July 27, 1965 G. K. ZIN 3,196,832

FLUID APPLICATOR APPARATUS

Filed Feb. 20, 1963

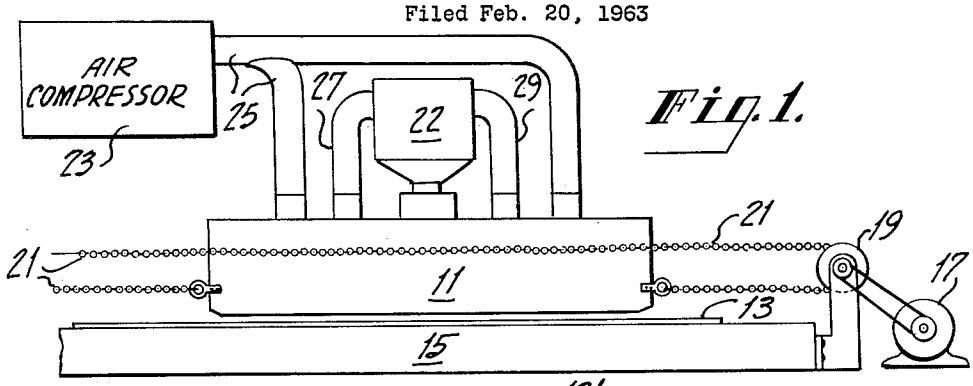


Fig. 1.

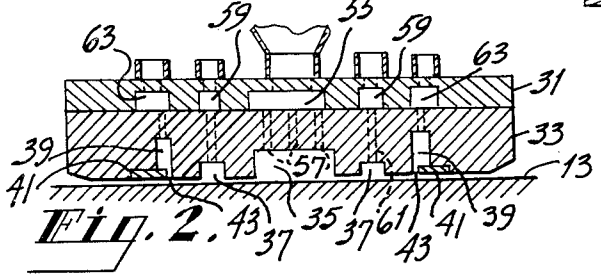


Fig. 2.

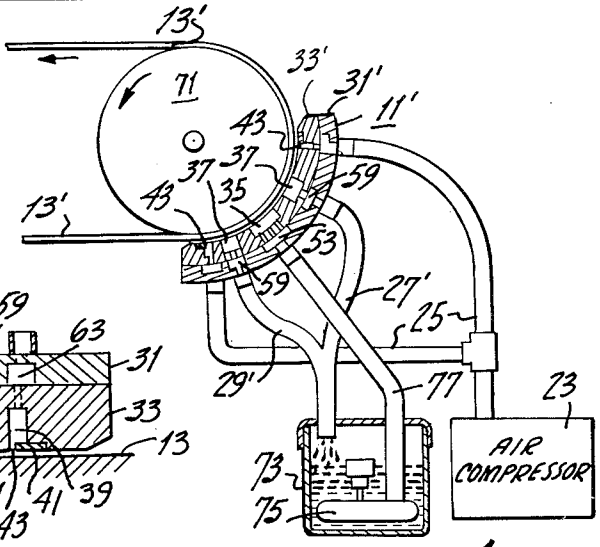


Fig. 4.

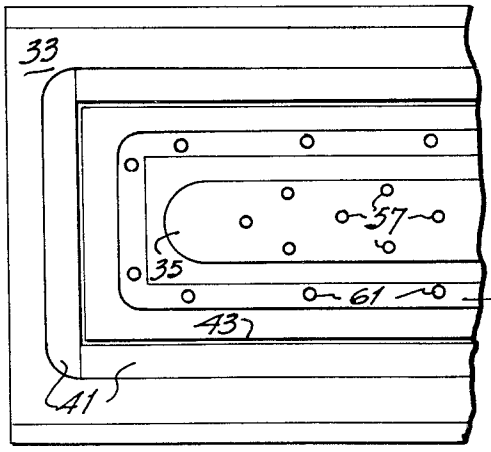


Fig. 3.

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FLUID APPLICATOR APPARATUS

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15 Claims. (Cl. 118—637)

This invention relates to apparatus for applying a fluid or fluid-like composition to a surface and more specifically to improved apparatus for developing electrostatic images on an insulating surface with a liquid developer composition.

In the art of electrostatic printing, electrostatic images are produced on the surface of an insulating material. Such images comprise a pattern of electrostatic charges on the surface. Visible images are commonly produced therefrom by applying to the surface finely-divided developer particles. The developer particles deposit on the surface in substantial configuration with the charge pattern to produce a visible image. Several methods of producing visible images are described in "Electrofax" Direct Electrophotographic Printing on Paper by C. J. Young and H. G. Greig, RCA Review, December 1954, vol. XV, No. 4.

A liquid developing process for electrostatic printing has been proposed in which solid developer particles are dispersed in an insulating carrier liquid. Liquid development provides many advantages over the use of dry developer mixtures and over other methods for some applications. Liquid development can be accomplished by flowing the developer composition over the surface to be developed or by immersing that surface in a tray of liquid developer. The developer may also be sprayed or rolled onto the surface. Liquid development and suitable compositions therefor are described in U.S. Patent 3,053,688 issued September 11, 1962 and U.S. Patent 3,076,722 issued February 5, 1963, both to Harold G. Greig.

Generally speaking, high developing speeds and high image contrast can best be achieved by using a roller to carry liquid developer over an electrostatic image bearing surface rather than by using the liquid spray, liquid flow, or immersion techniques mentioned above. Roller techniques, however, require that considerable care be exercised to avoid or reduce smearing of an image and to avoid or reduce offset printing of ghost images carried on the roller as it rolls over the surface being developed.

Accordingly it is a general object of this invention to provide improved apparatus for applying fluid compositions to surfaces.

Another object is to provide improved apparatus for developing electrostatic images with a fluid developer composition.

Yet another object of this invention is to provide improved apparatus for developing electrostatic images with liquid developer compositions so designed as to eliminate contact between the apparatus and the image bearing surface to thereby obviate or reduce image smearing and the off-setting of ghost images.

These and other objects and advantages are achieved by the improved apparatus of this invention which includes a conduit means or manifold for applying fluid composition to a surface, at least one conduit means or manifold for conducting the fluid composition away from the surface, and, surrounding these conduit means, additional conduit means or manifold for creating an air curtain between the apparatus and the surface to prevent escape of the fluid composition.

In a preferred embodiment, especially suitable for developing electrostatic images on an insulating surface, the surface to be developed is held on a suitable support and an applicator head is positioned adjacent to and closely spaced from the insulating surface. Means are provided

for moving the applicator head over the insulating surface while the surface is stationary or, in the alternative, means are provided for moving the insulating surface while the applicator head is stationary. Liquid developer composition is applied to the insulating surface through at least one first channel in the base of the applicator structure. Developer composition is carried away from the insulating surface through one or more parallel channels in the applicator base or through a pair of such channels, one on either side of the first channel. Developer composition is confined to the space between the applicator head and the insulating surface in the vicinity of the above mentioned channels by means of a gas or air curtain. This air curtain or barrier is created by forcing compressed air through a slot or a series of small holes surrounding the channels. This air curtain may have only the function of containing the developer composition in which case means are provided for spacing the applicator head from the insulating surface. In the alternative, the air curtain may also function as an air bearing between the applicator head and the insulating surface to maintain a proper spacing therebetween.

Other objects and advantages are included in the following detailed description which refers to the accompanying drawings wherein:

FIG. 1 is an end view in elevation of improved apparatus in accordance with this invention;

FIG. 2 is a sectional view through the center of an applicator head as in FIG. 1;

FIG. 3 is a bottom view of the applicator head of FIG. 2;

FIG. 4 is a cross-section, partly schematic of an alternative design of the apparatus shown in FIG. 1.

Similar reference characters are applied to similar elements throughout the drawings.

FIGURE 1 illustrates the general structure of an improved developer apparatus made in accordance with this invention. The apparatus includes an applicator head **11** adapted to move laterally over a sheet **13** of electrophotographic paper resting on a metal support **15**. Movement of the applicator head **11** is provided for by a reversible motor **17** coupled to a pulley **19** which in turn is coupled to the applicator head **11** by a bead chain **21**. A compressor **23** supplies air to the applicator head through flexible tubes **25** to provide an air curtain or barrier between the base of the applicator head **11** and the paper sheet **13** as will be described hereinafter. Mounted on the applicator head **11** is a funnel **22** adapted to contain a supply of liquid developer composition. Ducts **27** and **29** communicate between the interior of the applicator head **11** and the upper portion of the funnel **22** to return excess developer to the funnel as will also be described later.

The applicator head **11** is shown in greater detail in FIGURES 2 and 3. To facilitate fabrication, the applicator head is constructed of an upper plate **31** and a lower plate **33**. In the bottom of the lower plate **33** there is a central channel **35** through which liquid developer composition is brought into contact with the paper sheet **13**. A rectangular channel **37** surrounds the central channel **35** and provides a return path for developer composition after it has contacted the paper sheet **13**. Outwardly of this rectangular channel a rectangular groove **39** is cut in the bottoms of the lower plate **33**. This groove **39** is partly closed at its lower end by means of a baffle plate **41** to provide a narrow rectangular slot **43** through which air can be ejected to impinge upon the surface of the paper sheet **13**.

The upper plate **31** is correspondingly provided with channels in its lower portion. When the upper and lower plates are assembled, a central channel **55** in the upper

plate 31 forms a chamber communicating with the central channel 35 in the lower plate 33 through a series of holes 57 in the lower plate. A rectangular channel 59 in the upper plate 31 communicates with the rectangular channel 57 through a series of holes 61 in the lower plate 33. Another rectangular channel 63 in the upper plate 31 communicates with the rectangular groove 39 in the lower plate 33 through a like series of holes in the lower plate 33.

To develop an electrostatic image on the paper sheet 13, air, from the compressor 23, FIGURE 1, is forced into the outer rectangular channel 63 in the upper plate at approximately 5 to 20 pounds per square inch. The air passes through the rectangular groove 39 and slot 43 in the lower plate 33. The force of the air coming out of the slot 43 and impinging on the paper sheet 13 couses the entire applicator head 11 to rise and maintain between its bottom surface and the paper sheet 13 a spacing of about .0005 inch.

As the applicator head 11 is moved over the paper sheet 13, as shown in FIGURE 1, liquid developer is supplied to the funnel 22. This developer passes through the central channels 55 and 35 in the upper and lower plates 31 and 33 (shown in FIGURE 2) and contacts the paper sheet 13. The liquid developer spreads over the paper sheet 13 into areas which underlie the rectangular channel 37 in the lower plate 33. The effect of movement of the applicator head 11 is to create a moving volume of liquid developer traversing the paper sheet 13. Developer particles are electrostatically extracted from the liquid developer by the electrostatic charges on the paper sheet 13 and adhere thereto to form a visible developed image. A thin film of carrier liquid also adheres to the paper sheet. Air ejected through the rectangular slot 43 in the lower plate 33 forcibly impinges on the paper sheet 13 to form a rectangular air curtain. This air curtain functions as an air bearing on which the applicator head 11 is supported and also provides two other important functions. The first of these two other functions is to form an air curtain or barrier confining liquid developer to the area or zone on the paper sheet 13 being developed, the area underlying the central channel 35 and the rectangular channel 37. In practice, it has been found that little or no liquid developer escapes through the air curtain. An additional function of the air curtain is to remove developer composition from the paper sheet 13 after development. Air, which impinges upon the paper sheet 13, escapes not only around the outer periphery of the bottom plate 33 but also into the rectangular channel 37. Air escaping into the rectangular channel 37 picks up excess liquid developer from the paper sheet 13. This excess liquid developer is carried upwardly through the rectangular channels 37 and 59 in the lower and upper plates 33 and 31 and through the ducts 27 and 29 and into the funnel 22 shown in FIGURE 1. After application of and removal of excess liquid developer from the paper sheet 13, air continues to pass over the paper sheet 13 and accelerates evaporation of the liquid film thereon to promote drying of the paper sheet 13.

FIGURE 4 illustrates an embodiment of the developer apparatus of this invention designed to develop electrostatic images on a continuous web 13' of electrophotographic paper. The web 13' is carried over and supported by a roller 71 to pass adjacent a curved applicator head 11'. Both the roller 71 and the curved applicator head 11' are fixed in position by means not shown to provide a spacing between the web 13' and the applicator head 11' of approximately .0005 inch. Except for its curved shape, the applicator head 11' is substantially identical with the applicator head 11 shown in FIGURES 1 to 3. The applicator head 11', shown in FIGURE 4, has an outer plate 31' corresponding to the upper plate 31 shown in FIGURE 2 and an inner plate 33' corresponding to the lower plate 33 shown in FIGURE 2. Developer composition is brought into contact with the web 13' through

central channels in the plates 31' and 33' as was accomplished with the applicator head 11 of FIGURE 2. In this case, however, the developer composition is supplied to the applicator head 11' from a container or reservoir 73. A centrifugal pump 75 in the reservoir 73 forces the developer composition through a conduit 77 connected to the applicator head 11' and communicating with the central channels 55 and 35. Excess liquid developer is carried away from the web 13' through the rectangular channels 37 and 59 and back to the reservoir 73 through one or more ducts 27' and 29'. As before, a rectangular air curtain is produced by means of a compressor 23 feeding through flexible tubing 25 and a rectangular slot 43 adjacent the web 13'. Escaping air again carries excess liquid developer into the central channels 37 and 59, for return to the reservoir 73. In this embodiment (FIGURE 4), the applicator head 11' has been described as being fixed in position in relation to the roller 71. Thus, the rectangular air curtain need not function as an air bearing to support the applicator head 11' as described in connection with the embodiment of FIGURES 1 to 3 although it may do so. This embodiment functions to contain the developer composition as well as to remove excess developer liquid and enhance evaporation of the carrier liquid from the web 13'.

In the embodiments shown in the drawings, the applicator head 11 of FIGURES 1 to 3 has been shown and described as being positioned above the paper sheet 13'. The applicator head 11 can readily be adapted to operate in a different position to develop electrostatic images on a paper sheet positioned on the under side of the metal support 15 or with the metal support 15 inclined or vertical. Similarly, the applicator head 11' need not be in the position shown in FIGURE 4 but can, instead, be supported in any other position around the periphery of the roller 71. Also, the applicator head 11' could have a convex surface for developing electrostatic images on a concave surface.

What is claimed is:

1. Apparatus for applying a liquid composition to a surface comprising:
   - first means including a liquid supply conduit means for bringing said composition into contact with said surface;
   - second means including a liquid removal conduit means adjacent said first conduit means for conducting excess liquid composition away from said surface; and
   - third means including a gas supply conduit means surrounding said first and second conduit means for providing a curtain of gas between said apparatus and said surface and to prevent escape of said liquid composition.

2. Apparatus for applying a liquid composition to a surface comprising:
   - a first elongated manifold for bringing said liquid composition into contact with said surface;
   - at least one other elongated manifold adjacent to and parallel with said first manifold for conducting excess liquid composition away from said surface; and,
   - an additional manifold surrounding said elongated manifolds to provide a curtain of gas between said apparatus and said surface to prevent escape of said liquid composition.

3. Apparatus for applying a liquid composition to sheet material comprising:
   - a backing member providing a support surface for said sheet material;
   - an applicator head having a surface shaped to substantially mate with sheet material on said support surface;
   - first conduit means in said applicator head providing an opening through the surface thereof for the passage of said liquid composition;
   - second conduit means in said applicator head provid-

ing an opening through the surface thereof for the return passage of liquid composition;

third conduit means in said applicator head providing an opening through the surface thereof and surrounding said previously mentioned openings to provide for the ejection of a gas under pressure providing an air barrier for the confinement of liquid composition intermediate said sheet material and said head.

4. Apparatus for developing electrostatic images on an insulating surface with a liquid developer composition, said apparatus comprising:

means for supporting said surface for development;

first conduit means having an elongated opening adjacent said supported surface for applying said liquid developer composition thereto;

second conduit means having an elongated opening adjacent to the opening of said first conduit means for conducting liquid developer composition away from said supported surface;

third conduit means having an opening surrounding both said elongated openings providing for the ejection of a gas under pressure to impinge upon said supported surface and provide an air curtain for the containment of developer composition.

5. Apparatus for developing electrostatic images on an insulating surface with a liquid developer composition, said apparatus comprising:

backing means providing a surface;

an applicator head having a surface shaped to substantially mate with the surface of said backing means and positioned to receive between said mating surfaces the insulating surface;

first conduit means in said applicator head having an elongated opening through said shaped surface for applying said liquid developer composition to an insulating surface on said backing means;

second conduit means in said applicator head having an elongated opening through said shaped surface surrounding the opening of said first conduit means for conducting liquid developer composition away from said insulating surface; and

third conduit means in said applicator head having an elongated opening through said shaped surface surrounding the openings of both said first and second conduit means, said third means including a baffle plate partially closing said elongated opening to provide for the ejection of a gas under pressure to impinge upon said insulating surface and form an air curtain to confine said developer composition.

6. Apparatus for developing electrostatic images on insulating sheet material with a liquid developer composition, said apparatus comprising:

a flat plate for supporting said sheet material;

an applicator head having a flat surface adapted for positioning above said flat plate;

first conduit means in said applicator head having an elongated opening through said flat surface for applying developer composition to sheet material supported on said flat plate;

second conduit means in said applicator head having an elongated opening through said flat surface adjacent the opening of said first conduit means for the removal of developer composition from said sheet material on said flat plate;

third conduit means in said applicator head having an elongated opening through said flat surface surrounding the openings of both said first and second conduit means for the ejection of gas under pressure to impinge upon said insulating surface on said flat plate to form a gas curtain for the confinement of developer composition; and

means for providing relative motion between said applicator head and said insulating surface on said flat plate.

7. Apparatus for developing electrostatic images on insulating sheet material with a liquid developer composition, said apparatus comprising;

a flat plate for supporting said sheet material;

an applicator head having a flat surface adapted for positioning above said flat plate;

means for moving said applicator head across sheet material supported on said flat plate;

first conduit means in said applicator head having an elongated opening through said flat surface;

means supplying developer composition to said first conduit means for application to said sheet material through said elongated opening;

second conduit means in said applicator head having an opening through said flat surface adjacent to and parallel with said elongated opening for the removal of developer composition from said insulating surface;

third conduit means in said applicator head including a slot opening through said flat surface and surrounding the openings of both said first and second conduit means; and

means for supplying air to said third conduit means under sufficient pressure for ejection through said slot opening to support said applicator head above an insulating surface on said flat plate during movement thereacross and to provide an air curtain for containment of developer composition.

8. Apparatus for developing electrostatic images on insulating sheet material with a liquid developer composition; said apparatus comprising:

a flat plate for supporting a sheet of said insulating material;

an applicator head positioned above said flat plate and having a flat base surface;

means for moving said applicator head across said sheet on said plate;

an elongated channel formed in the base of said applicator head opening at said base surface;

container means for a supply of developer composition;

conduit means providing for the passage of developer composition from said container means to said elongated channel for application to a sheet on said flat plate;

a substantially rectangular channel formed in the base of said applicator head surrounding said elongated channel and opening at said base surface;

conduit means providing for the passage of developer composition from said rectangular channel back to said container means;

a substantially rectangular slot formed in the base of said applicator head surrounding both said elongated channel and said rectangular channel;

compressed air supply means;

at least one flexible conduit coupling said supply means and said applicator head;

conduit means communicating between said flexible conduit and said rectangular slot for the ejection of air through said slot to impinge upon said sheet to provide: means for supporting said applicator head above said sheet, means for containing developer composition and means for removing developer composition from said sheet through said rectangular channel.

9. Apparatus for developing electrostatic images on insulating sheet material with a liquid developer composition, said apparatus comprising:

a backing member having an arcuate surface for supporting said sheet material;

an applicator head having an arcuate base surface adapted to be positioned adjacent the arcuate surface of said backing member;

means for moving sheet material supported by said

backing member by said base surface of said applicator head;

first conduit means in said applicator head having an elongated opening through said base surface for applying developer composition to sheet material on said backing member;

second conduit means in said applicator head having an elongated opening through said base surface adjacent the opening of said first conduit means for the removal of developer composition from said sheet material; and

third conduit means in said applicator head having an elongated opening through said base surface surrounding the openings of both said first and second conduit means for the ejection of gas under pressure to impinge upon said insulating surface to form a gas curtain for the confinement of developer composition.

10. Apparatus for developing electrostatic images on insulating sheet material with a liquid developer composition, said apparatus comprising:

an applicator head having an arcuate surface;

a transport roller for supporting insulating sheet material in close proximity to said arcuate surface;

means for moving said sheet material over said roller;

first conduit means in said applicator head having an elongated opening through said arcuate surface;

means supplying developer composition to said conduit means for application to said sheet material through said elongated opening;

second conduit means in said applicator head having an opening through said arcuate surface adjacent to and parallel with said elongated opening for the removal of developer composition from said sheet material;

third conduit means in said applicator head including a slot opening through said arcuate surface and surrounding the openings of both said first and second conduit means; and

means for supplying air to said third conduit means under sufficient pressure for ejection through said slot to form an air curtain for confining developer composition and remove developer composition from said sheet material through said parallel opening.

11. Apparatus for developing electrostatic images on insulating sheet material with a liquid developer composition, said apparatus comprising:

an applicator head having an arcuate surface;

a transport roller for supporting insulating sheet material in close proximity to said arcuate surface;

means for moving said sheet material over said roller;

an elongated channel in said applicator head opening at said arcuate surface;

container means for a supply of said developer composition;

means for supplying developer composition to said elongated channel from said container means for application to said sheet material;

a substantially rectangular channel in said applicator head opening at said arcuate surface and surrounding the opening of said elongated channel;

conduit means for returning developer composition to said container means from said rectangular channel;

conduit means in said applicator head having a substantially rectangular slot opening at said arcuate surface and surrounding the openings of both said elongated channel and said rectangular channel;

compressed air supply means;

at least one flexible conduit coupling said supply means to said conduit means in said applicator head to provide for the ejection of air through said slot opening to impinge upon said sheet to provide means for confining said developer composition and to remove developer composition from said sheet material through said rectangular channel.

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

first conduit means for bringing liquid composition to said surface;

second conduit means for returning liquid composition from said surface; and

gas conduit means surrounding said first and second conduit means to provide a gas barrier against escape of liquid composition.

13. An applicator head for applying a liquid developer composition to an electrostatic image on a surface, said applicator head comprising:

first conduit means for bringing said composition to said surface;

second conduit means surrounding said first conduit means for returning excess developer composition from said surface; and

gas bearing conduit means surrounding said first and second conduit means to provide a gas barrier against escape of liquid developer composition.

14. An applicator head for applying a liquid developer composition to an electrostatic image on a flat surface, said applicator head comprising:

first conduit means opening through a flat surface of said applicator head for bringing said composition to said electrostatic image;

second conduit means surrounding said first conduit means and opening through the flat surface of said applicator head for the return passage of excess composition;

third conduit means surrounding said first and second conduit means and opening through the flat surface of said applicator head providing a gas barrier against escape of liquid developer composition and a gas bearing for supporting said applicator head.

15. An applicator head for applying liquid developer composition to an electrostatic image on a surface, said applicator head comprising:

first conduit means for bringing said composition to said surface;

second conduit means surrounding said first conduit means for the return of excess liquid developer composition from said surface; and

third conduit means surrounding said first and second conduit means to provide a gas barrier against escape of liquid developer composition;

said applicator head having an arcuate surface through which all of said conduit means open.

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