Feb. 21, 1961 W. LIMBERGER 2,972,332

APPARATUS FOR DEVELOPING LATENT ELECTROSTATIC IMAGE ON AN ELONGATED FLEXIBLE SUPPORT

Filed Aug. 16, 1957 3 Sheets-Sheet 1

FIG. 1

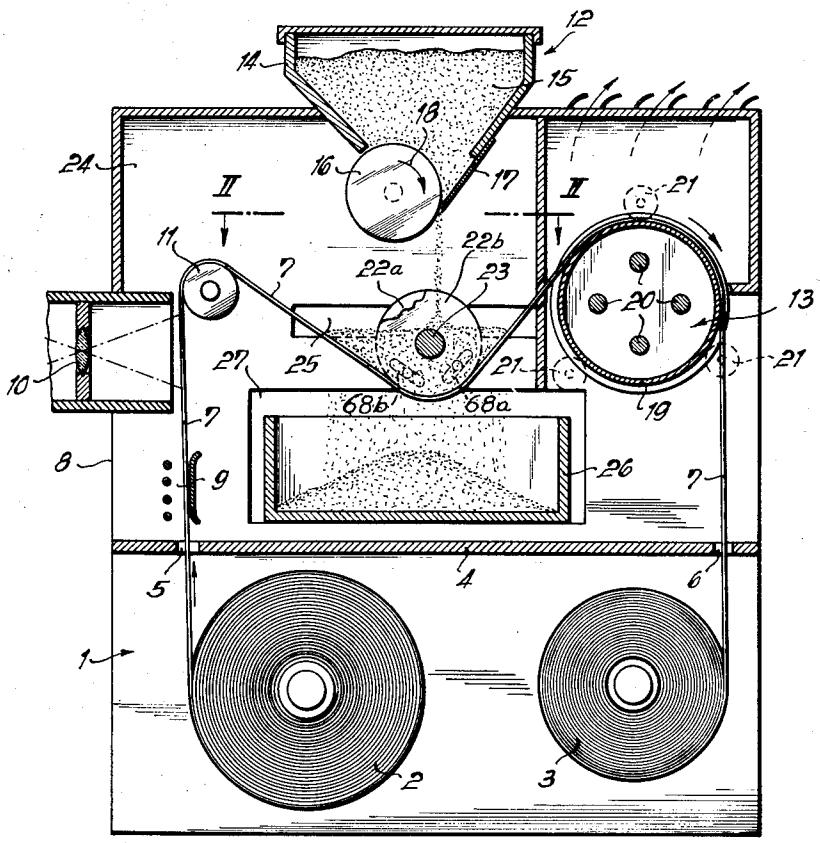
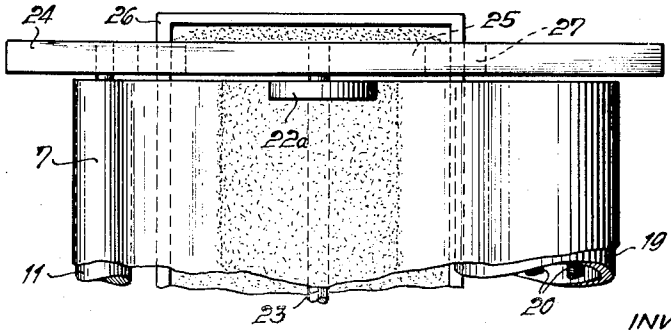


FIG. 2



INVENTOR:

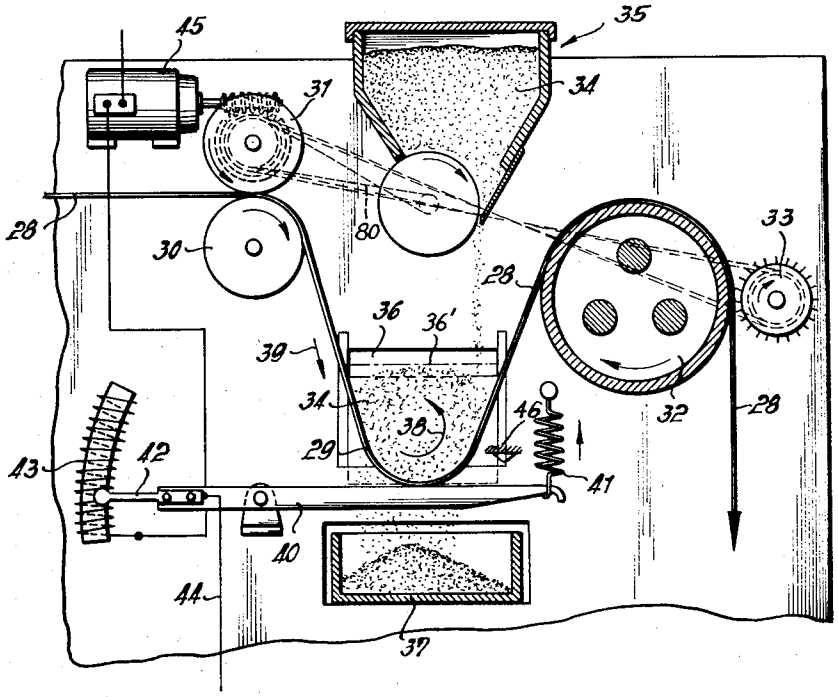
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FIG. 3



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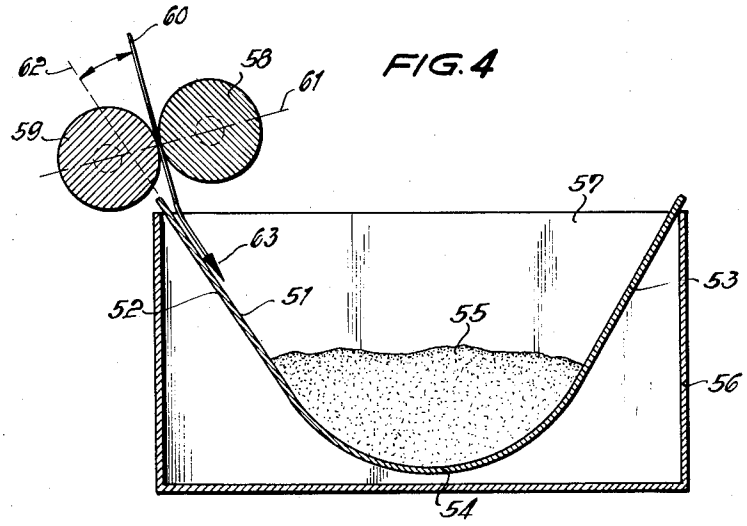
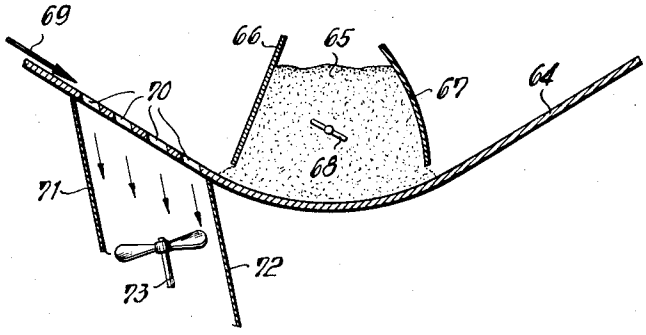


FIG. 4

FIG. 5



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2,972,332

APPARATUS FOR DEVELOPING LATENT ELECTROSTATIC IMAGE ON AN ELONGATED FLEXIBLE SUPPORT

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3 Claims. (Cl. 118—637)

The invention relates to a device for rendering visible a latent electrostatic image by means of a toner by distributing pigment particles onto a xerographic layer in which the latent electrostatic image is located and to an apparatus in which this device is used.

An apparatus for the preparation and the development of such images, in accordance with the invention, may include a forming device of the xerographic layer, which consists for example of wire-shaped electrodes arranged over the xerographic layer and a plate at the back of the layer support serving as the counter-electrode. Furthermore, the apparatus may include means for the preparation of the latent electrostatic image by exposure to an illuminating device or by a contact method. A powder-distributing device, provided in the apparatus for rendering visible the latent electrostatic image, is driven in synchronism with other moving parts of the apparatus, particularly the advance of a driving mechanism for the layer support. In one embodiment, a supply container for the toner is provided with a funnel-shaped base; a roller rotates in an opening in the base, preferably with depressions on its periphery, whereby a measured amount of the toner is delivered. The apparatus further contains a heating device which consists for example of a rotating drum and by means of which the pigment particles which have been distributed on to the contours of the latent electrostatic image are fused in.

The invention seeks to solve the problem of improving known devices for rendering visible an electrostatic image and to provide an apparatus in which the improved device is usable.

According to one aspect of the invention, a longitudinally loop-shaped open-topped container for receiving a pile of toner and guide devices for the layer support are provided whereby this support is guided under the toner pile with simultaneous agitation of the toner.

According to a more specific feature of the invention, this open-topped container is formed by a loop-shaped portion of the layer support under a powder-distribution device, so that the toner pile collects in the loop formed by the layer support. The layer support is so guided that the xerographic layer lies on the concave side of the loop.

In a particularly advantageous embodiment, the invention comprises a device for agitating the toner pile on the layer support. Furthermore, means are provided for controlling the accumulation of the toner on the xerographic layer, the toner being supplied for this purpose at a rate exceeding that at which the toner is entrained by the outgoing portion of the layer support; this oversupply and the continuous removal of excess toner, by means to be described, insures a constant rejuvenation of the developing material. The layer support is driven for the purposes of advance through the formed loop, the drive preferably running synchronously with the powder-distributing device.

The invention provides the important advantage that an intensive and uniform covering of the latent electrostatic image with the toner is ensured, whereby through

the advance of the layer support a continuous agitation and movement of the particles of the toner lying directly upon the upwardly facing xerographic layer are ensured. By this agitation, unused particles of the toner, for example glass spheres which are provided with pigment particles, are continually supplied to the xerographic layer. With a continuous supply of fresh toner particles furnished by the distributing device, as described above, sufficient unused toner is always available for contact with the xerographic layer. The agitating movement of the toner particles produced enhances transfer of the pigment particles to the xerographic layer support.

The device is advantageously provided with vertically and horizontally adjustably mounted guide means, for example rollers or feelers, for the layer support for adjusting the loop depth and/or the loop shape. The covering of the layer support with the toner can thereby be adjusted as to duration and intensity of the action. The aforementioned means for limiting the accumulation of toner on the layer support, through the removal of toner supplied in excess, may take the form of slots in the stationary wall parts which laterally limit the loop formed by the layer support and form a chute for the toner. These slots, through which the toner can escape, are preferably adjustable as to their height and in particular their inclination. The removal of the used toner from the outlet side of the loop can thus be controlled.

The edges of the layer support may be guided for example by wheels or wall parts, in order to limit the space for the accumulation of the toner laterally of the loop formed by the layer support. Such guide wheels are preferably constructed as pin wheels, so that the layer support merely comes into point contact with the guiding portions.

In a further embodiment, the layer support in the region of the loop is guided only ahead of and behind the loop, the latter being formed solely by the sag of the layer support under the load of the toner. In this embodiment, contact means such as a feeler may be provided to determine the sag of the loop, the drive motor for the advance of the layer support being controlled in dependence upon this sag. This enables the automatic maintenance of a predetermined depth of the loop; advantageously, the drive of the powder distributing device can be controlled at the same time and the means for maintaining the toner level above the support can also be adjusted. The slack of the loop can also be measured by other means such as, for example, photoelectric cells or the like.

The guide means for the layer support, particularly those beneath this support can be constructed as part of a fusing device for fixing the developed images, the fusing device being constructed for example as a heated cylinder over which the layer support is guided.

The device for rendering visible a latent electrostatic image can be part of an apparatus which, together with the fusing device, also includes means for forming the electrostatic layer and, for example, an illuminating device. Even in such apparatus, which combines all the elements for preparing and rendering visible a latent electrostatic image, the invention is usable with particular advantage since a completely enclosed arrangement of the toner is provided, whereby any disturbance of the toner in the transfer of the pigment particles to the xerographic layer is avoided.

Further advantages and features of the invention will appear from the description of certain embodiments thereof, of which only the parts essential to the invention are illustrated. In the accompanying drawing:

Fig. 1 shows a section through an apparatus according to the invention;

Fig. 2 shows a section through a part of the apparatus according to Fig. 1 along the line II—II to illustrate the loop arrangement of the layer support;

Fig. 3 shows a section through a part of a differently constructed apparatus according to the invention;

Fig. 4 shows a side view of another embodiment; in section; and

Fig. 5 shows a side view of a further embodiment in section.

In the lower part 1 of the apparatus illustrated in Figs. 1 and 2, a supply roll 2 for the layer support 7 is mounted and a further roll 3 is provided onto which the layer support is wound after development and fixation of the image in the xerographic layer. The lower part of the apparatus is separated from the remaining parts by a partition 4 which is merely interrupted by slots 5 and 6 for the passage of the layer support 7. In the embodiment illustrated, the layer support 7 is advanced substantially vertically upwards and parallel to the side wall 8 of the apparatus through a forming device 9 and past an illuminating device 10. The xerographic layer is located on the side of the layer support facing the device 10.

Beyond the illuminating device 10, the layer support is taken around a guide roller 11 and is guided under a powder-distributing device 12 to a heating device 13. The powder-distributing device consists essentially of a funnel-shaped container 14 for receiving the toner 15. The lower part of the container 15 is open. A part of the opening is closed by a glider or roller 16, whereas the other part is covered by a resilient wall surface or apron 17 whose free edge contacts the periphery of the roller 16. The roller 16 is provided on its surface with suitable depressions (not shown) so that, on rotation of the roller 16 in the direction of the arrow 18, an amount of toner measured in dependence upon the peripheral velocity of the roller 16 is supplied.

The heating device comprises a rotating cylinder 19 which consists for example of copper. Inside the cylinder are located several heating elements 20. In the embodiment illustrated, the cylinder 19 is externally supported by three rollers or pairs of rollers 21. The layer support 7 runs with its back over the cylinder 19 and is deflected by the cylinder so that it passes through the slot 6 to the wind-up roll 3.

Between the guide roller 11 and the cylinder 19, the layer support is so guided that it forms an upwardly open loop beneath the powder-distributing device 12. The depth of the loop is determined in the embodiment illustrated by two wheels 22*a*, 22*b* which run on the edges of the layer support. The periphery of the wheels 22*a*, 22*b* is so constructed as to offer the smallest possible contact surface between the wheels 22*a*, 22*b* and the layer support 7. Preferably, the wheels 22*a*, 22*b* have pin-studded peripheries, as illustrated in Fig. 3 for the wheel 33, so that there is merely a point contact with the layer support.

The toner falls into the looped part of the layer support 7 from the powder-distributing device and forms a pile. This pile is continually agitated on the xerographic layer by the advance of the layer support. The agitation can advantageously be enhanced by, for example, rods or stirrer blades 68*a*, 68*b* which may be provided between the wheels 22*a*, 22*b* and extend parallel to the shaft 23 of the wheels. These stirrer blades may be secured in any position relative to the wheels 22*a*, 22*b*, at a safe distance from the outer periphery of the wheels.

At least in the region of the loop formed by the layer support 7, the side walls 24 of the apparatus approach the layer support so that an unhindered lateral outflow of the toner is avoided. For the purpose of removal, slots 25 are provided in the side walls 24, the position of these slots determining the amount of toner which is accumulated within the loop. By a vertically adjustable mounting for example of the wheels 22*a*, 22*b*, or by

adjustability of the level of the slots 25 located on opposite sides of the layer support, the amount of toner accumulated in the loop can be controlled. The adjustment of the slots 25 can be effected, for example, by means of a slide member 36' (Fig. 3) whose upper edge forms the lower boundary of such slot. By a sloping positioning of the slide member, the inclination of a slot 25 can also be adjusted so that a more rapid renewal of the toner collected in the loop can be achieved, if required, with a more copious supply of fresh toner through the powder-distributing device 12.

Beneath the loop formed by the toner, a container 26 is provided for collecting the toner issuing through the slots 25. The container 26 extends through the side walls 24, which are provided with apertures 27, so that it can collect toner falling on the outside of these side walls.

In the embodiment illustrated in Fig. 3, the layer support 28 is guided only ahead of and behind the loop 29 by guiding or feeding devices 30, 31 and 32, 33 respectively. The feeding device 30, 31 consists of a pair of rollers or wheel assemblies between which the layer support is clamped preferably in the region of its edges. The feeding device 32, 33 is likewise formed of rotating parts, numeral 32 indicating the cylinder of the heating device which cooperates with pin wheels 33. The use of pin wheels prevents the xerographic layer, on which the latent electrostatic image has already been developed, from being subjected to any superficial stress. Between the feeding devices 30, 31 and 32, 33, the layer support 28 forms a loop as it sags under its own weight and under that of the toner 34 which has collected in this loop and which is supplied by the powder-distributing device 35. In this construction, slots 36 each defined by a sliding member 36', as described above, are provided in the side walls guiding the edges of the layer support 28 laterally of the loop. Through these slots, excess toner passes out and falls into the container 37.

The arrow 38 within the loop 29 indicates how the toner located in the loop is stirred during the advance of the layer support in the direction of the arrow 39, so that the used toner is discharged through the slots 36. In this connection, for control of the passage of the toner through the slots, the position of the loop 29 can be adjusted with reference to the location of the powder-distributing device 35, as can be the inclination of the slots 36.

In the embodiment illustrated in Fig. 3, the amount of toner located within the loop 29 is preferably controlled by the sag of the loop 29. This sag can be stabilized in various ways. In the embodiment illustrated, a two-armed feeler lever 40 is provided for this purpose, one arm being under the action of a force, for example the tension of a spring 41, which draws it in a direction toward the loop 29 while the other arm carries a sliding contact 42. The sliding contact cooperates with a potentiometer 43 which is connected in the circuit 44 of the driving motor 45 for one of the feeding devices 30, 31 or 32, 33. Reduction of the sag of the loop below a minimum is prevented by an abutment 46 for the feeler lever 40. In order to provide the desired synchronism between the admission of fresh toner 34 and the advance of the web 28, the driving motor 45 is coupled with the roller of distributor 35 by a suitable transmission schematically shown at 80.

The drive motor 45 is so controlled that, e.g. with increasing slack a resistance is progressively inserted into the circuit 44. This increasing resistance can be employed as a field resistance of a D.C. motor, so that the number of revolutions of the driving motor for the feeding device 32, 33 increases whereby the loop is decreased. This decrease causes a diminution of the resistance in the circuit of the motor, so that the drive of the device 32, 33 is regulated.

In Fig. 4, a guide surface 51, as seen in the direction of advance of the layer support, has a straight front

part 52 and a likewise straight rear part 53. These two parts are inclined with their upper ends diverging. The lower ends are interconnected by a curved section 54. Within the guide surface, which is formed as an upwardly open shell, is located the toner pile 55. In the embodiment illustrated the toner substantially fills the curved section 54, so that the layer support guided along the upper side of the guide surface 51 is pressed with its front edge continually onto the guide surface because of its stiffness.

The guide surface is itself supported in a frame 56. This frame carries walls 57 which laterally enclose the guide surface.

Above the guide surface 51, feed means 58, 59 are disposed. In this figure, the feed means are merely indicated at the supply side of the layer support. They consist of rollers which may be yieldingly pressed together and guide the layer support 60 in a predetermined direction perpendicular to the plane 61 connecting the axes of the rollers 58, 59. This direction, represented by a plane tangent to both rollers, is inclined towards the direction 62 of the front part 52 of the guide surface, so that the forward edge 63 of the layer support 60 contacting the guide surface is bent towards the toner pile 55. This insures that the layer support is guided directly along the guide surface and can push under the toner pile 55. The arrangement is such that the distance from the feed means 58, 59 along the guide surface 51 up to the feed means (not shown) behind the rear part 53 of the guide surface 51 is smaller than the length of the layer support, so that the layer support, after it has left the feed means 58, 59, is further advanced by the feeding devices located beyond the member 51.

In the embodiment illustrated in Fig. 5, the guide surface 64 is curved in a vertical plane which runs parallel to the direction of advance. In this embodiment, the toner pile 65 is guided by directing surfaces 66, 67, the rear directing surface 67 being curved to increase agitation of the toner. The agitation of the toner is also augmented by a stirrer element 68 projecting into the toner pile 65.

In the direction of advance of the layer support corresponding to the arrow 69, the guide surface 64 includes several apertures 70 in front of the toner pile 65 or in front of the directing surface 66. These apertures are so arranged that their axes on the upper side of the guide surface 64 do not intersect the toner pile 65. Furthermore, additional directing surfaces 71, 72 are provided beneath the guide surface as a means for directing the flow of air through the apertures 70 parallel to the axes of the apertures 70.

The channel formed by the directing surfaces 71, 72 is connected to the suction side of a fan 73. This fan may form part of the ventilation system of the apparatus, care being taken to prevent withdrawal of the total air volume through the channel formed by directing surfaces 71, 72 so that merely a lower pressure is produced in this channel. This lower pressure serves to guide the layer support smoothly on the upper side of the guide suface 64 in the direction of the arrow 69, whereby dust particles or the like, which may be located on the upper side of the guide surface 64, fall through the apertures 70. By the described arrangement of the apertures 70 in relation to the toner pile 65, the assurance is given that individual particles of the toner cannot be subject to the partial vacuum acting through the apertures 70 so that the back of the layer support can travel unhindered on the upper side of the guide surface 64.

What I claim is:

1. An apparatus for developing latent electrostatic images, comprising a housing, an elongated, flexible support for a xerographic layer inside said housing, guide means within said housing adapted to form a portion of said support into a freely depending loop, feed means for advancing said support past said guide means while maintaining said loop substantially at a predetermined location, said housing having a pair of stationary side walls positioned closely adjacent the sides of said loop and forming therewith a chute for a comminuted toner above said loop, said feed means including a roller and drive means for rotating said roller, feed-control means operatively coupled with said drive means and actuatable by the lowest loop portion for regulating the advance of said support in a manner maintaining the sag of said loop substantially constant, and supply means for said toner at the top of said chute, said supply means being adapted to deliver toner to the concave side of said loop at a rate exceeding the rate of removal of toner by said support, said side walls being formed with substantially horizontal slots above the bottom of said loop whereby toner deposited on said support by said supply means will form in the hollow of said loop a pile whose level is determined by the escape of excess toner through said slots.

2. An apparatus for developing latent electrostatic images, comprising a housing, an elongated, flexible support for a xerographic layer inside said housing, guide means within said housing adapted to form a portion of said support into a depending loop, feed means for advancing said support past said guide means while maintaining said loop substantially at a predetermined location, said housing having a pair of stationary side walls positioned closely adjacent the sides of said loop and forming therewith a chute for a comminuted toner above said loop, and supply means for said toner at the top of said chute, said supply means being adapted to deliver toner to the concave side of said loop at a rate exceeding the rate of removal of toner by said support, said side walls being formed with substantially horizontal slots above the bottom of said loop whereby toner deposited on said support by said supply means will form in the hollow of said loop a pile whose level is determined by the escape of excess toner through said slots.

3. An apparatus for developing latent electrostatic images, comprising a housing, an elongated, flexible support for a xerographic layer inside said housing, guide means within said housing adapted to form a portion of said support into a depending loop, feed means for advancing said support past said guide means while maintaining said loop substantially at a predetermined location, said housing having a pair of stationary side walls positioned closely adjacent the sides of said loop and forming therewith a chute for a comminuted toner above said loop, supply means for said toner at the top of said chute, said side walls being formed with substantially horizontal slots above the bottom of said loop whereby toner deposited on said support by said supply means will form in the hollow of said loop a pile whose level is determined by the escape of excess toner through said slots, and a pair of spaced-apart rollers extending above said slots and engaging marginal portions of said support, said support engaging said rollers over an arc substantially less than 180° whereby parts of said slots are left unobstructed for the outflow of said excess toner.

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