United States Patent

[11] 3,542,466

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[54] **DEVELOPMENT APPARATUS**
5 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **355/3;** 118/637
[51] **Int. Cl.** **G03g 15/08**
[50] **Field of Search** ..... 355/3, 14, 17; 118/637; 117/17.5 (Consulted)

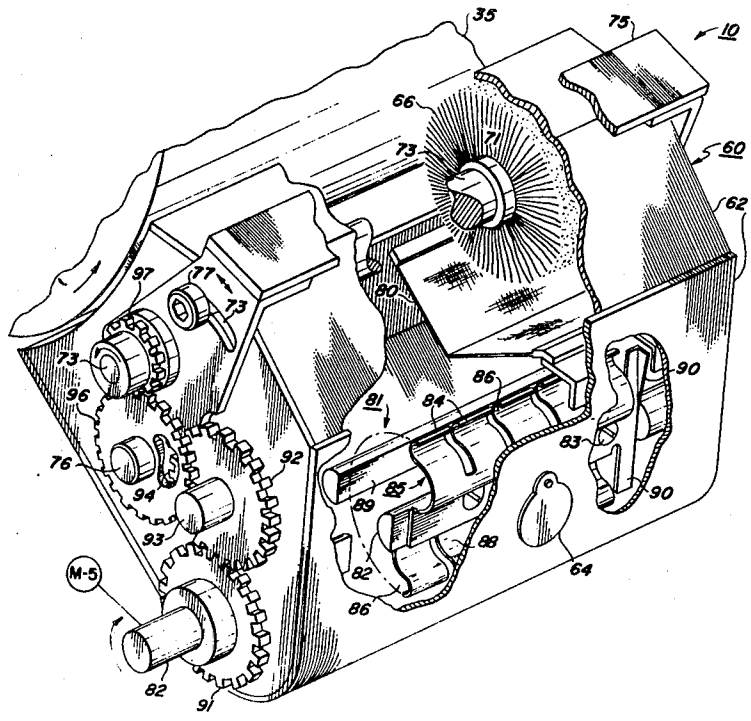
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ABSTRACT: Apparatus for the development of an electrostatic latent image which includes a housing having a sump area for containing a supply of electroscopic toner powder and a brush member for receiving the electroscopic toner powder charged to a polarity opposite that of an electrostatic latent image to be developed and delivering the electroscopic marking particles into contact with the surface of the electrostatic latent image. To affect the loading of the brush member, the electroscopic toner particles are scooped from the sump area and propelled in the direction of the brush member by a rotating plate member having finger elements which finger elements have a cup portion arranged at their extremity for scooping out a predetermined amount of toner powder from the sump portion of the housing. Each of the finger elements is formed with an arcuate shape from a resilient material in contact with interference member in the path of the fingers causing the fingers to flex and then return to an original position thereby propelling the toner powder toward the brush member. To affect proper charging of the toner particles, a screen member is positioned intermediate the brush member and the finger elements and is made out of a material characterized by an electrostatic property removed in triboelectric series from the toner particles thereby causing the particles to be properly charged when passed through the screen and before being received onto the brush member.



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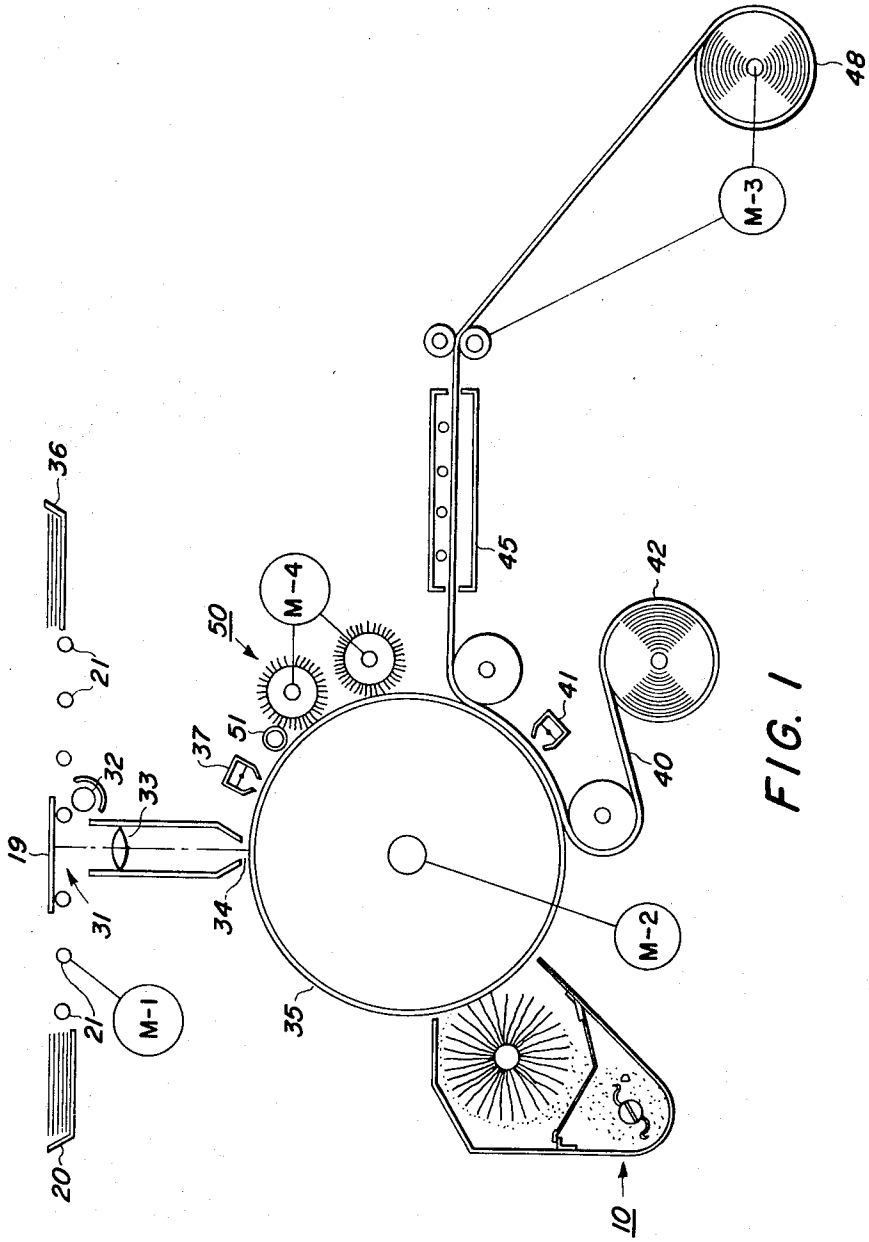


FIG. 1

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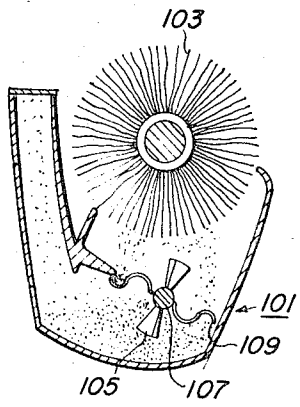


FIG. 3

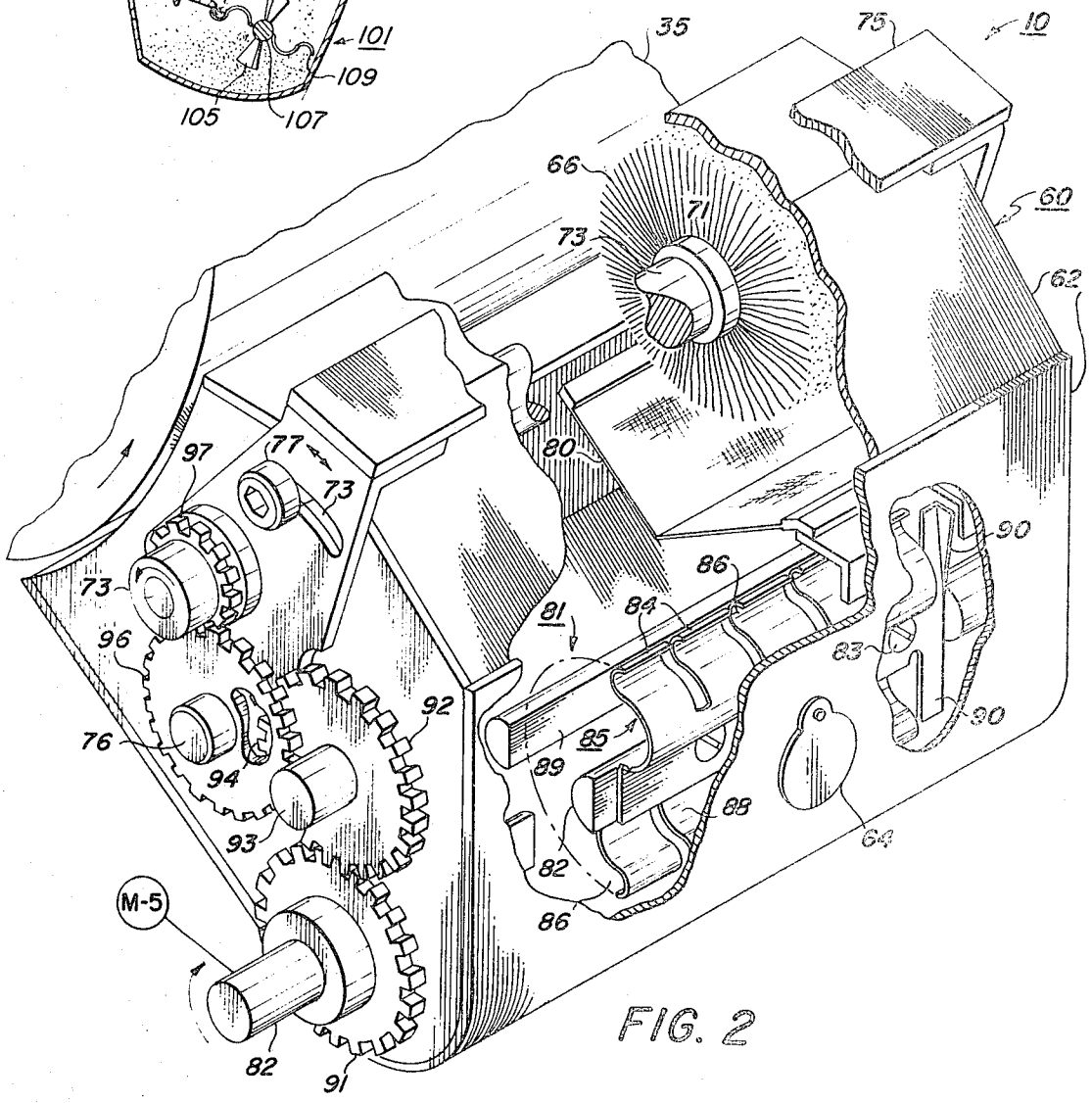


FIG. 2

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DEVELOPMENT APPARATUS

This invention relates in general to electrostatic copying and in particular to apparatus for developing electrostatic latent images.

In one form of electrostatic printing, referred to as xerography and described in U.S. Pat. No. 2,297,691 to Chester F. Carlson, a xerographic surface comprising a layer of photoconductive insulating material affixed to a conductive backing is used to support electrostatic images. Usually the xerographic plate is electrostatically charged uniformly over its surface and then exposed to a light pattern of document information to be reproduced to discharge the charge in the areas where light strikes the layer. The undischarged areas of the layer thus form an electrostatic latent image in conformity with the light pattern. The electrostatic latent image is developed by contacting it with a finely divided electrostatically attractable material such as an electroscopic resinous powder which is held in image areas by the electrostatic charges on the layer. The powder image is subsequently transferred to a sheet of paper or other support surface to which it is affixed to form a permanent print.

One of the more common methods of presenting developing material to the image is by cascading a two-component developer made up of electroscopic marking particles referred to as "toner" and coarse granular material called "carrier" over the image. The carrier is removed from the toner in the triboelectric series so that a triboelectric charge is generated between the toner and the carrier. Such charge causes the toner to adhere to the carrier which also provides mechanical control of the toner so that the toner can be readily handled and brought into contact with the image to be developed. The toner is then attracted to the electrostatic latent image to produce a visible powder image. One drawback of the two-component developer used in cascade-type development is that the bouncing action of the carrier granular material has an adverse effect on certain photoconductive layers. Also cascade-type development requires a great deal of physical space relative to the photoconductor surface and for these as well as other reasons has imposed certain limitations on the development of electrostatic latent images.

As an alternative there is brush development in which a brush in the form of a cylinder or the like frictionally electrifies toner particles which it contacts and presents the particles to the electrostatic latent image as described, for example, in U. S. Pat. No. 3,251,706. In brush development it is common to use brushes which are made from synthetic or vegetable fibers or animal fur. The developing material usually consists of the carrier and toner mentioned above or toner used alone. Also the brush fibers can be magnetic carrier granules formed into a brushlike formation through the use of a magnetic field as described, for example, in U.S. Pat. Nos. 2,832,311 and 2,874,063.

Although brush development has proved commercially successful, it has been noted that under certain atmospheric conditions, there has been a tendency to produce undesirable development characteristics. More specifically, at low relative humidities, images are developed at a decreased density and at high relative humidities toner is deposited in the background or nonimage areas. While it is not completely understood, it is believed that at low relative humidity conditions the brush frictionally contacting toner develops a net bias potential to suppress the image charges to limit the attraction of toner to the image. On the other hand with increasing relative humidity less charge is imparted triboelectrically by the brush to the toner thereby increasing background deposition due to loosely adhering toner being easily attracted to the image background.

Another problem with brush development has been the dispensing of toner onto the brush which is increasingly difficult to control under extreme conditions in humidity. Normally the brush, which is comparatively long and requires toner to be added along its full length, is moved through a batch of toner held in a container. As a result, the brush forms channels or scooped out areas in the toner.

Attempts to overcome the above-noted disadvantages have come in air-conditioning which is unduly burdensome and expensive or by electrically biasing the brush which has not proven entirely successful.

In accordance with the present invention the development of electrostatic latent images by brush action is greatly enhanced notwithstanding varying relative humidities enabling higher quality prints to be produced. Furthermore, due to the unique manner in which the toner particles are dispensed onto the brush, no channels or scooped out areas are formed in the toner sump.

It is therefore an object of the invention to improve the development of electrostatic latent images.

It is another object of the invention to minimize background in the development of images notwithstanding the fact that development is effected in an atmosphere of variable relative humidity.

It is another object of the invention to increase the density of developed images without any corresponding increase in background.

It is a further object of the invention to enhance the overall quality of prints attainable by brush developing techniques.

It is still a further object of the invention to dispense toner onto a brush to be used for developing images more simply than heretofore.

These and other objects of the invention are obtained, generally speaking, by imparting an electrostatic charge to the toner particles before they are received onto the developing brush and by loading them uniformly thereby insuring optimumly charged toner for development irrespective of relative humidity conditions.

For a better understanding of the invention as well as other objects and further features thereof, reference is had to the following detailed description of the invention to be read in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic illustration of xerographic reproduction apparatus utilizing developing apparatus according to the invention;

FIG. 2 is an isometric view of a brush developing assembly according to the present invention with its housing partially broken away to better illustrate its parts; and

FIG. 3 is a diagrammatic view of an alternative embodiment of apparatus according to the present invention.

Referring now to FIG. 1 there is shown a xerographic copying system adapted for continuous and automatic operation employing a brush development assembly generally designated **10** constructed in accordance with the present invention. As in all xerographic systems based on the concept disclosed in the above-cited Carlson patent, a light or radiation image of a document to be reproduced is projected on the sensitized surface of a xerographic plate to form an electrostatic latent image which is developed with an oppositely charged developing material. The material in image configuration is then transferred to a support surface to which it is permanently affixed.

As illustrated a document **19** to be reproduced is fed from a support tray **20** over a conveyor made up of guide rollers **21** driven by motor M-1 for movement past an exposure station **31**. During exposure illumination from a lamp **32** is reflected from the face of the document through an objective lens **33** and an exposure slit **34** onto the surface of a xerographic plate **35** in the form of a drum. Thereafter, document **19** is transported to an output tray **36**.

Xerographic drum **35** comprises a cylindrical member mounted in suitable bearings in a frame and driven in a counterclockwise direction by a motor M-2 at a constant rate such that the peripheral rate of the drum surface is identical to the rate of movement of the light image. The drum surface comprises a layer of photoconductive material, such as vitreous selenium, on a conductive backing.

Prior to exposure the drum surface is uniformly sensitized by means of a corona generating device **37** that is energized from a suitable high potential source. During exposure the light or radiation image discharges the photoconductive layer

in the areas struck by light leaving on the drum an electrostatic latent image corresponding to document **19**.

In accordance with the present invention, as the drum surface continues its movement, the electrostatic latent image passes development assembly **10** at which toner particles or powder electrostatically charged opposite in polarity to the latent image are presented to the drum surface as will be explained more fully hereinafter.

After development the powder image passes through an image transfer station at which the powder image is electrostatically transferred to a support surface web **40** by means of a second corona generating device **41** similar to corona generating device **37** mentioned above.

The support surface to which the powder image is transferred may be of any convenient type and is obtained from a supply roll **42** and is fed over suitable guide and tensioning rolls and directed into surface contact with the drum. After transfer the support surface is separated from the drum surface and guided through a suitable fusing apparatus **45** which may be of a type disclosed in U.S. Pat. No. 2,852,651. In this manner, the powder image is permanently affixed to its support surface which is fed over a system of guide and tensioning rolls and onto a takeup roll **48** that is driven by motor M-3.

After transfer the xerographic drum surface is brushed by a cleaning brush assembly **50** rotated by a motor M-4 to remove any residual developing material remaining on the drum surface. Also the drum surface is illuminated by a lamp **51** to remove any electrostatic charge that may remain thereon. The drum is now ready to receive charge from corona generating device **37** and undergo another reproduction cycle similar to that just described.

Referring now to FIG. **2** there is shown in greater detail brush development assembly **10** which presents optimumly charged toner to the electrostatic latent image according to the present invention to achieve high quality development. Brush development assembly **10** comprises a housing **60** formed by contiguous walls **62** which form an enclosure except for an opening adjacent to xerographic drum **35** where development of the electrostatic latent image is effected. The lower or sump portion of housing **60** is filled with developer material **63** which is in the form of toner marking particles. Any suitable electroscopic toner composition may be used. Typical compositions for these toners are described in U.S. Pat. Nos. 2,618,551 tto Walkup, 2,618,552 to Wise, 2,638,416 to Walkup and Wise, 2,788,288 to Rheinfrank, 2,753,308 to Landrigan, 2,891,011 and 3,079,342 to Insalaco and Re 25,135 to Carlson. The size and color of the toner particles depend upon the purpose intended as for example the size of xerographic toner in U.S. Pat. No. **3,079,342** is about 1 to about 30 microns. Usually these toners consist of an electroscopic resin and a colorant such as any suitable organic or inorganic pigment or dye. As toner is consumed by the development of the electrostatic latent images, it is replenished in any suitable manner as through a plate or cap **64** movably mounted on housing **60**.

In the upper portion of the housing is a brush member **66** which is continuously rotated and receives charged toner particles at a polarity opposite to that of the latent image in a manner to be described. The charged toner carried by brush member **66** is electrostatically deposited to the electrostatic latent image on the surface of drum **35** due to a greater attraction between the latent image normally charged positive and the toner particles which are charged negatively as will become more apparent. Brush member **66** is rotatable in a counterclockwise direction or direction opposite to that of xerographic drum **35** to effect a gentle wiping action on the surface of the drum. Any suitable speed of rotation can be used for brush member **66**. Typical surface speeds range from about one to about three times that of drum **35**. It should be understood that the drum and brush member can rotate in the same as well as opposite directions as illustrated and that they can run at the same or at relative speeds.

Any suitable material can be used for brush member **66** but certain materials have clearer preferences over others. For example, brush fibers should be soft and flexible so that while supported at one end, they can be brushed against the image without undue abrasion. Thus either easy flexibility or softness is essential and both are desirable. Another characteristic of the brush material is that it have the correct triboelectrical relationship with the toner. It should be noted, however, that the toner is primarily charged prior to its being received onto the brush member as will become more apparent. Other properties of the brush member are absence of film forming or scum forming ingredients and particularly electrically conductive ingredients, suitable durability, chemical and economical availability. In view of the balance of the many desirable properties and characteristics several animal furs and synthetic brush materials have proven satisfactory. Typical materials are New Zealand rabbit, domestic rabbit, Russian fox, Camel hair, **E**-180 alpaca, **CF**740 nylon acryla, **CF**622 Dynel (a synthetic fiber of 40 percent acrylonitrile and 60 percent vinyl chloride) and any combination of them.

Brush member **66** is secured as by an adhesive to a rotatable cylinder **71** which is in turn secured to a shaft **73** that is journaled in a yoke **75**. Yoke **75** is pivotally mounted on housing **60** on a pair of studs **76**, one of which is shown, to enable movement of the brush member **66** toward and away from the surface of the xerographic drum **35**. To fix the yoke and hence the brush member in relation to the drum a bolt member **77** received through an arcuate slot **78** formed in the sides of the yoke is threadingly received in side walls **62** of housing **60**. In this manner the desired degree of contact between the bristles of the brush member and the drum can be achieved.

In accordance with the invention toner from the sump portion of housing **60** is dispensed onto brush member **66** and is simultaneously charged optimumly to effect high quality development. To accomplish this, the toner is thrown or propelled through an apertured network or screen **80** to form a cloud adjacent to brush member **66**. Apertured network **80** is formed with openings large enough so that toner particles can readily pass through and is preferably made from a material having triboelectric characteristics such that proper charging can be effected. Any suitable material may be used for screen **80** such as silk and coated or uncoated carrier materials. Typical carrier materials include methyl methacrylate, glass, iron, steel, ferrite, nickel, and mixtures thereof. Many of the foregoing and other typical carriers are described by U.S. Pat. No. 2,618,551 to Walkup, U.S. Pat. No. 2,638,416 to Walkup et al., and U.S. Pat. No. 2,618,552 to Wise.

To propel the toner upwardly with sufficient force to reach brush member **66**, there is provided a flicker assembly **81**. Flicker assembly **81** comprises a rotatable shaft **82** to which is secured by screws **83** an array of finger elements **84** formed in a plate member **85**. Arranged on the ends of finger elements **84** are cuplike recesses **86** to facilitate the scooping of toner as shaft **82** is rotated through the sump portion of housing **60**. In the path of finger elements **84** there is positioned a flicker rod **87** which contacts cuplike recesses **86** causing the finger elements to flex and spring upwardly with great force thus propelling the toner through screen **80** and onto brush member **66**. It should be noted that each finger element is formed with an arcuate portion **88** extending from the midsection outwardly toward cuplike recess **86**. Arcuate portion **88** enables each finger element to be displaced from its normal path of rotation by flicker rod **87** without excessive strain or stress being imparted to the finger element. Flicker rod **87** is formed with a flat surface portion **89** which serves to strike finger elements **85** and is journaled for rotation in housing **60** to vary the surface contacted by the finger elements to achieve the desired striking force.

It should be noted that plate member **85** terminates in vane elements **90** which upon rotation serve as augers and caUse the toner material to be moved inwardly toward the center of the housing to insure that the toner material is continuously and uniformly available to cuplike recesses **86** of flicker as-

sembly **81**. Plate member **85** may be formed of any suitable material. Typical materials are metal foil and plastic with thicknesses ranging from .002 inches to about .015 inches.

Flicker assembly **81** and brush member **66** are driven in any suitable manner as from a motor M-**5** drivingly connected to shaft **82**. Shaft **82** rotates finger elements **84** and carries a gear **91** which meshes with an idler gear **93**. Idler gear **92** journaled on stud **93** meshes with gear **94** which is arranged integral with another gear **96** on stud **76**. Gear **96** drives gear **97** which is secured to shaft **73** thereby causing brush member **66** to rotate. Any combination of gear ratios to obtain a desired rate of speed for the flicker assembly and the brush member can be selected to affect proper proper toning of the brush. It has been found that brush rotation rates ranging from about **1** to about **10** times the speed of rotation of the flicker assembly perform well. A preferred ratio rate is about **3** to **5** at which prints of very high quality are produced.

In FIG. **3** there is shown an alternate embodiment of the invention in which charging of the toner is accomplished in the sump of the housing. The flicker assembly **101** for loading toner onto brush member **103** is similar to that illustrated in the embodiment of FIG. **2**. It is to be noted, however, that in place of a screen, toner triboelectrification is by vigorous rubbing of the toner by vane elements **105** which are secured to the same shaft **107** which drives flicker elements **109**. Vane elements **105** are similar in shape to vane elements **90** above, but are made from a carrier type material, such as those previously mentioned. In this manner, the toner is properly charged prior to being loaded onto the member. It should be understood, however, that the apertured network or screen shown in FIG. **2** can be used in addition to the charge imparted in the sump area if desired.

By the present invention there is provided a brush development apparatus capable of developing high quality images irrespective of ambient conditions. Heretofore brush development has not been altogether satisfactory because of its general unreliability in developing electrostatic images with a consistency of quality. The reason for this lack of reliability has been found to have a relationship with ambient humidity conditions. More specifically, developed images of decreasing density resulted with extremely low relative humidities. On the other hand at high relative humidities developer is deposited in the background or nonimage areas. It is believed that this is due to a breakdown in the triboelectrification between the brush and toner particles permitting toner weakly retained on the brush to be easily attracted from it to the relatively stronger field in the background or nonimage areas. With the present invention, the toner particles are charged prior to being loaded onto the fur brush which is rotated in a path past what is in effect a cloud of charged particles so as to achieve the proper triboelectrification necessary notwithstanding a variable relative humidity. Thus, the toner particles are precharged and do not necessarily require triboelectrification by frictional action of the brush bristles on the toner. Also, the toner particles are not overcharged because they are deposited onto the brush bristles when formed in a cloud rather than by immersing the brush into a toner sump as was previously the case.

Although the above description has particularly emphasized the use of development when producing positive copy from positive originals, it should be understood that the principles of the invention apply as well to reversal or negative development.

While the present invention as to its objects and advantages has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby; but it is intended to cover the invention broadly within the scope of the appended claims.

We claim:

1. Apparatus for developing latent electrostatic images comprising:

a housing havlng an opening formed therein;

brush means positioned in said housing adjacent said opening and adapted for rotation;

a supply of electroscopic toner powder contained in a sump portion of said housing;

an actuator disposed in the sump portion of said housing comprising a rotatable plate member having finger elements formed therein, each of said finger elements having a cupped portion arranged at its extremity for scooping out a predetermined amount of toner powder from the sump portion of the housing, each of said finger elements being formed with an arcuate shape and from resilient material to propel toner powder toward said brush means; and

an apertured member positioned intermediate said brush means and said supply of toner powder characterized by an electrostatic property removed in triboelectric series from said toner powder for causing said toner powder to be electrostatically charged prior to being received onto said brush means whereby upon said brush means contacting a latent electrostatic image, said charged toner powder is attracted thereto.

2. Apparatus according to claim **1** wherein an interference member is positioned in the path of said finger elements adjacent the outer extremity thereof thereby causing said finger elements to flex and then return to original form.

3. Apparatus according to claim **1** wherein said plate member is arranged with vane elements for causing continuous flow of toner powder across the sump portion of said housing.

4. Apparatus according to claim **1** including means for rotating said brush means and said plate member such that the rate of said brush means ranges from about one to about ten times that of said plate member.

5. An electrostatic copying machine of the type wherein a photoconductive member sensitive to electromagnetic radiation is moved in a predetermined path along which processing stations are disposed, the combination comprising:

a charging station for providing a substantially uniform electrostatic charge upon the surface of said photoconductive member;

an exposure station for exposing the charged surface to an electromagnetic radiation image to form a electrostatic latent image thereon;

a development station for developing the latent image said developing station comprising;

a housing having an opening formed therein adjacent to the path of said photoconductive member,

brush means positioned in said housing adjacent said opening to contact the surface of said photoconductive member,

a supply of electroscopic toner particles contained in a sump portion of said housing,

an actuator disposed in the sump portion of said housing comprising a rotatable plate member having finger elements formed therein, each of said finger elements having a cupped portion arranged at its extremity for scooping out a predetermined amount of toner particles from the sump portion of the housing, each of said finger elements being formed with an arcuate shape and from resilient material to propel toner powder toward said brush means; and

an apertured member positioned intermediate said brush means and said supply of toner powder characterized by an electrostatic property removed in triboelectric series from said toner powder for causing said toner powder to be electrostatically charged prior to being received onto said brush means.