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United States Patent [19]

Whited

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[54] **PARTICLE LEVEL INDICATOR**

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[52] **U.S. Cl.** ..... **355/3 DD,** 118/DIG. 24, 118/637, 73/290 V, 222/DIG. 1, 222/66

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

[58] **Field of Search** ..... 355/3 R, 3 DD; 118/DIG. 24, 637; 117/17.5; 96/15 D; 222/DIG. 1, 64, 66; 73/290 V

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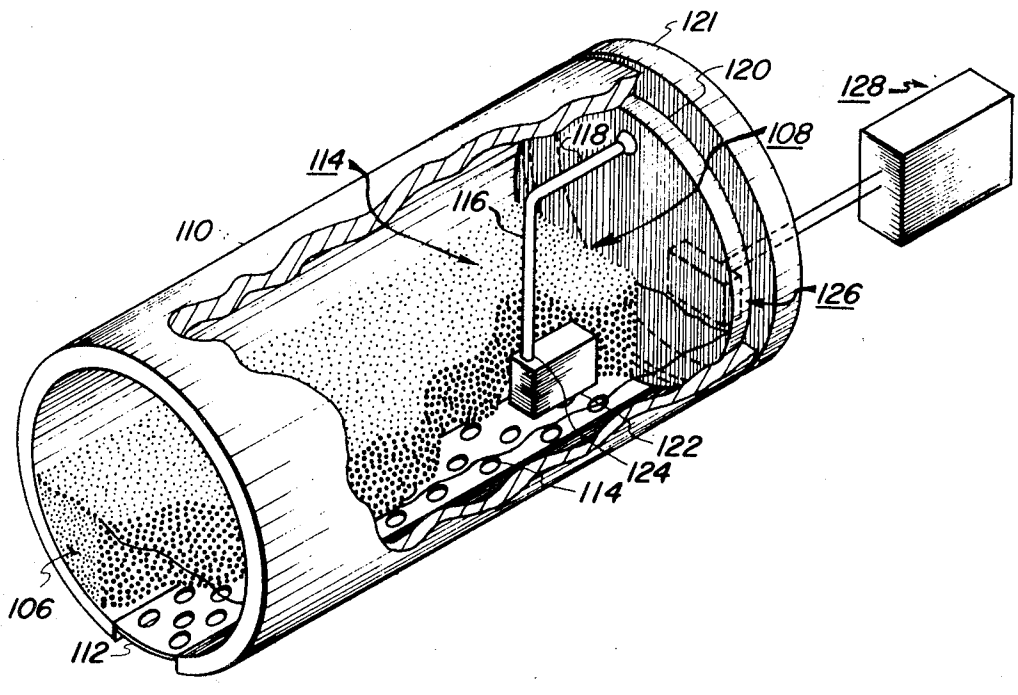
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[57] **ABSTRACT**

An apparatus arranged to indicate the level of particles remaining in a housing. The housing dispenses particles therefrom, and the apparatus senses when the particle level is diminished beneath a preselected level. In this manner, additional particles may be added to the housing when the apparatus indicates that the particles therein are depleted.

6 Claims, 4 Drawing Figures



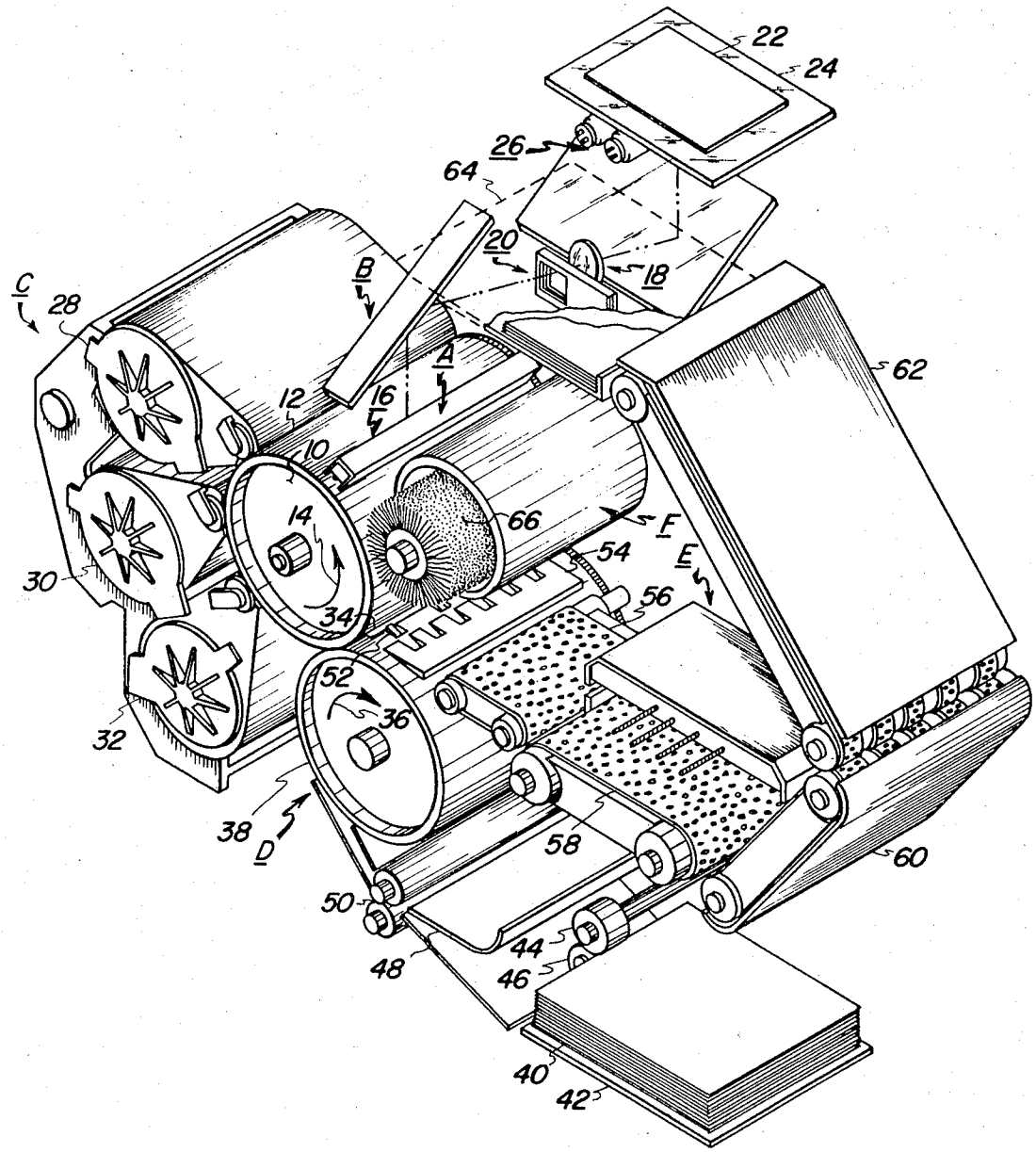

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FIG. 1

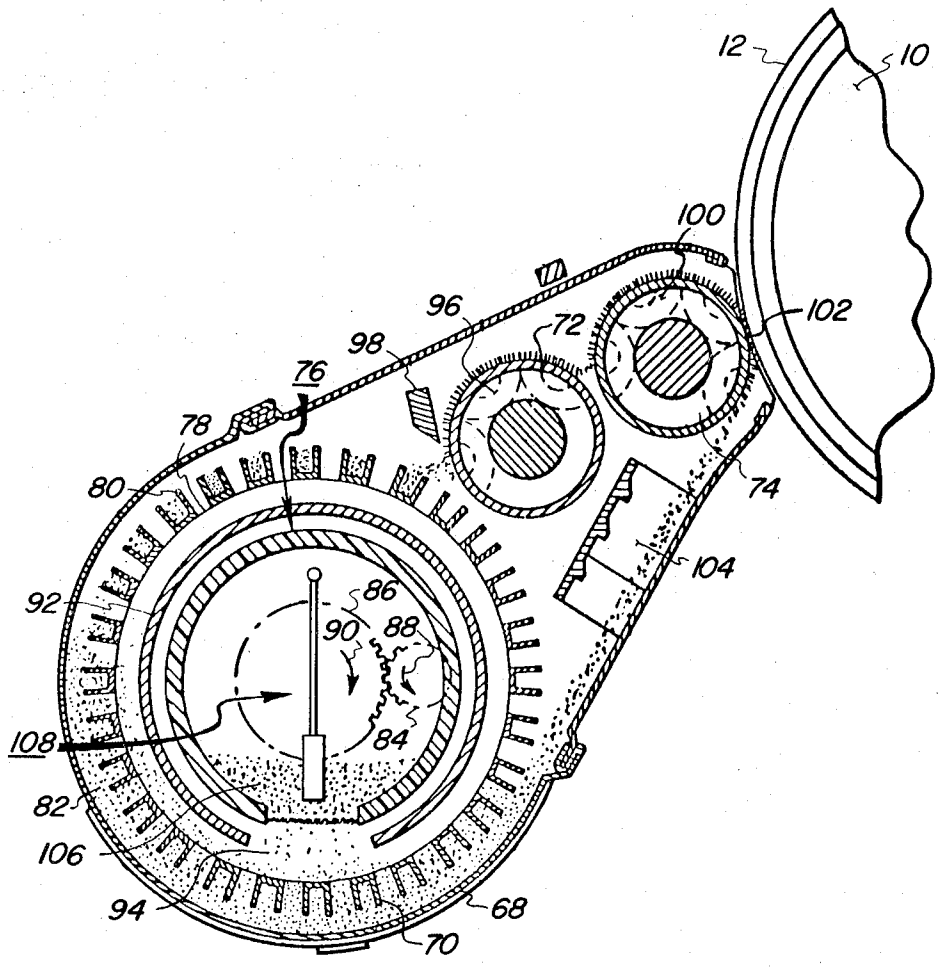

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FIG. 2

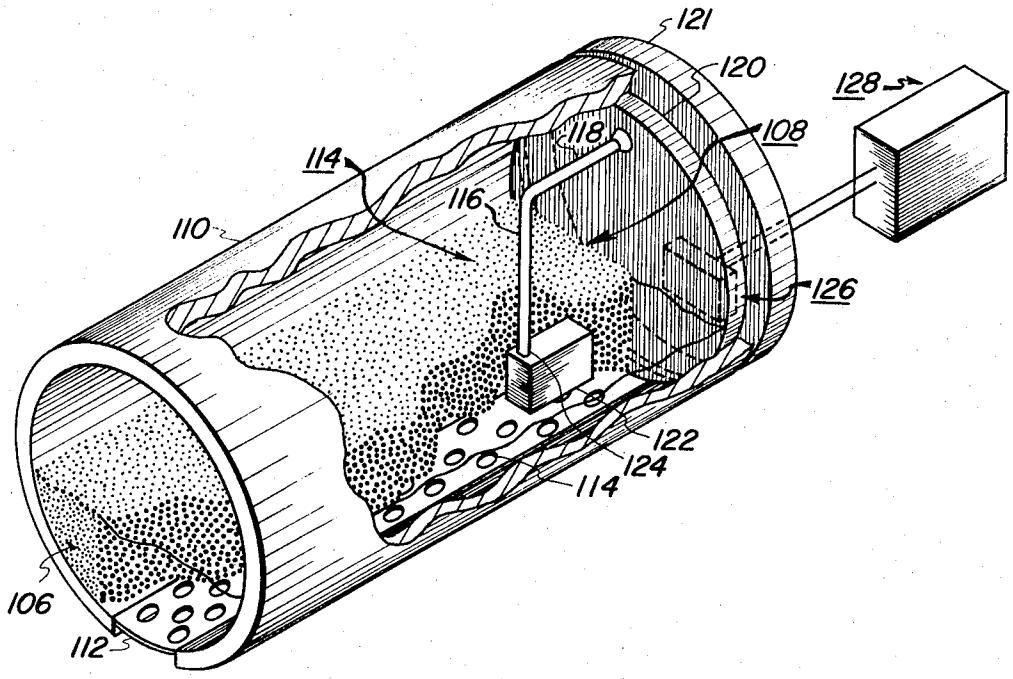

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FIG. 3

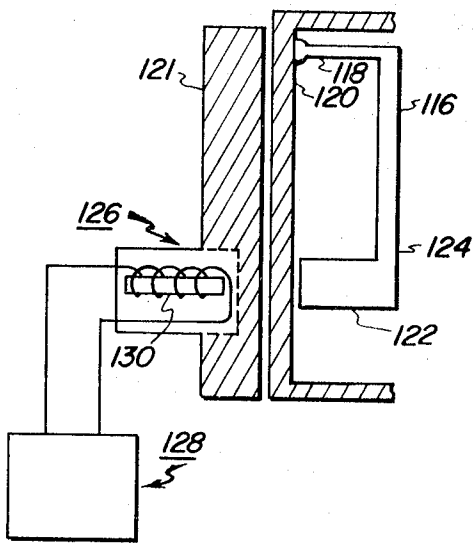

121
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128

FIG. 4

PARTICLE LEVEL INDICATOR

BACKGROUND OF THE INVENTION

This invention relates to an electrophotographic printing machine, and more particularly concerns an apparatus for indicating the level of particles within a toner particle storage housing utilized in the development system of the electrophotographic printing machine.

The process of electrostatographic printing comprises electrographic printing and electrophotographic printing. In both of the foregoing processes, an electrostatic latent image corresponding to an original document to be reproduced is recorded on an image bearing member. A viewable record is produced by depositing toner particles on the electrostatic latent image to form a powder image thereof. The foregoing is achieved, in electrophotographic printing, by charging a photoconductive surface to a substantially uniform potential. Thereafter, a light image of the original document is projected onto the charged photoconductive surface. The light image dissipates the charge on the photoconductive surface in the irradiated areas to record an electrostatic latent image thereon. Electrographic printing differs from the electrophotographic printing in that the electrostatic latent image is created without the use of a photoconductive material. That is, electrophotography requires the use of a suitable photoconductor, whereas electrography does not. The electrophotographic process was originally disclosed in U.S. Pat. No. 2,297,691 issued to Carlson in 1942.

A viewable record of the electrostatic latent image is achieved by contacting the electrostatic latent image with a developer mix of carrier granules and toner particles. Typically, toner particles are dyed or colored thermoplastic particles which are heat settable, whereas carrier granules are ferromagnetic granules. The toner particles and carrier granules are triboelectrically attracted to one another so that the toner particles adhere to the outer surface of the carrier granules. As the developer mix contacts the electrostatic latent image, the greater attractive force thereof causes the transfer and adherence of the toner particles to the electrostatic latent image. Additional toner particles are added to the developer mix as toner particles are depleted therefrom to maintain uniform image density.

In order to produce an efficient electrostatographic printing machine, it is necessary to conveniently and effectively replenish the toner particles used in the formation of copies. This is achieved by dispensing quantities of toner particles from a toner particle storage housing into the developer mix. However, it is readily apparent that as the toner particles are dispensed from the storage housing, the supply thereof becomes diminished. Thus, it is advantageous to have an apparatus associated with the storage housing for indicating when the toner particle supply therein has been substantially depleted. In this way, additional toner particles may be added to the storage housing to maintain uniform copy density.

Heretofore, various techniques have been utilized to detect the level of toner particles in the storage housing. For example, a machine operator may lower an indicator rod into the storage housing to determine the quantity of toner particles remaining therein. However, a disadvantage in handling toner particles in this manner is the tendency of the particles, due to their extremely small size, to become airborne when the storage housing is opened by the operator. The airborne toner particles contaminate the surrounding area, and reduce the efficiency of the printing machine as well as dirtying the operator and his clothing.

Another approach is to have a rotatable rod with a planar surface disposed in the storage housing. The rod is disposed along the longitudinal axis of the storage housing and biased by the toner particles to a position indicating the presence of toner particles in the storage housing. However, when toner particles are depleted, the rod rotates to a position indicating the absence of toner particles. Thus, as the toner particles are depleted from the storage housing, the rod rotates indicating that the toner particles therein are depleted beneath a pre-selected level. However, the foregoing type of apparatus does not appear to operate entirely satisfactorily when the storage housing is oscillated about its longitudinal axis. An apparatus of this type is described in co-pending application Ser. No. 266,936 filed in 1972.

Accordingly, it is a primary object of the present invention to improve the apparatus indicating toner particle quantity in a storage housing thereof.

SUMMARY OF THE INVENTION

Briefly stated and in accordance with the present invention, there is provided an apparatus for indicating particle quantity in a housing utilized for the storage thereof.

In the present instance, this is accomplished by housing means, vibrating means, sensing means, and detecting means. The housing means is adapted to store a supply of particles therein. As the vibrating means moves the housing means, particles are dispensed therefrom. The level of particles remaining in the housing means is measured by the sensing means. This is accomplished by mounting the sensing means for movement in the housing means. Only the particles stored in the housing means above a pre-selected level contact the sensing means. The movement of the sensing means relative to the housing means is measured by the detecting means. When the sensing means is in contact with the particles, it moves in unison with the housing means. Contrawise, when the sensing means is spaced from the particles, it moves relative to the housing means. The movement of the sensing means relative to the housing means is measured by the detecting means, thereby indicating that the particle level is beneath the pre-selected level.

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;

FIG. 2 is a sectional elevational view of the FIG. 1 printing machine developer unit having a toner particle storage housing therein;

FIG. 3 is a schematic perspective view of the FIG. 2 toner particle storage housing incorporating the present invention therein; and

FIG. 4 is a fragmentary view of the apparatus of the present invention utilized in the FIG. 3 toner particle storage housing.

While the present invention will be described in connection with a preferred embodiment, 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 modifications, alternatives 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 a multi-color 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 color copies from a colored original document. Although the particle level indicating apparatus of the present invention is particularly well adapted for use in the toner particle storage housing of the electrophotographic printing machine depicted in FIG. 1, it should become evident from the following description that it is equally well suited for use in a wide variety of electrostatographic printing machines and is not necessarily limited to the particular embodiment shown herein.

The printing machine illustrated in FIG. 1 employs an image bearing member including a drum **10** having a photoconductive surface **12** secured to and entrained about the circumferential surface thereof. Drum **10** is mounted rotatably within the machine frame (not shown). One type of suitable photoconductive material is disclosed in U.S. Pat. No. 3,255,377 issued to Sechak in 1972. As drum **10** rotates in the direction of arrow **14,** it passes sequentially through a series of processing stations. A drive motor (not shown) rotates drum **10** at a predetermined speed relative to the other machine operating mechanisms. Drum **10** has a timing disc (not shown) mounted on one end thereof. The timing disc is adapted to actuate the machine logic so that the various machine operations are coordinated with the rotation of drum **10.** Hence, the machine logic coordinates the sequence of events at the appropriate processing stations in conjunction with the rotation of drum **10.**

Initially, drum **10** moves photoconductive surface **12** through charging station A. At charging station A, a corona generating device indicated generally at **16,** is disposed in a generally transverse direction extending longitudinally across photoconductive surface **12.** Corona generating device **16** is adapted to spray ions onto photoconductive surface **12.** This charges photoconductive surface **12** to a relatively high substantially uniform potential. Preferably, corona generating device **16** is of the type described in U.S. Pat. No. 2,778,946 issued to Mayo in 1957.

After photoconductive surface **12** is charged to a substantially uniform potential, drum **10** rotates to exposure station B. At exposure station B, a color filtered light image of the original document is projected onto the charged photoconductive surface. Exposure station B includes a moving lens system, generally designated by the reference numeral **18,** and a color filter mechanism, shown generally at **20.** One type of 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. Referring once again to 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.** Filter mechanism **20,** lens **18** and lamp assembly **26** are moved in a timed relation with drum **10** to scan successive incremental areas of original document **22** disposed upon platen **24.** This creates a flowing light image of original document **22** which 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 region of the electromagnetic wave spectrum, hereinafter referred to as a single color electrostatic latent image.

After the charged photoconductive surface **12** has been exposed to a filtered light image, drum **10** rotates the single color electrostatic latent image recorded thereon to development station C. Three developer units, generally indicated by the reference numerals **28, 30** and **32,** respectively, are disposed at development station C. One of the foregoing developer units, i.e., developer unit **28,** will be described hereinafter in greater detail with reference to FIG. **2.** However, a suitable development station having a plurality of developer units is disclosed in co-pending 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 developer unit includes a magnetizable developer mix comprising carrier granules and toner particles therein. 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 contain discretely colored toner particles corresponding to the complement of the spectral region of the wave length of light transmitted through filter **20,** e.g., a green filtered electrostatic image is rendered visible by depositing green absorbing magenta toner particles thereon, whereas blue and red latent images are developed with yellow and cyan toner particles, respectively.

Drum **10** is next rotated to transfer station D where the toner powder image adhering electrostatically to photoconductive surface **12** is transferred to a sheet of final support material **34.** Final support material **34** may be, amongst others, a sheet of paper or a sheet of polysulfone thermoplastic material. A transfer roll, shown generally at **36,** recirculates support material **34** and is electrically biased 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 **34.** Transfer roll **36** rotates in the direction of arrow **38** in synchronism with drum **10.** Preferably, transfer roll **36** and drum **10** are rotated at the same angular velocity. Inasmuch as support material **34** is secured releasably to transfer roll **36,** it moves in a recirculating path therewith. This permits successive toner powder images to be transferred from the electrostatic latent image recorded on photodoncutive surface **12** to support material **34** in

superimposed registration with one another. Support material **34** is advanced from a stack **40** disposed on tray **42.** Feed roll **44,** operatively associated with retard roll **46,** advances and separates the uppermost sheet from stack **40** disposed on tray **42.** The advancing sheet moves into chute **48** which directs it into the nip between register rolls **50.** Thereafter, gripper fingers **52,** mounted on transfer roll **36,** secure releasably thereon support material **34** for movement in a recirculating path therewith. After a plurality of toner powder images have been transferred to support material **34,** gripper fingers **52** space support material **34** from transfer roll **36.** Stripper bar **54** is then interposed between support material **34** and transfer roll **36.** Support material **34** is separated from transfer roll **36** and advanced on endless belt conveyor **56** to fixing station E.

At fixing station E, fuser **58** coalesces the multilayered transferred toner powder image to support material **34.** One type of suitable fuser is described in U.S. Pat. No. 3,498,592 issued to Moser et al. in 1970. Upon completion of the fixing process, support material **34** is advanced by endless belt conveyors **60** and **62** to catch tray **64** for subsequent removal therefrom by the machine operator.

After the transfer process, residual toner particles remaining on photoconductive surface **12** are cleaned therefrom. The residual toner particles are removed from photoconductive surface **12** as it passes through cleaning station F. At cleaning station F, a cleaning corona generating device (not shown) initially neutralizes the electrostatic charge remaining on photoconductive surface **12** and the toner particles. The neutralized toner particles are then cleaned from photoconductive surface **12** by a rotatably mounted fibrous brush **66.** A suitable brush cleaning device is described in U.S. Pat. No. 3,590,412 issued to Gerbasi in 1971. Brush **66** is positioned at cleaning station F and maintained in contact with photoconductive surface **12.** Thus, after each successive transfer operation, residual toner particles remaining on photoconductive surface **12** are removed therefrom.

Referring now to FIG. **2,** there is shown on developer unit, i.e., developer unit **28,** in detail. Developer unit **28** is depicted in a sectional elevational view to indicate more clearly the various components utilized thereon. Only developer unit **28** has been described in detail as developer units **30** and **32** are substantially identical thereto. The developer units are distinguishable from one another by the color of the toner particles contained therein and by the geometrical differences due to the angle of mounting. Developer units **28** may have yellow toner particles therein, unit **30** magenta toner particles, and unit **32** cyan toner particles.

The major components of developer unit **28** are developer housing **68,** paddle wheel **70,** transport roll **72,** developer roll **74** and housing means or a toner particle storage housing, indicated generally at **76.** Paddle wheel **70** includes a rotary driven hub member **78** with buckets or scops **80** spaced substantially equally about the periphery thereof. As paddle wheel **70** rotates, developer mix **83** is elevated from the lower region of developer housing **68** to the upper region thereof. In operation, clutch gear **84** meshes with gear **86** secured to paddle wheel **70.** Gear **84** rotates in the direction of arrow **88** driving gear **86** in the direction of arrow **90,** thereby rotating paddle wheel **70** in the direction of arrow **90.** When developer mix **82** reaches the upper region of developer housing **68,** it is lifted from paddle wheel buckets **80** to transport roll **72.** Alternate buckets of paddle wheel **80** have apertures therein so that the developer mix carried in these areas falls back to the lower regions of developer housing **68.** As the developer mix falls to a lower region of developer housing **68,** it cascades over shroud **92** which is of a tubular configuration with an aperture **94** in the lower region thereof. Developer mix **82** is recirculated so that the carrier granules thereof are continually agitated to mix with fresh toner particles. This agitation generates a strong triboelectric charge to attract the toner particles to the carrier granules. As developer mix **82,** in the paddle wheel buckets approaches transport roll **72,** the magnetic field generated by fixed magnets **96** attract developer mix **82** thereto. Transport roll **72** moves developer mix **82** in an upwardly direction. If a surplus of developer mix **82** is furnished, metering blade **98** controls the amount of developer mix **82** carried over the top of transport roll **72.** Metering blade **98** shears surplus developer mix **82** from transport roll **72.** The surplus developer mix falls in a downwardly direction toward paddle wheel **70.**

The developer mix which passes metering blade **98** is carried over transport roll **72** and attracted to developer roll **74** by the magnetic field generated by fixed magnets **100** therein. Developer roll **74** moves developer mix **82** into development zone **102** located between photoconductive surface **12** and developer roll **74.** The electrostatic latent image recorded on photoconductive surface **12** is developed by contacting the moving developing mix **82,** i.e., the charged areas of photoconductive surface **12** electrostatically attract the toner particles from the carrier granules of developer mix **82.** At the exit of development zone **72,** the strong magnetic field in the direction generally tangential to developer roll **74** continue to secure thereto residual developer mix and denuded carrier granules, i.e., carrier granules lacking toner particles. Upon passing from the development zone, the residual developer mix and denuded carrier granules enter a region relatively free from magnetic forces and fall from developer roll **74** in a downwardly direction into the lower region of developer housing **68.** As the residual developer mix and denuded carrier granules descend, they pass through mixing baffle **104** which directs the flow from the ends toward the center of developer housing **58** to provide mixing in this direction.

Shroud **92** controls the fall of the surplus developer mix and denuded carrier granules so that they mix with the toner particles, rather than simply falling into the lower region of developer housing **68.** Furthermore, shroud **92** isolates, from the developer mix, an interior cylindrical enclosure in which toner particle storage housing **76** is located. Toner particle storage housing **76** contains a fresh supply of toner particles **106** which pass through aperture **94** in shroud **92** and into the stream of developer mix **82.** Adding toner particles at this location insures that they cannot be carried into development zone **102** without some degree of mixing with the denuded carrier granules. Additional toner particles are added to the developer mix in order to replace those used in forming toner powder images on the copies. This maintains the concentration of toner particles in the developer mix substantially constant providing substantially uniform image density.

The apparatus of the present invention, shown generally at **108**, indicates the level of toner particles remaining in toner particle storage housing **76**. Oscillation of toner particle storage housing **76** about the longitudinal axis thereof dispenses toner particles therefrom. This is achieved by an oscillator motor (not shown) adapted to vibrate toner particle storage housing **76** substantially about the longitudinal axis thereof.

Turning now to FIG. **3**, the detailed structural configuration of toner particle storage housing **76** is shown therein. As shown in FIG. **3**, toner particle storage housing **76** includes a tubular member **110** having a supply of toner particles **106** therein corresponding in color to that required by the respective developer unit. Tubular member **110** includes a perforated region **112** therein. When tubular member **110** is stationary, toner particles **106** form a bridge over the holes in perforated region **112** and are not dispensed therethrough. However, when tubular member **110** is oscillated about the longitudinal axis thereof this bridging effect is broken causing toner particles **106** to pass through perforated region **112** and into the lower region of developer housing **74**. Preferably, tubular member **110** may be molded from a suitable plastic material with perforated region **112** comprising a plurality of substantially parallel equally spaced slots **114** therein.

Sensing means, indicated generally at **114**, has a portion thereof in contact with toner particles **106**. Under these circumstances, sensing means **114** oscillates in unison with tubular member **110**. Sensing means **114** includes a shaft member **116** mounted pivotably at end portion **118** on end plate **120** of tubular member **110**. A generally planar member or plate **122** is mounted on the other end region **124** of shaft **116**. When planar member **122** is spaced from the toner particles **106**, shaft member **116** oscillates relative to tubular member **110**. The movement of planar member **122** relative to tubular member **110** is sensed by detecting means, indicated generally at **126**. Detecting means **126** senses the movement of plate member **122** relative to tubular member **110**. The detailed structural configuration of detecting means **126** will be described in conjunction with FIG. **4**. Circuit means, indicated generally at **128** develop an electrical output signal in response to detecting means **126** indicating that planar member **122** is oscillating relative to tubular member **110**.

Turning now to FIG. **4** there is shown the detailed structural configuration of the level indicating apparatus **108** of the present invention. As shown therein, detecting means **126** includes a suitable magnetic sensor or pick-up **130** adapted to sense the movement of planar member **122** relative to tubular member **110**. By way of example, a suitable magnetic pick-up **130** is preferably Model No. 340-001 manufactured by Airpax Electronic Company, Fort Lauderdale, Fla. If a sub-miniature magnetic pick-up **130** is required, Model No. 10024 may be suitable.

Magnetic pick-up **130** is mounted in door **121** of developer unit **28**. The movement of tubular member **110** and planar member **122**, in unison with one another, is detected, as well as the relative movement therebetween. Thus, magnetic pick-up **130** senses the movement of planar member **122** when it contacts toner particles **106**. Circuit means **128** is set such that the low level display is not energized when magnetic pick-up **130** senses the movement of planar member **122** in unison with tubular member **110**. However, circuit means **128** triggers the low level display when planar member **128** vibrates relative to tubular member **110**, i.e., when planar member **128** no longer contacts toner particles **106**. This permits tubular member **110** to be discarded when toner particles **106** are depleted beneath the preselected level, while permitting magnetic pick-up **103** to re-used for successive tubular members **110**.

Shaft member **116** and planar member **122** are preferably made from a suitable metallic material adapted to cut the lines of flux generated by magnetic pick-up **130**. Cutting the lines of flux produced by magnetic pick-up **130** generates an electrical output signal which, in turn, is suitably processed by circuit means **128**. Circuit means **128** may preferably be a suitable discriminator circuit adapted to produce an electrical output signal when the signal from magnetic pick-up **130** is above a predetermined level. The electrical output signal from discriminator circuit **128** is arranged to actuate suitable display means (not shown) such as a buzzer or light panel indicating that the toner particle level in tubular member **110** is beneath the preselected level. Thereupon, the printing machine may de-activate automatically permitting the operator to replace the empty tubular member **110** with one containing toner particles.

In recapitulation, it is apparent that the apparatus of the present invention is arranged to oscillate with the tubular member when the toner particle level therein is above a pre-selected level. However, the apparatus of the present invention oscillates relative to the tubular member when the toner particle level is beneath the preselected level. The oscillation of the sensing means relative to the tubular member is detected and an electrical output signal developed by the circuit means which, in turn, actuates a suitable display and de-energize the printing machine. The display indicates that the toner particle level in the tublar member is beneath the pre-selected level. Hence, the machine operator is advised that the toner particle level is low and that additional toner particles are required in order to produce satisfactory copies within the electrophotographic printing machine.

It is, therefore, evident that there has been provided in accordance with this invention, an apparatus for detecting the level of toner particles in a toner particle storage housing 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 electrostatographic printing machine of the type having an electrostatic latent image recorded on an image bearing member and a development system adapted to deposit toner particles from a developer mix onto the electrostatic latent image, wherein the improvement includes:

means for housing a supply of toner particles;

means for vibrating said housing means to dispense toner particles therefrom;

means for sensing the level of toner particles remaining in said housing means, said sensing means being mounted for movement in said housing means and

arranged to engage the toner particles stored therein above a preselected level; and

magnetic means, operatively associated with said housing means, for detecting the movement of said sensing means relative to said housing means, said sensing means being adapted to move relative to said housing means when the toner particles stored therein are beneath a preselected level and said vibrating means moves said housing means to dispense toner particles therefrom.

2. A printing machine as recited in claim **1,** further including:

circuit means arranged to produce an electrical signal in response to said detecting means indicating movement of said sensing means relative to said housing means; and

means, responsive to the electrical signal generated by said circuit means, for indicating that the quantity of toner particles remaining in said housing means is beneath the pre-selected level and for de-energizing the printing machine.

3. A printing machine as recited in claim **2,** wherein said housing means includes a generally tubular member journaled for oscillatory movement substantially about the longitudinal axis thereof and defining a chamber for storing a quantity of toner particles therein, said tubular member having a perforated region arranged to prevent the passage of toner particles therethrough when said tubular member is stationary while allowing the passage of toner particles therethrough when said tubular member is oscillated.

4. A printing machine as recited as claim **3,** wherein said vibrating means includes a motor adapted to oscillate said tubular member about the longitudinal axis thereof.

5. A printing machine as recited in claim **4,** wherein said sensing means includes:

a shaft member having one end portion thereof mounted pivotably in said tubular member, said shaft member extending in a direction substantially normal to the longitudinal axis of said tubular member; and

a generally planar member secured to said shaft member in the region of the other end portion thereof, said planar member moving substantially in unison with said tubular member when contacting the particles stored therein and oscillating relative to said tubular member when spaced from the particles stored therein.

6. A printing machine as recited in claim **5,** wherein said magnetic detecting means is mounted closely spaced to said tubular member in communication with said planar member so as to detect the oscillation thereof relative to said tubular member for indicating that said planar member is spaced from the toner particles in said tubular member.

* * * * *