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[54] COLOR BALANCE DISPLAY

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[58] Field of Search 355/4, 32, 35, 37, 88; 356/175, 188, 186; 350/311, 314, 316

[56] References Cited

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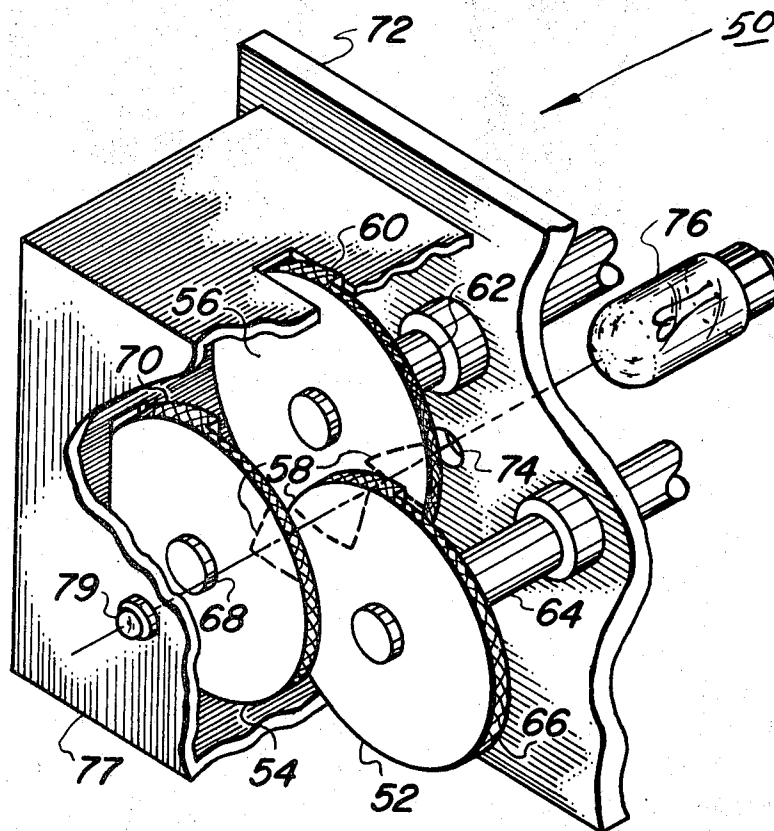
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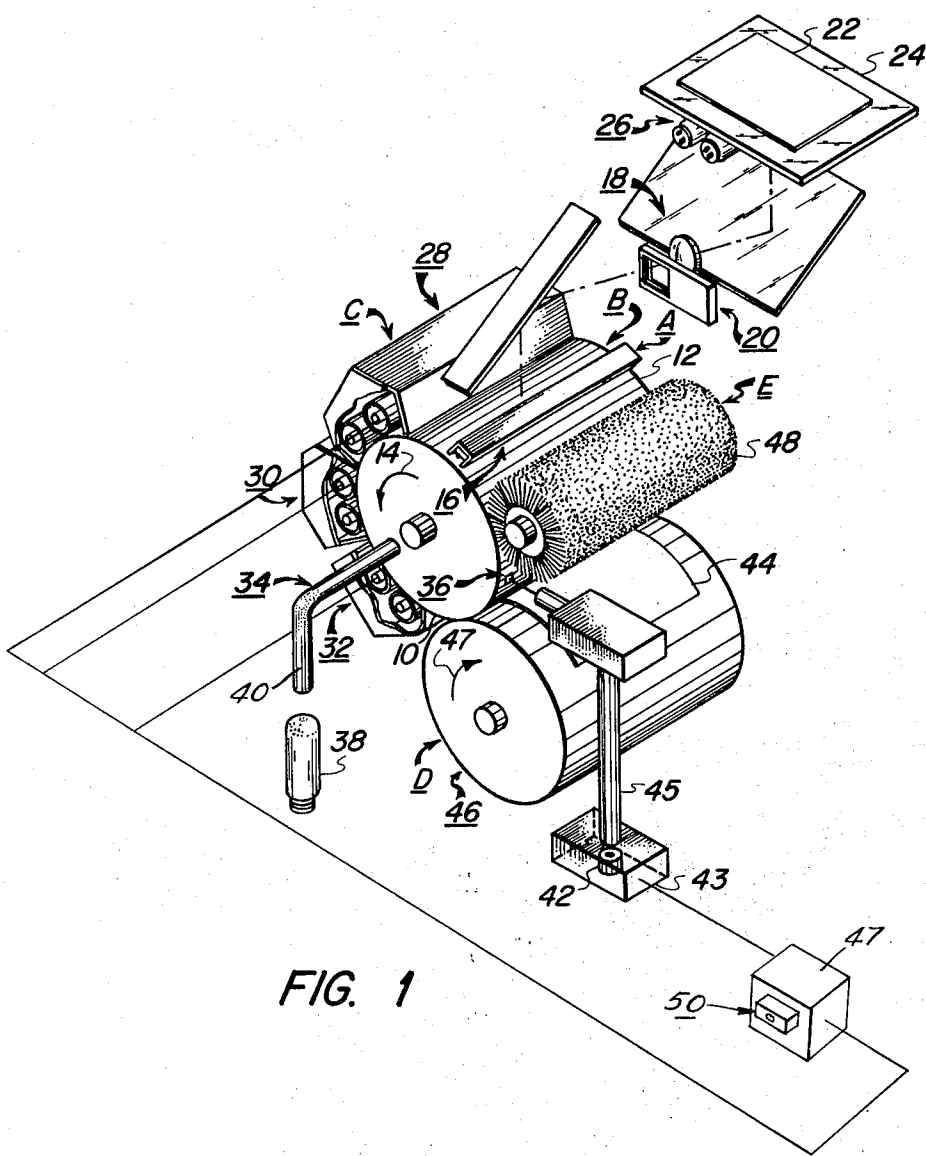
ABSTRACT

An apparatus in which the color relationship of a developability control system is displayed for indicating the balance thereof. The display apparatus is utilized in a multi-color electrophotographic printing machine and produces a visual indication of the color balance of copies being reproduced therein. A colored light ray is visible to the operator and functions as an indication of the color balance in the printing machine. When the colors of the copy are in balance, the operator will see a gray-black light. Adjustments are provided to vary the color balance; these adjustments, in turn, regulate the color of the light ray transmitted to the operator, thereby permitting the operator to visually note when the printing machine is producing copies having the requisite color balance.

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.

4 Claims, 2 Drawing Figures





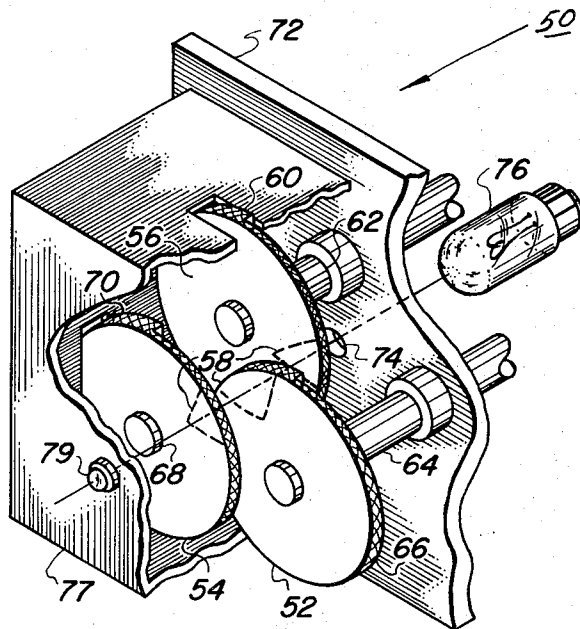


FIG. 2

COLOR BALANCE DISPLAY

BACKGROUND OF THE INVENTION

This invention relates generally to an electrophotographic printing machine, and more particularly concerns an apparatus for displaying the color balance of a developability control system utilized to regulate image density and color balance during the formation of a multi-color copy.

In an electrophotographic printing machine, developability is defined as the ability of the developer mix used therein to form an image having a specified density and color balance. Accordingly, a developability control system adjusts the characteristics of the developer mix to produce images on a copy which have a suitable density and color balance. Developability is related to the concentration of toner colorants in the developer mix. By this, it is meant that the percentage of toner colorants relative to carrier granules in the developer mix defines the developability capability of the printing machine. Thus, the function of the developability control system is to regulate the toner colorant concentration within the developer mix to maintain appropriate image density and color balance.

Frequently the color composition of the copies vary from that of the original. This may be achieved by adjusting the toner colorant concentration within the developer mixes so as to vary the color balance of the copy. Moreover, when the machine is initially set up the color balance of the copy must be adjusted to be in balance. This, also, is achieved by suitably regulating the concentration of toner colorants within the developer mixes. The display of the present invention indicates when the system is in color balance, thereby permitting the machine operator to readily return the system to the in-balance condition when the machine is not in color balance.

Generally, an electrophotographic printing machine, particularly a multi-color printing machine, utilizes a plurality of discretely colored toner colorants. The concentration of toner colorants relative to one another defines the color balance of the system. The developability control system has included therein appropriate circuitry arranged to provide a variable reference which represents the desired toner colorant concentration within the respective developer mix. Hence, as the level of the reference for the respective toner colorant within the developability control system is adjusted, the color balance within the electrophotographic printing machine changes. Heretofore, no apparatus has been provided for displaying in a simple fashion when the developability control system is adjusted such that the printing machine produces a copy in color balance.

Accordingly, it is a primary object of the present invention to improve the display apparatus utilized in conjunction with a developability control system for indicating the color balance thereof.

SUMMARY OF THE INVENTION

Briefly stated, and in accordance with the present invention, there is provided an apparatus for displaying the color balance of a developability control system.

In the preferred embodiment thereof, means is provided for adjusting the level of each reference in the developability control system to define the color balance thereof. The apparatus includes indicator means

operatively associated with the adjusting means. Pursuant to the present invention, the indicator means comprise a plurality of elements overlapping one another in a common region. The elements are arranged to move relative to one another an amount corresponding to the change in the level of the respective reference. Each of the elements is adapted to transmit therethrough a beam having a preselected wave length bandwidth with the energy content thereof depending upon the region of the element through which the beam passes. Furthermore, the apparatus includes means for generating a beam which passes through the common overlapping region of the indicator means. In this way, a beam passing through the common region having a predetermined wave length bandwidth and energy content indicates that the developability control system is in color balance.

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 an electrophotographic printing machine embodying the features of the present invention therein; and

FIG. 2 is an enlarged, fragmentary perspective view, partially in section, depicting the display apparatus incorporated in the developability control system of the FIG. 1 printing machine.

While the present invention will be described in connection with the 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 designate like elements, FIG. 1 schematically illustrates an electrophotographic printing machine in which the present invention may be incorporated. The electrophotographic printing machine depicted schematically in FIG. 1 illustrates the various components utilized therein for producing multi-color copies from a colored original. Although the display apparatus of the present invention is particularly well adapted for use in an electrophotographic printing machine, it should become evident from the following description that it is equally well suited for use in a wide variety of machines and is not necessarily limited in its application to the particular embodiment shown herein.

The printing machine illustrated in FIG. 1 employs a photoconductive member having 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 such that as drum 10 rotates in the direction of arrow 14 it passes sequentially therethrough. Drum 10 is driven at a predetermined speed relative to the other machine operating mechanisms from a common drive motor (not shown). The various machine operations are coordinated with one

another to produce the proper sequence of events at the appropriate processing stations.

Initially, drum 10 moves photoconductive surface 12 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. This readily enables corona generating device 16 to charge photoconductive surface 12 to a relatively high substantially uniform potential. Preferably, corona generating device 16 is of a type described in U.S. Pat. No. 2,778,946 issued to Mayo in 1957.

Thereafter, drum 10 is rotated to exposure station B where the 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. 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 copending application Ser. No. 830,282 filed in 1969, now abandoned. 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 and lens system 18 are moved in a timed relation with drum 10 to scan successive incremental areas of original document 22 disposed upon platen 24. In this manner, a flowing light image of original document 22 is projected onto photoconductive surface 12. Filter mechanism 20 is adapted to interpose selected color filters into the optical light path. The appropriate color filter operates on the light rays passing through lens 18 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.

After exposure, drum 10 rotates the single color electrostatic latent image recorded on photoconductive surface 12 to development station C. Development station C includes thereat three individual developer units, generally indicated by the reference numerals 28, 30 and 32, respectively. A suitable development station employing a plurality of developer units is disclosed in copending application Ser. No. 255,259, filed in 1972. Preferably, the developer units are all of a type referred to generally as magnetic brush developer units. A typical magnetic brush development system utilizes a magnetizable developer mix having carrier granules and toner colorants. The developer mix is continually brought through a directional flux field to form a brush thereof. The electrostatic latent image recorded on photoconductive surface 12 is developed by bringing the brush of developer mix into contact therewith. Each of the respective developer units contains discretely colored toner colorants corresponding to the complement of the spectral region of the wave length of light transmitted through filter 20, e.g., a green filtered electrostatic latent image is rendered visible by depositing green absorbing magenta toner colorant thereon, blue and red latent images are developed with yellow and cyan toner colorants, respectively.

Pursuant to the present invention, additional toner colorants are added to their respective developer mix when developability, as hereinbefore described, is reduced deleteriously. The developability control system,

indicated generally at 34, includes a transparent electrode assembly 36 mounted on photoconductive surface 12 of drum 10. A light source 38 cooperates with fiber optic light pipe 40 to transmit light rays through transparent electrode assembly 36. During development, the transparent electrode is biased electrically to attract toner colorants thereto. The toner colorants are deposited on transparent electrode 36 during development and the intensity of the light rays passing through is indicative of the density thereof. A photosensor 42 located in chamber 43, arranged to minimize thermal gradients, is in a light receiving relation with the light rays transmitted through transparent electrode 36 via fiber optic light pipe 45. In this way, photosensor 42 produces an electrical output signal corresponding to the density of the rays passing therethrough. Suitable analogue and reference circuitry compare the electrical output signal from photosensor 42 with an adjustable reference and generate a logic control signal for dispensing a selected toner colorant into the corresponding developer unit. The logic elements 47, preferably, include a suitable discriminator circuit for comparing the 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 has been obtained having a magnitude greater than the reference (i.e., set point). The signal from the discriminator circuit changes the state of a flip-flop to generate 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. The AND gate transmits a control signal to the toner dispenser housing the toner colorant corresponding to the developer unit generating the output signal. The control signal also resets the flip-flop. The type of logic circuitry heretofore disclosed is on-off. However, in the alternative, it is possible to utilize proportional circuitry which varies the quantity of toner colorant dispensed to the respective developer units of a function of the magnitude of the control signal. This may be achieved by a suitable integrated circuit module arranged to produce a stepped proportional dispensing rate. Duplicate logic elements are utilized for each developer unit, i.e., yellow developer unit, cyan developer unit and magenta developer unit. Hence, there are three separate, independent logic channels, each channel being associated with its respective developer unit. The density of toner colorant deposited on the surface of photoconductive surface 12 is a function of the concentration of toner colorant within the developer mix. The concentration of toner colorant is, in turn, a function of the magnitude of the reference. Thus, by adjusting the respective references, image density as well as color balance is regulated. The foregoing is described in greater detail in U.S. Pat. No. 3,754,821.

Drum 10 is next rotated to transfer station D where the 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 thermoplastic sheet. A bias transfer roll, shown generally at 46, recirculates support material 44 and is electrically biased to a potential of sufficient magnitude and polarity to attract electrostatically toner colorants from the latent image recorded on photoconductive surface 12 to support material 44. A suitably 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 47 in synchronism with drum 10. 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.

After the toner powder images have been transferred to support material 44, support material 44 is removed from bias transfer roll 46 and advanced to a suitable fuser (not shown) which coalesces the transferred powder image 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 fusing 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 the toner colorants are transferred to support material 44, invariably some residual toner colorants remain on photoconductive surface 12 after the transfer of the toner powder image to support material 44. These residual tone colorants are removed from photoconductive surface 12 as it moves through cleaning station E. Here the residual toner colorants are first brought under the influence of a cleaning corona generating device (not shown) adapted to neutralize the electrostatic charge remaining on the toner colorants. The neutralized toner colorants are then mechanically cleaned from photoconductive surface 12 by a rotatably mounted fibrous brush 48. A suitable brush cleaning device is described in U.S. Pat. No. 3,590,412 issued to Gerbasi in 1971. Rotatably mounted brush 48 is positioned at cleaning station E and maintained in contact with photoconductive surface 12. In this manner, residual toner colorants remaining on photoconductive surface 12 after each transfer operation are readily removed therefrom.

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 depicts schematically, in perspective, the display apparatus thereof. As shown in FIG. 2, indicator means shown generally by the reference numeral 50 includes a plurality of overlapping elements or disc members 52, 54 and 56, respectively. The disc members 52, 54 and 56, are wedge-shaped and overlap one another in a common region 58. Adjusting means or suitable potentiometers are associated with each of the disc means such that as the respective disc members rotate, the resistance of the corresponding potentiometers varies, changing the level of the reference in the logic circuitry of the developability control system for the respective toner colorant. For example, wedge shaped disc 56 may be of a yellow color and have the outer peripheral surface thereof 60 knurled so as to permit an operator to readily rotate disc 56. Disc 56 is mounted on a shaft 62 which is interconnected to the potentiometer adjusting the level of the reference for the developability control system regulating the yellow toner colorant. Hence, as disc 56 is rotated, the level of the reference for the yellow toner developability control system is also adjusted. In a similar manner, wedge shaped magenta disc 52 is mounted on shaft

member 64 which, in turn, is interconnected with a suitable potentiometer controlling the level of the reference for the magenta toner colorant. Disc 52 also includes a knurled circumferential surface 66 adapted to permit the operator to readily rotate disc 52, and, in turn, adjust the level of the reference for the magenta toner colorant. Referring now to wedge shaped cyan disc 54, this disc is also mounted on a shaft 68 which, in turn, is connected to the potentiometer controlling the level of the reference for the cyan toner colorant. Disc 54 is also knurled to facilitate the operator's rotation thereof, and permit the ready adjustment of the level of the reference for the cyan toner colorant. Disc members 52, 54 and 56, respectively, are mounted external to the printing machine of FIG. 1 and are arranged to permit the operator to readily rotate them. While the foregoing disc members have been described as being substantially wedge shaped and of a substantially uniform color, it is readily apparent to one skilled in the art that the disc members may be constructed in an alternate manner. For example, the disc members may be of a substantially uniform thickness with the color thereof graduated circumferentially about the surface thereof increasing from a light to a dark color.

Beam generating means or light source 76 is mounted interiorly of the printing machine of FIG. 1, i.e., light source 76 is mounted behind machine surface 72, and is adapted to project light rays through aperture or opening 74 therein onto the common region 58, i.e., the portion wherein disc members 52, 54 and 56 overlap one another. Light source 76 generates light rays which pass through aperture 74 and through common region 58. A suitable cover 77 may be utilized to encompass disc members 52, 54 and 56. Preferably, cover 77 has a clear indicator glass 79 mounted thereon substantially in alignment with common region 58. The foregoing beam of light is visible to the machine operator who adjusts the respective discs 52, 54 and 56 accordingly to obtain the desired resultant wave length bandwidth and energy content therefrom.

Each of the disc members is arranged to transmit a beam therethrough having a preselected wave length and energy content dependent upon the region through which the beam passes. Thus, the thickness or intensity of color of the respective disc determines the energy content and wave length bandwidth of the beam passing therethrough.

In a similar manner, the beam transmitted through the common region wherein the disc members overlap one another contains a discrete wave length bandwidth and energy content. As the disc members are rotated relative to one another, the wave length bandwidth and energy content of the beam passing through the common region changes. In operation, the discs are adjusted relative to one another until the beam of light passing through common region 58, and visible to the machine operator through indicator glass 79 is gray-black in color. When a gray-black light ray is displayed on indicator glass 79, the developability control system is in color balance.

Thus, it is seen from the foregoing description that the printing machine may readily be returned to the in-balance condition when the color balance is incorrect. For example, during initial alignment the machine may readily be adjusted to the in-balance condition by the operator merely adjusting the discs until a gray-black

light is visible in indicator glass 79. Similarly, if the machine has been intentionally placed in an out of balance condition to emphasize different colors in the copies than those contained in the original, the machine may be returned to the in-balance condition by once again adjusting the discs until a gray-black light is visible in indicator glass 79.

While the present invention has been described in connection with three disc members overlapping one another in a common region, one skilled in the art will appreciate that the invention is not necessarily so limited and that beams of light may be transmitted through any two disc members in order to determine the relationship of the color balance therebetween. Hence, a beam of light may be transmitted through the common region of the cyan and magenta discs in order to determine the respective color balance therebetween. Similarly, a beam of light may be transmitted through the yellow and magenta discs in order to determine the color balance therebetween. Finally, a beam of light may also be transmitted through the yellow and cyan discs in order to determine the color relationship between the yellow and cyan toner colorants. In addition a beam of light may also be transmitted through the common overlapping region of all three disc members to indicate the relative color balance therebetween. In this manner, the color balance between any two toner colorants in the developability control system as well as the color balance between all three toner colorants may be readily ascertained.

In recapitulation, by rotating one or all of the foregoing disc members, the level of the reference for the developability control system is adjusted to vary the toner colorant concentration in the respective developer mix. The concentration of toner colorant in the developer mix defines the color balance of the electrophotographic printing machine. A beam of light passing through the common overlapping region of the disc members indicates the condition of the color balance. Upon achieving a gray-black light beam the developability control system is in color balance.

Thus, it is apparent that there has been provided in accordance with the present invention, a display apparatus that fully satisfies the objects, aims and advantages set forth above. While the 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 in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications and variations as fall within the spirit and broad scope of the appended claims.

What is claimed is:

1. A multi-color electrophotographic printing machine employing a plurality of developer mixes having differently colored toner particles therein, including:

means for sensing the concentration of toner particles in each of the developer mixes and generating a plurality of electrical signals, each of the electrical signals being indicative of the sensed toner particle concentration in one of the developer mixes;

means for generating a plurality of adjustable reference signals, each of the reference signals being indicative of the selected toner particle concentration within one of the developer mixes;

means for comparing each of the electrical signals from said sensing means with the corresponding one of the reference signals from said generating means to produce an error signal indicative of the deviation therebetween;

a plurality of disc members mounted rotatably on the printing machine and overlapping one another in a common region, said plurality of disc members being coupled to said generating means so as to rotate relative to one another an amount corresponding to the change in the reference signals relative to one another; and

a light source mounted on the printing machine and transmitting a beam of light rays through the common overlapping region of said plurality of disc members, said plurality of disc members attenuating the wavelength bandwidth and energy content of the light rays passing through the common overlapping region as a function of the relative orientation of each of said disc members with respect to one another so as to display the relationship of each of the reference levels with respect to one another.

2. A printing machine as recited in claim 1, wherein each of said plurality of disc members has a continuously varying thickness so that the energy content of the beam transmitted therethrough depends upon the region thereof.

3. A printing machine as recited in claim 2, wherein said beam generating means includes a light source arranged to project light rays through the common overlapping region of said plurality of disc members.

4. A printing machine as recited in claim 3, wherein said plurality of disc members include a yellow disc member, a magenta disc member, and a cyan disc member overlapping one another in the common region so that when a gray-black light ray is transmitted through the common overlapping region said control system is substantially in color balance.

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