

[54] **TONER CONCENTRATION REGULATING APPARATUS**

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[51] Int. Cl. **G03g 15/08**

[58] Field of Search **355/3, 4; 118/637, 7; 117/17.5**

[56] **References Cited**

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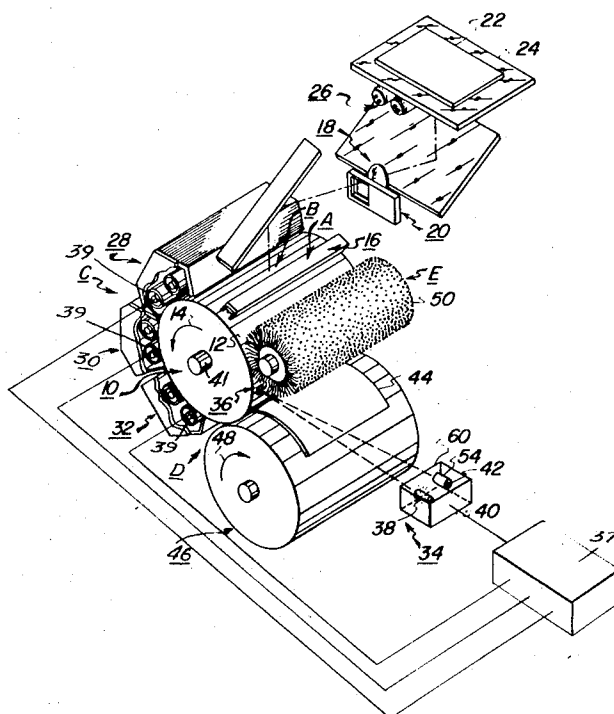
Primary Examiner—Robert P. Greiner

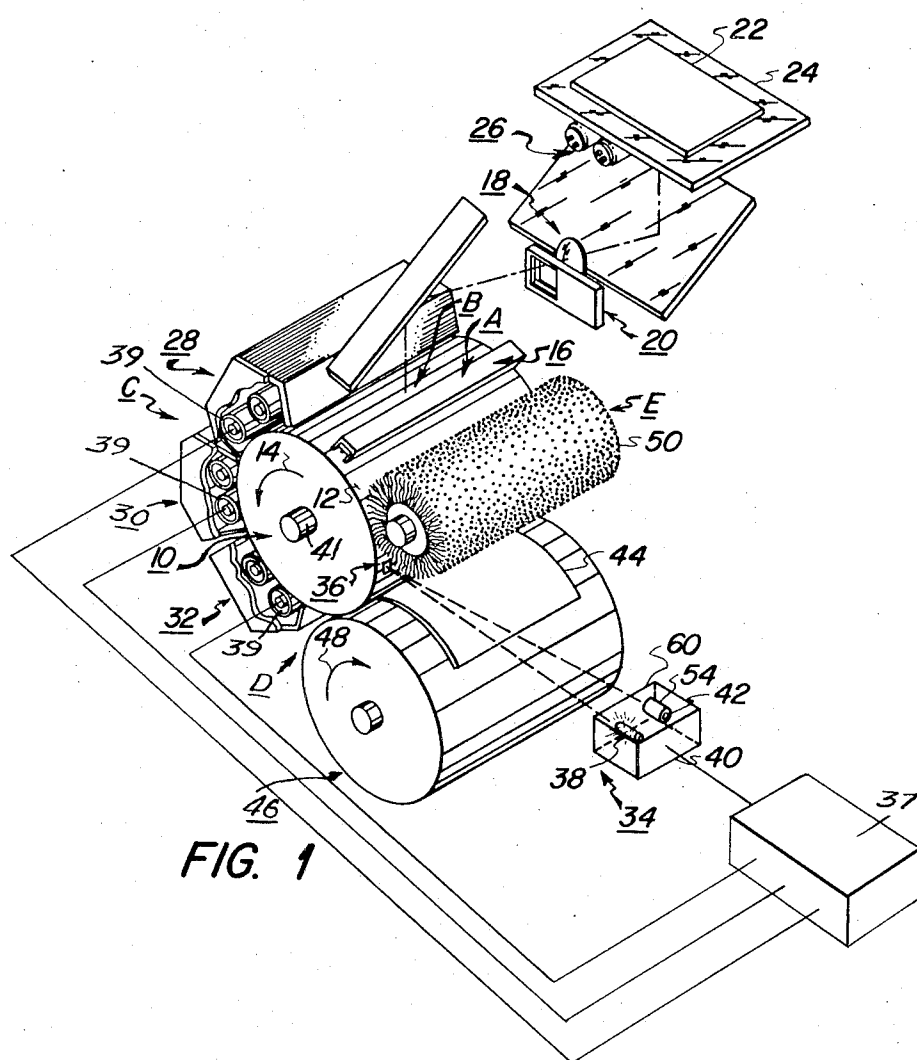
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[57] ABSTRACT

An apparatus in which the concentration of toner powder in a particulate mixture is regulated. The particulate mixture is utilized in a development system for producing a viewable toner pattern on an image bearing member.

4 Claims, 3 Drawing Figures





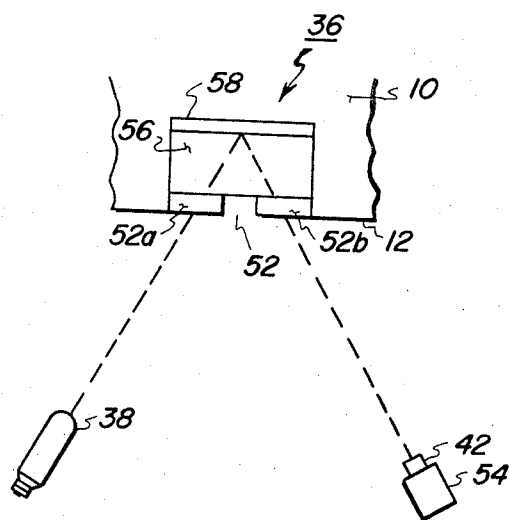


FIG. 2

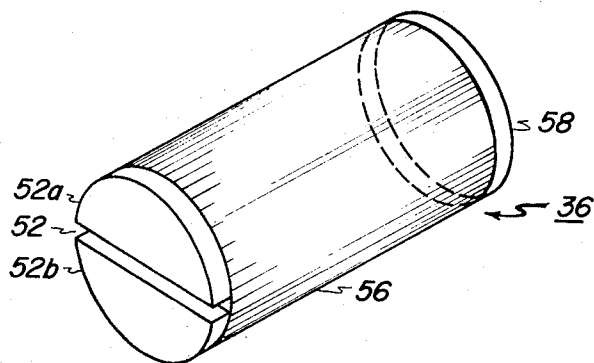


FIG. 3

TONER CONCENTRATION REGULATING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates generally to a multi-color electrophotographic printing machine, and more particularly concerns an apparatus for regulating the concentration of toner particles within the developer mix used in the development system thereof.

Toner particle concentration in the developer mix directly effects the developability of the multi-color electrophotographic printing machine. The concentration of toner particles within the developer mix, i.e., the percentage of toner particles relative to carrier, relates directly to the characteristics of the developed image. For example, the density of the image will be affected by the toner particle concentration.

Various types of systems have been developed which add toner particles to the developer mix. However, most of these systems are directed primarily to black and white printing machines rather than multi-color printing machines. A typical system used in a black and white printing machine is disclosed in U.S. Pat. No. 3,399,652 issued to Gawron in 1968. This patent discloses a rotating disc disposed in the developer mix. The disc is electrically biased to attract toner particles from the mix. A light beam is reflected from the surface of the disc onto a photoelectric unit. The intensity of light striking the photoelectric unit is an indication of the toner particle concentration within the developer mix. However, the foregoing system is not mounted on the photoconductive member and, hence, does not undergo the normal processing steps thereof. The apparatus disclosed in Gawron appears to be located in a developer mix sump external to the photoconductive member.

One system adapted for use in a multi-color electrophotographic printing machine is described in copending application Ser. No. 213,056, filed in 1971. As disclosed therein, the apparatus includes a transparent electrode mounted on the photoconductive member and adapted to attract electrostatically toner particles thereto. A light source generates a beam of light rays which are transmitted from the interior of the photoconductive drum through the transparent electrode onto a photosensor. The photosensor develops an electrical signal indicative of the density of toner particles adhering to the transparent electrode. In the foregoing system, light rays pass through the transparent electrode rather than being reflected therefrom. This introduces the added complexity of transmitting a light beam to the interior of the photoconductive drum so that it may pass through the transparent electrode.

Accordingly, it is a primary object of the present invention to improve the apparatus used to regulate toner particle concentration within a developer mix.

SUMMARY OF THE INVENTION

Briefly stated, and in accordance with the present invention, there is provided an apparatus for regulating toner powder concentration within a particulate mixture utilized in a development system arranged to deposit toner powder on an image bearing member.

Pursuant to the present invention, reflecting means, mounted on the image bearing member, is biased electrically to a potential of sufficient magnitude to attract

the toner powder thereto. Thus as the development system deposits toner powder on the image bearing member, toner powder is attracted to the reflecting means. Means are provided for generating a beam of light rays.

- 5 The reflecting means is arranged to be in a light receiving relationship with the beam of light rays after the toner powder is attracted thereto. In addition, detecting means sense the intensity of light rays transmitted from the reflecting means having the toner powder adhering thereto. Preferably, the detecting means is adapted to produce an electrical output signal indicative of the toner powder density deposited on the reflecting means.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention will become apparent upon reading the following detailed description and upon reference to the drawings, in which:

- 20 FIG. 1 is a schematic perspective view of a multicolor electrophotographic printing machine having the features of the present invention therein;

FIG. 2 is a fragmentary view of the regulating apparatus of the present invention; and

- 25 FIG. 3 is a perspective view of the reflecting arrangement utilized in the FIG. 2 apparatus.

While the present invention will be described in connection with a preferred embodiment thereof, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

For a general understanding of the disclosed electrophotographic printing machine in which the present invention may be incorporated, continued reference is had to the drawings wherein like reference numerals have been used throughout to designate like elements. FIG. 1 schematically illustrates the various components of the multi-color printing machine. Although the toner concentration regulating apparatus of the present invention is particularly well adapted for use in a multi-color electrophotographic printing machine, it should become evident from the following discussion that it is equally well suited for use in a wide variety of printing machines and is not necessarily limited in its use to the particular embodiment shown herein.

- 50 As shown in FIG. 1, the multi-color electrophotographic printing machine utilizes a drum 10 mounted rotatably within the machine frame (not shown). Photoconductive surface 12 is mounted on the exterior circumferential surface of drum 10. One type of suitable photoconductive material is disclosed in U. S. Pat. No. 3,655,377 issued to Sechak in 1972. A series of processing stations are disposed about drum 10 such that as it rotates in the direction of arrow 14, it passes sequentially therethrough. A drive motor rotates drum 10 at a predetermined speed relative to the other components of the printing machine. The machine logic coordinates the various operations with one another to produce the proper sequence of events at the corresponding processing stations.

65 Initially, as drum 10 rotates in the direction of arrow 14, photoconductive surface 12 passes through charging station A. Charging station A has positioned thereat

a corona generating device, indicated generally at 16. Corona generating device 16 extends in a generally transverse direction across photoconductive surface 12 and produces a spray of ions for charging photoconductive surface 12 to a substantially uniform potential. U. S. Pat. No. 2,778,946 issued to Mayo in 1957 describes a suitable corona generating device of the type utilized herein.

Thereafter, drum 10 rotates charged photoconductive surface 12 to exposure station B. At exposure station B, charged photoconductive surface 12 is exposed to a color filtered light image of the original document. Exposure station B includes thereat a moving lens system, generally designated by the reference numeral 18, and a color filter mechanism shown generally at 20. As shown in FIG. 1, an original document 22, such as a sheet of paper, book, or the like, is placed face down upon transparent viewing platen 24. Lamp assembly 26, lens system 18 and filter mechanism 20 are moved in a timed relation with drum 10 to scan successive longitudinally extending incremental areas of original document 22 disposed upon platen 24. In this way a flowing light image of original document 22 is projected onto photoconductive surface 12. During exposure, filter mechanism 20 interposes selected color filters in the optical light path of lens 18. The filter operates on the light rays passing through the lens to record an electrostatic latent image on photoconductive surface 12 corresponding to a preselected spectral region of the electromagnetic wave spectrum, hereinafter referred to as a single color electrostatic latent image. A suitable moving lens system is disclosed in U. S. Pat. No. 3,062,108 issued to Mayo in 1962, and a suitable color filter mechanism is described in co-pending application Ser. No. 830,282 filed in 1969.

Drum 10 next rotates the single color electrostatic latent image recorded on photoconductive surface 12 to development station C. Development station C includes three individual developer units indicated by the reference numerals 28, 30 and 32, respectively. The developer units are all of the type generally referred to in the art as "magnetic brush developer units." Generally, a magnetic brush developer unit includes a magnetizable developer mix having carrier granules and toner particles therein. The developer mix is continually brought through a directional flux field to form a brush of developer mix. The developer mix is continually moving so as to provide the brush with consistently fresh material. Development is achieved by bringing the brush of developer mix into contact with the electrostatic latent image recorded on photoconductive surface 12. Each of the developer units 28, 30, and 32, respectively, includes toner particles corresponding to the complement of the specific color separated latent electrostatic image recorded on photoconductive surface 12. The respective toner particles are selected to absorb light within a preselected spectral region of the electromagnetic wave spectrum corresponding to the complement of the wave length of light transmitted through filter 20. Thus, a green filtered electrostatic latent image is rendered visible by depositing green absorbing magenta toner particles thereon, blue and red latent images being developed with yellow and cyan toner particles, respectively. A suitable development station employing a plurality of developer units is disclosed in co-pending application Ser. No. 255,259, filed in 1972.

In accordance with the present invention, additional toner particles are added to the respective developer mix when the concentration thereof is beneath a predetermined level. The regulating apparatus, indicated generally at 34, includes reflecting means 36 mounted on photoconductive surface 12 of drum 10. Beam generating means or light source 38 is mounted in housing 40 and arranged to direct a beam of light rays onto reflecting means 36. Housing 40 includes a sidewall 60 having a shutter therein associated with light source 38. Hence, the light rays from light source 38 are received by reflecting means 36 and prevented from being transmitted to photoconductive surface. An air purge system cooperates with housing 40 to maintain the surrounding environment substantially free from particle contamination. During development, toner particles are deposited on reflecting means 36 and the intensity of the light rays reflected therefrom is indicative of the density thereof. Detecting means, such as photosensor 42, is adapted to receive the light rays reflected from reflecting means 36. In response to the light rays received thereon, photosensor 42 produces an electrical output signal corresponding to the density of toner particles adhering to reflecting means 36. Comparing means, i.e., suitable logic circuitry, compare the electrical output signal from photosensor 42 with a predetermined reference signal. A logic control signal corresponding to the deviation therebetween is generated for actuating the appropriate toner particle storage container to dispense toner particles into the corresponding developer unit. The detailed structural configuration of regulating apparatus 34 will be described hereinafter in greater detail with reference to FIGS. 2 and 3.

Continuing now with the description of the electrophotographic printing machine processes, after development, drum 10 rotates to transfer station D. At transfer station D, the toner powder image adhering electrostatically to photoconductive surface 12 is transferred to a sheet of final support material 44. Final support material 44 may be, amongst others, plain paper or a sheet of thermoplastic material. A transfer roll, shown generally at 46, recirculates support material 44 in the direction of arrow 48. Transfer roll 46 is biased electrically to a potential of sufficient magnitude and polarity to attract electrostatically toner particles from the latent image recorded on photoconductive surface 12 to support material 44. A suitable electrically biased transfer roll is described in U. S. Pat. No. 3,612,677 issued to Langdon et al. in 1971. Transfer roll 46 rotates in the direction of arrow 48 in synchronism with drum 10 (in this case at the same angular velocity therewith). Inasmuch as support material 44 is secured releasably thereon for movement in a recirculating path therewith, successive toner powder images may be transferred thereto in superimposed registration with one another. Preferably, transfer roll 46 includes a suitable recess therein for preventing reflecting means 36 from engaging transfer roll 46. Thus, toner particles deposited on reflecting means 36 remain undisturbed by the transfer process and represent an indication of the toner particle concentration within the developer mix.

After the toner powder images have been transferred to support material 44, support material 44 is stripped from transfer roll 46 and advanced to a fixing station (not shown) where a suitable fuser coalesces the trans-

ferred powder images thereto. One type of suitable fuser is described in U. S. Pat. No. 3,498,592 issued to Moser et al. in 1970. After the fixing process, support material 44 is advanced by a plurality of endless belt conveyors (not shown) to a catch tray (not shown) for subsequent removal therefrom by the machine operator.

Although a preponderance of toner particles are transferred to support material 44, invariably some residual toner particles remain on photoconductive surface 12 after the transfer of the toner powder image to support material 44. These residual toner particles are removed from photoconductive surface 12 as it passes through cleaning station E. Initially, the residual toner particles are brought under the influence of a cleaning corona generating device (not shown) adapted to neutralize the electrostatic charge remaining thereon. The neutralized toner particles are then mechanically cleaned from photoconductive surface 12 by rotatably mounted fibrous brush 50. Rotatably mounted fibrous brush 50 is positioned in contact with photoconductive surface 12 of rotating drum 10 and reflecting means 36 so as to remove residual toner particles remaining thereon after the transfer operation.

It is believed that the foregoing description is sufficient for purposes of the present application to illustrate the general operation of an electrophotographic printing machine embodying the teachings of the present invention.

Referring now to the specific subject matter of the present invention, FIG. 2 illustrates the detailed construction of regulating apparatus 34. Regulating apparatus 34 includes reflecting means 36, light source 38, photosensor 42, and comparing means 37 having suitable logic circuitry associated therewith for processing the electrical output signal. In addition, each of the developer units 28, 30, 32, respectively, have dispensing means 39 having a corresponding toner storage container an oscillator motor associated therewith. Each of the toner storage containers house a supply of selected toner particles having discrete colors so as to form a reservoir thereof for the appropriate developer unit. By way of example, the toner storage container of developer unit 28 houses cyan toner, that of developer unit 30 magenta toner, and that of developer unit 32 yellow toner. Each of the toner storage containers include perforations therein adapted to meter therefrom a specified quantity of the selected toner particles to the corresponding developer unit. A suitable oscillator motor vibrates the appropriate toner storage container to dispense toner particles. The toner particles pass through the perforations in the container to the corresponding developer unit. Regulating apparatus 34 actuates the oscillator motor to control the dispensing of toner particles from each of the toner storage containers to the respective developer unit.

As shown in FIG. 2, light source 38 produces a beam of light rays which are reflected from reflecting means 36 to photosensor 42. Reflecting means 36 is located on a non-image portion of photoconductive surface 12. As reflecting means 36 passes through the development zone, transparent electrically conductive layer 52 is biased to an electrical potential simulating the electrostatic latent image recorded on photoconductive surface 12. Preferably, electrically conductive layer 52 is biased to about 200 volts above the developer bias, the normal developer bias being about 500 volts. However,

electrically conductive layer 52 may be biased from about 100 volts to about 600 volts above the developer bias. The density of the image developed on electrically conductive layer 52 is sensed by photosensor 42. The output signal from photosensor 42 is processed by suitable logic elements. Thereupon, depending upon the density of toner particles deposited on electrically conductive layer 52, toner particles may or may not be added to the respective developer unit. Photosensor 42 is mounted exterior to and spaced from photoconductive surface 12 of drum 10. It is positioned to sense the density of toner particles deposited on electrically conductive layer 52 just prior to the entering thereof into cleaning station E. In this manner, electrically conductive layer 52 undergoes the regular photoconductive drum cleaning process.

In order to apply the appropriate voltage corresponding to the electrostatic latent image deposited on photoconductive surface 12, electrically conductive layer 52 must be biased to a suitable voltage level. This is achieved, preferably, by mounting a commutator assembly (not shown) in a region of the end bell of drum 10. A suitable slip ring assembly may be used in lieu of the commutator assembly. Timing for the application of the bias voltage to electrically conductive layer 52 may be controlled by alternating means such as suitable electronic switching or by use of split commutator ring, i.e. electrically conductive layer 52 being biased over one portion of the commutator and not over the remaining portion thereof. The bias voltage is removed from electrically conductive layer 52 during the cleaning process. It will be readily apparent to one skilled in the art that instead of applying a bias voltage to electrically conductive layer 52, a suitable bias may be applied thereto by electrical charging.

By way of example, light source 38 is, preferably, a de-rated tungsten lamp with a regulated voltage, e.g. a 7 volt tungsten filament lamp operating from a 5 volt source. Photosensor 42 is a commercially available silicone phototransistor such as is produced by the General Electric Company, Model No. L 14 B. Photosensor 42 is maintained in a controlled thermal environment to minimize the effects of temperature variations. Preferably, oven 54 (FIG. 1) maintains the thermal environment of photosensor 42 at about 50° C. plus or minus 1° C., or, at any appropriate temperature suitable therefor.

Suitable logic circuitry processes the electrical output signal from photosensor 42. The logic circuitry, preferably, includes a suitable discriminator circuit for comparing a reference with the electrical output signal from photosensor 42. The discriminator circuit may utilize a silicone control switch which turns on and effectively locks in after an electrical output signal having a magnitude greater than the reference level is obtained. The signal from the discriminator circuit changes the state of a flip-flop to develop an output signal therefrom. The output signal from the flip-flop, in conjunction with an output signal from the appropriate developer unit actuates an AND gate which, in turn, transmits a control signal to the oscillator motor of the toner storage container housing the toner particles corresponding to the developer unit generating the output signal to the AND gate. The control signal also resets the flip-flop. The type of logic circuitry heretofore disclosed is on-off. However, one skilled in the art will readily realize that it is possible to utilize proportional

circuitry which varies the quantity of toner particles metered to the respective developer units as a function of the magnitude of the control signal. This may be readily achieved by a suitable integrated circuit module adapted to develop a stepped proportional dispensing rate. Duplicate logic channels are utilized for each developer unit, i.e., the yellow developer unit, cyan developer unit and magenta developer unit all utilize the foregoing logic circuits. Hence, there are three separate, independent logic channels, each channel being associated with its respective developer unit. The density of toner particles deposited on photoconductive surface 12 is dependent upon the concentration of toner particles within the respective developer unit. The concentration of toner particles is, in turn, a function of the magnitude of the reference signal. In this way, the image density of each color may be adjusted independently relative to one another. Thus, by adjusting the respective references image density as well as color balance is regulated within the multi-color electrophotographic printing machine depicted in FIG. 1.

Turning now to FIG. 3, there is shown a perspective view of reflecting means 36. As shown therein, reflecting means 36 includes a transparent member which may be a suitable glass slug 56. Adhering to one surface of glass slug 56 is a reflective surface or silvered coating 58 adapted to reflect the light rays impacting thereon therefrom. Transparent electrically conductive surface 52 is suitably secured to the other surface of glass slug 56. As shown in FIG. 3, electrically conductive surface 52 includes two spaced portions, portion 52a and 52b. Preferably, portion 52a is adapted to transmit light rays from light source 38 therethrough to reflective surface 58. Reflective surface 58 is arranged to reflect the light rays transmitted thereto through portion 52b to impinge photosensor 42. Electrically conductive surface 52 is made preferably from a transparent tin oxide coating. A transparent electrically conductive glass, i.e. glass slug 56 and electrically conductive surface 52, of this type is made by Pittsburgh Plate Glass under the trademark NESA, or is made by the Corning Glass Company under the trademark Electro Conductive. As hereinbefore described, reflecting means 36 is suitably mounted on drum 10 and is adapted to be electrically biased to the appropriate voltage level.

While the present invention has been described in connection with reflecting means 36 having a glass slug with one surface coated with a reflective material and the other surface coated with a tin oxide layer, one skilled in the art will appreciate that the invention is not necessarily so limited. For example, reflective means 36 may be a polished stainless steel disc. Preferably, the reflective disc would be 09-1401 stainless steel having the reflecting surface polished to substantially about five rings flatness.

In recapitulation, a voltage is applied to reflecting means 36, preferably, simulating the electrostatic latent image recorded on photoconductive surface 12. This voltage is automatically applied to reflecting means 36 by the orientation of the segmented commutator, hereinbefore discussed, relative to reflecting means 36 as drum 10 rotates. Hence, just prior to entering the development zone, a voltage of about 200 volts above developer bias is applied to reflecting means 36. As drum 10 rotates in the development zone, the magnetic brush assembly of the respective devel-

oper unit applies toner particles to reflecting means 36 by the potential differential of approximately 200 volts between reflecting means 36 and the respective developer unit. As drum 10 continues to rotate, light rays from light source 38 are transmitted to reflecting means 36 and reflected therefrom to photosensor 42. Photosensor 42, in turn, produces an electrical output signal which is compared by the logic circuitry with a reference to develop a control signal for actuating the oscillator motor of the appropriate toner storage container housing the selected toner particles. In this way, toner particles are dispensed from the toner storage container into the developer mix of the respective developer unit. Thereafter, the biasing voltage is removed from reflecting means 36, i.e. the split commutator ring rotates to an open circuit position, and is not biased thereafter. Cleaning station E then removes toner particles adhering to reflecting means 36. The aforementioned procedure is repeated three successive times for each copy produced, i.e. it is reproduced for each of the toner particles utilized within the printing machine (cyan, magenta, and yellow). Hence, the regulating apparatus of the present invention controls the concentration of toner particles within the developer mix to create images having the requisite density and color balance.

It is, therefore, apparent that there has been provided, in accordance with this invention, an apparatus for regulating the concentration of toner particles within a development system that fully satisfies the objects, aims and advantages set forth above. While this invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

What is claimed is:

1. An apparatus regulating toner powder concentration within a particulate mix for a development system arranged to deposit toner powder on an image bearing member, including:

- a light source;
- a transparent member mounted on the image bearing member;
- a reflective surface affixed to one surface of said transparent member;
- a transparent electrically conductive surface affixed to the other surface of said transparent member, said conductive surface having at least two portions spaced from one another with a portion of the exterior surface of said transparent member interposed therebetween, said light source being positioned so that the beam of light rays pass through one portion of said conductive surface onto said reflective surface for reflection therefrom through the other portion of said conductive surface;
- a photosensor positioned so as to receive the light rays reflected from said reflective surface and adapted to produce an electrical output signal corresponding to the intensity of light rays received thereon;

means for comparing the electrical output signal with a reference to produce a control signal corresponding to the deviation therebetween; and

means, energized by the control signal from said comparing means, for dispensing toner powder into the particulate mix of the development system.

2. An apparatus as recited in claim 1, further including means, operatively associated with said conductive surface, for cyclically alternating the electrical charge on said conductive surface to attract toner powder thereto during the development thereof and to repel toner powder therefrom after the intensity of light rays reflected from said reflective surface has been sensed by said photosensor.

3. An apparatus for regulating the developability of an electrophotographic printing machine of the type having a photoconductive member, and a development system utilizing a developer material having toner particles adapted to be deposited on an electrostatic latent image recorded on the photoconductive member to produce a toner powder image thereon, including:

- a light source;
- a transparent member mounted on the photoconductive member;
- a reflective surface affixed to one surface of said transparent member;
- a transparent electrically conductive surface affixed to the other surface of said transparent member, said conductive surface having at least two portions spaced from one another with a portion of the exte-

rior surface of said transparent member interposed therebetween, said light source being positioned so that the beam of light rays pass through one portion of said conductive surface onto said reflective surface for reflection therefrom through the other portion of said conductive surface;

a photosensor positioned so as to receive the light rays reflected from said reflective surface and being adapted to produce an electrical output signal corresponding to the intensity of light rays received therein;

means for comparing the electrical output signal with a reference to produce a control signal corresponding to the deviation therebetween; and

means, energized by the control signal from said comparing means, for dispensing toner particles into the developer material of the development system.

4. An apparatus as recited in claim 3, further including means, operatively associated with said conductive surface, for cyclically alternating the electrical charge on said conductive surface to attract toner particles thereto during the development thereof and to repel toner particles therefrom after the intensity of light rays reflected from said reflective surface has been sensed by said photosensor.

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