

[54] **PARTICLE CONCENTRATION DETECTOR**
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[58] Field of Search **118/4, 7, 9, 10, 637; 117/17.5; 355/3 DD**

[56] **References Cited**

UNITED STATES PATENTS

3,348,521	10/1967	Hawk.....	118/7
3,430,606	3/1969	Pease et al.....	118/637
3,727,065	4/1973	Maksymiak.....	118/637 X
3,765,654	10/1973	Rarey et al.	259/4
3,791,744	2/1974	Erny et al.	118/7 X
3,801,196	4/1974	Knapp et al.	355/3

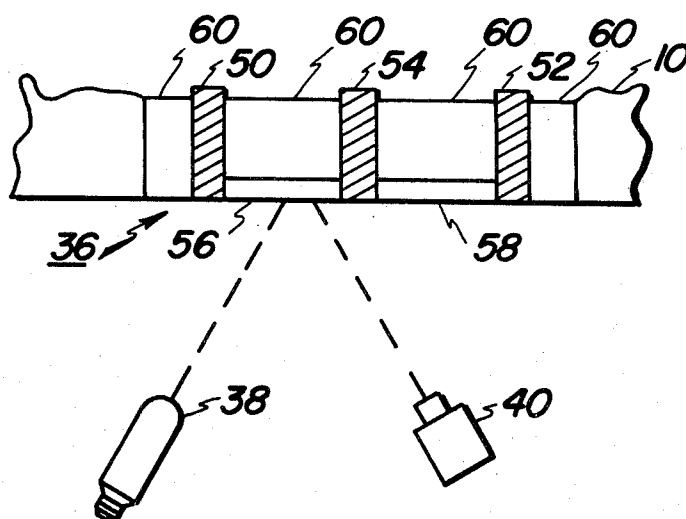
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[57] **ABSTRACT**

An apparatus in which a concentration of toner particles in a mix of carrier granules and toner particles is detected permitting the regulation thereof. A voltage gradient is impressed upon a reflecting surface and a beam of light rays illuminates a portion of the surface having a pre-selected potential thereon. The intensity of the light rays reflected from the illuminated portion is sensed and an electrical output signal generated. This electrical output signal is a measure of the toner particles deposited on the illuminated portion which indicates the concentration of toner particles within the mix.

The foregoing abstract is neither intended to define the invention disclosed in the specification, nor is it intended to be limiting as to the scope of the invention in any way.

22 Claims, 6 Drawing Figures



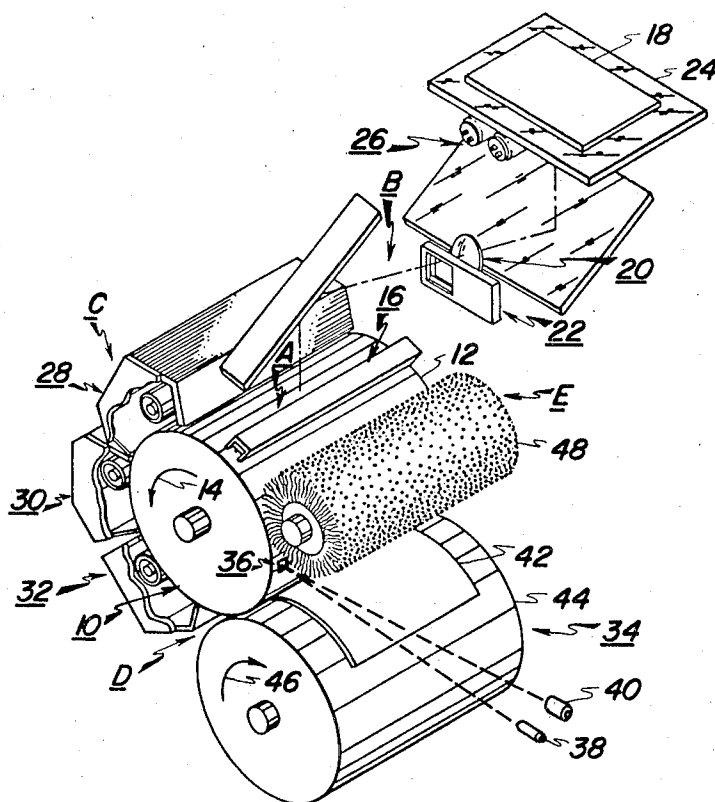
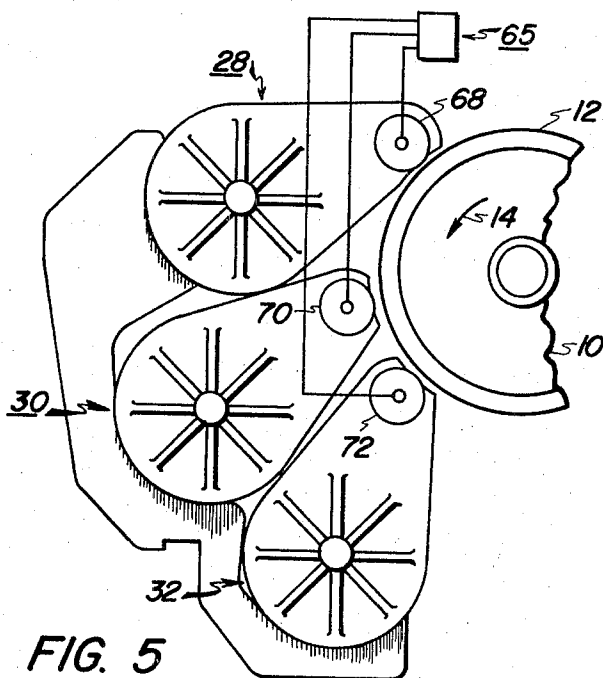
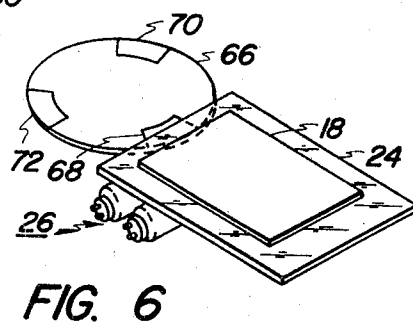
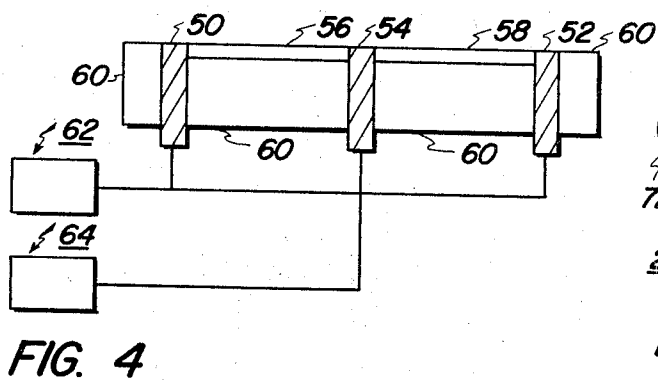
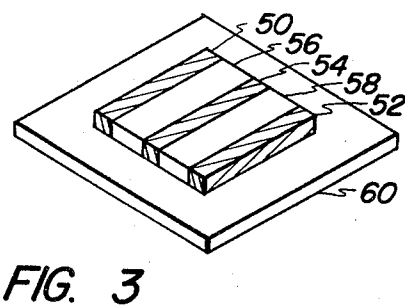
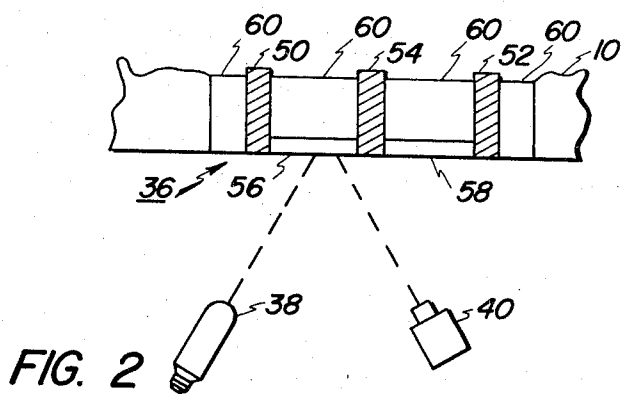


FIG. 1



PARTICLE CONCENTRATION DETECTOR**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 a developer mix of carrier granules and toner particles employed in the development system thereof.

The concentration of toner particles within the developer mix directly affects the quality of reproduction created by the multi-color electrophotographic printing machine. Toner particle concentration relates directly to the characteristics of the developed image. For example, the density and color balance of the image may be affected by the concentration of toner particles within the developer mix.

Various types of systems have been developed which add toner particles to the developer mix. However, the majority of these systems do not monitor the concentration of toner particles within the mix. Recently, systems have been developed which detect the concentration of toner particles within the mix and provide additional toner particles thereto as required. Most of the foregoing types of systems are directed to black and white printing machines rather than multi-color printing machines.

A typical system utilized in a black and white printing machine is disclosed in U. S. Pat. No. 3,399,652 issued to Gawron in 1958. Gawron describes a rotating disc positioned in a 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 the light rays striking the photoelectric unit is an indication of the density of toner particles deposited on the disc, which, in turn, corresponds to the toner particle concentration within the developer mix.

Another system employed in a black and white electrophotographic printing machine is disclosed in U.S. Pat. No. 3,094,049 issued to Snelling in 1963. Snelling describes a plate having a conductive film with a pattern inscribed thereon. The pattern is electrically biased to attract toner particles thereto simulating an image being developed. Light rays are transmitted through or reflected from the toner particles to indicate the density of toner deposited thereon. The density of toner particles adhering to the plate corresponds to the concentration of toner particles within the developer mix. However, the Snelling patent is directed primarily to edge development and does not address the problem of extending this technique to electroded or magnetic brush development wherein the entire solid area is developed.

One system adapted for use in a multi-color electrophotographic printing machine is described in co-pending application Ser. No. 213,056, filed in 1971, U.S. Pat. No. 3,754,821. 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.

The problem of detecting toner particle concentration within a development system having solid area capability is appreciably more difficult than one wherein the system has only edge development capability. In a solid area system, the light rays reflected from a surface having toner particles deposited thereon may be totally cut off by toner particles which are slightly separated from each other. Thus, the deposition of additional toner particles will have no effect in the light rays reflected therefrom. A detection system of this type is highly sensitive to a low degree development as compared to no development. However, it possesses little ability to differentiate between varying higher degrees of development. This type of system is effective for detecting edge development but has little ability to determine toner concentration in solid area development. In solid areas, the regulating apparatus may need to distinguish between a density of 0.8 and one of 0.9. The intensity of the light rays reflected from a toner powder image having a 0.8 density and a toner powder image having a 0.9 density would be substantially identical, and the system may be incapable of detecting a difference therebetween.

Accordingly, it is a primary object of the present invention to improve the apparatus used to regulate toner particle concentration within a developer mix employed in a development system having solid area capability.

SUMMARY OF THE INVENTION

Briefly stated, and in accordance with the present invention, there is provided an apparatus for regulating the concentration of toner particles in a mix of carrier granules and toner particles.

Pursuant to the present invention, reflecting means is disposed to attract toner particles thereto from the carrier granules of the mix. Means are provided for biasing electrically the reflecting means to produce thereon a voltage pattern having a greater potential in a first region than in a second region thereon. Generating means produce a beam of light rays. The reflecting means is in a light-receiving relationship so that a third region thereof having a potential intermediate the potential of the first region and second region is illuminated by the beam of light rays. Detecting means measure the intensity of the light rays reflected from the reflecting means. The detecting means produce an electrical output signal indicative of the density of toner particles deposited on the illuminated portion of the reflecting means.

Further in accordance with the present invention, an alternate embodiment thereof utilizes means for recording a sample electrostatic latent image on a photoconductive member of an electrophotographic printing machine. A voltage gradient is impressed on the sample electrostatic latent image such that the potential thereof decreases from a first potential to a second potential. As previously described, generating means produce a beam of light rays. The light rays illuminate a portion of the sample electrostatic latent image having a pre-selected potential intermediate the first and second potential. The intensity of the light rays reflected from the illuminated portion of the sample electrostatic latent image is detected. An electrical output signal is generated indicative of the density of toner particles

deposited on the illuminated portion of the sample electrostatic latent image.

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:

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

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

FIG. 3 is a perspective view of the reflecting means employed in the FIG. 2 regulatory apparatus;

FIG. 4 is a fragmentary plan view of the reflecting means and electrical biasing employed in the FIG. 2 regulating apparatus;

FIG. 5 is a schematic plan view of the development system used in the FIG. 1 printing machine; and

FIG. 6 is a perspective view of the modification required in the FIG. 1 printing machine to produce a sample electrostatic latent image.

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

With continued reference to the drawings wherein like reference numerals have been used throughout to indicate like elements, FIG. 1 depicts a multi-color electrophotographic printing machine in which the present invention may be incorporated. The various components of the multi-color printing machine are illustrated schematically in FIG. 1. Although the regulating apparatus of the present invention is particularly well adapted for use in this type of an electrophotographic printing machine, it should become evident from the following discussion that it is equally well-suited for use in a wide variety of electrostatic printing machines, and is not necessarily limited in its use to the particular embodiment shown herein.

Turning now to FIG. 1, the electrophotographic printing machine depicted therein employs an image-bearing member comprising a drum 10 having a photoconductive surface 12 secured to the exterior circumferential surface thereof. Drum 10 is mounted rotatably of the machine frame and driven at a substantially constant angular velocity, in the direction of arrow 14, by a drive motor (not shown). 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 the periphery of drum 10 such that as it rotates in the direction of arrow 14, photoconductive surface 12 passes sequentially therethrough. The drive motor rotates drum 10 at a predetermined speed relative to the other operating mechanisms of the printing machine. A timing disc mounted in the region of one end of the shaft of drum 10 cooperates with the machine logic to synchronize the various operations with the rotation of drum 10. In this manner, the proper sequence of events is produced at the respective processing stations.

First, drum 10 rotates photoconductive surface 12 through charging station A. At charging station A, a corona generating device, indicated generally at 16, extends longitudinally in a transverse direction across photoconductive surface 12. The corona-generating device 16 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 which may be utilized herein.

Thereafter, drum 10 rotates the charged photoconductive surface to exposure station B. At exposure station B, a color-filtered light image of original document 18 is projected onto charged photoconductive surface 12. Exposure station B includes a moving lens system, generally designated by the reference numeral 20, and a color filter mechanism indicated generally as 22. As shown in FIG. 1, original document 18, 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 18 disposed upon platen 24. In this manner, a flowing light image of original document 18 is projected onto charged photoconductive surface 12. During exposure, filter mechanism 22 interposes selected color filters into the optical light path of lens 20. The filter operates on the light rays passing through lens 20 to record an electrostatic latent image on photoconductive surface 12 corresponding to a pre-selected 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.

After the single color electrostatic latent image is recorded on photoconductive surface 12, drum 10 rotates to development station C. Development station C includes three individual developer units generally indicated by the reference numerals 28, 30, and 32, respectively. The developer units are all of a type referred to in the art as "magnetic brush developer units." In a magnetic brush developer unit, a magnetizable developer mix having carrier granules and toner particles is continually brought through a directional flux field to form a brush of developer material. The developer mix is continually moving to provide fresh developer mix to the brush. Preferably, the magnetic brush system comprises a magnetic member with a mass of developer mix adhered thereto by magnetic attraction. The developer mix includes carrier granules having toner particles clinging thereto by triboelectric attraction. This chain-like arrangement of developer mix simulates the fibers of a brush. 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, apply toner particles to the electrostatic latent image recorded on photoconductive surface 12 which is adapted to absorb light within a pre-selected spectral region of the electromagnetic wave spectrum corresponding to the wavelength of light transmitted through filter 22. For example, a latent image formed by passing the light image through a green filter will record the red and blue portions of the spectrum as areas of relatively high charge density on photoconductive surface 12, while the green light waves will pass

through the filter and cause the charge density on photoconductive surface 12 to be reduced to a voltage level ineffective for development. The charged areas are then made visible by applying green absorbing "magenta" toner particles to the latent image recorded on photoconductive surface 12. Similarly, a blue separation is developed with blue absorbing "yellow" toner particles, while the red separation is developed with red absorbing "cyan" toner particles. The development system will be further described with reference to FIG. 5.

Pursuant to the present invention, additional toner particles are added to the respective developer mixes when the concentration thereof is reduced beneath a specified level. The toner particle concentration is determined by the regulating apparatus of the present invention, indicated generally at 34. Regulating apparatus 34 includes reflecting means, indicated generally at 36, mounted on photoconductive surface 12 of drum 10 in the non-image area thereof. Generating means or light source 38, illuminates a portion of reflecting means 36. The light rays reflected from reflecting means 36 are detected by detecting means or photosensor 40. As the electrostatic latent image recorded on photoconductive surface 12 is developed, toner particles are deposited on reflecting means 36. The intensity of the light rays reflected from reflecting means 36 in the illuminated area is indicative of the density of toner particles deposited thereon. Photosensor 40 is positioned in a light receiving relationship with the light rays reflected from reflecting means 36. In this way, the density of toner particles deposited on reflecting means 36 is sensed by photosensor 40 and the electrical output therefrom corresponds thereto. It should be noted that the density of the toner particles deposited on reflecting means 36 is indicative of the concentration of toner particles within the developer mix. The detailed structural configuration of regulating apparatus 34 will be described hereinafter in greater detail with reference to FIGS. 2 through 4, inclusive.

Continuing now with the description of the various processing stations employed in the multi-color electrophotographic printing machine of FIG. 1, after development, drum 10 rotates photoconductive surface 12 to transfer station D. At transfer station D, the toner powder image adhering electrostatically to photoconductive surface 12 is transferred to a sheet of support material 42. Final support material 42 may be, amongst others, plain paper or a sheet of polysulfone thermoplastic material. A transfer roll, shown generally at 44, secures support material 42 releasably thereto for movement therewith in a recirculating path. Transfer roll 44 rotates in the direction of arrow 40, in synchronism with drum 10 (in this case at substantially the same angular velocity). Transfer roll 44 is biased electrically to a potential having sufficient magnitude and the proper polarity to attract electrostatically toner particles from the latent image recorded on photoconductive surface 12 to support material 42. 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 44 includes a recess therein arranged to prevent contact with the toner particles deposited on reflecting means 36. Thus, the toner particles deposited thereon are not disturbed by the transfer process and represent a true indication of the toner particle concentration within the developer mix.

After a plurality of toner powder images have been transferred from photoconductive surface 12 to support material 42, support material 42 is separated from the surface of transfer roll 44 and advanced to a fusing station (not shown). At the fusing station, the toner powder image is permanently affixed to support material 42. One type of suitable fuser is described in U.S. Pat. No. 3,498,592 issued to Moser, et al. in 1970. After the fusing process, support material 42 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 42, invariably some residual toner particles remain on photoconductive surface 12 after the transfer of the toner powder image to support material 42. These residual toner particles are removed from photoconductive surface 12 as it passes through cleaning station E. At cleaning station E, the residual toner particles are initially brought under the influence of cleaning corona generating device (not shown) adapted to neutralize the remaining electrostatic charge on photoconductive surface 12 and the residual toner particles. Thereafter, the neutralized toner particles are cleaned from photoconductive surface 12 by a rotating fibrous brush 48. Brush 48 is positioned in contact with photoconductive surface 12. One type of suitable brush cleaning device is described in U.S. Pat. No. 3,590,412 issued to Gerbasi in 1971.

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

Referring now to the specific subject matter of the present invention, FIG. 2 illustrates in a plan view the detailed construction of regulating apparatus 34. As hereinbefore indicated, regulating apparatus 34 includes reflecting means 36, light source 38 and photosensor 40. In addition, each of the developer units 28, 30, and 32, respectively, have a corresponding toner particle storage container associated therewith. As shown in FIG. 2, light source 38 produces a beam of light rays which are reflected from reflecting means 36 to photosensor 40. Reflecting means 36 is located on a non-image portion of photoconductive surface 12. As reflecting means 36 passes through the development zone, toner particles are attracted thereto. Light source 38 illuminates a portion of reflecting means 36, reflecting means 36 having a voltage gradient thereacross.

Turning now to the specific structural configuration of reflecting means 36, reflecting means 36 includes a plurality of conductive layers 50, 52, and 54, respectively. Conductive layers 50, 52, and 54 are spaced from one another and electrically coupled to one another by resistance layers 56 and 58. The entire assembly is secured to insulating layer 60. Resistance layer 56 and 58 are reflective and adapted to reflect the light rays from light source 38 to photosensor 40.

As shown in FIG. 3, conductive layers 50 and 52 are disposed in the marginal regions of reflecting means 36 while conductive layer 54 is disposed in the central portion thereof. By way of example, insulating support means 60 may be an epoxy coated glass member. Conductive layers 52, 54, and 56 may be aluminum evaporated onto insulating support 60. Resistance layer 56

and 58 are an electrically resistant coating secured to insulating layer 60.

Referring now to FIG. 4, there is shown the electrical biasing circuitry for reflecting means 36. As shown therein a high voltage source 62 is connected to conductive layers 50 and 52. A low voltage source 64 is connected to conductive layer 54. In operation, voltage source 64 may be adjusted to apply the same voltage to conductive layer 54 as is applied to the magnetic brush development system. For example, the developer bias may be about 500 volts. Under these circumstances power supply 64 would be similarly adjusted to about 500 volts. Contrawise high voltage source of power supply 62 would be adjusted to a substantially higher value, for example, about 900 volts. In this manner, a current flow is developed in resistance layers 56 and 58 to produce a voltage gradient decreasing inwardly from conductive layers 50 and 52 to conductive layer 54. Light source 38 is adapted to illuminate a selected region of resistance layer 56 or resistance layer 58 having a selected voltage value. By way of example, light source 38 may illuminate a region of resistance layer 56 having a voltage of about 750 volts. Toner particles will be attracted from the magnetic brush system to the regions of resistance layers 56 and 58 having a potential greater than the magnetic brush potential. However, the amount of toner concentration of toner particles within the developer mix will determine the amount of toner particles attracted thereto. Thus, for example, if few toner particles are attracted to the region being illuminated by light source 36 i.e., the portion of resistance layer 56 having a potential of about 750 volts, toner concentration within the developer mix is too low and additional toner particles have to be added thereto from the toner particle storage container. However, if relatively many toner particles are deposited on the illuminated area, toner particle concentration within the developer mix is satisfactory and no toner particles need be added to the developer mix. Thus, the circuit arrangement in conjunction with the reflecting means 36 is an ON/OFF type of controller, wherein the deposition of toner particles on the illuminated region prevents the addition of toner particles to the developer mix. Contrawise, the absence of toner particles from the illuminated region indicates that toner particles must be added to the developer mix. It is evident that the biasing voltage applied to reflecting means 36 may be suitably adjusted merely by adjusting the respective power supplies 62 and 64. In this manner, a variable voltage gradient may be produced on resistance layers 56 and 58 to produce the desired voltage pattern. In operation, it is preferred that the system operate such that when toner particles are deposited on the illuminated portion of the reflecting means, no additional toner particles are required in the development mix; whereas when no toner particles are deposited in the illuminated portion, additional toner particles are required in the developer mix.

Referring now to FIG. 5, there is shown developer units 28, 30, and 32 respectively in detail. Power supply 65 regulates the electrical potential applied to the respective developer rolls 68, 70, and 72. As hereinbefore described, power supply 64 (FIG. 4) electrically biases resistance element 54 is adjustable so as to substantially match the electrical biasing potential applied to developer rolls 68, 70, and 72 by power supply 65. If desired, power supply 64 and power supply 65 may

be a common power supply rather than two separate powers supplies. Each of the developer units 28, 30, and 32 are substantially identical, therefore, only development unit 28 will be briefly described hereinafter.

The developer mix is carried from the sump of developer unit 28 by a paddle wheel (not shown) to a transport roll (not shown) and then to developer roll 68 which is positioned closely adjacent to photoconductive surface 12 of drum 10. Developer roll 68 includes a non-magnetic tubular member, preferably made from aluminum having an irregular or roughened exterior surface. The tubular member is journaled for rotation by suitable means such as ball bearing mounts. A shaft made preferably of steel is concentrically mounted within the tubular member and serves as a fixed mounting for magnets. The magnets are barium ferrite in the form of angular rings and arranged with five poles on about a 284° arc about the steel shaft. The developer mix is brought into contact with the developer roll which in turn moves it into contact with the electrostatic latent image recorded on photoconductive surface 12 and recording means 36. Toner particles are attracted to recording means 36 from the carrier granules attached magnetically to developer roll 68.

Each of the developer units 28, 30, and 32, respectively, have a corresponding toner particles storage container associated therewith. The toner particle storage container has a supply of toner particles having discrete colors to form a reservoir thereof for the appropriate developer unit. By way of example, the toner particle storage container for developer unit 28 has cyan toner particles, that of developer unit 30, magenta toner particles, and that of developer unit 32 yellow toner particles. Each of the toner particle 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 particle storage container to dispense toner particles therefrom. 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 particle storage containers to the respective developer unit.

By way of example, suitable logic circuitry processes the electrical output signal from photosensor 40. The logic circuitry, preferably, includes a suitable discriminator circuit arranged to compare a reference with the electrical output signal from photosensor 40. The discriminator circuit may utilize a silicon control switch which turns on and effectively locks in after an electrical output signal having a magnitude greater than the reference is obtained. The signal from the discriminator circuit changes the state of the 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 particle 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. This type of logic circuitry is on/off. Thus, when the intensity of the light rays reflected from the illuminated portion of reflecting means 36 is diminished due to toner particles being deposited thereon, electrical output signal from photo-

sensor 40 is reduced. When the electrical output signal from photosensor 40 is reduced beneath the preselected reference, the oscillator motor of the appropriate toner particle storage housing is de-energized preventing the dispensing of toner particles therefrom. Contrawise, when no toner particles are deposited on the illuminated region of reflecting means 36, the intensity of the light rays reflected therefrom is not diminished and the electrical output signal from photosensor 40 is greater than the reference. Under these circumstances, the appropriate oscillator motor of the respective toner particle storage container is energized dispensing toner particles therefrom into the developer mix. Thus, the toner particle concentration within each of the respective developer mixes may be adjusted independently and relative to one another.

An alternate embodiment to the previously discussed apparatus utilizes a sample electrostatic latent image recorded on photoconductive surface 12. The sample electrostatic latent image has a voltage gradient thereon rather than on reflecting means 36 hereinbefore described. FIG. 6 illustrates a modification to the multicolor electrophotographic printing machine described in FIG. 1 which enables a sample electrostatic latent image to be recorded on photoconductive surface 12. As shown in FIG. 6, a disc 66 having a plurality of variable density samples (in this case three) disposed thereon is mounted rotatably beneath transparent platen 24. Disc 66 is mounted rotatably in the printing machine and is positioned beneath transparent platen 24 within the half angle of the optical system. Before Lamps 26 begin to scan, they are actuated to illuminate one of the variable density samples. In this manner, a sample electrostatic latent image is recorded on photoconductive surface 12 as drum 10 rotates. Lamps 26 are stationary and the appropriate filter is positioned in filter 22 forming a sample electrostatic latent image on photoconductive surface 12 which is a discharged strip having the desired potential gradient thereon. Preferably, disc 66 includes three equally spaced variable density samples located about the periphery thereof. Sample 68 is a variable density sample for a green separation, sample 70 is a variable density sample for red separation and sample 72 is a variable density sample for the blue separation. Each of the variable samples has a color gradient thereacross so that the intensity of the light reflected therefrom varies across the variable density sample. Thus, the intensity of the light irradiating charged photoconductive surface 12 will vary to discharge photoconductive surface 12 in accordance therewith. Preferably, the voltage gradient produced on photoconductive surface 12 decreases in the direction of rotation of drum 10 as indicated by arrow 14. Thus, toner particles are attracted to the areas of the sample electrostatic latent image having a greater charge than the magnetic brush developer bias. Once again, toner particles are attracted to the sample electrostatic latent image forming a toner powder gradient thereon. As drum 10 rotates, light source 38 illuminates the developed sample electrostatic latent image. The intensity of the light rays reflected therefrom is continually detected by photosensor 40. The electrical output signal from photosensor 40 is compared with the reference. Hence, the electrical output signal from photosensor 40 increases as a function of time. The time interval required for the electrical output signal from photosensor 40 to exceed a selected reference is

monitored. If this time interval exceeds a pre-selected time reference, toner particles are not added to the developer unit, whereas if the time interval is less than the pre-selected time reference, toner particles are added to the developer unit.

In recapitulation, a regulating apparatus has been disclosed wherein a reflecting means having a voltage gradient thereon is mounted on a photoconductive surface to attract toner particles thereto. Moreover, an alternate embodiment utilizes a sample electrostatic latent image having a voltage gradient thereon. In both of the foregoing instances, the density of the toner particles attracted thereto is dependent upon the voltage of either the reflecting means or the sample electrostatic latent image. A light source illuminates the reflecting means or sample electrostatic latent image and the intensity of the light rays reflected therefrom is detected by a photosensor. Suitable circuitry is associated with the photosensor to develop an electrical output signal arranged to energize the appropriate toner particle storage container to dispense toner particles therefrom. The toner particles replenish the depleted supply thereof in the respective developer mix. In this way, the toner particle concentration within the developer mix is maintained substantially constant to insure that the density and color balance off the multicolor reproduction is substantially optimized.

It is, therefore, evident that there has been provided, in accordance with the present invention an apparatus for regulating the concentration of toner particles within a developer mix employed in a development system of a multi-color electrophotographic printing machine 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 particle concentration within a mix of toner particles and carrier granules employed in a development system arranged to deposit toner particles on an image-bearing member, including:
 - reflecting means disposed to attract toner particles thereto from the carrier granules of the mix;
 - means for biasing electrically said reflecting means to produce a voltage pattern having a greater potential in a first region of said reflecting means than in a second region thereof;
 - means for generating of a beam of light rays, said reflecting means being in a light receiving relationship with the beam of light rays so that a third region thereof having a preselected potential intermediate the potential of the first region and second region is illuminated by the beam of light rays; and
 - means for detecting the intensity of the light rays reflected from said reflecting means, said detecting means producing an electrical output signal indicative of the intensity of light ray reflected from said reflecting means.
2. An apparatus as recited in claim 1, further including means, responsive to the electrical output signal from said detecting means, for dispensing toner particles into the mix of the development system to maintain

the concentration thereof at substantially about the desired level.

3. An apparatus as recited in claim 1, wherein said reflecting means includes:

insulating support means;

a pair of conductive layers mounted on said support means, one of said pair of conductive layers being positioned in the first region of said reflecting means and the other of said pair of conductive layers being located in the second region thereof; and
a resistance layer mounted on said support means connecting electrically said pair of conductive layers with one another.

4. An apparatus as recited in claim 3, wherein said electrical biasing means includes:

a first voltage source electrically coupled to said one of said pair of conductive layers disposed in the first region of said reflecting means; and
a second voltage source electrically coupled to said other of said pair of conductive layers disposed in the second region of said reflecting means, said second voltage source generating a greater potential than the potential generated by said first voltage source to create a current flow from said other of said pair of conductive layers to said one of said pair of conductive layers forming a potential pattern decreasing from the second region to the first region of said reflecting means.

5. An apparatus as recited in claim 4, wherein the development system includes magnetic means for depositing toner particles on the image-bearing member, said magnetic means being electrically biased to substantially the same potential as the potential generated by said first voltage source.

6. An apparatus as recited in claim 1, wherein: said generating means includes a light source; and said detecting means includes a photosensor positioned to receive the light rays reflected from said reflecting means.

7. An apparatus as recited in claim 1, wherein said reflecting means is mounted on the image-bearing member.

8. An electrophotographic printing machine of the type having a photoconductive member, and a development system employing a mix of carrier granules and toner particles, the toner particles being adapted to be deposited on an electrostatic latent image recorded on the photoconductive member, wherein the improvement includes:

reflecting means disposed to attract toner particles thereto from the carrier granules of the mix;
means for biasing electrically said reflecting means to produce a voltage pattern having a greater potential in a first region of said reflecting means than in a second region thereof;

means for generating a beam of light ray, said reflecting means being in a light-receiving relationship with the beam of light rays so that a third region thereof having a pre-selected potential intermediate the potential of the first region and second region is illuminated by the beam of light rays; and
means for detecting the intensity of the light rays reflected from said reflecting means, said detecting means producing an electrical output signal indicative of the intensity of light rays reflected from said reflecting means.

9. A printing machine as recited in claim 8, further including means, responsive to the electrical output signal from said detecting means, for dispensing toner particles into the mix of the development system to maintain the concentration thereof substantially at the desired level.

10. A printing machine as recited in claim 8, wherein said reflecting means includes:

insulating support means;

a pair of conductive layers mounted on said support means, one of said pair of conductive layers being positioned in the first region of said reflecting means and the other of said pair of conductive layers being located in the second region thereof; and
a resistance layer mounted on said support means connecting electrically said pair of conductive layers with one another.

11. A printing machine as recited in claim 10, wherein said electrical biasing means includes:

a first voltage source electrically coupled to said one of said pair of conductive layers positioned in the first region of said reflecting means; and
a second voltage source electrically coupled to said other of said pair of conductive layers disposed in the second region of said reflecting means, said second voltage source generating a greater potential than the potential generated by said first voltage source to create a current flow from said other of said pair of conductive layers to said one of said pair of conductive layers forming a potential pattern decreasing from the second region to the first region of said reflecting means.

12. A printing machine as recited in claim 11, wherein the development system includes magnetic means for depositing toner particles on the electrostatic latent image recorded on the photoconductive member, said magnetic means being electrically biased to substantially the same potential as the potential generated by said first voltage source.

13. A printing machine as recited in claim 8, wherein: said generating means includes a light source; and said detecting means includes a photosensor positioned to receive the light rays reflected from said reflecting means.

14. A printing machine as recited in claim 8, wherein said reflecting means is mounted on the photoconductive member.

15. An electrophotographic printing machine of the type having a photoconductive member, and a development system employing a mix of carrier granules and toner particles, the toner particles being adapted to be deposited on an electrostatic latent image recorded on the photoconductive member, wherein the improvement includes:

means for forming on the photoconductive member a voltage gradient having the potential in a first region greater than the potential in a second region so as to attract toner particles thereto from the carrier granules of the mix;

means for generating a beam of light rays, the voltage gradient formed on the photoconductive member being in a light-receiving relationship with the beam of light rays after toner particles are deposited thereon so that a portion thereof having a pre-selected potential intermediate the potential in the first region and the potential in the second region is illuminated by the beam of light rays; and

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means for detecting the intensity of the light rays reflected from the voltage gradient formed on the photoconductive member, said detecting means producing an electrical output signal indicative of the intensity of light rays reflected from the illuminated portion of the voltage gradient formed on the photoconductive member.

16. A printing machine as recited in claim 15, further including means, responsive to the electrical output signal from said detecting means, for dispensing toner particles into the mix of the development system to maintain the concentration thereof at substantially about the desired level.

17. A printing machine as recited in claim 16, wherein the development system includes magnetic means for depositing toner particles on the voltage gradient formed on the photoconductive member, said magnetic means being electrically biased to substantially the same potential as the potential of the central region of the voltage gradient formed on the photoconductive member.

18. A printing machine as recited in claim 17, wherein:

said generating means includes a light source; and
said detecting means includes a photosensor positioned to receive the light rays reflected from the sample electrostatic latent image recorded on the

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photoconductive member.

19. A printing machine having a rotary journaled photoconductive member as recited in claim 18, wherein said recording means produces a sample electrostatic latent image having a voltage gradient wherein the potential of the voltage gradient decreases in the direction of rotation of the photoconductive member.

20. A printing machine as recited in claim 19, further including means, responsive to the electrical output signal from said detecting means, for dispensing toner particles into the mix of the development system to maintain the concentration thereof at substantially about the desired level.

21. A printing machine as recited in claim 20, wherein the development system includes magnetic means for depositing toner particles on the sample electrostatic latent image recorded on the photoconductive member.

22. A printing machine as recited in claim 21, wherein:

said generating means includes a light source; and
said detecting means includes a photosensor positioned to receive the light rays reflected from the sample electrostatic latent image recorded on the photoconductive member.

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