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(71) Applicant: Benson, Inc.
385 Ravendale Drive
Mountain View California 94039-7169 (US)

(72) Inventor: Nieto, Robert L.
3141 Fitzpartick
Concord California 94519 (US)

Camacho, Joseph
5316 Escover Lane
San Jose California 95118 (US)

Hardy, Douglas
3076 Hazelwood
Santa Clara California 95051 (US)

Kamas, Peter
1186 Mary Avenue
Sunnyvale California 94087 (US)

(74) Representative: Monod, Jean-Yves et al
SCHLUMBERGER LIMITED 12 Place des Etats-Unis
F-92124 Montrouge Cedex (FR)

(54) **Plotter toner station.**

(57) A toner station for an electrostatic printer includes a writing head 10 and an integral toner application and removal station 28. The toner application station includes a longitudinally grooved roller 35 which rotates to contact a sheet of material to which toner is to be applied. Toner is applied to roller 35 by a sprayer 44. Adjacent toner roller 35 a low pressure chamber 40 is provided to remove excess toner from sheet 15. The integral toner application and removal stages provide rigidity for the writing head 10.

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Description

PLOTTER TONER STATION

BACKGROUND OF THE INVENTION

Field of the Invention

This invention relates generally to electrostatic plotting and in particular, to a station in an electrostatic plotter where toner is applied to paper or other material.

Description of the Prior Art

In electrostatic plotting (or printing), a writing head, which includes a large number of closely spaced electrodes (for example, 200 per inch), is positioned in proximity to a sheet of paper or other material. Another electrode, usually known as a "backplate," is positioned behind the paper or adjacent to the writing head. A potential applied between selected ones of the electrodes in the writing head and the backplate causes charge to accumulate on the paper. Toner applied to the paper adheres electrostatically to these charged regions, while undesired toner is then vacuumed off the paper, or otherwise removed.

In one commercially available color electrostatic plotter, the paper travels between a supply reel and a take-up reel. Between the two reels a single writing head is positioned in a location where charge may be applied to the paper as it passes the writing head. After passing the writing head the paper traverses four toning stations, one of which will be activated to apply a particular color to the paper. Following that application, the paper is rewound onto the supply reel, then pulled across the writing head where further charge is applied, then another toner station raised into position to contact the paper and apply a second color. The process is repeated four times for a full-color image (yellow, cyan, magenta, and black). This technology is termed "single station mutiple pass printing" because only a single writing head is used and multiple passes of the paper are made across the writing head to create the ultimate image.

Single station multiple pass electrostatic plotters suffer from several disadvantages. One significant disadvantage is that the finished image is produced much more slowly than desired because of the need to roll and unroll the paper once for each color employed in the image. Furthermore, such plotters require mechanisms for raising and lowering each toner station in proximity with the paper. Additionally, maintaining alignment among each of the four images printed on successive passes is difficult. The paper must be precisely repositioned, with proper account for any stretching, shrinkage, or other dimensional changes. Additionally, the electrostatic printer head must be rigidly mounted to maintain its aligment continuously. This requires bulky stiffeners, channels and the like.

Because of these disadvantages of single station multiple pass electrostatic plotters, the industry has turned toward multiple station single pass electrostatic plotters. In such apparatus, the paper passes from a supply roll across four separate spaced-apart electrostatic print heads, each of which is accompanied by its own toner applicator. At each station, an image is "written," the particular toner is applied, and excess toner is removed. In this manner the printing is accomplished much more rapidly and with a single pass of the paper through the machine. The single pass technology, however, requires four writing heads as well as four toner baths, and the writing heads must be spaced sufficiently far apart that for a given paper speed, the toner from a previous station is completely dry before a subsequent color is applied. At the same time each electrostatic writing head must be maintained in rigid alignment, yet the overall machine be sufficiently small to fit through a conventional doorway.

SUMMARY OF THE INVENTION

This invention provides a compact station for electrostatic plotting, which in the preferred embodiment includes a writing head for applying electrostatic charge to a sheet of material, a toner roller for applying toner of selected color to the sheet of material after the electrostatic charge, and a vacuum station for removing excess toner from the sheet. In the preferred embodiment, the toner roller is mounted in a trough to capture excess toner sprayed onto the roller and to enable the excess toner to be recycled. The vacuum chamber and trough are integrally formed and affixed to the writing head to provide rigidity, and eliminate the need for prior art channels, stiffeners, or other mechanical alignment devices.

The toner station of this invention provides a substantially more compact station than prior art electrostatic plotters, thereby enabling the fabrication of an overall compact plotter which can fit through an ordinary doorway, yet create E size drawings. Furthermore, in the preferred embodiment of this invention, the combined toner roller and vacuum chamber assembly provides rigidity to the writing head to maintain alignment while preventing, bowing, warping, or other distortion. The toner station is modular, enabling the same station construction to be used for each color of a multiple color plotter. In addition, the structure of the station enables independent control of the amount of toner applied to the roller, the speed of rotation of the toner roller, and the pressure of the vacuum system, enabling each station to be precisely tuned for the characteristics of the particular toner chosen for that station.

IN THE DRAWINGS

Figure 1 is a cross-sectional view of a toner station fabricated according to the preferred embodiment of this invention;

Figure 1A is an enlarged view of the writing head of Figure 1;

Figure 1B is an enlarged view of the surface of the toner roller of Figure 1;

Figure 2 is a top view of the toner station depicted in Figure 1;

Figure 3 is a side view of a four color plotter, having four of the toner stations depicted in Figures 1 and 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 is a cross-sectional view of a oreferred embodiment of the toner station of our invention. As shown in Figure 1, the station includes an electrostatic writing head 10 for applying charge to a sheet of material 15, typically paper, which passes over the writing head 10. The paper is caused to pass across the writing head and other apparatus depicted in the Figure, for example, by a friction drive mechanism (not shown). Alignment of the paper with the writing heads is achieved by marking the paper at the first head, then detecting the location of the marks at each subsequent head.

The electrostatic charge is applied to paper 15 by a network of electrodes formed within the writing head 10. The writing electrodes comprise a network of fine parallel wires 16 which extend to the upper surface 17 of head 10. Also fabricated on the surface of head 10 are a larger series of electrodes 19 (See Figure 1A). By applying appropriate electrical signals between electrodes 16 and 19 charge may be deposited on paper 15.

Once the paper is charged, toner applied in a subseqent operation will adhere to the charged regions on the paper until a solvent within the toner evaporates and fixes the image. Toner applied to uncharged regions will be removed before the solvent evaporates. By pulsing the potential applied across selected ones of electrodes 16 and 19 small "dots" of charge are applied to the paper, and a half-toned image may be created from three primary colors--cyan, yellow, and magenta. To enhance the quality of the image, however, black, is employed.

Paper 15 is held in close proximity to head surface 17 by a roller 22 rotating on shaft 24. The outer surface of roller 22 is generally fabricated from a resilient material, for example, foam rubber, to allow the roller to deform while applying suitable pressure to the sheet 15. A printed circuit board 25, or other well-known apparatus, is used to interconnect the electrodes in head 10 to other control apparatus in the electrostatic plotter.

Typically, writing head 10 is fabricated from epoxy, fiberglass, or other dimensionally stable material to minimize thermal changes in the spacings of the indivldual electrodes 16. In a preferred embodiment, head 10 includes about 9,000 wires 16 and is approximately 38" long. Such heads are commercially available, and have been the subject of many patents.

Because of its relatively long length and small cross-sectional area, electrostatic printing heads, such a printing head 10, tend to flex, warp, or bow, in response to stresses applied by the framework in which the head is mounted, the frictional forces applied by the paper moving past the head, as well as other effects, including thermal expansion and contraction. To maintain precise alignment of the writing electrode 16, such dimensional variations must be minimized. Any such change in head orientation can create lines or other undesirable effects in the ultimately created image. Accordingly, the writing heads must be mounted in a manner as to minimize dimensional or orientational changes.

As shown in Figure 1, in the preferred embodiment of this invention, the electrostatic writing head 10 is affixed to an integral toner application and removal apparatus 28. Assembly 28 is affixed to head 10 by being bolted, screwed or otherwise attached to a bar 30, on head 10. Bar 30, typically aluminum or other metal, is typically provided as a part of head 10 by the manufacturer of head 10. By itself bar 30 does not provide sufficient rigidity.

Assembly 28 includes two primary components, a toner roller 35 and a vacuum chamber 40. Toner is applied to roller 35, and in turn to paper 15. Excess toner applied to the paper is removed by chamber 40 in manner described in further detail below. Although the word "toner" is used herein, it should be understood that it is being used in a generic sense to describe generally liquid material which may contain dyes for producing colored images.

Toner roller 35 rotates on shaft 37. The exterior surface of roller 35 includes a series of ridges 38 which are sufficiently closely spaced that capillary action allows toner 40 to adhere to the exterior surface of roller 35 and forms a thin film over ridges 38 (see Figure 1B). Thus, as sheet 15 passes roller 35 a roll of toner is applied to the lower surface of sheet 15.

Toner is applied to roller 35 by a sprayer 44. Sprayer 44 consists of a tube having a longitudinal axis substantially parallel to the axis of rotation of shaft 37. A series of very small closely spaced openings are drilled through the wall of tube 44 to allow toner pumped into tube 44 under pressure to spray out onto the exterior surface of roller 35. Toner in excess of that adhering to the surface of roller 35 is removed by a drain 47 and recycled. Typically, a flexible plastic tube or other suitable plumbing is coupled between drain 47 and a reservoir of toner (not shown).

Positioned adjacent to roller 35 is a vacuum chamber 40 having openings 48 in its upper surface. Vacuum chamber 40, together with openings 48, removes excess toner from paper 15. Excess toner will typically be present on sheet 15 because roller 35 continuously applies toner to the sheet, regardless of whether writing electrodes 16 and 19 are active. Even if the writing heads are active, undesired toner is applied between the "dots" of charge, and this toner must be removed.

By maintaining vacuum chamber 40 at less than atmospheric pressure, excess toner on sheet 15 will be sucked through openings 48 into chamber 40. One or more drains 49 in the lower portions of chamber 40 allow the excess toner to be recycled, in the same manner as toner removed from drain 47. The drain(s) 49 also allow connection of hoses between chamber 40 and a vacuum pump, or other suitable apparatus for maintaining less than ambient pressure. Although the word "vacuum" is used throughout this application, it will be understood, of

course, that by virtue of openings 48, chamber 40 will not provide a vacuum per se, but will instead provide a region of reduced atmospheric pressure to allow suction of toner from sheet 15.

To assure complete removal of the toner applied, extrusion 60 is grounded. In this manner, any excess untoned electrostatic charge present on paper 15 will be removed, thereby enabling complete removal of undesired toner by the vacuum station.

Of particular benefit to the preferred embodiment of the toner station of this invention is the use of a single extrusion 60 to provide rigid aligment of the writing head 10, a trough and support for the toner application roller 35, and a vacuum chamber 40. In prior art toning stations, each of these components was separately fabricated and assembled. Of course, not shown in the cross-sectional view of Figure 1 are the end plates necessary to seal the ends of chamber 40 and trough 55, as well as provide the necessary support for sprayer 44 and for the bearings for shaft 37.

Figure 2 is a top view of the apparatus shown in Figure 1, but in which the paper 15 has been cut away to illustrate the underlying structure. As shown in Figure 2 writing head 10 extends laterally across the full width of sheet 15 and includes in its upper surface a large number of electrodes 16 and 19. Toner roller 35 is also shown with its grooved exterior surface 38. Finally, the upper surface of the vacuum chamber 40 with openings 48 is depicted, as well as end plates 62. Not shown in Figure 2 is the small electric motor and drive belt used to rotate roller 35. By employing a voltage dependent motor, the speed of rotation of roller 35 may be adjusted to suit each application.

Figure 3 is a cross-sectional view of a single-pass multiple station electrostatic printer illustrating the manner in which four stations 70,71, 72 and 73, may be combined into an integral unit for the making of large color plots in a single pass, yet on a machine less than 36" wide. The apparatus depicted in Figure 3 includes a frame 65 for supporting the four station and auxilliary equipment such as the toner reservoirs. The paper upon which the image is to be plotted is wound on a roll (not shown) along the left side of the machine, then passes from left to right in Figure 3. A protrusion 74 from frame 65 provides an axis for rotation of a lid (not shown) which covers the upper surface of the structure.

The toner stations depicted in Figure 3 are shown in different views to illustrate different aspects of each. Each station includes a roller 22 for pressing the sheet of material into contact with the upper surface of the writing head 10. As discussed above, each roller 22 rotates about a shaft 24 and includes a resilient exterior surface for pressing paper against the supper surface.

The second toner station 71 depicts a drive belt 75 for driving toner-roller 35. The precise location of the drive motor is adjusted by the elongated slots in plate 78. The location of threaded openings 81 is also shown for attaching the end plate to the extrusion 60, for example, with bolts and a gasket. Each station is similar equipped.

Although a preferred embodiment of the multiple station single pass electrostatic printer has been described above, this embodiment is intended only to illustrate the invention and not to limit it. The scope of the invention may be ascertained in the appended claims.

Claims

1. Apparatus for applying toner to a sheet of material comprising:
means for applying an electrostatic charge to the sheet, said means extending across a desired dimension of the sheet;
means for supplying toner to the sheet; and
means for removing excess toner from the sheet, wherein the means for supplying toner to the sheet and the means for removing excess toner comprise an integral unit attached to the means for applying an electrostatic charge.

2. Apparatus in Claim 1 wherein the means for supplying toner comprises a roller having a longitudinal axis extending laterally across the desired dimension of the sheet, the roller disposed to contact the sheet.

3. Apparatus in Claim 2 wherein the means for supplying further comprises means for coating an external surface of the roller with toner.

4. Apparatus in Claim 3 wherein the external surface of the roller includes a plurality of longitudinal grooves.

5. Apparatus in Claim 4 wherein the means for coating comprises a sprayer to which toner is supplied under pressure, which sprayer is disposed to spray toner onto the roller.

6. Apparatus in Claim 5 wherein the sprayer comprises a tube having a longitudinal axis disposed generally parallel to the longitudinal axis of the roller, which tube includes a series of openings perpendicular to the longitudinal axis of the tube through which openings toner is sprayed.

7. Apparatus in Claim 2 wherein the roller comprises a cylinder having a plurality of ridges on the outside surface, the ridges disposed in sufficiently close proximity to each other to maintain a film of toner therebetween.

8. Apparatus in Claim 1 wherein the means for removing comprises a vacuum chamber having a longitudinal axis disposed substantially parallel to the longitudinal axis of the roller, the chamber having an upper surface disposed to contact the sheet of material, which upper surface includes at least one opening therethrough to allow suction of any excess toner from the sheet of material through the opening and into the vacuum chamber.

9. Apparatus in Claim 8 wherein the chamber further includes a plurality of openings in a lower surface of the chamber for removing toner from the chamber.

10. Apparatus in Claim 1 wherein the integral unit comprises a trough means within which the means for supplying toner to the sheet are disposed.

11. Apparatus in Claim 10 wherein the means for removing comprises chamber means adjoining the trough means, the chamber means adapted to position a region of reduced atmospheric pressure in close proximity to the sheet of material.

12. Apparatus in Claim 11 wherein the trough means comprises a longitudinally extending generally U-shaped member having a first leg affixed to the means for applying an electrostatic charge.

13. Apparatus in Claim 12 wherein the member has a second leg comprising chamber means.

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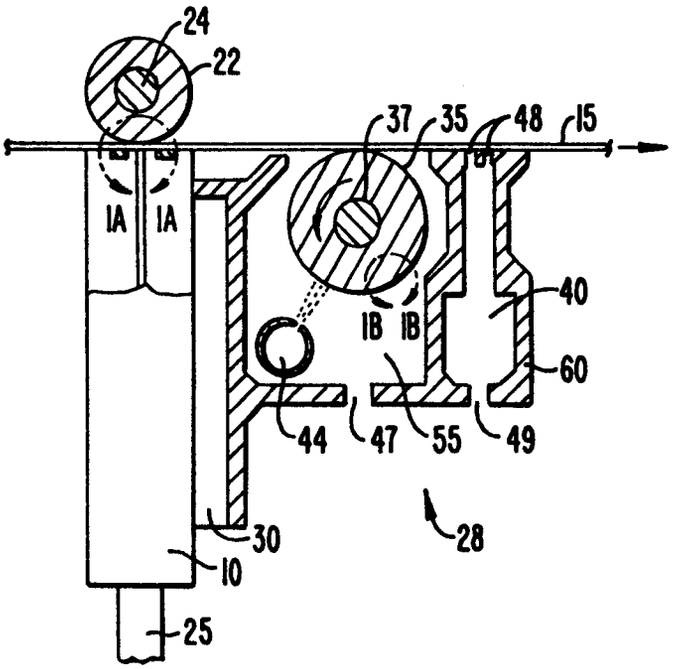


FIG.__1.

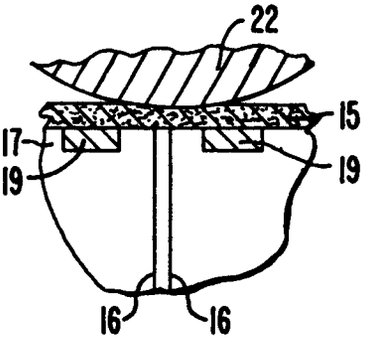
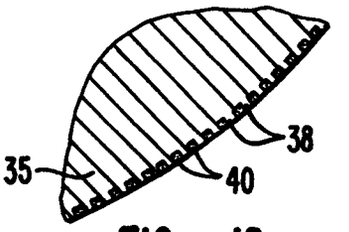


FIG.__1A.



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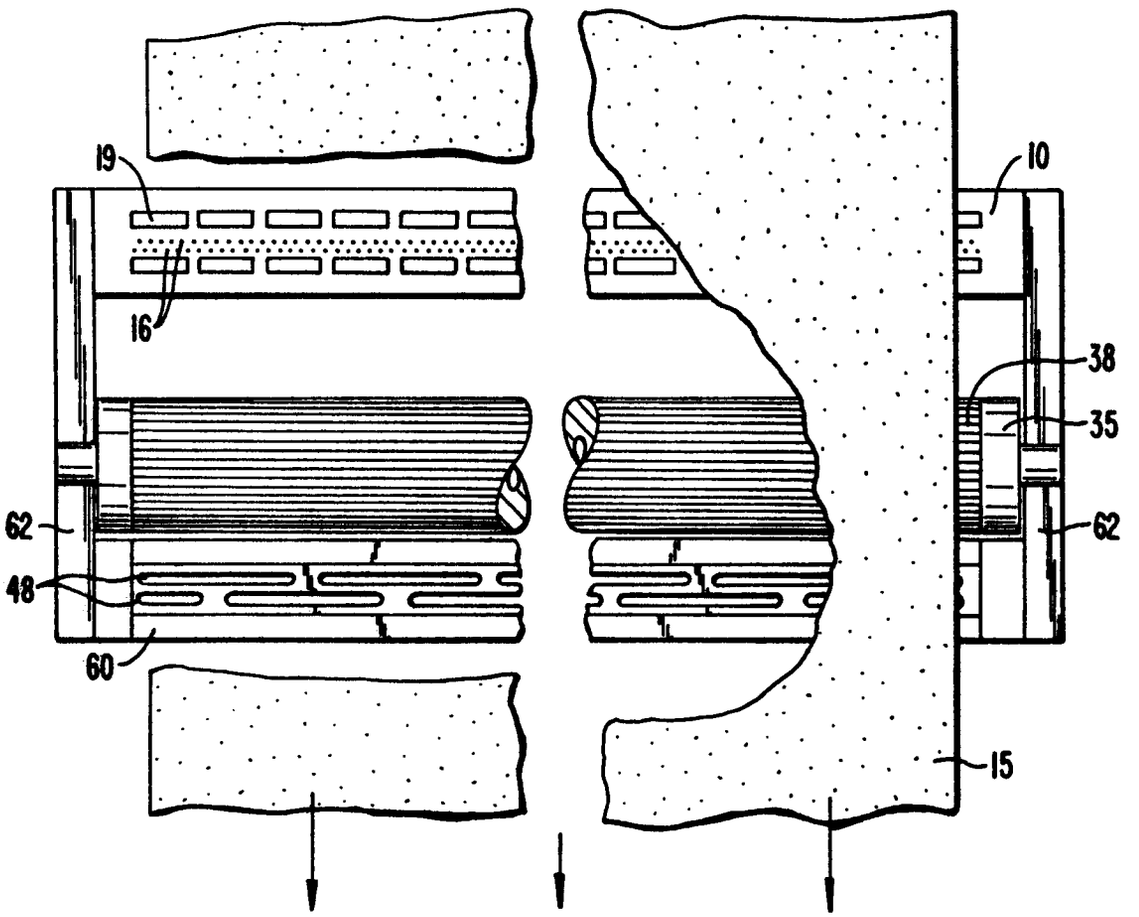

FIG.__2.

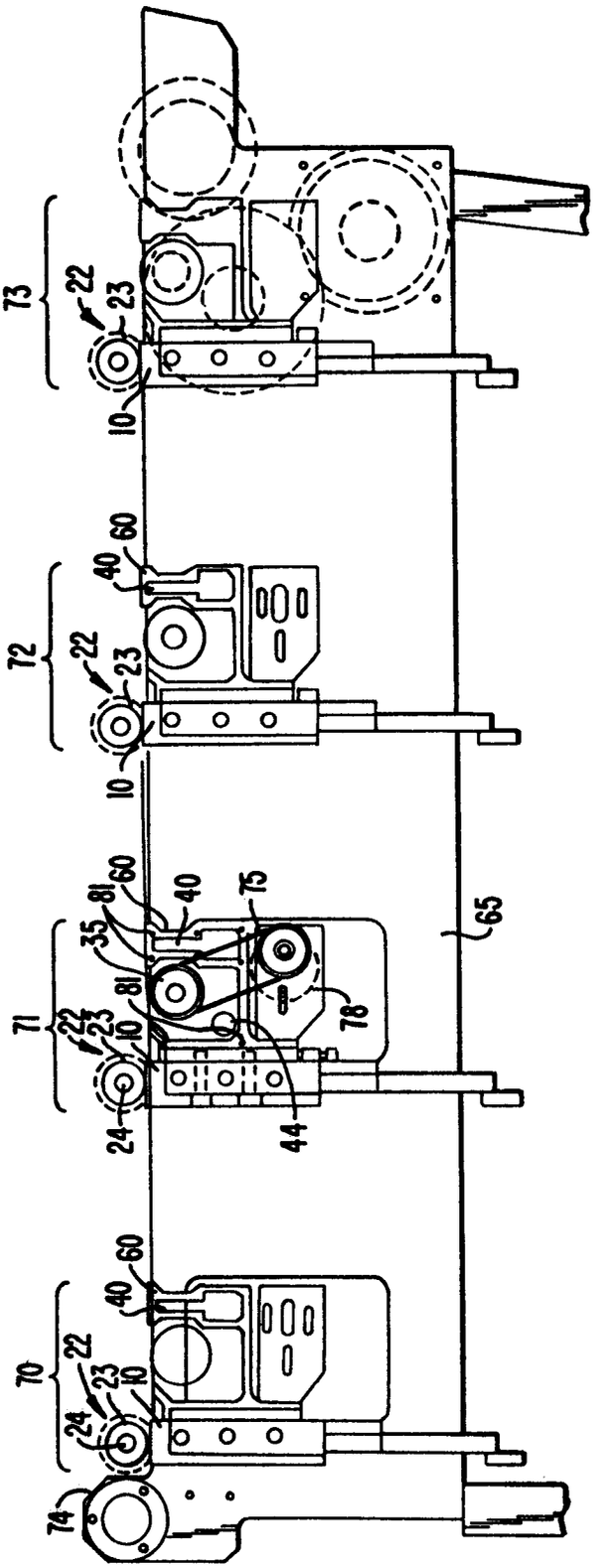

FIG._3.