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WET DIAPHRAGM ELECTROSTATIC PRINTER

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9 Claims. (Cl. 118-637)

This invention relates to electrostatic printers in general and more particularly to an electrostatic printer wherein electrostatically attractable ink is deposited on one side of a thin porous sheet member and an electrostatic pattern deposited on the other side thereof to selectively draw ink through the porous member for transfer purposes.

In most electrostatic printers in use today, a latent electrostatic image is formed by conventional means on an insulator member. The electrostatic image is then dusted with an electroscopic powder known as toner which is attracted to the latent electrostatic image to form a visible image of the charge pattern. The thus toned image is then transferred to a paper or other similar output member. The toner is then heat-fixed or solvent-fixed to the paper to provide the final image.

Problems attendant present day systems which utilize toner for a developer are that large black areas in an image are usually not uniformly developed; instead, there is a heavy concentration of toner particles at the outer edge of the large black area with a much lesser concentration of toner particles in the inner portions of the area. Additionally, the toner is quite messy and hard to handle and the fixing operation slows down to a considerable extent the throughput of the system.

Attempts to devise a system wherein the developer is not a microscopic powder to thereby provide a system capable of producing large black areas satisfactorily and which does not require the fixing operation, have resulted in a liquid development type of system. Liquid development type systems have proved satisfactory in most applications, but in certain applications such as where the electrostatic image is formed, not through use of conventional photoconductor techniques, but is formed, for instance, by the selective energization of electrostatic probes or pins disposed adjacent the insulator belt, as in the case of computer output printers, terminal or facsimile printers, airborne printers, etc., certain shortcomings have arisen. For example, one electrostatic printer in use today employs electrostatic probes which are disposed on one side of a paper web which is to be printed on and an ink source disposed on the other side of the paper web. The probes are selectively energized and the electrostatic attraction provided thereby pulls ink from the ink supply onto the print medium to form images. This system is quite limited in speed of operation due to the relatively slow response of the ink to the electrostatic charge.

An object of the present invention is to provide a novel electrostatic printer employing a liquid development technique.

Another object of the present invention is to provide a relatively high speed probe-type development electrostatic printer.

Another object of the present invention is to provide an electrostatic printer wherein liquid development techniques are used without resultant high background print-outs.

Other and further objects and advantages of the invention will be apparent from the following more particular description of the preferred embodiment of the invention, as illustrated in the accompanying drawings in which:

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FIG. 1 is an overall block schematic diagram of the herein disclosed novel electrostatic printing system;

FIG. 2 is an isometric view of the preferred embodiment of the herein described electrostatic printer; and

FIG. 3 is a sectional view of the insulating belt utilized in the electrostatic printing system described herein.

Briefly, in the preferred embodiment, input information forms an electrostatic image on the surface of an endless belt made of thin, insulating plastic material, such as Teflon. The belt is perforated with many small, closely spaced holes. An inking roller applies ink to the underside of the perforated plastic belt. The latent electrostatic image is formed on the upper surface of the belt by means of a high D.C. potential selectively applied across charging wires and the inking roller beneath the belt. Since the belt contains numerous small holes, the polarized molecules of ink on the underside are attracted by charges of opposite sign forming the latent image on the upper surface of the belt. Consequently, ink will be pulled upward through the holes in accordance with the charge pattern of the latent electrostatic image. By the time the belt reaches an associated print station, sufficient ink will have been pulled up through the holes so that full characters can be transferred to a paper web which is brought into pressure contact with the upper side of the belt.

For a more detailed description, refer first to FIG. 1. In FIG. 1 is shown a thin porous belt 1 made of an insulator such as Teflon being moved in the direction of the arrow 2 by suitable means (not shown) past a latent image forming means 3 and a polarized ink applicator 4. The insulator belt 1 then passes in rolling contact with a paper web or other similar print member 5 which is moved in the direction of the arrow 6. The paper web 5 is pressed by means of roller 7 into rolling contact with the belt 1.

As better shown in FIG. 3, the insulator belt is porous, having formed therethrough numerous tiny holes 9. While for simplicity of drawing, the insulator belt of FIG. 3 is illustrated as having cylindrical openings or holes formed therethrough, commercially available materials suitable for use in the subject application are more sponge-like in makeup.

In operation, a latent image 10 is formed by means of the latent image forming means 3 on the upper surface of the insulator belt 1. Any of several latent image forming means may be utilized. For instance, as in the preferred embodiment of the invention, a head having selectively energizable electrostatic probes may be utilized as the latent image forming means 3. Another type of latent image forming means which may be utilized in the subject invention is the photoconductor type wherein the photoconductor is charged in darkness to a uniform potential. An image is then projected onto the charged photoconductor to form a latent electrostatic image. This latent electrostatic image may then be transferred to the belt 1.

Polarized ink is supplied by means of the polarized ink applicator 4 to the opposite or under surface of the belt 1. The polarized ink may be applied to the underside of the belt 1 through use of a roller as in the preferred embodiment or by any other suitable means. The sequence of application of the latent image 10 to the belt and the application of the ink to the opposite surface of the belt need not necessarily be in the order as depicted in FIG. 1. Instead, the ink may be applied to the under surface of the belt prior to or simultaneously with the application of the latent image to the upper surface of the belt 1.

As the belt 1 travels toward the contact station which comprises roller 7, ink is drawn through the small holes from the underside of the belt 1 by the latent image 10

on the upper surface of the belt such that by the time that the portion of the belt bearing the latent image reaches roller 7, an ink image 11 will have been formed on the upper surface of the belt 1 in the configuration of the electrostatic pattern 10. The ink image 11 then passes in rolling contact with the paper web 5 thus transferring it to the paper web.

With respect to the belt 1, any of several types of insulators may be utilized. It has been found, however, that the laws of capillarity may work against clean printing such that ink may seep through all of the holes of the porous sheet and print out as a heavy background when wettable insulators are used. Thus, Teflon, which is relatively non-wettable, has been found to be a good insulator belt material. Likewise, any of several types of electrostatically attractable ink may be used. For instance, the coloring material in the ink may be a colloidal suspension in which case only the coloring particles will be drawn through the sheet or the coloring material may comprise a dye which is dissolved in the liquid in which case the entire ink must be susceptible to electrostatic attraction.

Refer next to FIG. 2 wherein is shown a preferred embodiment of the novel subject electrostatic printer. In the following description of FIG. 2, as in the case of FIG. 1, numerous rollers are shown which are suspended in suitable bearing means and driven by suitable rotating means neither of which are shown, but which are obviously necessary. In FIG. 2 the thin endless insulator belt 1 having a plurality of holes 9 passing therethrough is mounted on rollers 12, 8, 13, 14 and 15. Disposed adjacent the upperside of endless belt 1 is a latent image forming means 3 which comprises a head member 16 having a plurality of electrostatic pins or probes 17 disposed in a line transverse to the movement of belt 1 as indicated by arrow 2. The pins 17 of the latent image forming means 3 are in charging association with the insulating belt 1 such that when a D.C. potential is selectively applied thereto, a latent image 10 may be formed on the upper surface of the belt 1. The latent image forming means 3 is connected along line 18 to an image formation control unit 19 which is connected along line 20 to one side of a direct current voltage supply 21. The other side of the direct current voltage supply is connected to line 22 which in turn is connected to lines 23 and 24. Line 23 is connected to the conductor bar 25 which is disposed in the lower portion of an ink chamber 26 while line 24 is connected to a corona discharge unit 27.

The image formation control unit 19 is a control unit for controlling the selective application of pulses to the pins 17 of the latent image forming means 3. Any of many well known types of image formation control units 19 can be utilized to perform this function. The image formation control unit in turn accepts an input from a computer or other similar associated master control unit.

The conductor probe or bar 25 extends the length of the ink chamber 26 which in turn extends across the full width of the insulator belt 1. An ink roller 28 is mounted for rotation and held by the ends of the ink chamber 26. An electrostatically attractable ink 29 is contained in the ink chamber 26. Conductor bar 25 is in conductive association with the electrostatically attractable ink 29 contained in the ink chamber 26. The roller 28 is held by the ends of ink chamber 26 such that it is in rolling contact with the lower surface of belt 1 and in contact with the ink 29 held in the ink chamber 26.

The corona discharge unit 27 is a conventional commercially available corona discharge unit which functions to uniformly charge the surface of insulator belt 1 adjacent thereto as the belt is driven past it.

Rollers 13, 14 and 15 define a belt path which passes down into cleaner chamber 30 which contains a liquid cleaning agent 31. The belt is pinched between a cleaning blade or portion 32 and a pinch roller 33 which functions to clean any excess cleaning liquid from the belt 1 as it leaves the cleaning unit. Roller 14 is mounted for rotation and held by the ends of the cleaner chamber 30.

As in FIG. 1, a paper or print web 5 is brought in contact with the upper surface of the insulator belt 1 by means of roller 7.

In operation, as the endless thin porous insulator belt 1 moves in the direction indicated by arrow 2 and the paper print web 5 moves in the direction as indicated by arrow 6, a latent electrostatic image 10 is formed on the upper surface of belt 1 through selective energization of the electrostatic pins or probes 17 disposed in a line transverse to the movement of the belt 1. Energization of the electrostatic pins or probes 17 of the head member 16 is under control of the image formation control unit which receives an input from a computer or other associated master control unit (not shown). The image formation control unit 19, which controls the selective energization of the pins 17, selectively applies a direct current of a first polarity provided by the direct current voltage supply 21 to the pins 17. The latent image 10 then is moved past the polarized ink applicator 4 which contains ink 29 which is polarized by means of the conductor bar 25 which is connected to the opposite side of the direct current voltage supply 21. Thus, electrostatically attractable ink of an opposite polarity is applied to the lower surface of insulator belt 1. As the belt 1 moves toward the contact station comprising roller 7, the ink is pulled through the holes 9 in the belt 1 by the latent image 10 to form an ink image 11. In those areas where the latent electrostatic image 10 is not present, the ink is not pulled through the holes 9. The ink image 11 then passes in rolling contact with the paper or print web 5 and is thereby transferred to the paper print web.

The insulator belt 1 containing the remnants of the ink image 11 and the portions of ink 29 applied to the underside thereto which were not transferred to the paper print web 5 then passes down through the liquid cleaning agent 31 contained in the cleaner chamber 30. The ink remaining on the belt 1 is removed in the cleaner chamber 30. While only one cleaner chamber 30 and cleaning liquid 31 has been illustrated, it is obvious that any number of baths can be provided to assure adequate or thorough cleaning of the ink 29 from the insulator belt 1. The belt then passes between the cleaning blade 32 and pinch roller 33 which remove the fluid 31 from the belt.

While a fast drying cleaning agent 31 may be utilized such that the insulator belt 1 is completely dry by the time that it reaches the charging and inking station, it is obvious that additional drying means such as a heater, air movement mechanism or vacuum cleaner, may be provided.

The corona discharge unit 27 is not necessary for satisfactory operation of the system. It has been found, however, that if the upper portion of the insulator belt 1 is precharged to a polarity opposite to that applied by the pins 17 of the head member 16, that increased or higher resolution images will result.

While, in the heretofore described system, the electrostatic image has been applied directly to the insulator belt 1, it will be obvious to those skilled in the art that if the paper 5 had insulating properties that the electrostatic image could be applied to the side of the paper which contacts the insulator belt. In such an application, as is obvious, the duration of contact between the insulator belt and paper would have to be long enough to permit the electrostatic image to draw the ink through the insulator belt.

In summary, an electrostatic printer is described in which the input information forms a latent image 10 on the upper surface of an endless belt 1 made of thin insulating plastic material such as Teflon. The belt 1 is perforated with many small, closely spaced holes 9. An inking roller 28 applies electrostatically attractable ink 29 to the under surface of the porous belt 1. A latent electrostatic image 10 is formed on the upper surface of the belt 1 by means of a high D.C. potential selectively applied across charging probes 17 and the inking roller 28 beneath the belt 1. This charging station may be replaced with an electrostatic image transfer station.

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Since the belt 1 contains numerous small holes 9, the polarized molecules of ink 29 on the under surface are attracted by charges of opposite sign forming the latent image 10 on the upper surface of the belt 1. Consequently, ink 29 will be pulled upward through the holes 9 in accordance with the charge pattern of the latent electrostatic image 10. By the time the belt 1 reaches the print station comprising roller 7, sufficient ink 29 will have been pulled up through the holes 9 so that ink characters can be transferred to a paper web 5 which is brought into contact with the upper surface of the belt 1.

In the above described manner, I have provided a novel electrostatic printing means which employs a liquid developer to thereby eliminate handling and fixing problems associated with the use of powder developers. Additionally, one of the problems associated with prior art electrostatic printers utilizing probe electrostatic heads to pull ink from an associated roller onto a paper or print medium has been overcome since in the herein described system the timewise separation of the image forming-inking step and the contact printing step allows sufficient time for the electrostatic ink to respond to the latent image pattern to provide relatively high operational speeds.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in the form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An electrostatic printer comprising:
 - a thin, porous insulator belt of non-wettable material, means for applying polarized ink to one side of said insulator belt,
 - means for causing said polarized ink to be selectively drawn through said insulator belt to the other side thereof,
 - a print member, and
 - means for bringing said print member in printing contact with said other side of said insulator belt.
2. An electrostatic printer comprising:
 - a thin, porous insulator belt of non-wettable material, means for applying polarized ink to one side of said insulator belt,
 - means for applying an electrostatic image to the other side of said insulator belt to cause said polarized ink to be selectively drawn therethrough,
 - a print member, and
 - means for bringing said print member in printing contact with said other side of said insulator belt.
3. An electrostatic printer comprising:
 - a thin, porous insulator belt of non-wettable material,
 - a latent image forming means disposed in operable association with a first surface of said insulator belt,
 - a polarized ink applicator means disposed in operable association with the other surface of said insulator belt, and
 - means for bringing a print member in printing contact with said first surface.
4. An electrostatic printer for printing on a print member comprising:
 - a thin, porous insulator belt of non-wettable material, first and second roller members operable to cause said print member to be brought into contact with a first surface of said insulator belt,
 - a latent image forming means disposed in operable association with said first surface of said insulator belt, and
 - a polarized ink applicator means disposed in operable association with the other surface of said insulator belt.
5. An electrostatic printer comprising:
 - a thin, porous insulator belt of non-wettable material,

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- a latent image forming means comprising a plurality of selectively energizable electrostatic probes disposed in operable association with a first surface of said insulator belt,
 - a polarized ink applicator means disposed in operable association with the other surface of said insulator belt, and
 - means for bringing a print member in contact with said first surface.
6. An electrostatic printer for printing on a print medium comprising:
 - a thin, porous insulator belt of non-wettable material, first and second roller members operable to cause said print member to be brought into contact with a first surface of said insulator belt,
 - a latent image forming means comprising a plurality of selectively energizable electrostatic probes disposed in operable association with said first surface of said insulator belt, and
 - a polarized ink applicator means disposed in operable association with the other surface of said insulator belt.
 7. An electrostatic printer for printing on an insulating print medium having an electrostatic image thereon comprising:
 - a thin, porous insulator belt of non-wettable material, first and second roller members operable to cause said electrostatic image to be brought into contact with a first surface of said insulator belt, and
 - a polarized ink applicator means disposed in operable association with the other surface of said insulator belt.
 8. An electrostatic printer for printing on a print member comprising:
 - a thin, endless, porous insulator belt of non-wettable material,
 - a latent image forming means including a plurality of selectively energizable electrostatic probes disposed adjacent a first side of said insulator belt,
 - an image formation control unit electrically connected to said latent image forming means for applying a direct current of a first polarity to said selectively energizable electrostatic probes,
 - a polarized ink applicator disposed on the opposite side of said insulator belt comprising an ink roller in rolling contact with said opposite side of said insulator belt electrically connected to a direct current potential of opposite polarity,
 - first and second rollers operable to cause said print member to be brought into contact with said first surface of said insulator belt,
 - cleaning means in operable association with said insulator belt, and
 - means for moving said insulator belt in a direction such that a given portion of said insulator belt passes in sequence past said latent image forming means and said polarized ink applicator means, between said first and second rollers, and through said cleaning means.
 9. An electrostatic printer for printing on a print member comprising:
 - a thin, endless, porous insulator belt of non-wettable material,
 - a latent image forming means including a plurality of selectively energizable electrostatic probes disposed adjacent a first side of said insulator belt,
 - an image formation control unit electrically connected to said latent image forming means for applying a direct current of a first polarity to said selectively energizable electrostatic probes,
 - a polarized ink applicator disposed on the opposite side of said insulator belt comprising an ink roller in rolling contact with said opposite side of said insulator belt electrically connected to a direct current potential of opposite polarity,

first and second rollers operable to cause said print member to be brought into contact with said first surface of said insulator belt,

3,096,198 7/1963 Schaffert ----- 118—637 X
3,102,045 8/1963 Metcalfe et al. ----- 117—37

cleaning means in operable association with said insulator belt,

References Cited by the Applicant

a corona discharge unit in operable association with said first side of said insulator belt, and

5	UNITED STATES PATENTS		
	2,483,462	10/1949	Huebner.
	2,520,504	8/1950	Hooper.
	2,558,900	7/1951	Hooper.
	2,558,901	7/1951	Hooper.
10	2,583,375	1/1952	Hooper.
	2,633,796	4/1953	Pethick.
	2,758,524	8/1956	Sugarman.
	2,758,525	8/1956	Moncrieff-Yeates.
15	2,932,548	4/1960	Nau.
	2,932,690	4/1960	Adams.

means for moving said insulator belt in a direction such that a given portion of said insulator belt passes in sequence past said latent image forming means and said polarized ink applicator means, between said first and second rollers, through said cleaning means, and past said corona discharge unit.

References Cited by the Examiner

UNITED STATES PATENTS

2,777,745 1/1957 McNaney ----- 117—17.5 X
2,832,511 4/1958 Stockdale et al. --- 118—637 X
3,045,644 7/1962 Schwertz ----- 118—637 X

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