

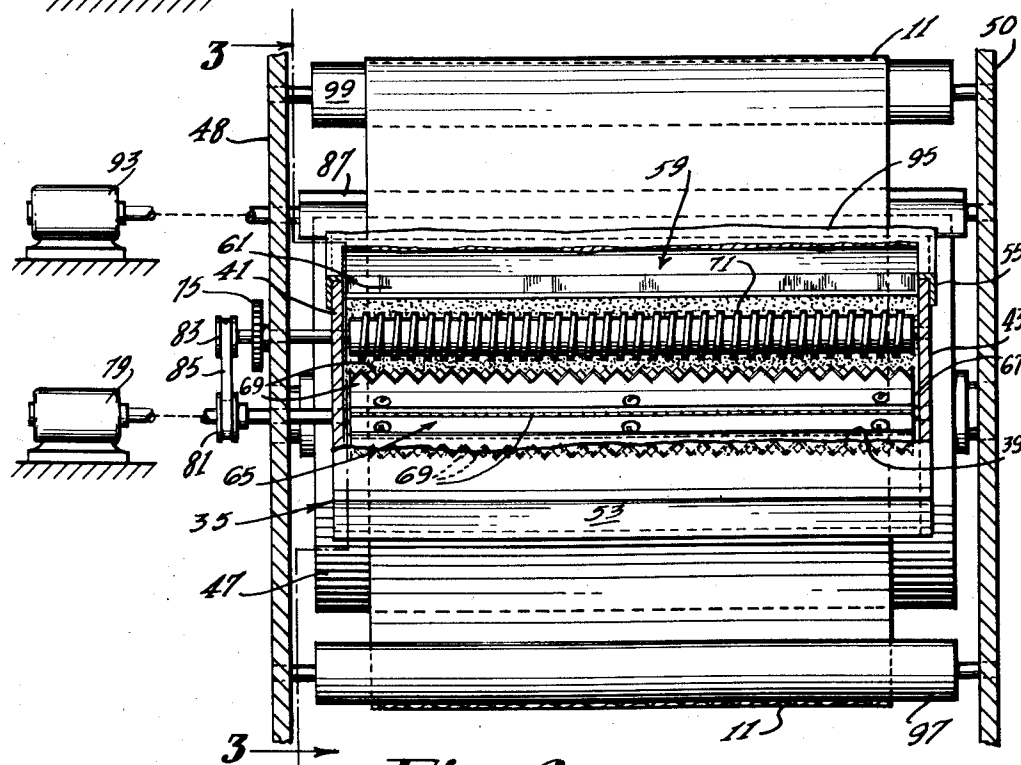
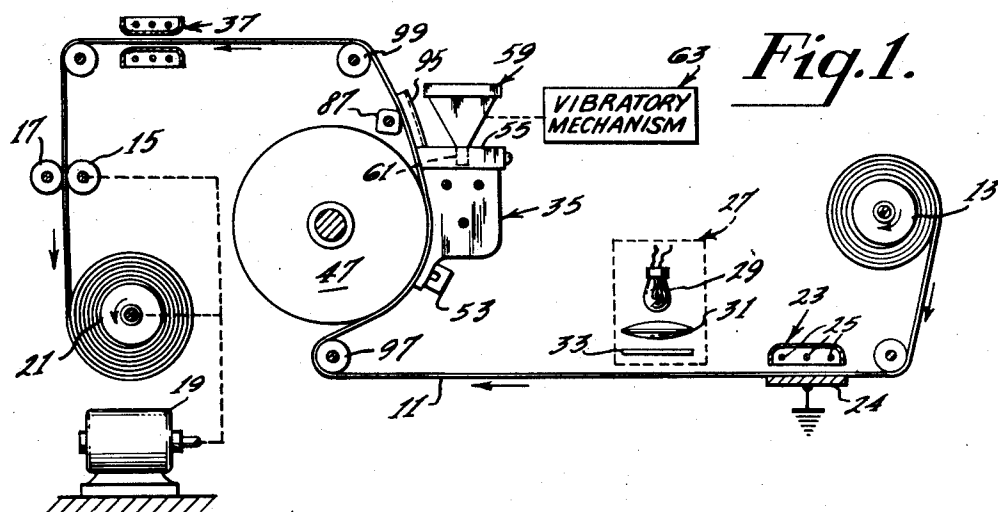
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A. STAVRAKIS ET AL
ELECTROSTATIC PRINTING

2,910,964

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2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 3.

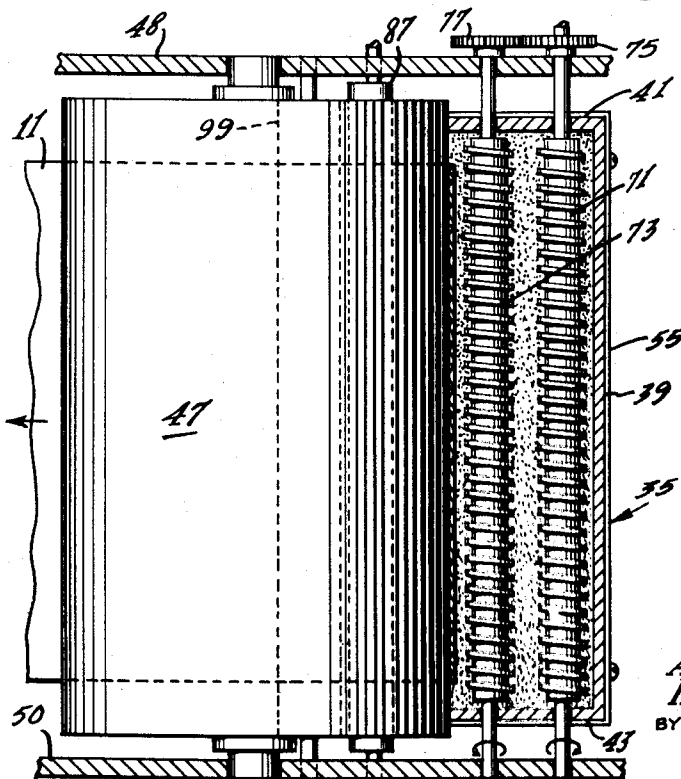
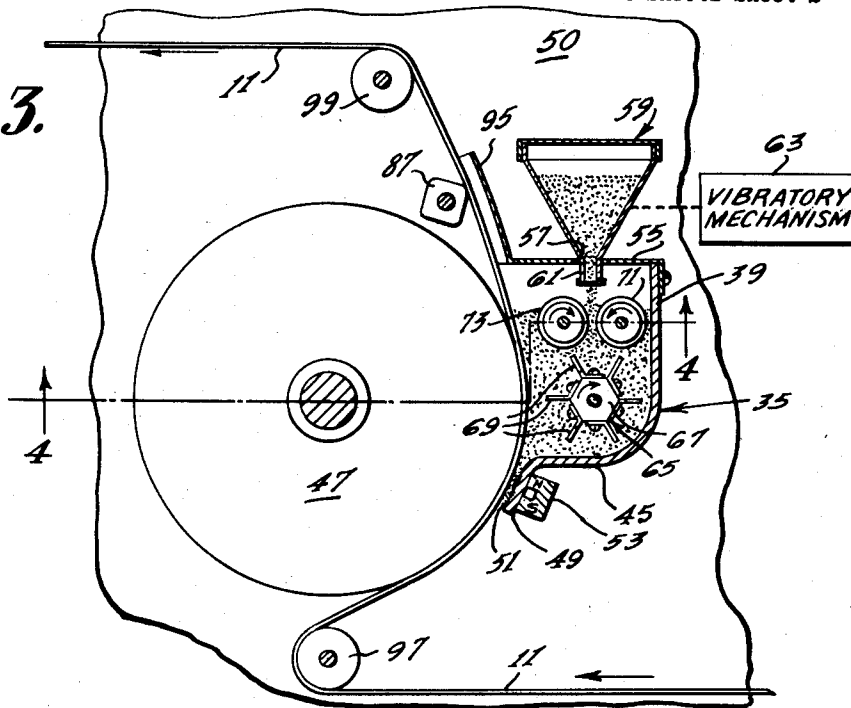


Fig. 4.

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2,910,964

ELECTROSTATIC PRINTING

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7 Claims. (Cl. 118—637)

This invention relates to electrostatic printing, and more particularly to an improved apparatus for applying developer powder to a record, such as a continuously moving web, bearing an electrostatic charge image.

An electrostatic printing process is a process for producing a visible reproduction, or copy, which includes the steps of converting a light image to a latent electrostatic charge image and converting the latent charge image into a visible image.

A typical electrostatic printing process may include first producing a uniform electrostatic charge upon the surface of a photoconductive insulating material, such as selenium, anthracene, or zinc oxide dispersed in an electrically-insulating film-forming vehicle, carried on one surface of a record. Then, the charged surface of the photoconductive material is exposed to a light image through a photographic transparency or by other suitable means. The portions of the surface irradiated by light rays become discharged while the remainder of the surface remains in a charged condition, thereby forming a latent electrostatic image corresponding to the light image. The latent electrostatic image is developed by applying a colored developer powder which is held electrostatically to selected areas of the surface. The visible powder image thus formed may be fixed directly to the photoconductive surface by fusing.

When the record carrying the photoconductive surface is an elongated strip, or web, upon which it is desired to make a plurality of reproductions at a rapid rate, a problem arises in presenting a sufficient quantity of developer powder to the surface of the web to permit development at the desired rate.

A desired developer mixture includes a developer powder and a granular carrier chosen with regard to the triboelectric series to produce charges of opposite polarities in the developer and carrier particles when they are mixed together. The polarity of the developer powder will be opposite to that of the charge image. The carrier particles are generally larger than the developer particles so that a number of developer particles will adhere to each carrier particle after mixing. The specific problem then is to continuously present new carrier particles to the charge image surface so that sufficient developer particles will be available for transfer from the carrier to the charge image surface.

An object of this invention is to provide an improved apparatus for applying developer powder to the surface of a continuously moving record.

Another object of this invention is to provide an improved apparatus for mixing developer powder and granular carrier particles to produce electrostatic charges of opposite polarities and for presenting the mix to the surface of a continuously moving record.

A further object of this invention is to provide an improved apparatus for presenting a continuous supply of freshly mixed developer powder and granular carrier particles to the surface of a continuously moving record.

A still further object of this invention is to provide an improved apparatus for uniformly mixing developer powder and granular carrier particles, and for presenting a continuous supply of the uniform mix to the continuously moving record.

Apparatus in accordance with the present invention includes a trough for containing a mixture of developer and carrier particles. One wall of the trough is formed by a rotatable drum. A path is provided through the trough to permit the passage of a movable record upwardly through the trough contiguous to the cylindrical surface of the drum which is or may be rotated by the record. One surface of the record is directly contacted by the mixture contained in the trough. A blender means is provided in the trough for working developer powder particles, dispensed from a hopper, into the carrier particles and for transporting developer mixture from one end of the trough to the other. An agitating means is provided in the trough for mixing the developer and carrier particles to maintain a substantially homogeneous mixture and to produce charges of opposite polarities in the developer and carrier particles.

The novel features of the invention, as well as additional objects and advantages thereof, will be understood more fully from the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic view illustrating an electrostatic printing system embodying the present invention;

Figure 2 is a view in front elevation, partially broken away, of a developing apparatus in accordance with the present invention;

Figure 3 is a side view taken along the line 3—3 of Figure 2 looking in the direction of the appended arrows; and

Figure 4 is a view taken along the line 4—4 of Figure 3 looking in the direction of the appended arrows.

Referring now, particularly, to Figure 1 of the accompanying drawings, a system for electrostatically printing on a continuous web 11 is illustrated diagrammatically. The web 11 carries a photoconductive coating on one surface which, as shown in Figure 1, is the upper surface of the web as it is fed from a supply reel 13. The web is fed from the supply reel 13 and is directed through the various units of the system and is drawn by drive rollers 15 and 17 driven by a motor 19. The web is then collected on a take-up reel 21, which may also be driven by the motor 19, or the web may be fed to additional processing devices.

The web is first passed through a corona charging unit 23 in which a uniform electrostatic charge is applied to the coated surface of the web. The corona charging unit includes a grounded plate 24 and a plurality of spaced wires 25 which are under a high potential with respect to the plate 24. The web is then passed through an exposure unit 27 which includes a light source 29 and an optical system 31. In the exposure unit, the web is exposed to a light image produced through a photographic transparency 33 or by other suitable means. The light image produces a latent electrostatic charge image on the photoconductive surface of the web.

The web is next passed through a developer unit 35 in which electroscopic developer powder is applied to the charge image. It is the developing unit 35 to which this invention is primarily related. The web is next passed through a fusing unit 37 wherein the developer powder is fused to the web to form a permanent visible image.

Referring now, particularly, to Figures 2, 3 and 4 of the accompanying drawings, the developer unit 35 includes an elongated trough comprised of a side wall 39, end walls 41 and 43, and a bottom wall 45. A side wall,

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opposite from the side wall 39, is formed by a cylindrical drum 47. Both the trough and the drum are supported by structural members 48 and 50. The cylindrical surface of the drum is constructed of a non-magnetic material. The end walls of the trough are provided with sealing means at their edges adjacent the drum 47 to prevent the escape of developer mix from the trough. The sealing means is provided in the illustrative embodiment by having the edge of each end wall 41 and 43 contact the web 11 as the latter lies in contact with the drum 47. The bottom wall 45 of the trough extends downwardly adjacent the surface of the drum to form a wall extension 49 substantially parallel with the drum surface. This extension 49 in cooperation with the drum surface provides a very narrow channel 51 through which the web 11 enters the trough.

In order to provide a means for sealing the trough at the channel 51, an elongated magnetic member 53 is secured to the wall extension 49 and extends the entire length of the trough. This member has a U shape cross section and is magnetized to provide a magnet having elongated pole faces. The magnet 53 is mounted so that its magnetic field passes through the wall extension 49, which is constructed of a non-magnetic material, and through the channel 51. A granular magnetic material is introduced into the channel and is held therein by the magnetic field. The magnetic material provides a brush-like seal which prevents the passage of the developer mix from the trough through the channel. While the magnetic material fills the channel, it will be noted that the attractive force of the field for the particles is away from the drum 47, and hence is away from the web which passes adjacent the drum. With this arrangement, there is no magnetic pressure of the magnetic particles against the web to effect the development characteristic of the apparatus.

A cover 55 encloses the top of the trough. The cover 55 is provided with an elongated slot 57 for receiving the discharge end of a hopper 59. The hopper 59 is supported above the developer trough and consists of an elongated trough, having a funnel shaped cross section. The hopper has an elongated narrow discharge spout 61 which extends the length of the hopper and is adapted to discharge the developer powder uniformly over its length into the developer trough. The hopper may be actuated by a vibratory mechanism 63, or by other suitable means, to control the rate of discharge of the developer powder from the hopper.

A mixer 65 is mounted in the lower portion of the developer trough. The mixer consists of a hexagonal shaft 67 disposed longitudinally in the trough and rotatably mounted in the end walls 41 and 43. Six longitudinal vanes 69 are secured to the surfaces of the shaft and extend outwardly from the shaft. The outermost edges of these vanes 69 have a saw-tooth configuration and the saw-teeth of each vane are displaced longitudinally from the teeth of adjacent vanes to produce efficient mixing.

A blender unit, consisting of a pair of conveyor type screws 71 and 73, is mounted above the mixer 65. The conveyor screws 71 and 73 are rotatably mounted in the end walls 41 and 43, adjacent each other with their axes of rotation in a horizontal plane. In operation, the developer trough is filled with developer mix to a level where the top portions of the screws are exposed above the surface. The screws are driven in opposite directions, by means of mating gears 75 and 77 fixed to the screw shafts, to provide a downward movement at the adjacent peripheries of the two screws. With this arrangement, the screws are driven to convey developer mix laterally in opposite directions. The mixer 65 is driven by means of a motor 79 which is mechanically coupled to the mixer shaft 67. Pulleys 81 and 83 are attached, respectively, to the mixer shaft and one of the screw shafts. These pulleys are coupled by a belt 85 which provides the driv-

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ing means for the blender unit. Rotational speed of the mixer 65 with respect to rotational speed of the blender unit may be determined by selecting two pulleys 81 and 83 of desired respective diameters. The spout 61 of the hopper 59 is aligned directly above the conveyor screws 71 and 73 so that the developer powder dispensed from the hopper falls between the conveyor screws.

A paper vibrator 87 consists of an elongated member having a square cross section which is rotatably mounted, by means of shaft extensions, in the structural members 48 and 50. The vibrator 87 is mounted so that the web 11 contacts the vibrator as it passes out of the developer trough. The vibrator is driven, at relatively high speed, by means of a motor 93, and acts to shake from the web spurious particles which may cling to the surface of the web. The trough cover 55 extends upwardly adjacent the point of exit of the web from the developer trough to provide a shield 95 to deflect the free particles back into the trough.

The operation of the apparatus will now be briefly described. The coated web 11 is first threaded through the various units of the system and is directed into engagement with the drum 47 by idler rollers 97 and 99. As the web passes through the developer trough, the photoconductive surface faces away from the drum 47. The trough is filled with a developer mix consisting of electroscopic developer powder particles and granular magnetic carrier particles. The trough is filled to a level near the top of the conveyor screws 71 and 73. For purposes of the present description, the carrier consists of iron particles, such as iron filings. This carrier is chosen for its desirable properties. It will be understood however that any suitable carrier material may be used and that it need not be a magnetic material. The mix is prevented from passing through the entrance channel 51 by means of the magnetic brush seal provided in the channel. The proportions of the mix ingredients are predetermined for best developing efficiency. A supply of developer powder is provided in the hopper 59. The web may be threaded through the trough while it contains the developer mix by taping the leading edge of the web to the drum.

The web 11 is first driven past the charging unit 23 where a uniform electrostatic charge is applied to the photoconductive surface. The web next passes the exposure unit where the charged surface is exposed to a light image to form a latent electrostatic image.

The web next passes through the developer unit 35 wherein the developer powder and magnetic carrier particles are mixed by the mixer 65. Through this mixing, the developer powder particles acquire a charge opposite to that of the charge image and opposite to that of the carrier particles. The mixer continuously provides lateral and vertical mixing to present new developer mix to the surface of the moving web where the developer powder particles are attracted away from the carrier particles to selected areas of the web surface. The hopper 59 is actuated to provide a continuous supply of developer powder to the developer trough to maintain the desired mix proportions. The rate, at which the developer powder is supplied, is maintained equivalent to the average rate at which it is deposited on the web surface. The developer powder is received in the developer trough between the conveyor screws 71 and 73. The action of these screws forces the developer powder downwardly into the main body of the developer mix. This action is significant since the very light developer powder particles would otherwise tend to pile up on top of the more dense carrier particles which constitute a majority of the developer mix. The conveyor screws also tend to distribute the developer powder longitudinally along the length of the trough to compensate for an uneven supply of developer powder by the hopper along the length of the trough. These conveyor screws make possible the supplying of developer powder to the trough at a single point between the conveyor screws rather than along a

line extending the length of the trough since the screws will provide the longitudinal distribution. A further function of the conveyor screws is the conveying of developer mix along the length of the trough to compensate for uneven demand of developer powder by the web along the length of the trough. The action of the conveyor screws in cooperation with the mixer provides for a substantially homogeneous mixture throughout the trough at all times.

As the web passes through the developer trough, certain of the magnetic carrier particles may adhere to the web surface and certain of the developer powder particles may adhere to uncharged portions of the web surface due to physical pressure. As the web passes out of the trough, these particles are freed from the web by the vibrator. This provides a better background characteristic of the finished record. After development, the web passes through the fusing unit 37 wherein the developer powder is permanently fused to the web surface, by means of heating, to provide a permanent visible image and record.

A particular advantage of the developer apparatus described herein is that the web may be passed through the developer unit at a rate faster than any developer units known heretofore. This is possible because of the inherently large supply of developer powder which may be made available for transfer of the web surface. No intricate or rate limiting transfer mechanism is required for presenting developer powder to the web. The apparatus is simple in structure and efficient in operation.

Another advantage of the apparatus described herein is the provision of means for mixing and distributing the developer mix throughout all portions of the trough. By this means, the developer mix is maintained substantially homogeneous throughout the trough and a uniform development of all portions of the web surface is accomplished. A further significant advantage of the apparatus is that, as a result of its inherent structure, the trough may be made as long as desired in order to accommodate a web having any desired width dimension. Regardless of the web width, the entire web surface will be developed uniformly. This feature is significant in permitting the reproduction of large size drawings, for example.

A still further advantage of the apparatus is that the web may be fed through the developer trough without removing the developer mix from the trough. This may be accomplished, for example, by taping the leading edge of the web to the lower surface of the drum and manually rotating the drum to carry the leading edge to the upper surface thereof. The web may then be threaded through the remaining units of the system. This facilitates the setting up of the apparatus for different production runs and the rethreading of the web in the event of web breakage.

What is claimed is:

1. Apparatus for developing a latent electrostatic charge image on a record receiving member, said apparatus comprising a container adapted to hold a quantity of developer powder mix, said container including a rotatable member forming a side wall of said container, said container having a bottom opening, means for guiding and moving said record receiving member along a pathway through said opening in said container contiguous to said rotatable member and extending from the bottom of said container to the top of said container, said rotatable member being adapted to shield one surface of said guided and moved record receiving member from said quantity of developer powder mix, and means disposed adjacent to said opening in said container to provide a seal at said opening capable of being penetrated by said record receiving member and adapted to retain said developer powder mix in said container.

2. Apparatus for developing a latent electrostatic charge image on a record receiving member comprising a container adapted to hold a quantity of developer pow-

der mix, a roller comprising a side wall of said container and defining an edge of a bottom opening in said container, means for guiding and moving said record receiving member along a pathway through said bottom opening in said container and extending contiguous to said roller from the bottom of said container to the top of said container, mechanical means for distributing said developer powder mix over the length of said container, mechanical means for providing vertical and lateral mixing of said developer mix within said container, said developer powder mix including magnetic particles, and magnetic means disposed adjacent to said opening to magnetize and to align said particles whereby to form a magnetic seal of said aligned magnetized particles at said opening.

3. Apparatus for developing a latent electrostatic charge image on a record receiving member comprising a container formed with a slit opening at the bottom thereof for holding a quantity of developer powder mix, said developer powder mix including magnetic particles disposed to contact said record receiving member, a rotatable drum comprising one side wall of said container and defining an edge of said slit opening, means for guiding and moving said record receiving member along a pathway through said slit opening in said container contiguous to said rotatable drum and extending from the bottom of said container to the top of said container, said rotatable drum being adapted to shield one surface of said guided and moved record receiving member from said quantity of developer powder mix, mechanical means for distributing said developer mix over the length of said container, mechanical means for providing vertical and lateral mixing of said developer mix within said container, and means disposed adjacent to said slit opening to provide magnetic lines of force across said slit opening for causing the magnetic particles adjacent to said slit opening to align themselves thereat and to form a brush to provide a seal for said developer powder mix.

4. Apparatus adapted to develop a latent electrostatic charge image on a record, said apparatus comprising a trough for holding a powder mixture of developer particles and magnetic carrier particles, a rotatable drum comprising a side wall of said trough, said trough being formed with a longitudinal opening at its lower surface, said rotatable drum defining an edge of said opening, magnetic means adjacent said opening to form a brush of said magnetic carrier particles across said opening and to seal said opening against the passage of said powder mixture therethrough, means defining a path for said record through said opening from the bottom of said trough to the top of said trough and contiguous to said rotatable drum, mechanical means for mixing said particles in said trough to produce charges of opposite polarity on said developer particles and said carrier particles and to provide vertical and lateral mixing of said particles, and means for providing longitudinal distribution of said mixed particles in said trough.

5. Apparatus adapted to develop a latent electrostatic charge image on a record, said apparatus comprising a trough for containing a mixture of electroscopic developer powder particles and granular carrier particles, a rotatable drum defining one side wall of said trough, said trough having a longitudinal opening at its lower wall contiguous to said drum, means providing a magnetic field in said opening to cause magnetic particles placed in said opening to align themselves across said opening and form a brush adapted to provide a seal at said opening to thereby support said mixture, means defining a path for said record through said opening contiguous to said rotatable drum, means for feeding said record upwardly through said trough, means for maintaining a flow of developer powder into said trough, mechanical means for distributing said developer powder longitudinally of said trough, means adapted for agitating said mixture in said trough to produce triboelectric charges of

opposite polarity on the developer and the carrier and to maintain said mixture substantially homogeneous and vibratory means rotatably mounted to contact said record after it is contacted by said particles to shake spurious particles from the surface of said record.

6. Apparatus adapted to develop a latent electrostatic charge image on a web, said apparatus comprising a trough for containing a mixture of electroscopic developer powder particles and magnetic carrier particles, a rotatable drum defining one side wall of said trough, said trough having a longitudinal opening at its lower wall contiguous to said drum, means providing a magnetic field in said opening to cause the magnetic particles situated in said opening to align themselves across said opening and form a brush adapted to provide a seal at said opening to thereby support said mixture, means defining a path for said web through said opening and contiguous to said rotatable drum, means for feeding said web upwardly through said trough, means for maintaining a flow of developer powder into said trough, mechanical means for distributing said developer powder over the length of said trough, mechanical means for agitating said particles in said trough to produce triboelectric charges on the developer and carrier particles and to maintain a substantially homogeneous mixture of said particles, and vibratory means adapted to contact said web after it is contacted by said particles to free spurious particles from the surface of said web.

7. Apparatus adapted to develop a latent electrostatic charge image on a web, said apparatus comprising a trough for containing a mixture of developer powder particles and magnetic carrier particles, a rotatable drum defining one wall of said trough, said trough having a longitudinal opening at its lower surface extending substantially the length thereof contiguous to said rotatable drum, means providing a magnetic field in said opening

to cause the magnetic particles situated in said opening to align themselves across said opening and form a brush adapted to provide a seal at said opening to thereby support said mixture, means defining a path for said web through said opening and contiguous to said rotatable drum, means for feeding said web upwardly through said trough, said charge image on said web facing inwardly in said trough, hopper means for maintaining a continuous feed of developer powder particles into said trough, screw conveyor means for distributing said developer powder over the length of said trough, a rotating vane mixer comprising a plurality of sawtooth shaped vanes secured to the surface of a shaft, said means used for agitating said particles in said trough to produce triboelectric charges of opposite polarity on the developer powder and magnetic carrier particles and to maintain a substantially homogeneous mixture of said particles, and a vibratory member disposed above said trough to contact said web as it emerges from said trough, said vibratory member being adapted to remove from the surface of said web any spurious particles adhering thereto.

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