

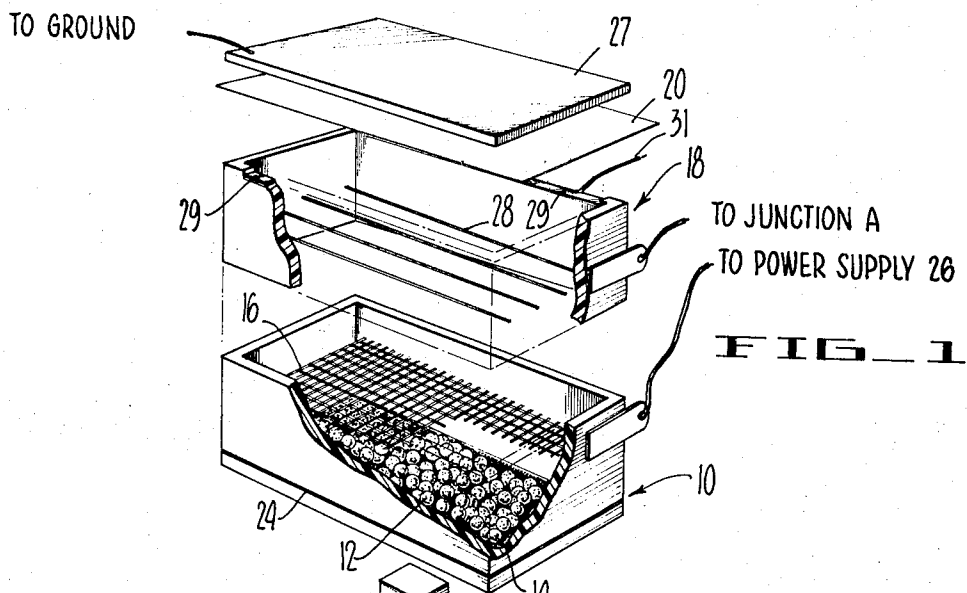
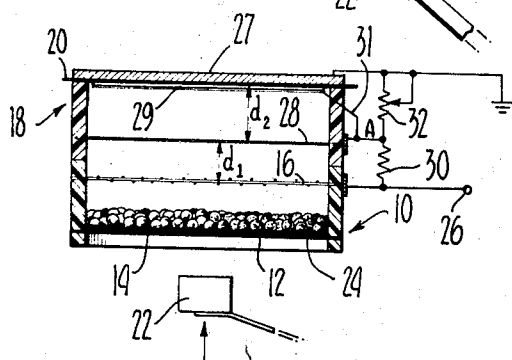
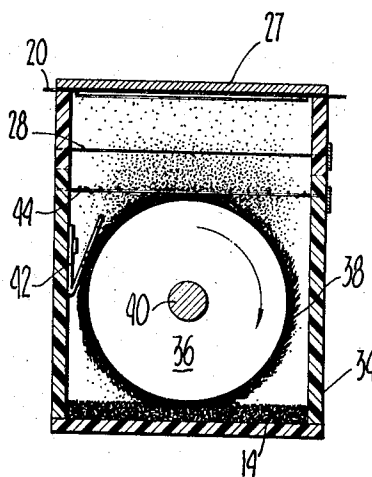
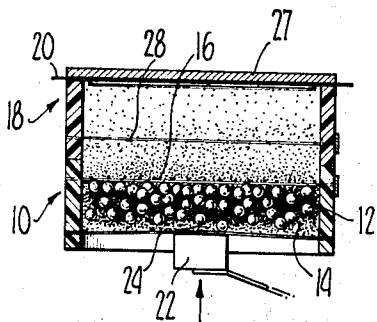
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ELECTROSTATIC IMAGE PROCESSOR

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3,372,675

ELECTROSTATIC IMAGE PROCESSOR

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ABSTRACT OF THE DISCLOSURE

A toner applying apparatus for use in developing electrostatic images on a record medium wherein mechanical actuation is initially used to both charge the toner particles, due to friction with a carrier material, and to elevate the charged toner particles toward the record medium. The elevated toner particles enter a first electric field which accelerates them toward the record medium. Before reaching the record medium the accelerated charged particles enter a second electrical field which maintains the charged particles in an air slurry or cloud closely adjacent to the record medium, whereby the electrical fields associated with the latent image in combination with the uniform field of the drift region cause the toner particles to be gently deposited on desired portion of the record medium.

This invention relates to a novel means for processing electrostatic images and, in particular, to an improved toner applying means useful for electrostatic image development.

Presently known electrostatic developers or copiers employ radiation or light to generate an electrostatic charge in a pattern corresponding to an image, which is being copied from a document, for example. The charge is produced on a photoactive body which receives reflected light from the document to be copied. The photoactive body with the latent electrostatic image is then subjected to a developer in order to convert the nonvisible charge image to a visual print-like facsimile.

The developer includes a toner formed from a finely ground pigmented resinous powder, and a carrier, such as glass spheres, that supply an electrical charge of the proper polarity to the toner, and also lend mass to the toner. The toned or developed image may be directly formed on electrophotographic paper or transferred from an electrophotographic drum or plate to a paper or other medium, which then serves as the copy.

One problem encountered with the use of a toner in a contact copying technique is the triboelectric effect, which is a localized charging caused by friction between the copy paper or photoactive body and the toner particles. This charging by friction during image development results in a dirtying of the areas where toner is not desired, and necessitates one or more additional steps or structures to provide a clean copy of the image, such as using a reverse field zone, for example. Also, in presently known electrostatic copiers, the toner powder requires frequent replenishment or replacement, and it would be desirable to have a convenient means for rapid and facile replacement of toner. Furthermore, during operation the toner powder tends to escape and disperse freely through the machine, thus necessitating frequency cleaning and service to remove toner accumulation.

An object of this invention is to provide a novel and improved toner applying device for an electrostatic copier.

Another object of this invention is to provide a toner applying device that affords a simple and inexpensive structure and which can take the form of a replaceable cartridge.

Another object is to provide a toner applying device in an electrostatic copier, wherein high image resolution is realized.

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According to one aspect of this invention, means are provided in a toner applying device for an electrostatic copier to move toner particles toward and onto a medium or paper by discrete stages. The first stage utilizes mechanical actuation whereby the toner particles, after being charged, are separated from a carrier. The particles are then accelerated by an electric field, and are driven into a drift region. During the final stage of travel by the toner before impingement on the paper, the properly charged toner particles are levitated in an air slurry or cloud closely adjacent to the paper, and by means of charge attraction of predetermined magnitude, the toner is deposited on relatively oppositely charged portions of the paper with a minimum of impact. Where the paper is charged similarly to the toner particles, the latter are rejected by the paper, preventing contact between toner and paper where toning is not required. In this way, triboelectric frictional effects between the particles and paper and resultant dirtying are avoided. Furthermore, poor image resolution that may arise from impact of carrier particles contacting the toned portions is precluded.

In a particular embodiment of this invention, a toner applying means or hopper is formed as a replaceable container or cartridge, which contains toner powder and a carrier. The toner and carrier are disposed at the bottom of the cartridge adjacent to a flexible member that is actuated periodically to agitate the toner and carrier. The toner is charged triboelectrically, and is urged upward toward a medium or paper that has oppositely charged portions formed in a pattern similar to an image being duplicated. The energy imparted to the toner by the mechanical actuation drives the particles of the toner part of the way toward the paper into an accelerating region, from which the particles are further propelled by a predetermined electric field toward the paper. The toner particles are moved into a drift region, close to the charged paper surface. The electric field associated with the latent image on the paper in combination with the uniform field of the drift region, selectively attract the charged toner particles and cause the particles to be gently deposited on desired portions of the paper. The particles adhere to the paper thereby forming the image pattern. Subsequent heating effects a permanent adhesion of the toner to the paper.

In another embodiment of the invention, the toner applying means includes a rotary brush that traverses the toner particles, whereby the particles are charged and adhere to the brush by electrostatic attraction. The brush carries the particles past a screen through which toner particles are pushed by the brush bristles or scraped therefrom. The free particles then are driven by a suitable electric field through an accelerating region and a drift region, respectively, to be deposited gently on charged areas of the paper corresponding to the image being copied.

The invention will be described in greater detail with reference to the drawing in which:

FIG. 1 is a perspective view, partly broken away, of a toner applying device, made in accordance with this invention;

FIG. 2 is a cross-sectional view of the novel toner applying device of FIG. 1, prior to actuation of the toner particles;

FIG. 3 is a cross-sectional view of the toner applying device of FIG. 1, indicating the levitation of the toner particles upon agitation; and

FIG. 4 is a cross-sectional view of an alternative embodiment of the present invention, utilizing a rotary brush device.

Similar numerals refer to similar elements throughout the drawing.

With reference to FIGS. 1-3, a toner applying device or

hopper comprises a housing or cartridge 10 that contains a multiplicity of glass spheres or beads 12, which may be made of borosilicate glass. A quantity of toner material 14, which may be resinous carbon powder or particles of about six to twelve microns in diameter, is disposed at the bottom of the cartridge 10. The glass spheres 12 serve as a carrier for the toner particles 14, and impart a negative charge to the particles when the spheres and particles are rubbed together upon mechanical agitation. To contain the carrier glass beads within the cartridge 10, a mesh screen 16 having openings with a diameter less than that of the individual spheres is secured above the toner 14 and carrier 12.

When carried in stock, the replaceable cartridge 10 may be covered with a cellophane membrane which is removed when used with the copier apparatus. In operation, the cartridge 10 is affixed to a portion 18 of the copier through which the copy paper 20 passes during the developing process. The copy paper 20 has been previously charged with a latent electrostatic image that is to be developed to form a copy, and is to be toned in order to provide a permanent visible image.

During the developing procedure, an actuator 22, which may be a hammer assembly coupled to a motor driven eccentric or an ultrasonic generator, strikes a flexible member 24 periodically at the bottom of the cartridge 10. The membrane 24, which may be made of Mylar, for example, imparts an agitation or force to the glass spheres 12 and to the toner 14, causing an interaction accompanied by friction and triboelectric charging. The glass spheres 12 assume a positive charge, whereas the toner particles become negatively charged.

The force imparted by the actuator 22 to the membrane 24 is sufficient to drive the toner particles 14 past and above the mesh screen 16 in opposition to gravitation. The screen 16 is coupled to a source of negative potential 26, such as -1.5 kv. (kilovolts), by way of example, and thus accelerates the toner particles toward the paper 20, which is disposed adjacent to a plate 27 that is at ground potential (or other reference potential that is substantially positive relative to the negative potential source 26). Thus an electric field is established between the screen 16 and the plate 27, with the paper 20 positioned at one end of the effective field.

Above the screen 16 and in the path of motion of the charged toner particles, there is positioned a control grid 28 having a negative potential substantially less than that of the accelerating screen 16. In this respect, it should be noted that the screen 16 is coupled to the -1.5 kv. potential source 26 directly, whereas the control grid 28 is tied to the source 26 through a high value resistance 30 at a junction point A of a voltage divider, which includes resistance 30 and a variable resistor 32 in series. The resistance 30 may be typically twenty megohms, and the variable resistance 32 may be set at ten megohms, by way of example. The spacing d_1 between the screen 16 and grid 28 defines an accelerating region, in which the field strength is approximately 1000 volts/cm. The charged toner particles are driven from the accelerating region past the control grid 28 into a drift region, in which the field strength is approximately 600 volts/cm. The drift region is defined as the spacing d_2 between the grid 28 and the paper 20.

The control grid 28 acts to maintain the upward travel of the toner particles 14 to the paper 20, but the grid potential is not sufficient by itself to propel the charged particles to the surface of the paper 20. In accordance with this invention, the spacings of the screen 16 and grid 28 relative to the flexible membrane 24 and the paper 20, and the potentials applied to the screen 16, grid 28 and plate 27 are such that the toner particles 14 reach an area just below and closely adjacent to the paper 20. In this area or zone, the particles form an air slurry or cloud-like formation and are in a temporary state of suspension or levitation.

To prevent toner particles from migrating out of the desired volume through a narrow aperture that exists between the paper and the edges of the toner applying means, the upper edges 29 of the device nearest the paper surface is metallized. A negative potential, for example the same potential as the grid electrode 28, is applied to these metallized edges 29 via a conductor 31, thereby preventing migration of toner particles out of the desired volume.

It is understood that the paper 20, which may be about .0005 inch thick, has a photosensitive surface, such as a zinc oxide coating, that is charged electrostatically in a pattern corresponding to the image on the document being copied. When the toner particles are in the drift zone between the grid 28 and paper 20, the electric field associated with the charged areas of the paper 20 acts to repel the similarly charged particles from these areas. The charged particles that reach the paper adhere to the discharged paper portions. Subsequently, the paper is heated so that the toner becomes permanently affixed to the paper, in a well known manner.

In the alternative embodiment of FIG. 4, a toner applying means comprises a toner 14 disposed within a housing 34. A rotary brush or roller 36, having short metallic fibers or bristles 38 on its surface, is so positioned that, upon rotation of the brush, the fibers 38, which may be made of beryllium or stainless steel for example, traverse the toner material. Means for rotating the roller 36 is represented by the shaft 40 for simplicity and convenience. The resultant moving contact and friction between the brush fibers and the toner charges the toner particles and the brush oppositely. The particles cling to the brush surface and are carried upward in the direction of the paper 20. To ensure a uniform layer of toner, a scraper blade 42 is fixed to the housing 34 and extends close to the fiber surface 38 of the roller 36. As the particles on the roller pass the scraper 42, excess toner is removed from the roller surface.

At the topmost level of the roller 36, a coarse metallic screen 44 of about No. 20 mesh is provided. The screen 44 is coupled to a source of potential in the same manner as the screen 16 found in the embodiment of FIG. 1. When the uniform layer of particles reaches the screen 44, the brush fibers carrying the toner engage and flex against the screen 44, thereby flipping the toner particles upward and above the screen into an accelerating zone. Thereafter, the toner particles are moved into a draft zone and follow the same course as delineated for the embodiment of FIG. 1.

This disclosed toning means embodies a device wherein charged toner particles are first launched by a mechanical means toward the target paper, and then urged toward the paper by electric fields of different intensities. The use of different fields affords a self-filtering effect whereby only toner particles that are suitably charged reach the record medium or paper, and those that are improperly charged or not charged at all fall back to the toner reservoir.

It should be noted that the particular material used as a carrier for the toner may be varied, and may provide a positive charge in lieu of a negative charge to the toner particles. In such event, the polarity of the applied potentials and the resultant electric fields are reversed to provide an equivalent action. Also, the values of the field strengths, the electrode spacings and potentials, as well as other parameters set forth above, may be modified within the scope of this invention.

The toner applying means of this invention affords clean copies having sharply defined lines and high resolution. The embodiment in a cartridge allows easy and rapid replacement and the electrode arrangement prevents dirtying of the machine by escape of toner. Also, the presently disclosed apparatus overcomes the previous disability of cloud toning in that improperly charged

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particles cannot penetrate the zone of the electric field.

What is claimed is:

1. In an electrostatic developer apparatus wherein a medium having electrostatically charged portions is to be toned to form a visible record, a toner applying means comprising:
 - a toner material;
 - a carrier for said toner material;
 - mechanical means for causing moving contact between said toner material and said carrier to charge said toner material, and for elevating said charged toner material to a predetermined area;
 - means for forming a first electric field wherein said elevated toner material is accelerated toward said medium;
 - means for forming a second electric field wherein said toner particles drift closely adjacent to said medium;
 - whereby said charged toner material closely adjacent to said medium is attracted onto the relatively oppositely charged portions of said medium.
2. In an electrostatic developer apparatus as in claim 1, wherein said toner material is a resinous carbon powder.
3. In an electrostatic developer apparatus as in claim 1, wherein said carrier comprises a multiplicity of glass spheres.
4. In an electrostatic developer apparatus as in claim 1, wherein the carrier comprises a rotary brush having a surface material that causes triboelectric charging upon friction with said toner material.
5. In an electrostatic developer apparatus as in claim 1, wherein said mechanical means comprises a mechanically actuated hammer assembly.
6. In an electrostatic developer apparatus as in claim 1, wherein said mechanical means comprises a motor driven roller.

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7. In an electrostatic developer apparatus as in claim 1, wherein said first electric field means comprises a screen electrode and a control grid electrode spaced therefrom, said electrodes forming an accelerating zone wherein said charged toner material is accelerated toward said medium; and a power supply coupled to said electrodes.

8. In an electrostatic developer apparatus as in claim 7, wherein said control grid electrode is coupled to said power supply through a resistance.

9. In an electrostatic developer apparatus as in claim 7, wherein said second electric field means comprises said control grid electrode and a conductive plate coupled to a source of reference potential, the spacing between said control grid electrode and conductive plate defining a drift zone.

10. In an electrostatic developer apparatus as in claim 1, wherein the field strength of said first electric field is approximately 1,000 volts per centimeter, and that of said second electric field is about 600 volts per centimeter.

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