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FLUID APPLICATOR APPARATUS

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2 Sheets-Sheet 2

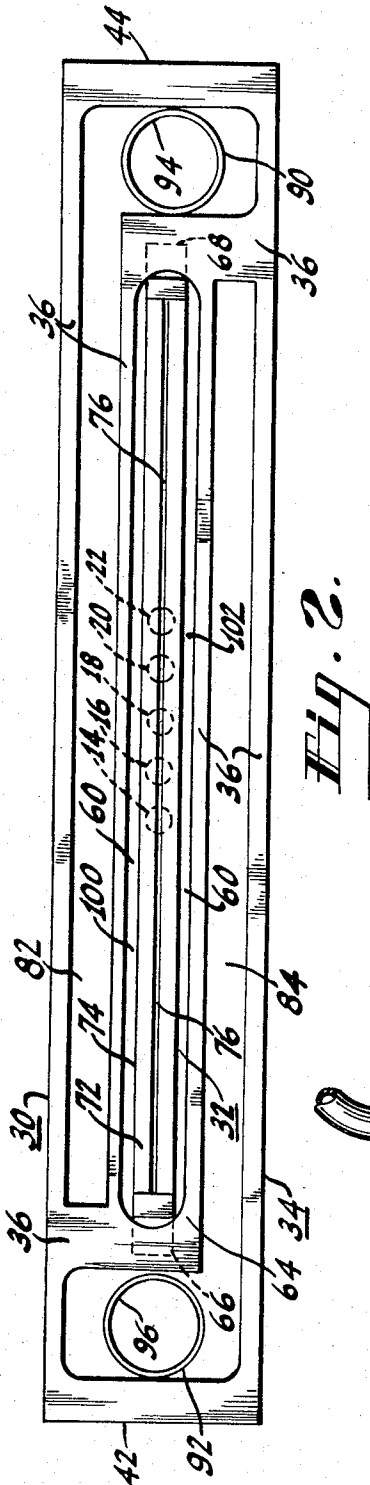


Fig. 2.

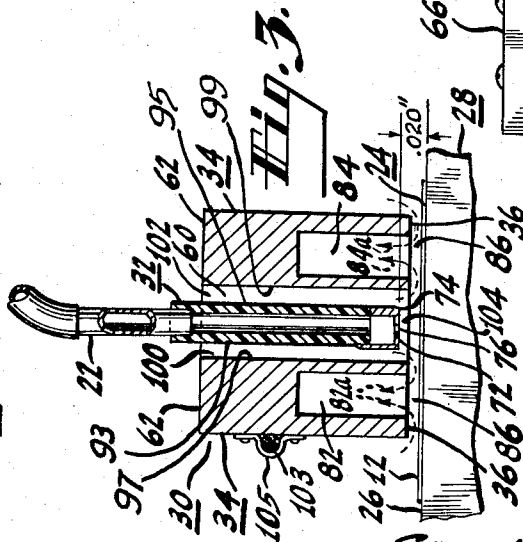


Fig. 3.

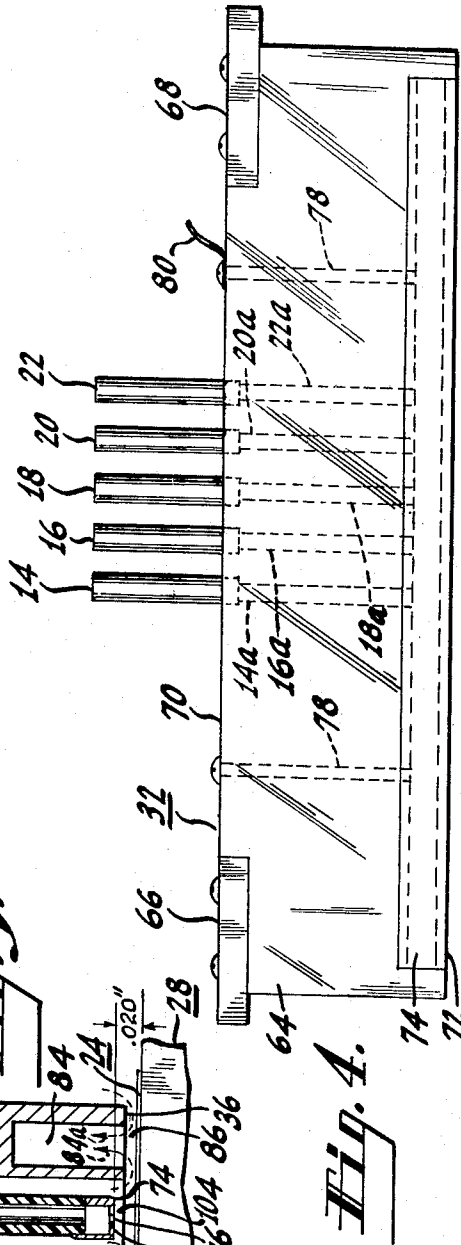


Fig. 4.

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FLUID APPLICATOR APPARATUS

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This invention relates generally to apparatus for applying a fluid to a surface, and more particularly to improved apparatus for rendering visible an electrostatic charge pattern on an insulating surface. The improved apparatus is particularly useful for developing a latent electrostatic charge image on an insulating surface of a recording element with a liquid developer containing electrically charged toner particles.

In the art of electrostatic printing, charge patterns, or latent electrostatic images, are produced on the surface of an insulating material. The charge patterns are rendered visible by applying finely divided, charged toner particles of suitable polarity to them. The charge toner particles are attracted to the insulating surface in substantial configuration with the charge patterns to produce visible images. Several methods of producing a visible image from a latent electrostatic image are described in "Electrofax" Direct Electrostatic Photographic Printing on Paper, by C. J. Young and H. G. Greig, RCA Review, December 1954, volume XV, No. 4.

It has been proposed to develop electrostatic charge patterns with a liquid developer wherein solid, charged toner particles are dispersed in an insulating carrier liquid. Liquid development is usually accomplished by flowing the liquid developer over the surface to be developed or by immersing the surface in a tray filled with liquid developer. Processes of liquid development and suitable liquid developers therefor are described in U.S. Patent 3,053,688, issued Sept. 11, 1962 and U.S. Patent 3,076,722, issued Feb. 5, 1963, both to H. G. Greig.

It has also been proposed to provide apparatus for applying a liquid developer to a surface through an applicator head wherein the liquid developer is circulated through conduits and wherein air from a source of compressed air provides means for supporting the applicator out of contact with the surface. While such a fluid applicator head is suitable for some purposes, the adjustments for the compressed air to provide an air curtain which functions as an air bearing to support the applicator head are very critical, and smearing of the developed image results if the applicator head touches the surface containing the charged pattern. If the air pressure is too high, liquid developer escapes from the applicator head because the applicator head is lifted too high from the image. Furthermore, the latter applicator head may also produce too turbulent a flow of liquid developer, also resulting in a smeared developed image.

Apparatus for applying liquid developer to a surface by means of an applicator head has also been proposed for developing photographic film, but such applicator heads touch the film surface and, while such touching may be tolerated by photographic film, it cannot be tolerated by a charge pattern without either discharging the pattern and/or smearing the developed image.

It is a general object of the present invention to provide improved apparatus for applying a fluid to a surface.

Another object of the present invention is to provide improved apparatus for applying a liquid composition to a surface so that the apparatus does not touch the surface and the liquid composition is preferably applied as a smooth laminar flow, substantially without agitation.

Still another object of the present invention is to provide improved apparatus for applying liquid developer to the surface of a sheet, right side up, without touching or

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moving the sheet, whereby many charged patterns can be produced successively on the sheet in good registration.

A further objective of the present invention is to provide improved apparatus for applying a plurality of liquid compositions simultaneously or successively to a surface, as desirable for making multi-colored prints in the electrostatic printing art.

Still a further objective of the present invention is to provide improved apparatus for applying a liquid to a surface uniformly, employing an applicator head that is relatively leakproof.

Briefly stated, the improved apparatus for applying a liquid to a surface comprises an applicator head adapted to be moved over the surface in a given direction and at a predetermined distance from the surface. The applicator head comprises liquid supply conduit means for bringing the liquid into contact with the surface and liquid removal conduit means spaced, by gas conduit means, from the liquid supply conduit means for conducting excess liquid away from the surface by suction.

In a preferred embodiment of the improved apparatus, the gas conduit means is defined between the liquid supply conduit means and the liquid removal conduit means and is vented to the ambient air. When a source of suction is applied to the liquid removal conduit means, a stream of air is caused to flow from the gas conduit means to the liquid removal conduit means, carrying with it any excess liquid previously applied to the surface. The suction also causes a stream of air to flow from outside the applicator head to the liquid removal conduit means, preventing any liquid from escaping from the applicator head.

The improved apparatus for applying a liquid to a surface will be described in detail with reference to the accompanying drawings, in which:

FIG. 1 is a perspective view of the improved apparatus for applying a liquid to a surface,

FIG. 2 is a bottom view of the lower face of an improved applicator head shown in the apparatus in FIG. 1,

FIG. 3 is an enlarged cross-sectional view of the applicator head taken along the line 3-3 in FIG. 1, and

FIG. 4 is a front elevational view of improved liquid supply conduit means of the applicator head shown in FIG. 1.

The improved apparatus will be described, for illustrative purposes, in connection with an arrangement for applying liquid developers with different pigmented toner particles to charge patterns on an insulating surface in a process of making colored prints by an electrostatic printing process.

Referring now to FIG. 1 of the drawings, there is shown improved apparatus 10 for applying one or more liquids to a surface 12. The surface 12 may be that of a sheet 24 of a recording element of the type used in either the electrostatic printing or the photographic arts. For example, the surface 12 may have a latent electrostatic image thereon to be developed by a liquid developer.

The liquid is applied to the surface 12 by means of an applicator head 30 that is adapted to be moved over the surface 12, at a predetermined distance from it, by motive means including a bead chain 56 in a manner to be explained hereinafter in detail. The sheet 24 is held flat on an upper surface 26 of a base plate 28, as by suction applied to a rectangular groove 29 in the base plate 28, in a manner well known in the photographic printing arts.

The liquid to be applied to the surface 12 may be either a one-phase composition, such as water, or a multi-phase composition, such as a liquid developer comprising finely divided, charged, pigmented toner particles dispersed

in a carrier liquid of the type used in an electrostatic printing process.

Liquids to be applied, successively, simultaneously, or in a desired sequence, to the surface 12 may be, for example, cyan, magenta, yellow, and black liquid developers (toners). These liquid developers are introduced into conduits or tubes 14, 16, 18 and 20, respectively, as by gravity feed, from suitable sources. The source of cyan liquid developer 19, for example, is a vented container 21. Similar containers (shown partially in phantom) are provided for the other liquids. A rinse liquid, such as liquid "Freon TF," for example, is inserted into the tube 22 from a suitable vented source. The liquids are applied to the tubes 14-22 selectively by controlling valves, such as valve 23, for example, in the conduit means connected between the sources of liquid supply and the tubes 14-22.

The applicator head 30, comprising a liquid supply conduit means 32 and a liquid removal conduit means 34, is disposed for movement over the surface 12, always at a predetermined distance from the surface 12. The applicator head 30 comprises an elongated parallelepiped structure having a bottom or lower face 36 adapted to be disposed a distance of about 15 mils from the surface 26 of the base plate 28, that is, a distance of about 10 mils from the surface 12, the thickness of the sheet 24 being about 5 mils. The face 36 is illustrated as planar but it may have any contour to mate with the surface 12 if the surface 12 is other than planar.

Guide means comprising plates 38 and 40 are attached adjustably, as by screw and slot means, to the ends 42 and 44, respectively, of the head 30. A plurality of vertical spacing, front rollers, such as vertical spacing, front rollers 46 and 48 are fixed to the plates 38 and 40, respectively, so that they ride on the surface 26 of the base plate 28. Vertical spacing, rear rollers (not shown) are also attached to the plates 38 and 40 to cooperate with the front rollers 46 and 48 for maintaining the head 30 a predetermined distance from the surface 12 when the head 30 is moved over the surface 12. Horizontal guide rollers are also attached to the plates 38 and 40 to guide the head 30 in its path over the surface 12. To this end, horizontal guide rollers 50 and 52, for example, are attached to the plate 40, by any suitable means, so that they may roll against a vertical surface 54 of the base plate 28. A similar set of horizontal guide rollers (not shown) are connected to the plate 38. A chain 56, such as a bead chain, is connected to the plate 40 and coupled to suitable drive means (not shown) for moving the head 30 reciprocally over the surface 12.

It is also within the contemplation of the invention to move the base plate 28 with respect to the head 30.

Referring now to FIGS. 2, 3, and 4 of the drawings, details of the head 30 are shown. The liquid removal conduit means 34 is formed with a centrally located longitudinal slot 60 which is a through opening that extends from the lower face 36 to an upper face 62 thereof. The liquid supply conduit means 32 is removably disposed within the liquid removal conduit means 34 so that the former can be removed for cleaning purposes, when necessary.

The liquid supply conduit means 32 comprises a rectangular sheet or plate 64 of electrically insulating material, such as "Plexiglas," for example, for the purpose hereinafter appearing. A pair of tabs 66 and 68 are fixed in recessed portions in opposite corners of an upper surface 70 of the plate 64, as by screw means, so that they extend laterally from the plate 64. A metal manifold 74, having a lower surface 72, is fixed to the lower surface of the plate 64. The tabs 66 and 68 serve to position and hold the liquid supply conduit means 32 within the slot 60 so that the lower surface 72 of the manifold 74 of the liquid supply conduit means 32 is a predetermined distance above the surface 12, e.g., a distance of about 15 mils, for applying liquid to the surface 12. When

the liquid supply conduit means 32 is positioned in the slot 60, the lower surfaces of the laterally extending tabs 66 and 68 rest on the upper surface 62 of the liquid removal conduit means 34. Shims may be inserted between the surface 62 and the tabs 66 and 68 for adjusting the lower surface 72 of the manifold 74 with respect to the surface 12, if desired.

The tubes 14-22 of the liquid supply conduit means 32 communicate with the manifold 74 through separate bores 14a-22a formed in the "Plexiglas" plate 64. The lower surface 72 of the manifold 74 is formed with a longitudinal slit 76 therein, as shown in FIG. 3. The slit 76 is about 5 mils wide and extends almost the full length of the slot 60. The cross-sectional area of the slit 76 is relatively small, that is, substantially the same as the cross-sectional area of one of the tubes 14-22, and provides even spreading and proper flow rate of the liquid. Liquid introduced into any of the tubes 14-22 flows through the bores 14a-22a, into the hollow manifold 74, and emerges from the manifold 74 through the slit 76. Thus, the liquid comes in contact with the surface 12. Because of the relatively small width of the slit 76 and because the liquid is gravity fed, the flow of liquid onto the surface 12 is substantially a laminar flow, that is, not agitated.

In the art of electrostatic printing, it is often desirable to bias the toner applicator with a bias voltage of suitable polarity with respect to the conductive support on which the recording element is disposed, in a manner and for a purpose well known in the art. To this end, one or more metal screws 78 (FIG. 4) extend through the insulating plate 64 and contact the metal of the manifold 74. A wire 80 is connected to the screw 78 for applying the aforementioned bias voltage. Such voltage biasing is possible in the improved head 30 because the manifold 74 is electrically insulated from the rest of the apparatus 10 by the electrically insulating plate 64.

Referring now particularly to FIGS. 2 and 3, the liquid removal conduit means 34 comprises two elongated channels 82 and 84 formed therein on opposite sides of the slot 60. The channels 82 and 84 have openings on the lower face 36 and communicate with the space 86 between the surface 12 and the lower face 36. The channel 82 is enlarged adjacent to one end 44 of the head 30, and the channel 84 is enlarged adjacent to the other end 42 of the head 30 to provide means for communicating with a source of reduced gas pressure, that is, suction, for the purpose hereinafter appearing. To this end, openings 90 and 92 are formed in the liquid removal conduit means 34 which communicate with the enlarged portions of the channels 82 and 84, respectively, for receiving flexible exhaust hoses 94 and 96, respectively, therein. The hoses 94 and 96 are connected to a common hose 98 (FIG. 1) for communicating with a source of suction, such as a vacuum pump (not shown).

An important feature of the improved applicator head 30 is its relatively wide slot 60, vented to the ambient gas, that is, the ambient atmosphere (air) in most practical cases, to provide a substantially constant (atmospheric) pressure adjacent the openings of the channels 82 and 84. This results from the fact that the opposed major surfaces 93 and 95 of the liquid supply conduit means 32 are spaced from the opposed major surfaces 97 and 99, respectively, that define the slot 60 so that the liquid supply means 32 displaces only about one-half, or less, of the volume of gas (air) in the slot 60. Thus, the liquid removal conduit means 34 is separated from the liquid supply conduit means 32 by conduit means filled with a gas of substantially constant pressure, viz atmospheric, the slot 60 being vented to the ambient atmosphere. The spaces between the liquid removal conduit means 34 and the liquid supply conduit means 32 actually constitute two channels 100 and 102 (FIG. 3) that are vented to the gas of the ambient atmosphere to supply a substantially constant (atmospheric) gas pressure adjacent the openings

of the channels 82 and 84 for the purpose hereinafter appearing.

An electric heater 103, in the form of a rod, is attached to the applicator head 30, as by brackets 105, to warm the head 30 electrically, if necessary. The heater 103 tends to prevent excessive moisture condensation during operation of the head 30 caused by cooling due to reduced gas pressures within the channels 82 and 84.

The operation of the improved apparatus 10 for applying a liquid to the surface 12 will now be explained. Let it be assumed that an electrostatic charge pattern has been applied to the surface 12, by any suitable means known in the art, and that it is desired to apply the cyan liquid developer 19 to the surface 12 to render the charge pattern visible. A source of suction, such as a vacuum pump, is connected to the hose 98 to create a strong suction therein, that is, a gas flow velocity of about 3500 feet per minute, equivalent to a vacuum of about 2 feet of water, and to provide a reduced gas (air) pressure within the channels 82 and 84. The cyan liquid developer 19, hereinafter called the liquid, is caused to flow into the manifold 74, through the tube 14 and the bore 14a, by opening the valve 23. The liquid emerges from the manifold 74 through the slit 76 and into the space 104 between the surface 12 and the lower surface 72 of the manifold 74. The liquid emerges slowly in a laminar flow under the aforementioned conditions.

While the liquid is flowing onto the surface 12, the head 30 is caused to move in one direction over the surface 12 by a motor (not shown) connected to the bead chain 56. Most of the pressure causing the liquid to flow through the manifold 74 is produced by the head of the liquid above the slit 76, i.e., by gravity flow, and the liquid flows through the slit 76 and toward both sides of the manifold 74. Since the gas pressure within the channels 82 and 84 has been reduced below that of the ambient gas (atmosphere), the ambient gas on both sides of the channels 82 and 84 is constantly sucked into the channels 82 and 84, in the directions indicated by the dashed arrows 82a and 84a, respectively, entraining any excess liquid deposited on the surface 12 with it. The ambient gas sucked into the channels 82 and 84 from outside of the head 30 prevents any liquid from leaking beyond the head 30, i.e. confines liquid dispersed through the slit 76 to the area underneath the head 30. The liquid sucked into the channels 82 and 84 may be recovered, if so desired, by connecting a trap in the hose 98 in a manner well known in the art.

If excessive moisture condensation tends to form about the channels 82 and 84 during the operation of the applicator head 30, the electric heater 103 may be connected to a suitable source of voltage to heat the head 30 and thereby rectify this condition. The amount of moisture condensing on the head 30 is a function of the volatility of the liquid applied to the surface 12.

Thus, there has been described improved apparatus for applying a liquid to a surface and for removing excess liquid from the surface. One or more liquids may be applied to the surface either sequentially or simultaneously, and the liquid supply conduit means may have as many tubes leading into its manifold as is desired. Since the cross-sectional area of the slit in the manifold is relatively small, being substantially the same as the cross-sectional area of each of the conduits leading into the liquid supply conduit means, no liquid flows in a conduit if the valve between the liquid supply and the tube is closed. Hence, the applicator head 30 is substantially leakproof and economical of liquid. Also, since the applicator head never touches the surface to which the liquid is applied and since the liquid is applied to the surface in a laminar flow, developed images on the surface are not smeared.

What is claimed is:

1. Liquid applicator apparatus for applying liquid to a

surface and adapted for movement in a given direction over said surface, said apparatus comprising

an applicator head having three adjacent conduit means each having an opening at a surface of said head and disposed along said given direction of movement, the leading one of said conduit means constituting liquid supply conduit means, the intermediate one of said conduit means constituting gas conduit means communicating with the gas of the ambient atmosphere, the trailing one of said conduit means constituting liquid removal conduit means, means for feeding liquid to said liquid supply conduit means, and

means for applying suction to said liquid removal conduit means, whereby said liquid is deposited from said liquid supply conduit means onto said surface and then sucked up into said liquid removal conduit means by entrainment in an exhausting gas flow along said surface from said intermediate gas conduit means to said liquid removal conduit means.

2. Liquid applicator apparatus as defined in claim 1 comprising, in addition:

means for spacing said head at a predetermined distance above said surface to which said liquid is applied, and said face of said head having a contour that mates with that of said surface.

3. Liquid applicator apparatus as defined in claim 2, wherein said applicator head has two additional conduit means each having an opening at said surface of said head and disposed in said line along said given direction of movement,

one of said additional conduit means comprising a second gas conduit means communicating with said gas in the ambient atmosphere and disposed in front of said liquid supply conduit means, and

the other of said additional conduit means comprising a second liquid removal conduit means, having means to apply said suction thereto, and disposed in front of said second gas conduit means.

4. Apparatus adapted for relative motion with respect to a surface for applying a liquid to said surface, said apparatus comprising:

an applicator head having liquid supply conduit means for bringing said liquid into contact with said surface, gas conduit means vented to the gas of the atmosphere, liquid removal conduit means, spaced by said gas conduit means from said liquid supply conduit means, for conducting excess liquid away from said surface, and

means cooperatively associated with said head to maintain said head a predetermined fixed distance from said surface with said relative motion between said surface and said head, said liquid removal conduit means comprising means to communicate with means for reducing the gas pressure within said liquid removal conduit means below that of said atmosphere, whereby said gas from said atmosphere flows into said liquid removal conduit means, carrying said excess liquid with it.

5. Apparatus for applying a liquid to a surface as defined in claim 4, wherein said liquid supply conduit means is removably attached to said liquid removal conduit means, whereby said liquid supply conduit means may be removed from said liquid removal conduit means for cleaning purposes.

6. Apparatus for applying a liquid to a surface as defined in claim 5, wherein said liquid supply conduit means comprises an electrically conductive manifold fixed to an electrically insulating member, said manifold being electrically insulated from said liquid removal conduit means when said liquid supply conduit means is attached to said liquid removal conduit means.

7. Apparatus for applying a liquid to a surface as defined in claim 4, wherein said liquid supply conduit means

comprises an elongated manifold formed with an elongated slit adjacent said surface, at least one conduit communicates with said manifold for introducing liquid thereto, and said liquid removal conduit means is formed with two channels adjacent two opposite sides, respectively, of said elongated manifold, each said two channels having openings adjacent said surface.

8. Apparatus for applying a liquid to a surface, said apparatus comprising:

an applicator head having a lower face spaced from said surface and a contour to mate substantially with said surface,

first conduit means having a first opening into the space between said lower face and said surface for applying said liquid thereto,

second conduit means having a second opening, into said space, which is spaced from said first opening of said first conduit means,

means for maintaining a reduced gas pressure within said second conduit means to draw liquid applied to said surface thereinto, and

third conduit means, defined between said first and said second conduit means, having a third opening, into said space, between said first and said second openings, said third conduit means communicating with the gas of the ambient atmosphere, said atmosphere having a substantially constant pressure which is greater than that of said reduced gas pressure, whereby to provide a flow of gas to aid in moving said liquid from said surface into said second conduit means.

9. Apparatus for applying a liquid to a surface as defined in claim 8, wherein said applicator head is an elongated structure, has an upper face, and is formed with an elongated slot extending between said upper and lower faces, said first conduit means has opposed major surfaces which are spaced from major surfaces that defined said slot, and said first conduit means is removably attached to said second conduit means.

10. Apparatus for applying a liquid to a surface as defined in claim 9, wherein said first conduit means comprises an electrically conductive manifold, said first opening is formed in said manifold, and said first conduit comprises means electrically insulating said manifold from said second conduit means when said first conduit means is attached to said second conduit means.

11. Apparatus for applying a liquid to a surface as defined in claim 8, wherein said applicator head is an elongated structure adapted to be moved over said surface, said applicator head has a pair of ends and guide means cooperatively associated with each of said ends for maintaining said lower face of said applicator head a predetermined distance from said surface with relative movement between said applicator head and said surface.

12. An applicator head for applying a liquid to a surface comprising:

liquid supply conduit means for bringing said liquid into contact with said surface,

liquid removal conduit means for removing excess liquid from said surface comprising an elongated body having upper and lower faces and an elongated slot extending between said upper and lower faces,

said liquid supply conduit means comprising a manifold formed with an elongated slit therein,

means positioning said liquid supply conduit means within said slot in a removably attached relationship to said liquid removal conduit means,

two channels formed in said liquid removal conduit

means each opening on said lower face and each on a different side of said slot, and

said liquid supply conduit means having a pair of opposed major surfaces spaced from said liquid removal conduit means and defining gas conduit means therewith, said gas conduit means communicating with the ambient gas.

13. An applicator head as defined in claim 12, wherein said elongated body of said liquid removal conduit means comprises a pair of ends, and means are cooperatively associated with said ends to maintain said applicator head a predetermined distance from said surface and to provide relative motion between said applicator head and said surface.

14. An applicator head as defined in claim 12, wherein said liquid removal means is formed with a pair of openings each communicating with a different one of said two channels, whereby to apply a source of suction to each of said two channels.

15. An applicator head as defined in claim 14, wherein said liquid supply conduit means comprises a plurality of tubes communicating with said manifold for introducing said liquid therein, and the cross-sectional area of said slit is substantially equal to that of each of said tubes.

16. Apparatus for developing a latent image on a sheet with a liquid developer, said apparatus comprising

a plate for supporting said sheet,

an applicator head comprising liquid removal conduit means having a lower face positioned above said plate,

means for providing relative motion between said head and said sheet while maintaining said head at a predetermined distance from said sheet,

said liquid removal conduit means having an upper face and an elongated slot extending between said upper and lower faces and communicating with the ambient air,

said head comprising liquid supply conduit means disposed within said slot, having a pair of opposed major surfaces spaced from surfaces forming said slot and defining gas conduit means vented to said ambient air, and being removably attached to said liquid removal conduit means, said liquid supply conduit means also comprising means to apply said liquid developer to said sheet,

said liquid removal conduit means being formed with two channels each on an opposite side of said slot and each opening on said lower face, and

means communicating with said channels to apply a lower gas pressure thereto than the pressure of said ambient air, whereby to provide a flow of gas so that excess liquid developer deposited on said sheet may be removed through said channels.

17. Apparatus for developing a latent image on a sheet with a liquid developer as defined in claim 16, wherein heating means are cooperatively associated with said applicator head to heat said applicator head, whereby to prevent excessive moisture condensation at said applicator head.

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