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[54] XEROGRAPHIC DEVELOPMENT APPARATUS
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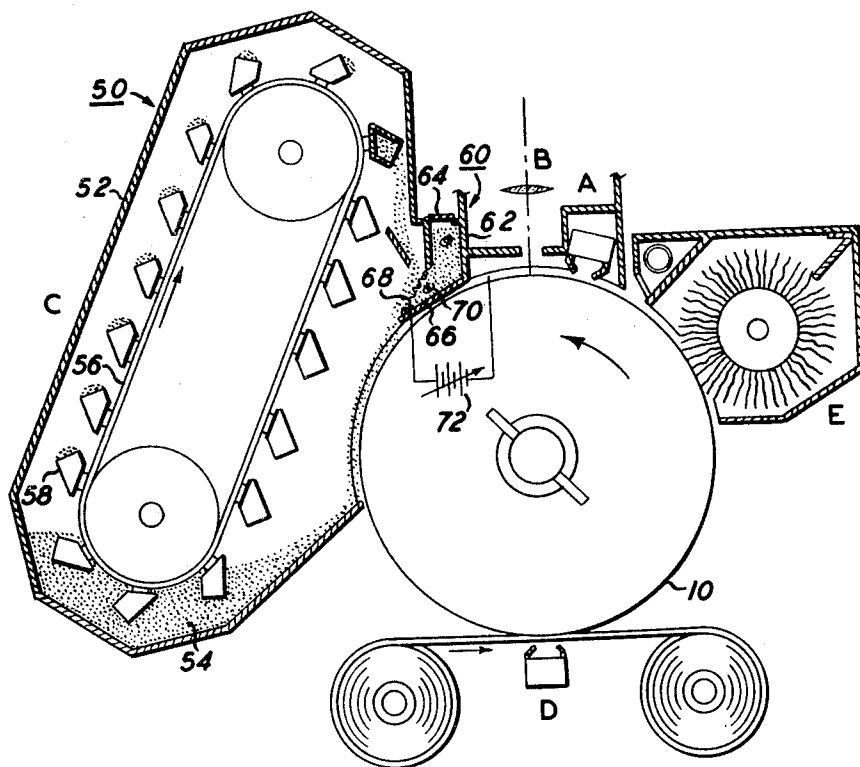
[50] **Field of Search**..... 117/17.5;
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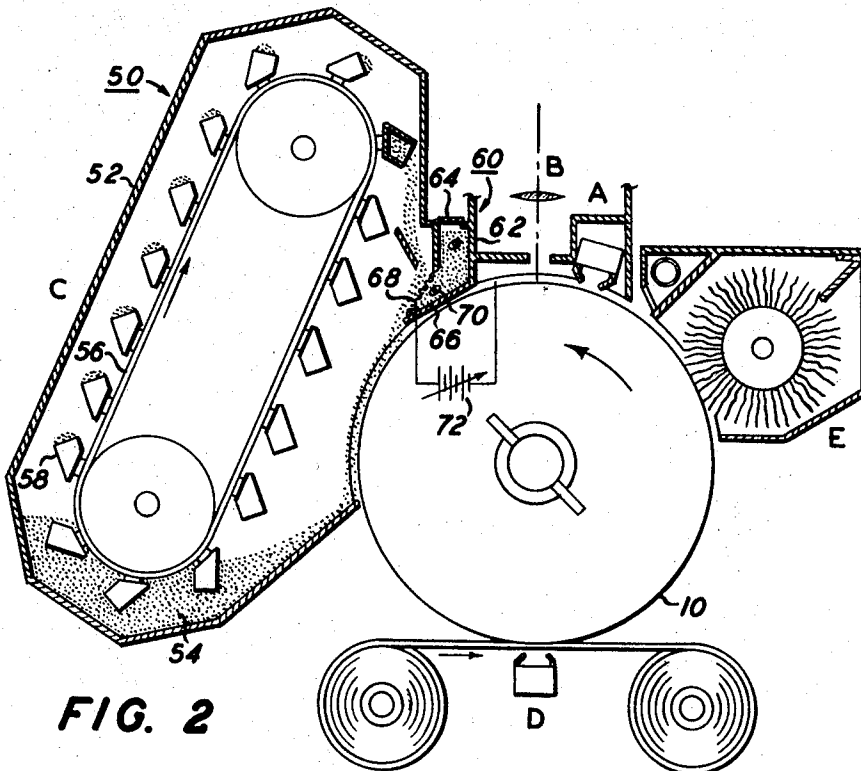
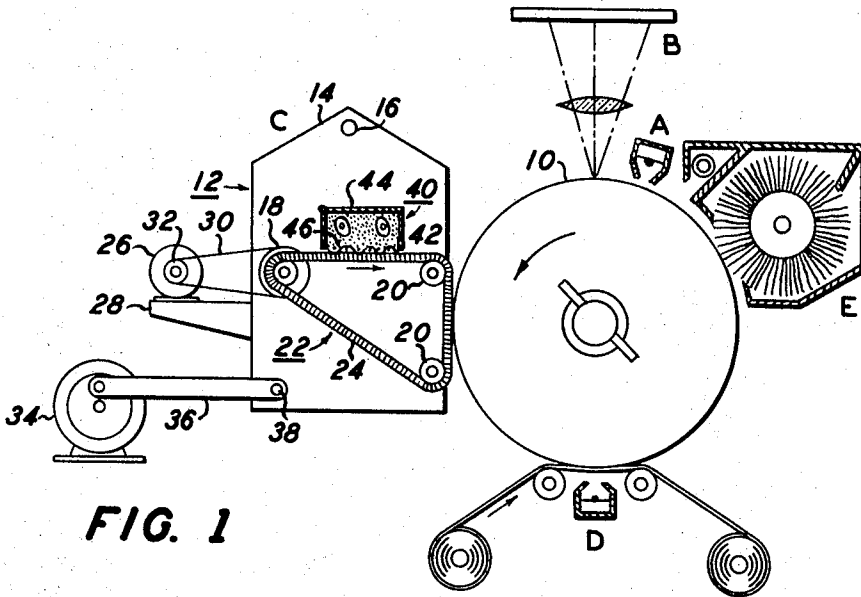
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ABSTRACT: Apparatus for dispensing toner into a two-component development system at a self-regulating rate in accordance with the electrostatic property of the carrier. A screen with triboelectric properties similar to the carrier is positioned in contact with a quantity of charged toner powder causing the toner to become attracted to the screen. Carrier moved across the face of the screen remote from the quantity of toner will attract toner from the screen until the carrier becomes optimally toned. At such time the electrostatic attraction between the screen and toner equals the electrostatic attraction between the carrier and toner so that the carrier can attract no more toner from the screen.





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XEROGRAPHIC DEVELOPMENT APPARATUS

This invention relates in general to the dispensing of toner powder into a xerographic development system which employs a two-component developer mixture, and in particular, relates to apparatus for electrostatically dispensing toner particles to a carrier in a self-regulating fashion.

In the practice of xerography as 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. In the usual method of carrying out the process, the xerographic plate is electrostatically charged uniformly over its surface and then exposed to a light pattern of the image being reproduced to thereby discharge the charge in the areas where light strikes the layer. The undischarged areas of the layer thus form an electrostatic charge pattern in conformity with the configuration of the original light pattern.

The latent electrostatic image can then be developed by contacting it with a finely divided electrostatically attractable material such as a resinous powder. The powder is held in image areas by the electrostatic charges on the layer. Where the charge is greatest, the greatest amount of material is deposited; and where the charge is least, little or no material is deposited. Thus, a powder image is produced in conformity with the light image of the copy being reproduced. The powder is subsequently transferred to a sheet of paper or other surface and suitably affixed to thereby form a permanent print.

The electrostatically attractable developing material commonly used in xerography consists of a pigmented resinous powder referred to here as "toner" and a second material called "carrier". The carrier can take the form of granular beads formed with glass, sand or steel cores coated with a material removed in the triboelectric series from the toner so that a triboelectric charge is generated between the toner powder and the granular carrier. Such charge causes the toner to adhere to the carrier. The carrier also provides mechanical control so that the toner can be readily handled and brought into contact with the exposed xerographic surface. The toner is then attracted to the electrostatic image to produce a visible powder image on the xerographic surface.

The carrier can also take the form of brush-like fibers having properties and functions similar to the granular carrier particles. Such a brush-type carrier is described for example in U.S. Pat. No. 3,251,706. The brush could also be formed of fibers formed of magnetic carrier granules formed into a brush-like formation through the use of a magnetic field as described for example in U.S. Pat. No. 2,832,311 or 2,874,063.

Regardless of the type of carrier employed, toner particles which are mixed with carrier adhere to and coat the surface of the carrier due to the electrostatic attraction between them. This two-component mixture of carrier and toner constitutes the developer mixture. During development the toner-coated carrier moves across the xerographic surface at which time toner particles are electrostatically pulled away from the carrier by the charged areas of the surface and are selectively deposited thereon to form a visible powder image. The partially denuded carrier then moves beyond the xerographic surface. As toner images are formed, additional toner powder must be supplied to the carrier in proportion to the amount of toner deposited on the xerographic surface.

If developed copy, made by the xerographic process, has heavy deposits of toner in image areas accompanied by partial toner deposits in the non-image background areas, the toner concentration in the developer mixture is too great. If the copy has less than adequate toner deposits in the image areas, the quantity of toner powder in the developer mixture is insufficient. Thus, in order to continually obtain prints of good quality, the quantity of toner powder in the developer mixture must be held constantly optimum by the addition of toner to the carrier in proportion to the amount of toner deposited on the xerographic surface.

In the past, efforts have been made to control the amount of toner dispensed to the developer mixture by various methods and means. An initial attempt to control the toner concentration involved the visual observation of copies produced by a xerographic system. When the copies became too light in image areas, thus indicating a low toner concentration, additional toner would be added by manually energizing a gravity feed of toner to the system from a toner dispenser. More sophisticated approaches to the problem involved the adding of additional toner automatically in response to the density of the developer mixture before being moved into contact with the image to be developed or automatic toner dispensing in response to copy density. Note U.S. Pat. No. 3,094,049.

While such systems are somewhat satisfactory, they have certain obvious shortcomings. For example, when toner is added to the developer it is generally added equally across the length of the development zone. If, however, the image being reproduced has large dark sections in one area, as the middle, then the central portions of the developer mixture would be reduced to a lesser toner concentration than the side portions. The addition of toner to the developer evenly across the length of the development zone would not rectify this imbalance. Furthermore, systems of the known type which are somewhat self-regulating generally need time to react to a sudden depletion of toner caused by the development of large dense image areas. Hence, this time delay might cause sporadic density of development. This problem can be aggravated in some types of time regulated toner dispensers. While these problems are not overly critical today it appears that they will become magnified in the future due to increasing speeds and the advent of improved solid area capabilities.

The present invention contemplates the dispensing of additional toner to a two-component development system in a self-regulating fashion in response to, and in proportion to, the electrostatic property of the developer prior to its movement into contact with the latent electrostatic image to be developed.

It is, therefore, an object of the present invention to maintain an optimum toner concentration in two-component xerographic development systems.

It is another object of the present invention to dispense toner to a two-component development system in accordance with the amount of toner given up by the system through the development of latent electrostatic images.

Another object of the invention is to electrostatically control toner concentration across the length of xerographic development zones.

It is a further object of the present invention to electrostatically add toner to carrier in response to the needs of the carrier.

These and other objects of the invention are obtained by moving carrier across an apertured network which is adapted to electrostatically hold charged toner particles thereon. Due to the electrostatic properties of the various materials, the undertoned carrier will electrostatically attract the toner from the network until the electrostatic attraction between the carrier and toner equals the electrostatic attraction between the network and toner. This system can be regulated to insure optimally toned carrier within a xerographic development system.

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 diagrammatic sectional view illustrating self-regulating toner dispensing apparatus constructed in accordance with the principles of the instant invention as applied to a machine adapted for continuous and automatic operation.

FIG. 2 is a diagrammatic sectional view illustrating a second embodiment of a self-regulating toner dispenser also constructed in accordance with the principles of the instant invention as applied to a machine adapted for continuous and automatic operation.

The principle upon which the instant invention is based is that a carrier granule exhibits an attractive electrostatic force on a toner particle due to their relative locations on the triboelectric scale. As carrier attracts toner to its surface, its electrostatic attraction for additional toner decreases in proportion to the amount of toner already being held on its surface. Once the carrier can electrostatically accept no more toner, it is said to be saturated. This saturation level is greater than the optimum toner concentration level desired in two-component development systems. It has been found, however, that by providing a supplemental electrostatic force of like polarity to the carrier granule and against which the carrier granule must act in order to attract additional toner particles, the saturation concentration of toner on a carrier can be reduced. By employing a proper competing electrostatic force, the saturation level of the carrier may be decreased to the point which produces optimum toner concentrations for xerographic development. A competing or supplemental force which can be regulated will consequently permit selective control and regulation of the toner concentration.

To practice the instant invention, there is required an apertured network with electorstatic properties similar to the carrier. When charged toner powder is located in contact with one face of the network, the powder is electrostatically attracted and held to the network. Then, when untuned carrier is moved across the other face of the network, the carrier electrostatically attracts the toner from the network. This is because the electrostatic force between the toner particles and the network is less than the electrostatic force between the toner on the network and the untuned carrier. As the carrier attracts additional toner, its electrostatic force attracting the toner particles from the network decreases until the force of the network for the toner is equal to the elctrostatic force of the carrier for the toner. At this time the carrier is optimuimly toned for developing and cannot accept additional toner. The carrier may then be moved into contact with the latent electrostatic image for development.

Shown in the FIGS. are two xerographic machines employing toner dispensers adapted to carry out the method of the instant invention. The elements of these machines, which are constructed for continuous and automatic operation, are all conventional in the xerographic arts except for the novel toner dispensers. For the purpose of the present disclosure, the several xerographic processings stations in the path of movement of the xerographic surface for each machine may be briefly described as follows:

A charging station A, at which a uniform electrostatic charge is deposited on the photoconductive layer of the xerographic drum;

An exposure station B, at which the light or radiation pattern of copy to be reproduced is projected onto the drum surface to dissipate the drum charge in the exposed areas thereof to thereby leave a letent electrostatic image of the copy to be reproduced;

A developing station C at which a xerographic developing material, including toner particles having an electrostatic charge opposite to that of the electrostatic latent image, are moved into contact with the drum surface, whereby the toner particles adhere to the electrostatic latent image to form a xerographic powdered image in the configuration of the copy being reproduced;

A transfer station D, at which the xerographic powder image is electrostatically transferred from the drum surface to a transfer material or a support surface; and

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

As noted above, these machines are conventional in the xerographic arts except for the toner dispensers which form the basis of the instant invention.

The development station C of the first embodiment is constructed to accommodate fur brush development as more fully described, for example, in U.S. Pat. No. 3,251,706. Mounted adjacent one peripheral segment of the xerographic drum is the development assembly 12. These elements are entirely mounted on a support plate 14 which is pivotally supported on a pivot pin 16, whereby the entire development assembly may be oscillated against and away from this surface of the zero-graphic drum which supports the latent electrostatic images to be developed. Mounted on the support plate is a drive roller 18 and a plurality of guide rollers 20 around which is passed a developing belt 22. The rollers and developing belt extend for a length at least equal to the length of the xerographic drum to permit the belt to come into developing contact with the entire surface of the drum.

The outer surface of the developing belt is brush-like in characteristics and has a multitude of elongated carrier members 24 such as cloth or brush fibers extending outwardly from the surface of the belt. In general, this member may be a brush-like surface of fur or the like, cloth such as knitted, woven, or tufted pile fabric or any other support surface bearing a multiplicity of elongated carrier members on its surface. Any such similar surface is equally suitable so long as it has the required triboelectric properties.

At least one of the rollers, such as roller 18, is desirably power driven as illustrated by the motor 26 mounted on the support base 28 and adapted to drive roller 18 through belt 30 operating on pulley 32.

A motor driven roller 34, operating the shaft 36 which is connected to support plate 14 by pin 38, is constructed and adapted to oscillate the support plate 14 and thereby the entire developing assembly 12, through the drive action of the motor driven roller 34 which imparts an oscillating motion to the shaft. In this manner the developing web is moved into and out of contact with the surface of the xerographic drum, with a stippling type of powder application which has been found to develop images in the best manner.

Also mounted on the support plate is a dispensing hopper or reservoir 40 containing a supply of conventional toner powder and a small quantity of conventional carrier granules. The dispenser is formed with upstanding side walls 42, and a lid type covering 44, through which additional developer may be added to the hopper. The lower face of the hopper is formed with an apertured member formed as screen 46 of such mesh that the toner particles can freely pass therethrough but such that the carrier granules within the hopper are too large to pass through the apertures. The screen is preferably fabricated of a material removed in the triboelectric series from the toner so that upon mutual agitation therebetween the toner particles will become electrostatically held to the screen. In conventional positive xerography, a silk screen has been found to work satisfactorily.

As the developer belt is continually moving towards the xerographic drum for development thereof, the fibers thereof are continually brushing against the surface of the screen for electrostatically attracting toner powder which is being electrostatically held on the screen. The agitation of the developer within the hopper creates the necessary charge on the toner. This action may be supplemented by the use of rotating augers 48 within the hopper. Since the fibers of the brush are not fully toned at this stage of operation, the electrostatic attraction for the toner is greater than that exhibited by the screen. This permits the fibers to attract supplemental toner thereto up until the point when the electrostatic attraction of the screen equals the electrostatic attraction of the fibers. At this time the fibers are optimuimly toned for movement to the surface of the drum for development of images thereon.

In practice, individual fibers of the belt 22 occasionally project through the apertures of the screen 46 as it is brushed past the screen. Toning of the projected fibers occurs, in this instance, as the fibers are retracted from the apertures. It is considered that this feature is beneficial since it would tend to free the apertures in the event that clogging of the screen occurred.

The use of a striking plate in the brush embodiment, which was required in former devices as described in the aforementioned U.S. Pat. No. 3,251,706, is eliminated by the instant invention. Such a striking plate was required to agitate the toned carrier fibers to thereby increase the mutual interaction between the toner and brush-type carrier. This was needed to effectuate triboelectrification of the two materials sufficient to carry out good development. According to the instant invention, however, the agitation of the fur brush bristles against the screen effectuates all the charging that is required.

The second embodiment of the instant invention shows development apparatus 50 capable of developing latent electrostatic images through the cascade techniques. Positioned within the housing 52 for the development apparatus there is a lower or sump portion 54 for accumulating two-component developer material. Mounted within the developer housing is also a driven bucket-type conveyor 56 with buckets 58 used to carry the developer material previously supplied to the developer housing to the upper portion of the developer housing from where it is cascaded over a portion of the drum 10.

As the developer material cascades over the drum, toner particles of the developer material adhere electrostatically to the previously formed latent electrostatic image areas of the drum to form a visible powder image. The remaining developer material falls off the peripheral surface of the drum into the sump. In the past, toner particles consumed during development were replenished by a gravity feed toner dispenser positioned adjacent the conveyor on the side thereof remote from the xerographic drum.

The conventional toner dispensers of past devices are replaced, according to the instant invention, by a self-regulating toner dispenser indicated generally as 60.

The toner dispenser of the instant invention comprises upstanding side walls 62 spanning the machine to a length equal to the length of the drum 10 as well as the length of the buckets 58 on the conveyor. It is formed with its upstanding side walls 62 between the imaging station B and the developer housing 52. Its upper surface is covered with a lid 64 through which additional developer may be added to the toner supply area or reservoir within the dispenser. The lower face of the dispenser includes an angled imperforate plate 66 and an apertured member formed as extended screen 68, positioned to intercept the flow of developer prior to its contact with the drum. The angled lower face and screen of the dispenser allow a gravity feed of toner within the dispenser to the space adjacent the screen.

Within the dispenser is positioned a quantity of conventional toner powder with a small amount of conventional carrier granules which may impart the necessary triboelectric properties to the toner upon mutual agitation. Such agitation may be supplied by means of augers 70 positioned within the dispenser.

The screen is adapted to be of a mesh such that the carrier granules cannot pass therethrough but such that the toner particles can pass therethrough. The screen is adapted to possess triboelectric characteristics similar to the carrier. One form of screen which can be preferably employed includes a conductive base screen coated with the material with which the carrier granules are coated. Such materials are described for example in U.S. Pat. No. 2,618,551. The coating insures the proper triboelectric properties of the screen. The use of the conductive core within the screen permits a varying electrical charge to be passed therethrough. By applying this supplemental potential to the screen as by a variable potential source 72, the potential thereof may be varied to thereby vary the electrostatic properties of the screen. The conductive screen could also be uncoated in which case only its electrostatic properties would be employed to attract and retain the charged toner.

In order to develop images on the xerographic drum in accordance with this embodiment, the developer is merely dropped from the buckets of the conveyor onto the toner dispensing screen. Those carrier particles which are less than optimally toned will roll down the screen and attract thereto charged toner particles which are electrostatically being held

to the screen. Those carrier particles moving over the screen will attract toner thereto until each carrier granule is optimally toned at which time they can attract no more toner inasmuch as the electrostatic attraction of the screen equals the electrostatic attraction of the optimally toned carrier. Optimally toned carrier granules cannot attract additional toner from the screen while carrier granules which have inadvertently become overtoned will have their excess toner particles attracted thereaway by the force of the screen.

If lighter or darker images are required, the potential through the screen may be varied in order to vary the electrostatic attraction of the screen. When this is done, the toner saturation level of the individual carrier particles may be varied to thereby increase or decrease the amounts of toner capable of being held by the carrier particles.

Whether the unbiased screen of the brush developing apparatus of the first embodiment, or the biased screen of the cascade development apparatus of the second embodiment is used, the mode of operation for dispensing toner is substantially the same. In either embodiment, a quantity of toner particles is positioned adjacent one side of a screen with the screen having triboelectric characteristics similar to the carrier material. The toner particles are then given the proper triboelectric charge whereby they are attracted to and held by the screen. Carrier is then moved across the opposite surface of the screen for mutual agitation with respect to the toner held on the screen. At this point, the triboelectric characteristics between the materials cause toner to migrate from the screen to the carrier up until the point that the electrostatic attraction of the carrier equals the electrostatic attraction of the screen. When this occurs, the carrier is optimally toned and can accept no more toner. Development with the toned carrier may then take place. The use of the electrically biased screen coated with the carrier material permits selective regulation of the triboelectric properties of this screen and as such permits variations in the saturation level of the carrier.

While it has been disclosed that the present invention can be carried out in brush or cascade type development, it should be understood that any other type of two-component development apparatus may be so modified as to encompass the principles of the instant invention. The use of a silk screen in the fur brush embodiment and the use of the coated and electrically biased screen in the cascade development have been selected as illustrative only. It should be obvious that these types of screens are completely interchangeable. Various other types of screened material could be used to effectuate the toner dispensing of the instant invention. All that is required is an aperture sufficient to permit toner but not carrier to pass therethrough with triboelectric properties at the edges of the aperture similar to the carrier which are capable of holding and dispensing toner in competition with the forces of the carrier.

Screens have been chosen as the toner dispensing surface in the two embodiments disclosed. It should be understood that any similar type of aperture network would work equally as well. For example, the screens could be replaced by parallel wires or strips so long as they have the necessary triboelectric characteristics with the proper spacings therebetween. In like manner, a pair of plates spaced to form an aperture could serve the same function.

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.

I claim:

1. Latent electrostatic image developing apparatus including a member supporting a latent electrostatic image to be developed, a toner dispenser and means to move carrier means with charged toner particles electrostatically adhering thereto in a path of movement into contact with and across said toner dispenser and then said member supporting the latent electrostatic image for its development, said toner dispenser comprising:

a reservoir containing charged toner particles and carrier granules;
 means to agitate the contents of said reservoir to triboelectrically charge the toner particles;
 an electrically conductive screen positioned along the path of movement in contact with the contents of said reservoir to separate the carrier means from said reservoir, said screen having apertures of such a size as to permit the movement of toner particles but not carrier granules therethrough; and
 means to apply an electrical potential to said screen to electrostatically attract toner particles from said reservoir whereby the amount of toner particles electrostatically picked up by the carrier means contacting said screen is dependent on the potential applied to said screen.

2. Latent electrostatic image developing apparatus including a member bearing a latent electrostatic image to be developed, a toner dispenser above at least a portion thereof and conveyor means to cascade carrier granules with charged toner particles electrostatically adhering thereto in a path of movement into contact with and across said toner dispenser and then across said latent electrostatic image bearing member for its development, said toner dispenser comprising:
 a reservoir containing charged toner particles and carrier granules;
 means to agitate the contents of said reservoir to triboelectrically charge the toner particles;
 an electrically conductive screen positioned along the path of movement in contact with the contents of said reservoir to separate the cascading carrier granules from said reservoir, said screen having apertures of such a size as to

permit the movement of toner particles but not carrier granules of either the reservoir or cascading developer therethrough; and
 means to apply an electrical potential to said screen to electrostatically attract toner particles from said reservoir whereby the amount of toner particles electrostatically picked up by the cascading carrier granules contacting said screen is dependent on the potential applied to said screen.

3. Latent electrostatic image developing apparatus including a member bearing latent electrostatic image to be developed, a toner dispenser, a brush having fibers capable of electrostatically retaining charged toner particles thereon and means to move said brush with charged toner particles electrostatically adhering to its fibers in a path of movement contacting said toner dispenser and then said latent electrostatic image bearing member for its development, said toner dispenser comprising:
 a reservoir containing charged toner particles and carrier granules adapted to triboelectrically charge the toner particles; and
 a screen positioned along the path of movement to separate the carrier means from said reservoir, said screen having apertures of such a size as to permit the movement of toner particles but not carrier granules therethrough, the surface of said screen being of a material capable of electrostatically attracting toner particles from said reservoir whereby the amount of toner particles electrostatically picked up by said fibers contacting said screen is dependent on the amount already on said fibers.

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