United States Patent

Royka

[15] **3,695,224**

[45] **Oct. 3, 1972**

[54] **CASCADE DEVELOPMENT**

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[21] Appl. No.: **202,181**

Related U.S. Application Data

[62] Division of Ser. No. 866,320, Oct. 14, 1969, Pat. No. 3,663,291.

[52] **U.S. Cl.**.....**118/637,** 117/17.5, 118/DIG. 24, 355/3

[51] **Int. Cl.**.....**G03g 13/00**

[58] **Field of Search**.....118/636, 637, DIG. 24; 117/17.5; 222/371; 355/3

[56] **References Cited**

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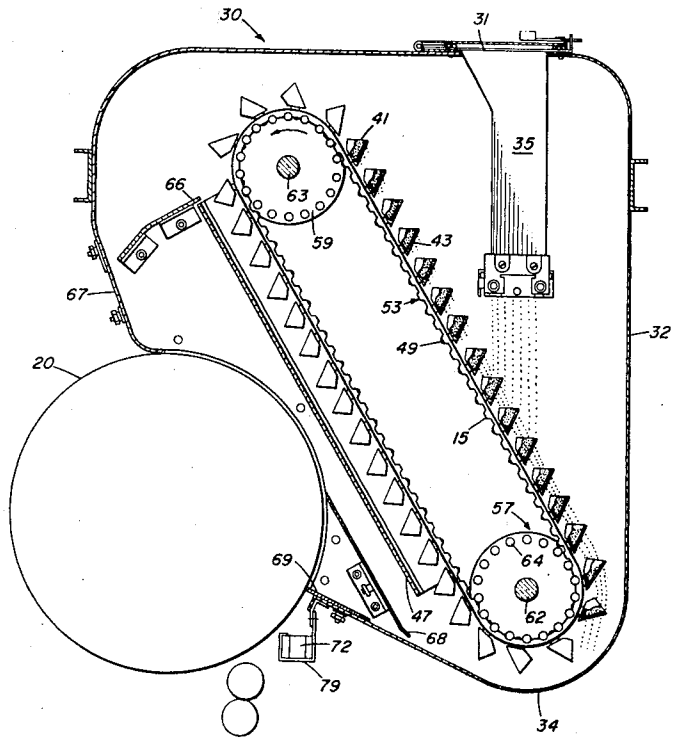
Primary Examiner—Mervin Stein
Assistant Examiner—Leo Millstein
Attorney—Paul M. Enlow et al.

[57] **ABSTRACT**

Processes are provided for improving the mixing efficiency of carrier and toner in electrostatographic apparatus by causing a partial reverse cascade of developer from the buckets of a bucket-type conveyor in the electrostatographic developing apparatus prior to said developer cascading across the electrostatographic surface whereby developer falls back upon subadjacent buckets and mixes with toner newly deposited therein.

An improvement in electrostatographic development apparatus is obtained by providing the buckets of the bucket-type conveyor of the development apparatus with a plurality of apertures in the posterior wall of each bucket thereby obtaining buckets adapted to allow a partial egress of developer from said apertures prior to said developer cascading across the electrostatographic surface whereby developer falls back upon subadjacent buckets and mixes with fresh toner released from the toner dispenser.

3 Claims, 4 Drawing Figures



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SHEET 1 OF 2

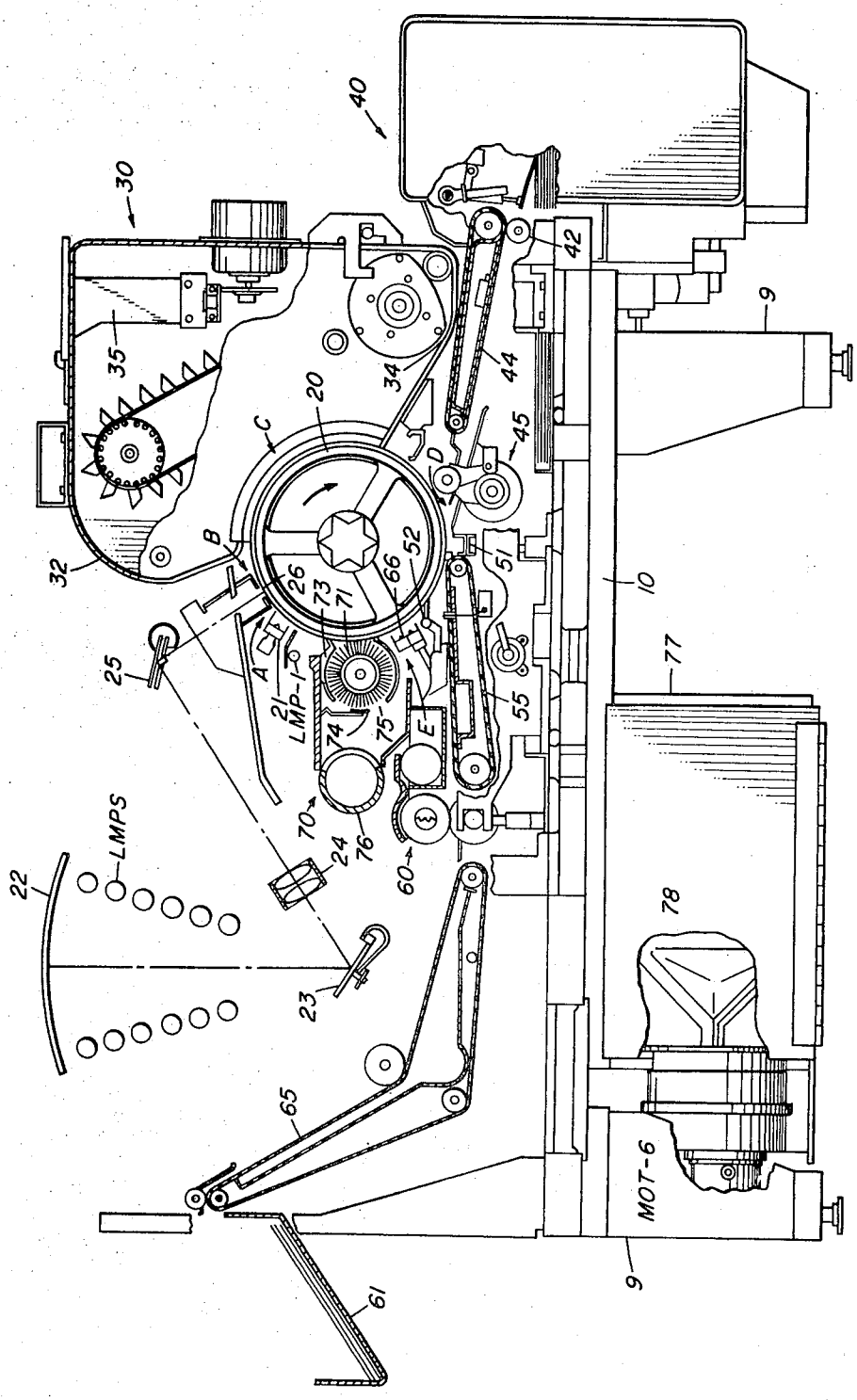


FIG. 1

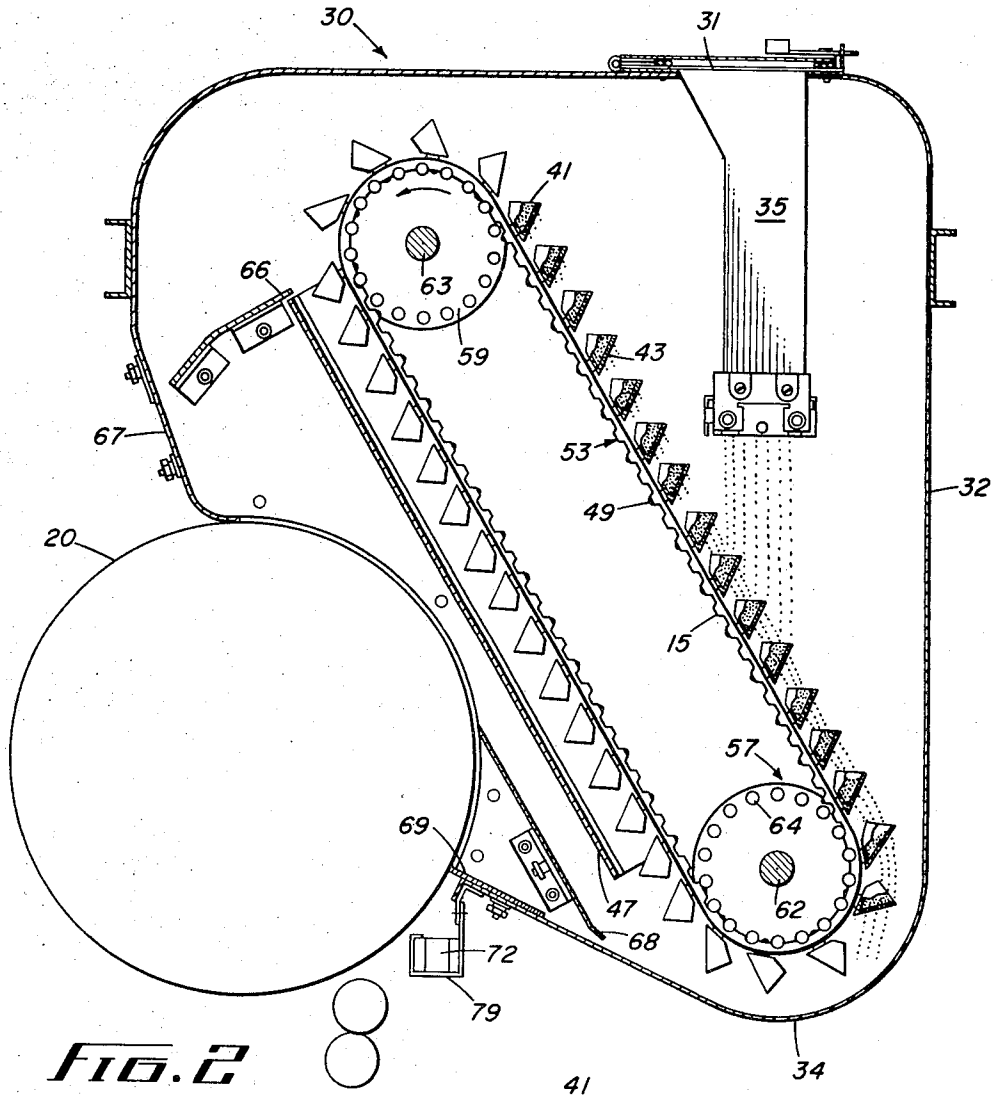


FIG. 2

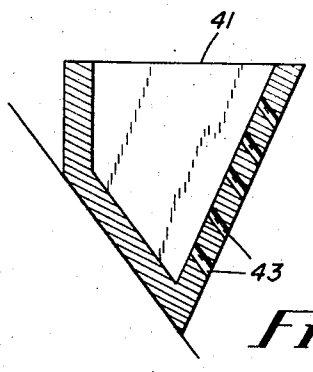


FIG. 3

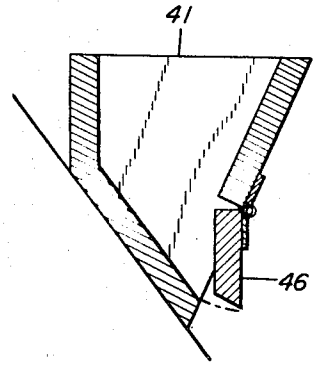


FIG. 4

CASCADE DEVELOPMENT

This is a division of application Ser. No. 866,320, filed Oct. 14, 1969, now U.S. Pat. No. 3,663,291.

This application is concerned with electrostatographic reproduction and, more particularly, with improved development apparatus for use in electrostatographic machines.

In electrostatographic processes, an electrostatic latent image is formed and developed or made visible by the attraction thereto of finely divided pigmented material. The most widely used electrostatographic processes involve the use of electrophotographic machines which employ a photoconductive insulating member in the form of a cylinder, web, plate or the like, and use the so-called cascade type of development in which a developer material is poured or cascaded over the surface of said photoconductive member. As is well-known, cascade developer generally comprises a mixture of granular particles having a diameter in the range of from about 20 mesh to about 200 mesh and much smaller pigmented powder particles generally smaller than about 50 microns which electrostatically cling to the larger particles. Since the smaller particles, called toner, are adherent upon the larger particles, called carrier, the developer mixture flows and otherwise behaves substantially as a granular rather than a powdered material. As the developer mixture is poured over the electrostatic latent image, toner particles are selectively separated from the carrier and deposit in image configuration.

As toner is consumed, fresh toner is fed to the developing station of the machine. As machine speed is increased with present developing apparatus, image density begins to fall off and other forms of image degradation appear which are associated with incomplete development. The trend in electrostatographic reproduction is towards machines running at higher speeds and providing higher copy quality. At higher speeds in most machines, the toner being dispensed into the developing station of the machine does not have an opportunity to mix well with the developer which is necessary to properly charge the toner. The resulting effect is loss of copy quality due to high background and unstable developer concentrations. Moreover, in many such machines, lubricants such as zinc stearate are added to the developer to assist the cleaning device in removing any residual developer from the photoconductive surface. Addition of lubricant, however, tends to lower the mixing efficiency. Thus, the need for more efficient mixing becomes even greater in such machines running at high speed and/or containing lubricants in the developer composition where high copy quality is required.

Accordingly, it is an object of the present invention to provide improved development apparatus permitting more efficient mixing of fresh toner and developer. It is another object of this invention to provide apparatus which will enable high copy quality to be attained at high operating speeds and/or with lubricated developer compositions.

For a better understanding of this invention, as well as other objects and further features thereof, reference is made to the following detailed description of the invention to be read in connection with the accompanying drawings, wherein for purposes of illustration, the invention is described with reference to an automatic

electrophotographic reproducing apparatus. It is readily apparent, however, that the invention is similarly applicable to any electrostatographic reproducing apparatus:

FIG. 1 is a schematic cross-sectional view of a typical electrostatic electrophotographic machine having a developing apparatus constructed in accordance with the invention;

FIG. 2 is an enlarged side view of the developing apparatus shown in FIG. 1;

FIG. 3 is an enlarged sectional view of one embodiment of the bucket construction of the present invention;

FIG. 4 is an enlarged sectional view of an alternate embodiment of the bucket construction of the present invention.

As shown schematically in FIG. 1, the automatic electrostatic electrophotographic reproducing apparatus comprises a photoresponsive surface 20, including a photoconductive layer or light receiving surface on a conductive backing and formed in the shape of a drum, which is mounted on a shaft journaled in a frame to rotate in the direction indicated by the arrow to cause the drum surface sequentially to pass a plurality of electrophotographic processing stations.

For the purpose of the present disclosure, the several electrostatic electrophotographic processing stations in the path of movement of the photoresponsive surface may be described functionally as follows:

A charging station at which a uniform electrostatic charge is deposited on the photoresponsive surface;

An exposure station at which a light or radiation pattern of copy to be reproduced is projected onto the photoresponsive surface to dissipate the charge in the exposed areas thereof and thereby form a latent electrostatic image of the copy to be reproduced;

A developing station at which a developing material, including toner particles having an electrostatic charge opposite to that of the electrostatic latent image, is cascaded over the photoresponsive surface whereby the toner particles adhere to the electrostatic latent image to form a powdered image in the configuration of the copy being reproduced;

A transfer station at which the powdered image is electrostatically transferred from the photoresponsive surface to a transfer material or support surface; and,

a cleaning and discharge station at which the photoresponsive surface is brushed to remove residual toner particles remaining thereon after image transfer and at which said surface is exposed to a relatively bright light source to effect substantially complete discharge of any residual electrostatic charge remaining thereon.

The charging station is preferably located as indicated by reference character A. As shown, the charging arrangement includes a corona charging device 21, which includes a corona discharge array of one or more corona discharge electrodes that extend transversely across the photoresponsive surface and are energized from a high potential source and are enclosed within a shielding member.

Next subsequent thereto in the path of motion of the photoresponsive surface is an exposure station B. An optical scanning or projection system is provided to project a flowing image onto the photoresponsive surface from a stationary original.

The optical scanning or projection assembly comprises a stationary copy board which consists of a transparent platen member **22**, such as, for example, a glass plate or the like, positioned on the exterior of the cabinet which is adapted to support a document to be reproduced, the document being uniformly illuminated and arranged in light projecting relation to the moving light receiving surface of the electrophotographic drum. Uniform lighting is provided by banks of lamps LMPS arranged on opposite sides of the copy board. Scanning of the document on the stationary copy board is accomplished by means of a mirror assembly, which is oscillated relative to the copy board, in timed relation to the movement of the said drum.

The mirror assembly, which includes an object mirror **23**, is mounted below the copy holder to reflect an image of the document through a lens **24** onto an image mirror **25** which in turn reflects the image onto the drum through a slot in a fixed light shield **26** positioned adjacent to the drum surface.

Adjacent to the exposure station is a developing station C, in which there is positioned a developer apparatus **30**, including a casing or housing having a lower or sump portion for accumulating developer material. A bucket type conveyor is used to carry the developing material to the upper part of the developer housing where it is cascaded over a hopper chute onto the photoresponsive surface to effect development. A toner dispenser **35** is used to accurately meter toner to the developing material as toner particles are consumed during the developing operation.

Positioned next and adjacent to the developing station is the image transfer station D which includes a sheet feeding arrangement adapted to feed sheets of support material, such as paper or the like, successively to the electrophotographic drum in coordination with the presentation of the developed image on the drum surface at the transfer station.

The sheet feeding mechanism includes a sheet feed device **40** adapted by means of vacuum feeders to feed the top sheet of a stack of sheets on a tray, to rollers **42** cooperating with the belts of paper transport **44** for advancing the sheets sufficiently to be held by paper transport **44** which, in turn, conveys the sheet to a sheet registration device **45** positioned adjacent to the drum. The sheet registration device arrests and aligns each individual sheet of material and then in timed relation with the movement of the drum advances the sheet material into contact with the drum in registration with a previously formed powder image on the drum.

The transfer of the powder image from the drum surface to the sheets of the support material is effected by means of the corona transfer device **51** that is located at or immediately after the line of contact between the support material and the rotating drum. In operation, the electrostatic field created by the corona transfer device is effective to tack the support material electrostatically to the drum surface, whereby the support material moves synchronously with the drum while in contact therewith. Simultaneously with the tacking action, the electrostatic field is effective to attract the toner particles comprising the powder image from the drum surface and cause them to adhere electrostatically to the surface of the support material.

Immediately subsequent to the image transfer station, there is positioned a stripping apparatus or paper pick-off mechanism **52** for removing the sheets of support material from the drum surface. This device, which is of the type disclosed in Rutkus et al., U.S. Pat. No. 3,062,536, includes a plurality of small diameter orifices supplied with pressurized aeriform fluid by a suitable pulsator or other device. The pulsator is adapted to force jets of pressurized aeriform fluid through the outlet orifices into contact with the surface of the electrophotographic drum slightly in advance of the sheet or support material to strip the leading edge of the sheet from the drum surface and to direct it onto an endless conveyor **55** whereby the sheet material is carried to a fixing device **60**. At the fixing device, the transferred powder image on the sheet of support material is permanently fixed or fused thereto as by heat. After fusing, the reproduction is discharged from the apparatus at a suitable point for collection externally of the apparatus by means of the conveyor **65**. In the embodiment shown the reproductions are discharged from the conveyor **65** into a receiving tray **61**.

The next and final station in the device is a drum cleaning station E, having positioned therein a corona preclean device **66** a drum cleaning device **70** adapted to remove any powder remaining on the drum after transfer by means of a rotating brush **71**, and a discharge lamp LMP–1 adapted to flood the photoresponsive surface with light to cause dissipation of any residual electric charge remaining on said surface.

To remove residual powder from the drum, there is disposed a cylindrical brush **71** rotatably mounted on an axle and driven by a motor, not shown. For collecting powder particles removed from the drum by the brush, there is provided a dust hood **73** that is formed to encompass approximately two-thirds of the brush area. To ensure thorough cleaning of the brush, a flicking bar **74** is secured to the interior of the dust hood adjacent the edge of the outlet duct **75** of the dust hood and in interfering relation with the ends of the brush bristles whereby dust particles may be dislodged therefrom.

For removing dust particles from the brush and dust hood, an exhaust duct **76** is arranged to cover the outlet of the dust hood, the exhaust duct being connected at its other end to the wall of a filter box **77** attached to the duct hood. A filter bag **78** is secured within the filter box, with the mouth of the filter bag in communication with the exhaust duct. A motor fan unit MOT–6 connected to the filter box, produces a flow of air through the filter box drawing air through the area surrounding the drum and the dust hood, the air entraining powder particles removed from the drum by the brush as the air flows through the dust hood. Powder particles are separated from the air as it flows through the filter bag so that only clean air reaches the motor unit.

Suitable drive means are provided to drive the drum, rotating mirror and sheet feed mechanism at predetermined speeds relative to each other, and to effect operation of the bucket-type conveyor and toner dispenser mechanism and the other operating mechanisms.

It is believed that the foregoing description is sufficient for the purposes of this invention to illustrate one mode of operation of electrostatographic reproducing apparatus. For further details concerning the specific

construction, reference is made to R. F. Osborne et al., U.S. Pat. No. 3,301,126, issued Jan. 31, 1967, and J. E. Cranch et al., U.S. Pat. No. 3,303,817, issued Feb. 14, 1967, the pertinent portions of which are incorporated herein by reference.

The Cranch et al. patent describes the bucket-type conveyor in general use in electrophotographic developing apparatus. In this type of apparatus the toner dispenser **35** is situated at the top of the developer housing **32** and is adapted to dispense toner into the lower or sump portion **34** of the housing and often into the rising buckets **41**. This toner does not have an adequate opportunity to mix well with the developer which is necessary to properly charge the toner. The resulting effect is loss of copy quality due to high background and unstable developer concentrations. This need for more efficient mixing is even greater on machines running at high speed having a high copy quality requirement.

Improvement in mixing efficiency is afforded in accordance with the present invention by providing a plurality of apertures **43** in the posterior walls of the developer buckets **41** which permits a partial reverse cascade of developer to exit from the buckets **41** before they are dumped. The size and the location of the apertures depends upon the developer required to remain in the buckets for adequate development. The apertures can assume any geometric configuration such as holes, slits, or the like. Any equivalent means of providing a reverse cascade of developer back into the sump in the area of toner dispensing is considered equally suitable for purposes of this invention. For example, as the buckets proceed up the incline of the endless conveyor belt **53** a small gate situated in the posterior wall of each bucket can be adapted to be forced open to a minor extent by gravitational effects and dispense a predetermined portion of the developer contained therein to provide the desired reverse cascade of developer back into the sump area. The provision of means for effecting a reverse cascade of developer has been found to greatly improve mixing efficiency of toner and carrier. As a result, high background, particularly in solid area development systems where large quantities of toner are employed, has been substantially reduced or eliminated because of the improved mixing achieved in accordance with the present invention.

Referring now to the subject matter of the instant invention, there is shown in FIGS. **2** and **3** a preferred form of developing apparatus constructed in accordance with the present invention.

In order to effect development of the electrostatic latent image on the photoresponsive surface, the developing system shown includes a developer apparatus which coacts with the cylindrical photoresponsive plate or drum to form a development zone wherein the latent image on the drum in developed to form a powder image of the original document.

For this purpose, a developer housing is mounted adjacent to the drum to form the development zone. Mounted within the developer housing is a driven bucket-type conveyor used to carry the developer material previously supplied to the developer housing to the upper portion of the developer housing from where the developer material is cascaded over a hopper chute onto the drum. As the developer material cascades over the drum, toner particles of the developer material adhere electrostatically to the electrostatic latent image areas on the drum, the residual developer material and partially denuded carrier particles falling off the peripheral surface of the drum into the bottom of the developer housing. Toner particles consumed during the development operation to form the visible powder images are replenished by a toner dispenser mounted within the developer housing.

Specifically, the developer assembly or apparatus **30** includes a box-like developer housing having side walls **32** forming in the lower portion thereof a reservoir or sump **34** for developer material. As shown in FIG. **2**, the side walls **32** are formed with a concave edge portion in conformity with the shape of the drum to permit the developer housing to be positioned closely adjacent to the drum. An inclined baffle **47** is secured to the inside faces of the side walls and extends therebetween to prevent dust and air currents from circulating within the housing adjacent to the surface of the drum.

A suitable bucket-type conveyor is used to convey the developer material from the reservoir portion of the developer housing to the upper portion of the developer housing from where it is cascaded over the drum. In the embodiment disclosed, the bucket-type conveyor consists of a plurality of parallel spaced buckets **41** secured as by rivets **49** to an endless conveyor belt **53** wrapped around conveyor drive pulley **57** and conveyor idler pulley **59** secured on drive and idler shafts **62** and **63**, respectively, to rotate therewith. Each of these pulleys consists of side discs, not shown, to which are fastened pins **64** which engage the lugs **15** on the inner surface of belt **53**.

The drive pulley, not shown, is adapted to be driven by a belt connected to a suitable source of power. As the conveyor is operated by means of the pulley, the buckets will pick up a charge of developer material previously placed in the bottom or sump portion of the casing and carry this material upward. As the buckets travel around the upper set of pulleys, the developer material will be discharged onto a guide plate **66** which in turn discharges the developer against a chute **67** adjustably secured to the inside of the outer shell or cover of the casing.

With this arrangement of the guide plate **66** and the chute **67**, developer material discharged onto the guide plate will fall by gravity and pick up speed before it contacts the chute **67** at which time, although the direction of travel of the developer material will be changed, it is directed downward at a steeper angle so that the developer material will pick up considerable speed in sliding or falling down this chute before it is deflected by the radius portion of the chute **67**. With this arrangement the developer material will contact the drum surface at approximately the 12 o'clock position of the drum at a speed slightly in excess of the lineal surface speed of the drum.

As the drum rotates, developing material discharged into contact with the uppermost portion of the drum, as directed thereto by the curved portion of chute **67**, will cascade over the drum and will eventually fall off or be thrown off the surface of the drum at a point which is about 70° removed from the top of the drum. This is because the horizontal momentum acquired by the developer in sliding and rolling against the inclined sur-

face of the drum causes it to be thrown off at a point other than at a point 90° from the top of the drum as might be expected.

To catch the developing material that falls from the drum so that it may be returned to the reservoir in the developer housing, an upper pickoff bar **68** is secured in a position to overlie a lower pickoff bar **69**. Pickoff bar **68** is secured to the side walls of the developer housing while pickoff bar **69** is adjustably secured to the outer shell of the housing directly adjacent the drum. Any developing material not caught and returned to the reservoir of the developer housing by the pickoff bars is caught by a pan **72** held in place by a depending pan support **79** secured to the bottom portion of the outer shell of the developer housing. As a supply of developing material accumulates in this pan, it must be manually removed by an operator and returned to the developer housing.

As the developing mixture is cascaded over the drum, toner particles are pulled away from the carrier and deposited on the drum in image configuration, while the partially denuded carrier particles pass off the drum into the reservoir. As toner powder images are formed, additional toner particles must be supplied to the developing mixture in proportion to the amount of toner deposited on the drum. To supply additional toner particles to the developing mixture, a toner dispenser **35** is used to accurately meter toner to the developer mixture.

Although any one of a number of well-known powder or granulated material dispensers may be used, the toner dispenser shown is of the type disclosed in Hunt U.S. Pat. No. 3,013,703.

The toner dispenser **35** includes a hopper **31**, secured to the outer shell of the housing. A reciprocating plunger, not shown, is provided to actuate the metering element, not shown, of the toner dispenser. Reciprocation of the plunger is effected in a manner similar to the toner drive mechanism disclosed in Lewis et al. U.S. Pat. No. 3,067,720.

The provision of means for providing a reverse cascade of developer has been found to promote mixing efficiency of the developer with newly supplied toner particles. The provision of a plurality of apertures **43** or an aperture such as a gate **46**, as shown respectively in FIGS. **3** and **4** with respect to bucket **41**, allows a portion of the developer in the buckets to exit from the buckets before they are dumped on the electrostatic latent image-bearing surface. The exiting developer falls back upon and mixes with newly added toner being deposited in subadjacent buckets for the toner dispenser. The improved mixing afforded by the reverse cascade effected by the apertures in the buckets of the present invention has been found to reduce high background, particularly in electroded solid area development systems where large quantities of toner are used. In developer systems heretofore available, the toner upon its egress from the toner dispenser did not have an adequate opportunity to mix well with the developer which is necessary in order to properly charge the toner. Consequently, nonuniform and unstable developer concentrations were obtained.

The following examples are for illustrative purposes only and are not to be considered as imposing any limits or restrictions upon the scope of the present invention. Unless otherwise stated, all percentages and parts are by weight.

CONTROL

Employing a conventional electrophotographic reproduction system (Xerox 813), several copies are made in succession without the addition of toner. After about 100 copies, it is readily observed that the copy density is appreciably lower than that of the initial copy. The toner dispenser is then opened and fresh toner is added to the developer mixture. Thereafter, several copies are made in succession. The copies are initially found to be of high background and several cycles, i.e., about 12 cycles, are found necessary before copy quality reaches an acceptable level.

EXAMPLE 1

The procedure employed above to evaluate the mixing efficiency of a conventional electrophotographic reproducing apparatus (Control) is followed using the embodiment of the present invention shown in the drawings. It is observed that after fresh toner is added, copy quality reaches an acceptable level in less than about 6 cycles without the incurrence of initial background deposits.

EXAMPLE 2

Employing the conventional electrophotographic reproduction system of the Control, good quality copy is produced at normal operating speed (copy speed of 1.5 inches per second). When the speed of all components is increased to attain a copy speed of about 2.5 inches per second, copy quality is observed to decrease in a manner characterized by poor mixing of fresh toner with the developer.

When, however, the embodiment of the present invention as shown in the drawings is employed, good copy quality is maintained at the increased operating speed substantially throughout the test period (1,000 cycles).

While the invention has been described with reference to the structures disclosed herein, it is not to be confined to the specific details set forth since modifications or changes may readily become apparent to those skilled in the art and, therefore, this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

What is claimed is:

1. In electrostatographic developing apparatus comprising an imaging surface adapted to receive a latent electrostatic image to be developed; an endless bucket-type conveyor spaced from said drum and adapted to provide a cascade of developer thereupon; a reservoir adapted to receive and contain developer situated below said conveyor and in charging relationship with said buckets; a toner dispenser spaced from and above said conveyor adapted to supply additional toner to compensate for that consumed in the developing operation and a housing containing said developing apparatus, whereby the buckets are continuously charged with developer from the reservoir and cause said developer to cascade across the imaging surface depositing toner thereon in image configuration and

said deposited toner being continually replenished, the improvement which comprises increasing the mixing efficiency of toner and carrier particles by providing at least one aperture in the posterior wall of said buckets thereby causing a partial egress of developer from said aperture prior to said developer cascading across the imaging surface whereby developer falls back upon subadjacent buckets and mixes with toner released from said toner dispenser.

2. Apparatus as defined in claim 1 wherein a gate is provided in the posterior wall of said buckets to enable the partial egress of developer from said buckets.

3. Apparatus as defined in claim 1 wherein a plurality of apertures is provided in the posterior wall of said buckets to enable the partial egress of developer from said buckets.

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