

[54] **TONER APPARATUS FOR ELECTROPHOTOGRAPHIC DEVELOPMENT**

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[51] **Int. Cl.²** **G03G 15/10**

[58] **Field of Search**..... **118/637, DIG. 23; 117/37 LE; 355/3 P, 10; 427/15, 16**

[56] **References Cited**

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[57] **ABSTRACT**

An apparatus for the development of latent electrostatic images on dielectric sheeting includes a developing electrode surface for receiving the sheeting. In accordance with this invention, toner fluid is circulated across the electrode surface, typically in a generally unidirectional flowing stream. The sheeting is supported by the stream of toner fluid, whereby the sheeting is spaced from the developing electrode surface in automatic, uniform manner by the stream of toner fluid, for improved toning development of latent electrostatic images. In another aspect of this invention, toner fluid is supplied to flow in a stream across the developing electrode surface through several fluid inlets, including at least one central fluid inlet, and several spaced toner fluid outlets are also provided, so that fresh toner fluid may be continually dispersed in a large area across the developing electrode surface, and spent toner fluid withdrawn, in a staged manner of flow.

14 Claims, 5 Drawing Figures

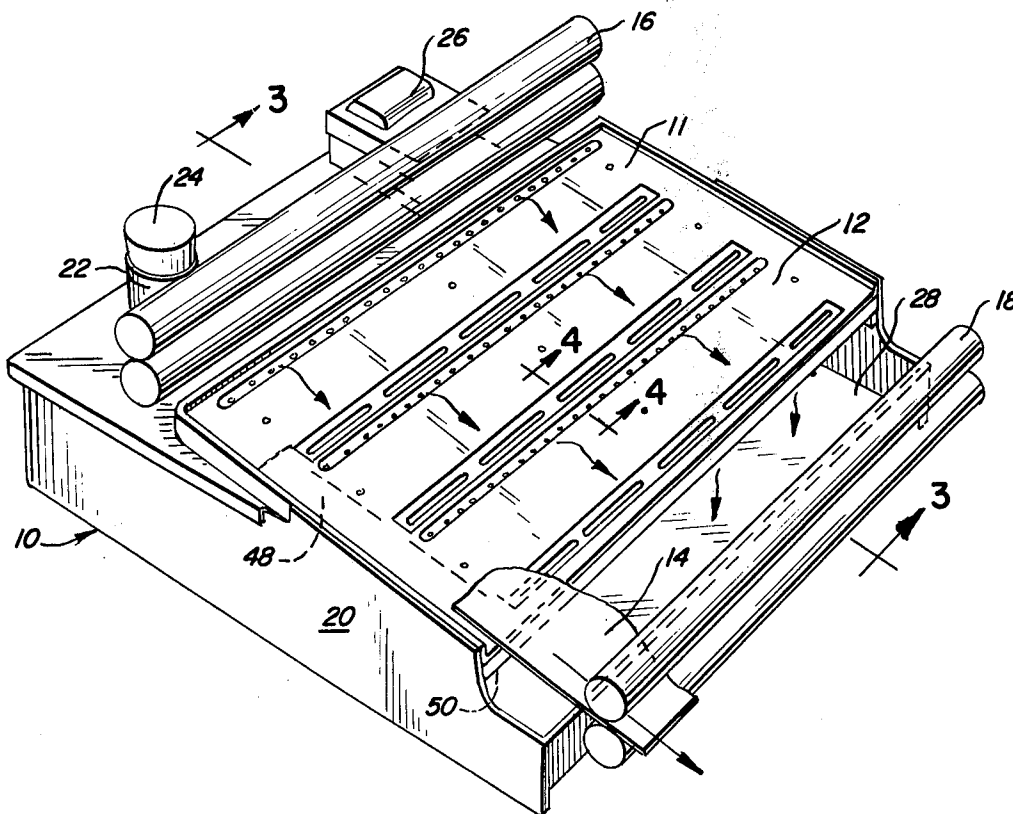


FIG. 1

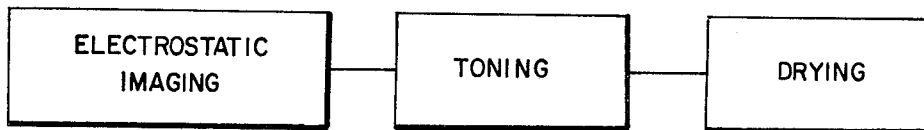


FIG. 2

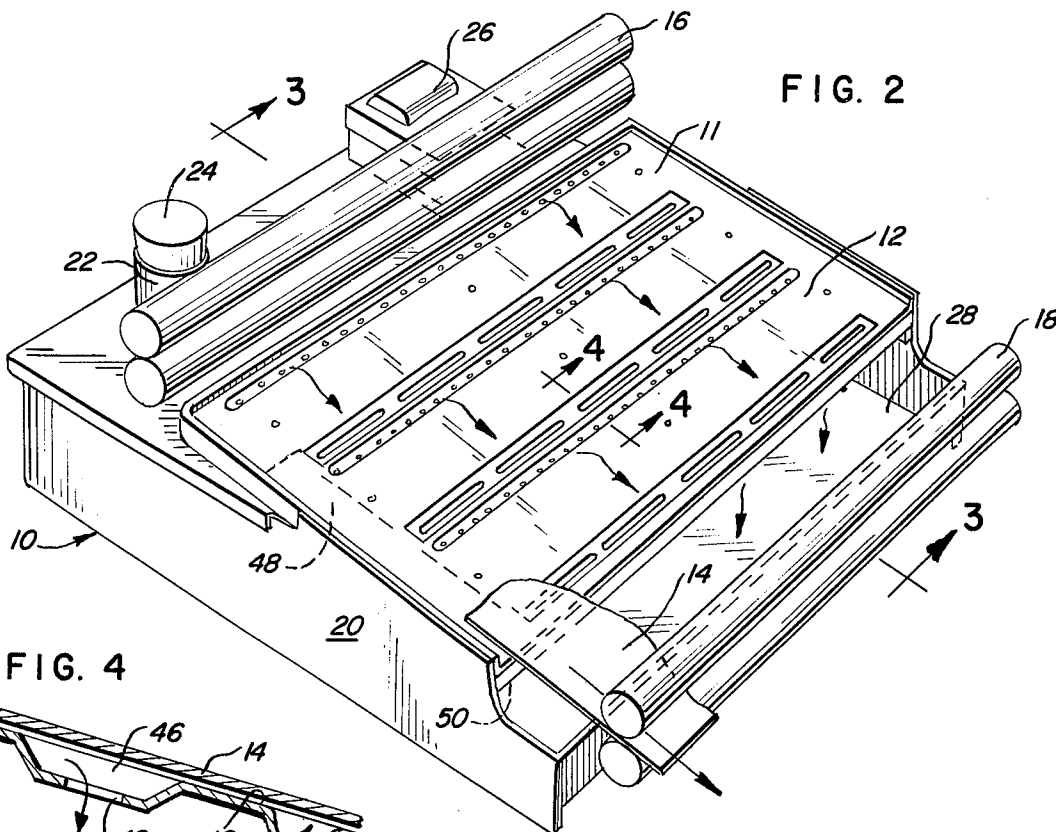


FIG. 4

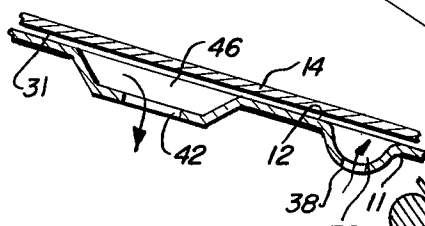


FIG. 3

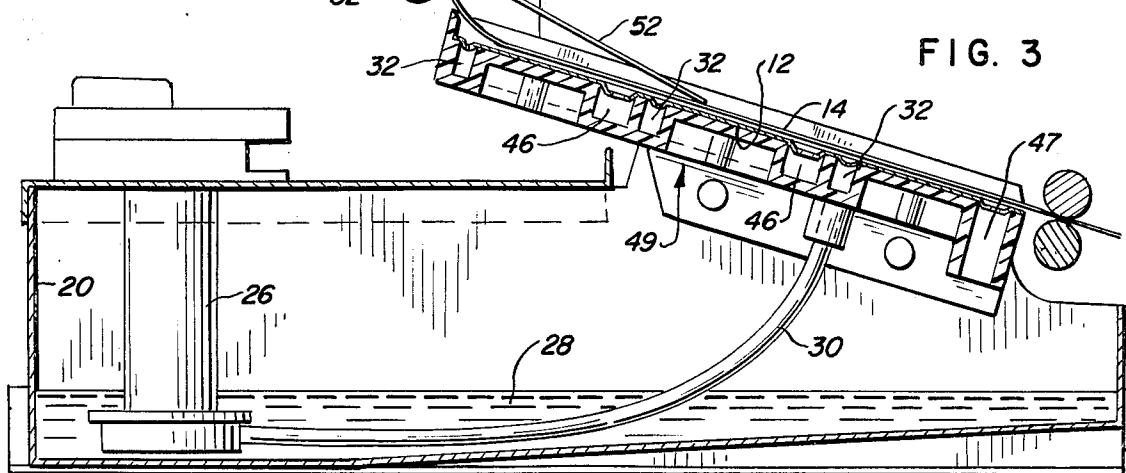
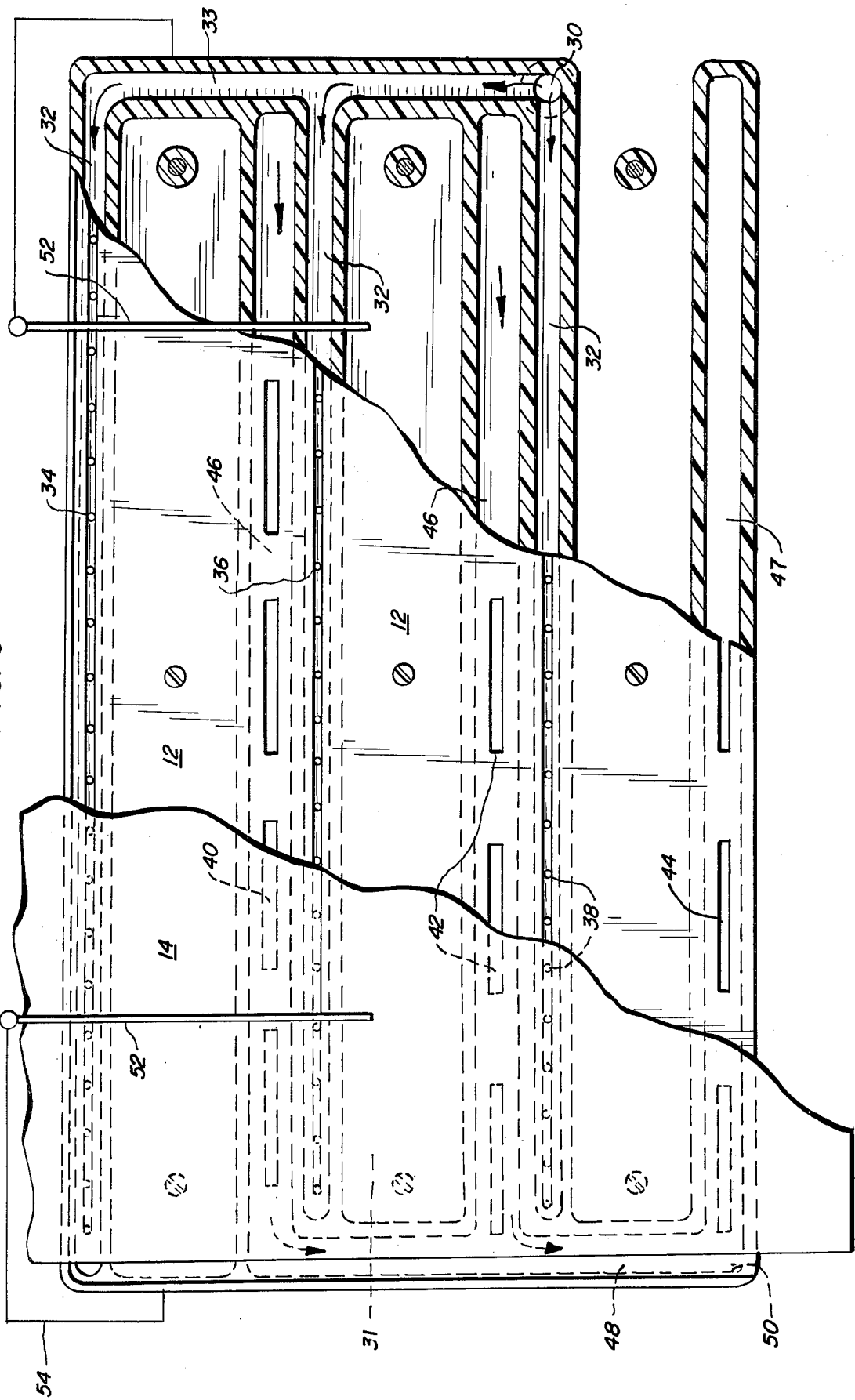


FIG. 5



TONER APPARATUS FOR ELECTROPHOTOGRAPHIC DEVELOPMENT

BACKGROUND OF THE INVENTION

In various well-known Transfer of Electrostatic Image (TESI) processes, and the like, an electrostatic charge pattern corresponding to a desired image is impressed on dielectric sheeting, such as conventional coated paper, in any well-known manner. This electrostatic or latent image is quite stable, and may be retained for a matter of minutes, or even hours or days, but is, of course, invisible to the eye.

Accordingly, in TESI and similar processes, after an electrostatic image has been impressed upon dielectric sheeting, the sheeting is passed through a toner apparatus to cause particles of carbon black or the like to adhere selectively to the areas of electrostatic charge on the dielectric sheeting, without adhering to the electrostatically neutral areas of the sheeting.

A large number of toner device designs for developing latent, electrostatic images exist; a few of these being disclosed in U.S. Pat. Nos. 3,202,526; 3,203,395; 3,627,410; and 3,651,782.

The basic principle involved in many toner apparatus is to place the electrostatically-imaged dielectric sheet in proximity to a developing electrode surface. Simultaneously, toner fluid is circulated across the dielectric sheet, to cause the pigment particles of the fluid to adhere to the electrostatically-charged image areas. Thereafter, the dielectric sheet is dried, to permit a binder agent such as a resin to cause the pigment to permanently adhere to the dielectric sheet.

Significant problems have existed in the prior art, which have restricted the utility of fluid toner devices as a means of developing dielectric sheets having latent electrostatic images. First, during the development process, the electrostatic sheet is desirably precisely and uniformly spaced from the developing electrode, yet with room for toner solution to circulate between the dielectric sheet and the developing electrode surface. Generally, the prior art has not provided a satisfactory solution for accomplishing this.

Also, the toner solution in use is quickly depleted of pigment particles. If the spent toner solution is permitted to continue to circulate in the presence of the electrostatic image on the dielectric sheet, it will begin to wash away pigment particles which have already been deposited on the electrostatic image, resulting in a poor, smeared image on the dielectric sheet.

In accordance with this invention, the above problems are effectively eliminated, resulting in toner apparatus which can reliably provide uniformly-toned electrostatic images, thus providing an effective toner module for a photocopying system using the TESI principle, or other related systems.

DESCRIPTION OF THE INVENTION

In one aspect, the apparatus of this invention utilizes a generally flat developing electrode surface for receiving dielectric sheeting. Typically, the electrode surface acts as a ground in order to intensify the electric field in the toning region. Means are provided for circulating toner fluid across the developing electrode surface in a unidirectional, flowing stream. Means are also provided for laying the sheeting on the flowing stream of toner fluid, so that it in effect floats on the flowing stream. As a result of this, the sheeting is spaced from

the developing electrode surface in automatic, uniform manner by the stream of toner fluid, utilizing the self-regulating thickness of the fluid stream for improved development of latent electrostatic images.

While not wishing to be restricted to any particular theory of operation of this invention, it is believed that the well-known Bernoulli Effect exhibited by flowing streams in enclosed flow conditions is an important principle utilized by this invention. Basically, the Bernoulli Effect is based on the fact that the pressure of an enclosed flowing stream of fluid is inversely related to the velocity of that stream. As a result, referring to the unidirectional flowing stream of toner across the electrode surface, the dynamics of the flowing stream between the electrode surface and the sheeting results in a self-regulating uniformity of fluid stream thickness. Accordingly, the dielectric sheet will be uniformly-spaced from the electrode surface as it floats on the stream of fluid.

In another aspect of this invention, toner fluid staging means are provided, comprising means for simultaneously supplying fresh toner fluid to flow in a stream across the developing electrode surface from several, spaced toner fluid inlets, including at least one central fluid inlet which is spaced from the ends of the electrode surface. Means are also provided for simultaneously withdrawing spent toner fluid from the electrode surface at several, spaced fluid outlets. One of the fluid outlets is positioned adjacent the above central fluid inlet. As a result of this, fresh toner fluid may be continually dispersed in large areas across the electrode surface, for contact with the dielectric sheeting, circulating across the electrode in two or more stages or circulating flow paths. This can be utilized to prevent the smearing problem previously encountered when spent toner fluid is allowed to remain in contact with the dielectric sheeting too long.

Preferably, the developing electrode surface is, as stated above, flat, and, in position of use, defines a small angle to the horizontal plane in a direction to permit a unidirectional stream of toner fluid to flow downwardly at the angle selected. The angle is preferably about 5° to 20° from the horizontal plane. While the electrode surface may be electrically charged in some circumstances, excellent results are achieved with uncharged electrode surfaces that are grounded.

The toner fluid staging means described above preferably defines three or more separate, spaced fluid inlets for supply of fresh toner fluid to the developing electrode surface, and a corresponding number of separate, spaced fluid outlets for spent toner fluid. These are arranged to provide at least three successive, generally separate toner fluid flow paths across the electrode surface, so that the dielectric sheeting is continuously in contact with fresh toner fluid.

Preferably, the stream of toner fluid is pumped across the developing electrode surface in such quantity that the uniform depth of the stream across the developing electrode surface is from about 0.5 to 2 millimeters.

For the developing electrode specifically disclosed in the drawings below, which may be 11 inches wide, and has interconnecting fluid inlets of uniform dimension, to provide an essentially equal flow rate through each of the fluid inlets, a total toner fluid flow rate of about 3,600 ml. per minute has been found to be suitable.

A suitable toner fluid for use with this invention is LP 2770, sold by the GAF Corporation of Wayne, N.J. This toner fluid comprises carbon pigment in a hydro-

carbon solvent and a dissolved resin binder.

Referring to the drawings,

FIG. 1 is a schematic illustration of a basic set of steps involved in the preparation of photocopies from an original or negative transparency by means of a transfer of electrostatic image process or the like.

FIG. 2 is an elevational view of a toner module device incorporating the invention of this application, with some parts removed for clarity.

FIG. 3 is a sectional view taken along Line 3—3 of FIG. 2, showing the relationship of electrostatically-imaged dielectric paper, and showing contact electrode means on the back side of the electrostatically-imaged paper.

FIG. 4 is an enlarged, sectional view taken along Line 4—4 of FIG. 2.

FIG. 5 is an enlarged, plan view, with portions partially broken away, of the developing electrode surface of the toner module of FIG. 2.

Referring to FIG. 1, the series of process steps typically accomplished in transfer of electrostatic image reproduction is shown. An electrostatic image corresponding to a visual image in a transparent negative or the like is prepared by any conventional process involving the transfer of an electrostatic image, typically from a photoconductive electrode across an air gap no larger than several microns to a sheet of paper coated with a dielectric material. Such coated papers are available from the Weyerhaeuser Company as Type M dielectric-coated paper, or may be made in accordance with U.S. Pat. No. 3,519,819.

The coated papers, after receiving an electrostatic image, are toned by being brought into contact with liquid toner in accordance with this invention, and are thereafter sent through a pair of squeegee rollers and briefly heated in a conventional manner to dryness, to produce permanent photocopies of the original transparent negative.

Referring to FIGS. 2 through 5, a toner device 10 of this invention is shown, which may be incorporated as a module into a complete device, which incorporates the electrostatic imaging, toning, and drying functions in a single operation. Toner device 10 comprises a sheet metal member defining a flat, developing electrode surface 12 for receiving paper sheeting 14 having a conventional dielectric surface (a fragment of which is shown in FIG. 2). Sheet 14 may be advanced into proximity with developing electrode surface 12 through a pair of rollers 16, so that sheeting 14 rests above the developing electrode surface 12, being supported by a stream of toner fluid in a manner described below. Sheet 14 then is advanced through a second pair of rollers 18, which may function as squeegee rollers for the drying step, if desired.

Developing electrode surface 12 is flat to facilitate improved uniformity of spacing of sheet 14 from surface 12, for the improved results which may be obtained by this invention. Electrode surface 12 is supported by receptacle 20 at a slight angle of about 5° to 20° from the horizontal (shown in this embodiment to be about 10° to 15°) to facilitate the flow of toner fluid across electrode surface 12.

Receptacle 20 constitutes a fluid tight container for a supply of toner fluid, which may be added or removed through sealable inlet 22, having sealing plug 24.

Fluid pump motor 26 is provided to pump toner fluid 28, which is stored in the bottom of receptacle 20, through conduit 30 to developing electrode surface 12,

where it flows in a broad stream 31 (FIGS. 4 and 5), which is of generally uniform thickness (with the exception of the inlet and outlet areas to be described below), to uniformly support sheet 14 on a uniform, generally unidirectionally flowing stream of toner fluid, for uniform toning of the underside of dielectric sheeting 14.

Referring in particular to FIG. 5, toner fluid inlet conduit 30 may be seen at its position where it joins developing electrode surface 12. Branch inlet channels 32, 33 pass underneath electrode surface 12 for distribution of toner fluid across the surface. Toner fluid enters said surface from channels 32 at three different, spaced zones through a plurality of inlet ports 34, 36, and 38, which pass through sheet metal electrode surface 12. Accordingly, several spaced fluid inlets are provided for supply of fresh toner fluid to the developing electrode surface, to assure a continuing supply of fresh toner solution across the entire electrode surface 12.

Correspondingly, spent toner fluid may be withdrawn through apertures 40, 42, and 44 which provide communication through electrode surface 12 with collection channels 46, 47. Channels 46 in turn communicate with main collecting channel 48, which is open at end 50, and from which toner fluid flows back into receptacle 20. Channel 47 is open at the bottom, so toner fluid falls directly back into receptacle 20.

Inlet channels 32, 33, and collection channels 46, 47 may be defined by an integral plastic member 49, as shown in FIG. 3.

As a result of this arrangement, as dielectric sheeting 14 passes over electrode surface 12, fresh toner fluid pours from inlet ports 34 across electrode surface 12 in a uniform stream, supporting sheeting 14 and uniformly spacing it from surface 12. After moving approximately 1½ inches, in the embodiment shown, most of the toner fluid from inlet ports 34 is collected through collection apertures 40 and recycled in the manner described above.

Similarly, a new supply of fresh toner fluid is provided to surface 12 by inlet ports 36 at a flow rate equal to that of ports 34. This toner fluid also flows across surface 12, and is mostly collected through apertures 42 for recycling.

Likewise, a third supply of fresh toner fluid at a similar flow velocity to the previous supplies is emitted through inlet ports 38, to flow across surface 12 and to be generally collected by apertures 44.

Sufficient toner fluid preferably remains in the vicinity of collection apertures 40, 42 to keep dielectric sheeting spaced from surface 12 in the region between each aperture 40, 42, and its adjacent, downstream inlet ports 36, 38.

The uniformity of flow of toner fluid from inlet ports 34, 36, and 38 is controlled by the fact that the ports are of equal, transverse dimension and are interconnected with common inlet 30. Channels 32 are of sufficiently large transverse dimension so that the flow through all of ports 34, 36, and 38 is generally uniform.

As a result of the above, a staged, generally unidirectional flow of three successive, generally separate toner fluid flow paths is provided across electrode surface 12, beginning at inlet ports 34 and ending at outlet apertures 44, for generally uniformly-spaced support of dielectric sheeting, which preferably moves in the general direction of the toner fluid flow across electrode 12 at a velocity of 2 to 6 inches per second, and at least

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as fast as the velocity of the stream of toner solution, to prevent toner solution from wetting the upper side of the forward edge of the sheeting 14. The triple staged flow arrangement utilized in this invention assures that the dielectric sheeting is continuously exposed to fresh toner fluid, which prevents the wash-out of toned images by prolonged exposure to spent toner fluid.

Similarly, the wide and uniform flow of toner solution carries dielectric sheeting 14 across electrode surface 12 in a manner to generally uniformly space dielectric sheeting 14 from surface 12.

Typically, the flow through inlet 30 and accordingly through inlet apertures 34, 36 and 38 is so adjusted to provide an essentially uniform depth across the developing electrode surface of 0.5 to 2 mm., except, of course, at the various apertures and ports in surface 12. Hence, the spacing between electrode surface 12 and dielectric sheeting 14 is uniform.

Electrically-conductive members 52, which may be spring-biased wires or the like, rest gently against the back side of dielectric sheet 14, i.e., the side of sheet 14 which is not facing electrode surface 12. Member 52 is in electrical communication with electrode surface 12 by means of conductor member 54. It is believed that the providing of this electrical communication between electrode surface 12 and the back of dielectric sheet 14 improves the quality of the toning of the electrostatic image on sheet 14. Spring-biased members 52 may also serve as guides to facilitate the positioning of dielectric sheeting 14 on electrode surface 12.

The above has been offered for illustrative purposes only, and is not intended to define the invention of this application, which is as defined in the claims below.

That which is claimed is:

1. In apparatus for the development of latent electrostatic images on dielectric sheeting, said apparatus having a generally flat developing electrode surface for receiving said sheeting, the improvement comprising:

means for circulating toner fluid across said generally flat developing electrode surface in a generally unidirectional flowing stream of uniform thickness; and means for laying said sheeting on said flowing stream of toner fluid, whereby said sheeting is spaced from said developing electrode surface in automatic, uniform manner by said stream of toner fluid, for improved development of latent electrostatic images, and

toner fluid staging means provided for supplying a flow of fresh toner fluid to a plurality of locations on said developing electrode surface, including at least one location on said developing electrode surface spaced from the edges thereof and at an intermediate point along said path of travel, and means for removing spent toner fluid from said developing electrode surface at a location upstream from said one location at said intermediate point.

2. The apparatus of claim 1 in which said developing electrode surface, in position of use, defines a small angle to the horizontal plane in a direction to permit said stream of toner fluid to flow downwardly at said angle.

3. The apparatus of claim 2 having means for moving said sheeting in a path of travel across said developing electrode member in the general direction of said stream of toner fluid.

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4. The apparatus of claim 3 in which said moving means comprises pairs of cooperating rollers at opposite ends of said developing electrode surface, for moving said dielectric sheeting while also removing excess toner fluid after development.

5. In apparatus for the development of latent electrostatic images on dielectric sheeting having a developing electrode surface, the improvement comprising:

toner fluid staging means, comprising means for simultaneously supplying fresh toner fluid to flow in a stream across said developing electrode surface from a plurality of spaced toner fluid inlets, including at least one central fluid inlet spaced from the edges of said electrode surface; and means for simultaneously withdrawing spent toner fluid from said electrode surface through a corresponding plurality of spaced fluid outlets, one of said fluid outlets being adjacent said central fluid inlet, whereby fresh toner fluid may be continually dispersed in large areas across said surface for contact with said sheeting.

6. The apparatus of claim 5 in which said stream of toner fluid across said electrode surface is generally unidirectional, and said toner fluid withdrawing outlet which is adjacent said central fluid inlet is upstream thereof.

7. The apparatus of claim 6 in which said staging means defines at least three separate, spaced fluid inlets for supply of fresh toner fluid to said developing electrode surface, said means for withdrawing spent toner fluid comprising at least three separate, spaced, fluid outlets, to provide at least three successive, generally separate toner fluid flow paths across said electrode surface.

8. The apparatus of claim 7 in which said developing electrode surface, in position of use, defines a small angle to the horizontal plane in a direction to permit said toner fluid to flow downwardly at said angle.

9. The apparatus of claim 8 having means for moving said sheeting in a path of travel across said developing electrode member in the general direction of said stream of toner fluid.

10. The apparatus of claim 9 in which said moving means comprises pairs of cooperating rollers at opposite ends of said developing electrode surface, for moving said dielectric sheeting while also removing excess toner after development.

11. The apparatus of claim 9 in which said dielectric sheeting lies on said stream of toner fluid, to be uniformly spaced thereby from said developing electrode.

12. The apparatus of claim 11 in which said stream of toner fluid is of an essentially uniform depth across said developing electrode surface of 0.5 to 2 mm., whereby said sheeting is uniformly spaced from said electrode surface by said stream of toner fluid.

13. The apparatus of claim 11 in which electrically conductive means provides electrical communication between said developing electrode surface and the side of said dielectric sheet facing away from electrode surface.

14. The apparatus of claim 11 in which said spaced, fluid inlets are of equal transverse dimension and interconnected, whereby the fluid flow from each of said inlets is essentially equal to the fluid flow of the other inlets.

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