

[54] **ELECTROSTATIC LIQUID DEVELOPING APPARATUS**

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[51] Int. Cl.²..... **G03G 15/10; B05B 1/30**

[58] Field of Search..... **118/429, 637, DIG. 23; 117/37 LE; 355/3 D, 10**

[56] **References Cited**

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Primary Examiner—Mervin Stein

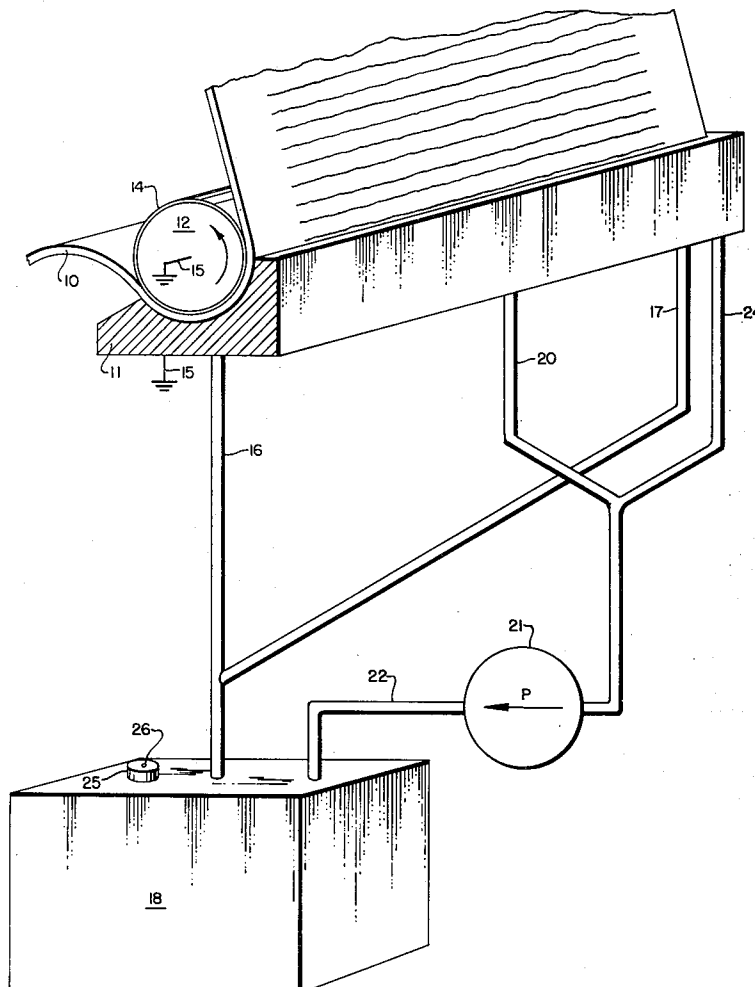
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[57] **ABSTRACT**

Liquid developing apparatus for electrostatic images in which a single compact developing head applies liquid developer to the image face only of an image carrying web and then evacuates remaining liquid, the applying and evacuating being performed through consecutive transverse channels the edges of which are substantially sealed by the image carrying web passing over them.

10 Claims, 5 Drawing Figures



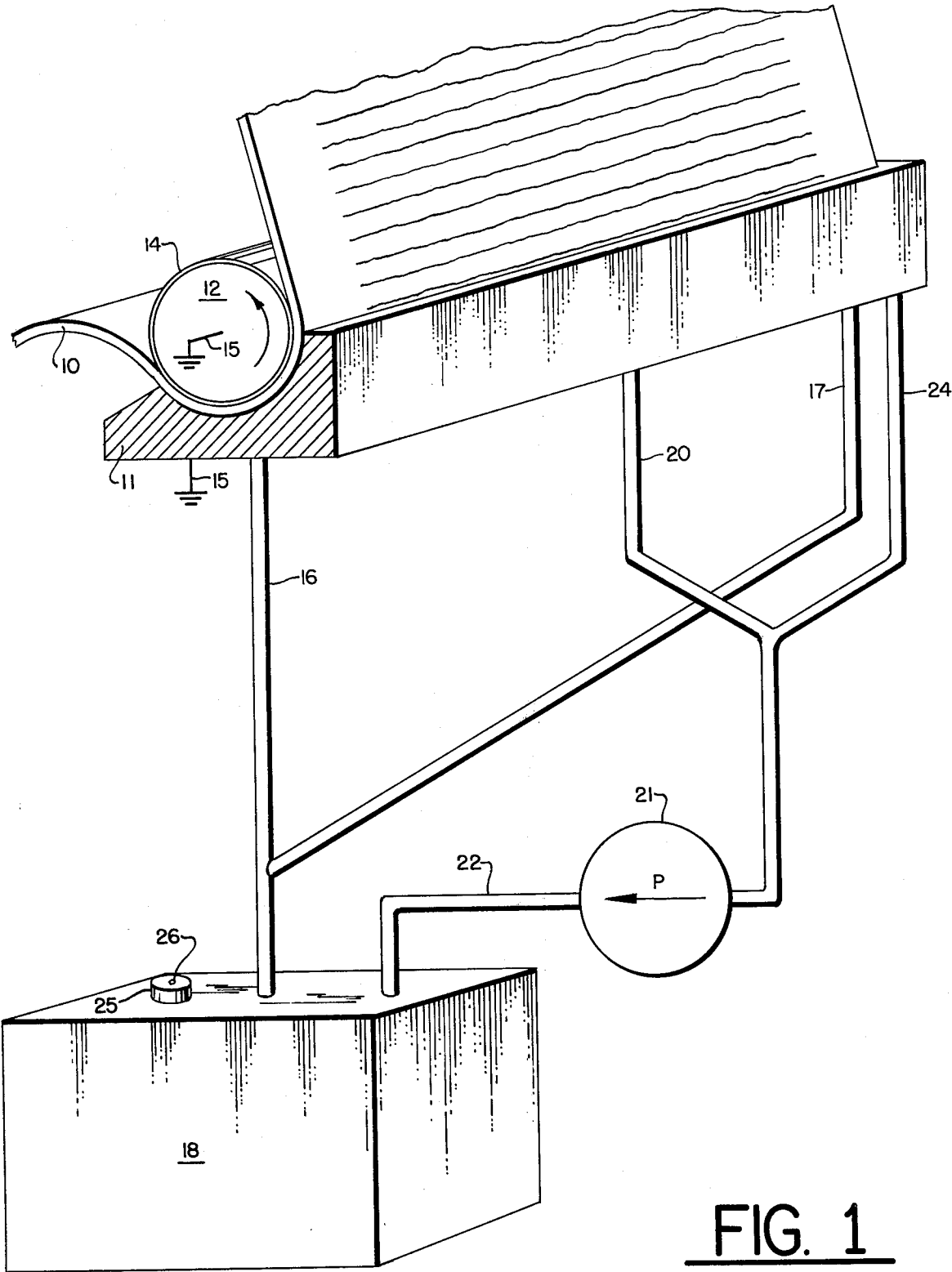


FIG. 1

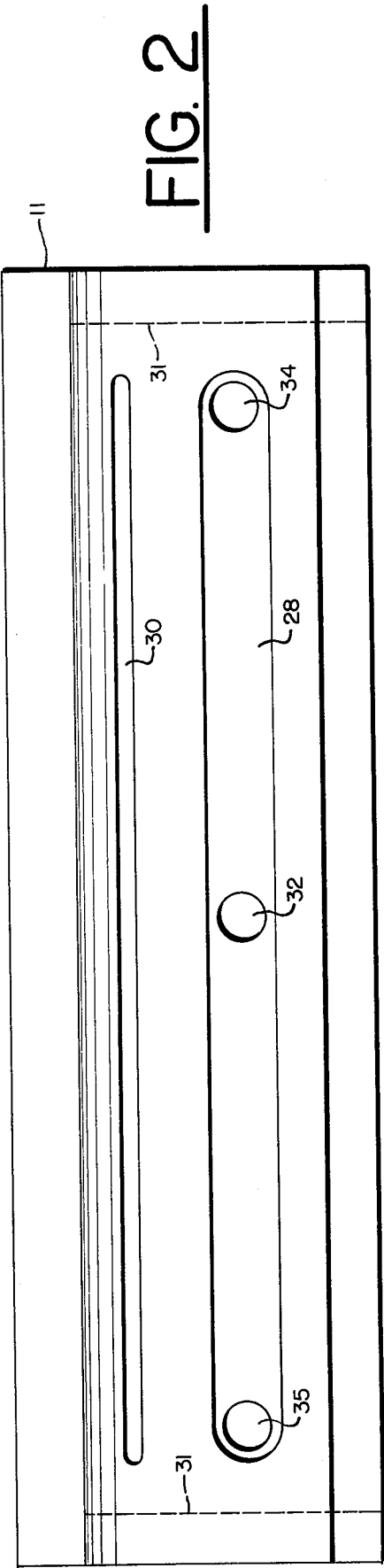


FIG. 2

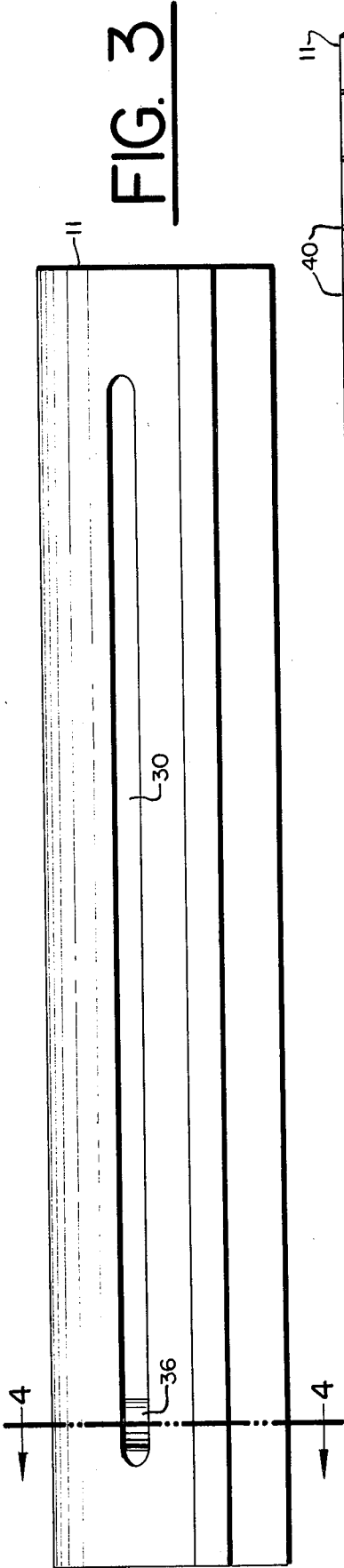


FIG. 3

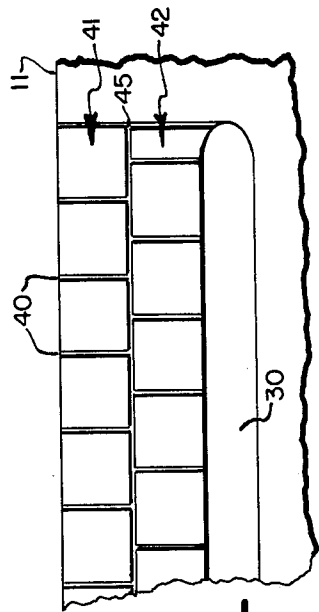


FIG. 5

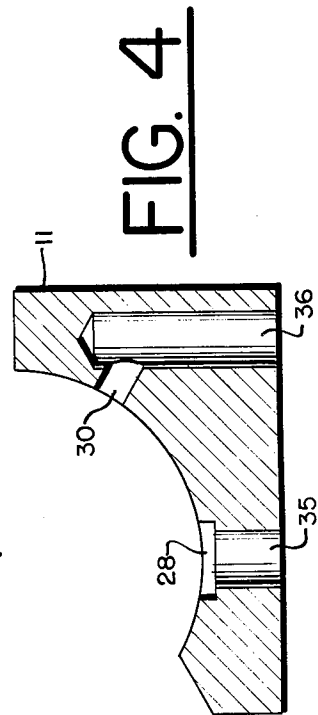


FIG. 4

ELECTROSTATIC LIQUID DEVELOPING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to liquid developing apparatus for electrostatic images and particularly to such apparatus that wets and then dries only the image surface of the image carrying web.

2. Description of the Prior Art

Liquid developing of electrostatic images is common both in electrophotographic reprography and in electrostatic printing. A web, such as paper, with a highly electrically insulating coating is either selectively electrostatically charged or is electrostatically charged and selectively discharged to provide a latent electrostatic image. The web is commonly then passed through an electrically insulating liquid carrying toner particles which are selectively attracted to the image areas. After passing out of the liquid, the web receives some combination of wiping, blowing and heating to remove retained liquid.

The usual apparatus either has a long developing zone or is restricted severely in web speed. Another problem is high consumption of the insulating liquid which at the same time pollutes the surrounding atmosphere.

To overcome these problems, developing electrodes have been used to increase electrostatic field strength and various flow constraints have been imposed on the liquid to speed up development and limit the carrying off of excess liquid. Vacuum pumping has also been applied to pump off excess liquid and return it to the reservoir. These endeavors have commonly led to apparatus of high cost and/or questionable reliability.

SUMMARY OF THE INVENTION

In the present invention a developing and drying head is made in a compact unit which may be a single casting. A driver roller conforming closely to the head drives the image carrying web in sealing contact with consecutive transverse channels cut in the head. A first channel has vacuum and developer connections for pulling developer up from the reservoir and across the web. A later channel has vacuum connections only and is connected by small grooves to the ambient atmosphere so as to draw in air for aiding removal of excess liquid.

Thus it is an object of the invention to provide a novel developer head for liquid development of electrostatic images. It is a further object of the invention to provide a compact developing head that applies developer to one face of an image carrying web through a transverse channel and evacuates excess liquid from a consecutive channel;

Still a further object of the invention lies in a novel configuration of grooves and channels in an electrostatic liquid developing head and the combination therewith of a conforming drive roller to obtain fast and efficient development.

Further objects and features will become apparent upon reading the following description together with the drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic illustration of the inventive developing apparatus;

FIG. 2 is a full scale plan view of a developing head according to the invention;

FIG. 3 is a front elevation of the developing head of FIG. 2;

FIG. 4 is a cross section taken along 4—4 of FIG. 3; and,

FIG. 5 is an enlarged portion of FIG. 3 showing a pattern of minute grooves.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the developing apparatus of the present invention as with many of the prior art devices, the reservoir for the developing fluid and the pump are located separately from the developing station. This arrangement, in the present invention, permits the developing and drying station to be reduced to almost negligible size.

FIG. 1 depicts the inventive developing apparatus diagrammatically. It will be understood that this is only a stage in a more complete system and is preceded by some form of electrostatic printing or imaging means. Thus printing web 10 entering developing head 11 already carries a latent electrostatic image. Drive roller 12 is a cylindrical roller conforming to a concave cylindrical curvature in the upper surface of head 11. Roller 12 is covered with a resilient high friction layer 14 such as rubber or neoprene. Roller 12 is suitably made of metal, such as aluminum or steel, but in any case is either electrically conductive or has an electrically conductive layer, which may be the resilient layer 14 or a layer immediately beneath resilient layer 14. The roller or conductive layer is electrically connected to head 11 as depicted by symbolic ground connections 15. As is known in the art, electrical bias can be applied between the roller and head instead of direct connections in order to improve developing. However, the close proximity of the conductive surfaces provided by the invention provides sufficient electrical field enhancement so that electrical bias has been found necessary.

Roller 12 rests in light contact with head 11 so that it presses web 10 firmly against the head when web 10 is passed between the two. Roller 12 is driven by drive connections (not shown) from the rest of the apparatus.

Head 11 is suitably cast in one piece from brass, aluminum or other metal. It may also be extruded and machined or fashioned in other ways known to the metal working art. Head 11 contains at least two transverse channels in its upper cylindrically curved surface. These channels will be described in more detail below.

The first channel in the direction of web movement is connected at each end by tubes 16 and 17 to a developer reservoir 18.

Third tube 20 provides a vacuum connection to the middle of the channel. Vacuum pump 21 pulls a vacuum on tube 20 which pulls developer from reservoir 18 up through tubes 16 and 17 and along the channel to the connection of tube 20. Pump 21 passes the developer on back to reservoir 18 through tube 22.

A further channel is connected at one end by tube 24 to vacuum pump 21 to pull residual developer liquid from the surface of web 10.

The ends of the channels are sealed by web 10 under pressure from roller 12. The channels are shorter than the web width to permit sealing. Reservoir 18 may be open, but as depicted is enclosed and has fill cap 25 with an integral air vent 26.

While additional channels may be utilized, two are sufficient and a full scale developing head with two channels 28 and 30 is depicted in FIGS. 2-5. Head 11 in FIGS. 2 and 3 is 9 inches long for accommodating a standard 8½ inch paper web. Channels 28 and 30 are each 8½ inch long allowing for a 3/16 inch overlap of the web at each edge for sealing. Dashed lines 31 indicate where the edges of the paper web would lie.

Channel 28 is the first channel and provides the developer liquid to the face of the web. Suction tube 20 (FIG. 1) is connected to central orifice 32 in channel 28 and pulls developer in through end orifices 34 and 35 connected to tubes 16 and 17 respectively. Orifice 35 is depicted in cross section in FIG. 4 and is essentially similar to orifices 32 and 34. Channel 28 is also depicted in cross section at the top of orifice 35 in FIG. 4 and is similar along its entire length.

Due to the curvature of head 11, channel 30 is also visible in plan view FIG. 2. However, the front elevation of FIG. 3 shows channel 30 more clearly. Channel 30 follows channel 28 in the direction of web motion. It is narrower and deeper than channel 28 as can be seen in cross section in FIG. 4. Aperture 36 connects channel 30 to vacuum pump 21 through tube 24. Thus channel 30 pulls a continuous suction against the web.

A direct unrelieved suction will tend to prevent web travel and will serve poorly in removing residual fluid. Dynamic flow conditions function better. Dynamic flow to channel 30 is provided by a network of minute grooves 40 depicted in FIG. 5.

FIG. 5 is depicted at twice scale since grooves 40 are very small. In an exemplary embodiment grooves 40 are each 0.003×0.003 in. in cross section. The number and arrangement is not critical as long as they pass a minute flow of evenly distributed air from the upper edge of head 11 down to channel 30. This has been done satisfactorily by arranging the grooves in two parallel sets 41 and 42. Set 41 has vertical grooves 40 extending through upper surface 44 of head 11 and half the distance to channel 30. Second set 42 has similar vertical grooves offset horizontally to fall half way between grooves 40 of set 41 and extending from the bottom of set 41 through the upper edge of channel 30. Sets 41 and 42 are joined by horizontal groove 45 extending across them halfway between surface 44 of head 11 and the upper edge of channel 30. Grooves 40 have not been illustrated in FIGS. 1-4 since they are too small to show.

While the invention has been described with respect to a specific embodiment, many variations obvious to those skilled in the art are contemplated and it is intended to cover the invention within the full scope of the appended claims.

I claim:

1. Developing apparatus for liquid development of electrostatic images comprising:

- (a) A developing head having a cylindrically curved surface and a transverse channel in said surface for carrying developer fluid;
- (b) a drive roller conforming to said cylindrically curved surface, said roller having an outer resilient frictional layer for driving an electrostatic image carrying web in sealing contact against said chan-

nel; (and, (c) means to draw developing liquid continuously through said channel.)

- (c) a reservoir of developer liquid and means to connect said reservoir to said transverse channel; and,
- (d) suction means connected to said transverse channel for drawing developer liquid from said reservoir through said means to connect and along said transverse channel.

2. Developing apparatus according to claim 1 wherein said suction means are applied to the center of said channel and the ends of said channel are connected to said reservoir of developer liquid whereby said suction means draws said developer liquid through said channel.

3. Developing apparatus according to claim 1 wherein said developing head has at least a second transverse channel connected to suction means for removing residual developer fluid.

4. Developing apparatus according to claim 1 wherein said roller and said head are each electrically conductive and are electrically connected together.

5. Developing apparatus for liquid development of electrostatic images comprising:

- a. A developing head having a cylindrically curved surface, a first transverse channel in said surface for carrying developer fluid, and a second transverse channel in said surface;
- b. a drive roller conforming to said cylindrically curved surface, said roller having an outer resilient frictional layer for driving an electrostatic image carrying web in sealing contact against said first transverse channel;
- c. means to draw developing liquid continuously through said first transverse channel; and,
- d. suction means connected to said second transverse channel for removing residual developer fluid, said second channel being connected by a network of minute grooves in said curved surface to ambient atmosphere so as to provide dynamic flow of air to said second transverse channel.

6. Developing apparatus according to claim 5 wherein said network is comprised of two rows of offset substantially vertical grooves all connected by a single horizontal groove.

7. Developing apparatus according to claim 5 wherein said head is made of a unitary metal element.

8. Developing apparatus according to claim 5 wherein said means to draw developing liquid comprises a reservoir of liquid developer, a suction pump, connections from said reservoir and from said suction pump to said channel for carrying developer, and a connection from the outlet of said suction pump to said reservoir.

9. Developing apparatus according to claim 8 wherein said suction means is said suction pump and further comprising a connection from said second channel to the inlet of said suction pump in common with a connection from said channel for carrying developer.

10. Developing apparatus according to claim 5 wherein said roller and said head are each electrically conductive and are electrically connected together.

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