparatus for a particular toner density.

The charge being built up on the plate 40 is stored in the capacitor 52 when the switch arm 46 is against the contact 47. When the cam 53 rotates to actuate the switch arm 46 against the contact 48, the charge built up in the capacitor 52 is discharged into the sensor 50. The sensor may be devised so that when a signal, such as a capacitor discharge, is induced therein of high magnitude, beyond a pre-set adjustable level, no output signal is produced and, when the input signal is below the pre-set level, an output signal, is produced by the sensor. This dispensing of the toner will be in small evenly spaced quantities which will affect the density of the developed image in the matter of a few dispensing cycles.

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-to-carrier relationship or ration 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, other means for producing actuation of the mechanism 32 or for that matter, dispensing by the dispenser 17, for signals produced by the sensor 50 may be provided on the machine.

What is claimed is:

1. A toner dispensing device and control system therefor for use in an electrostatic reproduction apparatus having an electrostatic reproducing plate and a developer

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mechanism adapted to apply developer material to exposed images on the plate thereby producing powdered 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,

means for sensing the electrical charging rate of the toner in the developing mechanism including a conductor plate arranged to receive a steady stream of developing material thereacross whereby an electrical charge is induced in said conductor plate in accordance with the amount of toner within the developer mechanism,

and means associated with said sensing means for actuating said actuator device to dispense toner into the developer mechanism when the amount of the charge produced by the toner during a predetermined time period falls below a predetermined value.

2. A toner dispensing device and control system therefor for use in an electrostatic reproduction apparatus having an electrostatic reproducing plate and a developer mechanism adapted to apply developer material to exposed images on the plate thereby producing powdered 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,

means for sensing the electrical charging rate of the toner in the developing mechanism,

means associated with said sensing means for actuating said actuator device to dispense toner into the developer mechanism when the amount of the charge produced by the toner during a predetermined time period falls below a predetermined value,

said sensing means including a capacitor and means for charging the capacitor in accordance with the amount of toner in the developing mechanism.

3. A toner dispensing device and control system therefor for use in an electrostatic reproduction apparatus having an electrostatic reproducing plate and a developer mechanism adapted to apply developer material to exposed images on the plate thereby producing powdered 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,

means for sensing the electrical charging rate of the toner in the developing mechanism,

means associated with said sensing means for actuating said actuator device to dispense toner into the developer mechanism when the amount of the charge produced by the toner during a predetermined time period falls below a predetermined value,

said sensing means including a mechanism for periodically accumulating an electrical charge and means for comparing each accumulated charge with a pre-set value.

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

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a container for the toner,
means for dispensing toner from the container into
the developer mechanism for replenishing the de-
veloping material with toner,
an actuator device associated with the said dispensing
means for controlling the introduction of the toner
into the developer mechanism, 5
means for sensing the electrical charging rate of the
toner in the developing mechanism,
means associated with said sensing means for actuating
said actuator device to dispense toner into the de- 10
veloper mechanism when the amount of the charge
produced by the toner during a predetermined time
period falls below a predetermined value,
said sensing means including a capacitor and means 15
for charging the capacitor in accordance with the

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amount of toner in the developing mechanism, and
said capacitor being periodically grounded in order
to permit periodic charging of said capacitor and
thereby effect periodic sampling of the toner content
in the developer mechanism.

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