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Borelli et al.

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[54] **PRINTING SYSTEM**

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[52] **U.S. Cl.**.....**118/637,** 101/DIG. 13, 117/37 LE, 118/DIG. 23

[51] **Int. Cl.**.....**G03G 13/00**

[58] **Field of Search**.....118/624, 637, 637 LX, 203; 117/37 LX; 101/45, 416 A; 100/121

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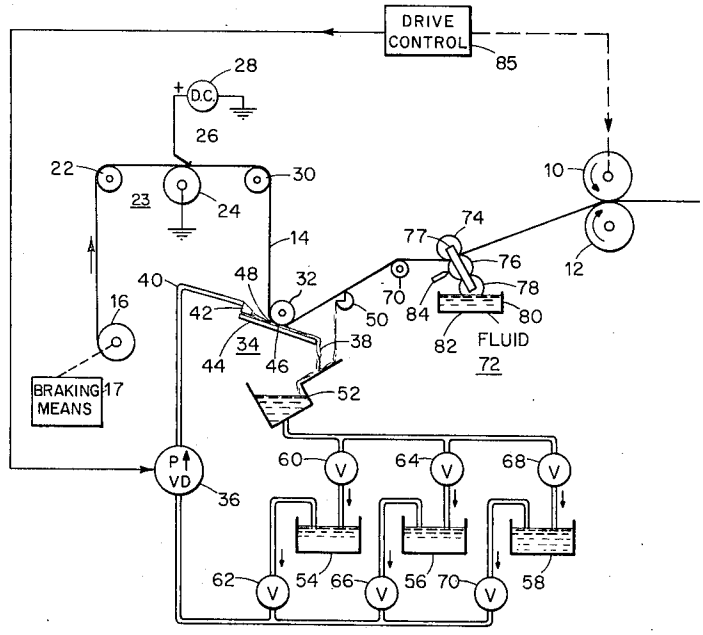
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Assistant Examiner—Leo Millstein
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[57] **ABSTRACT**

A recording medium is printed upon by exciting it with energy corresponding to the shapes to be printed, developing it, and drying it. The paper is dried by squeezing it between two surfaces at least one of which is absorbent, and then scraping the absorbent surface so as to render it absorptive again.

8 Claims, 4 Drawing Figures



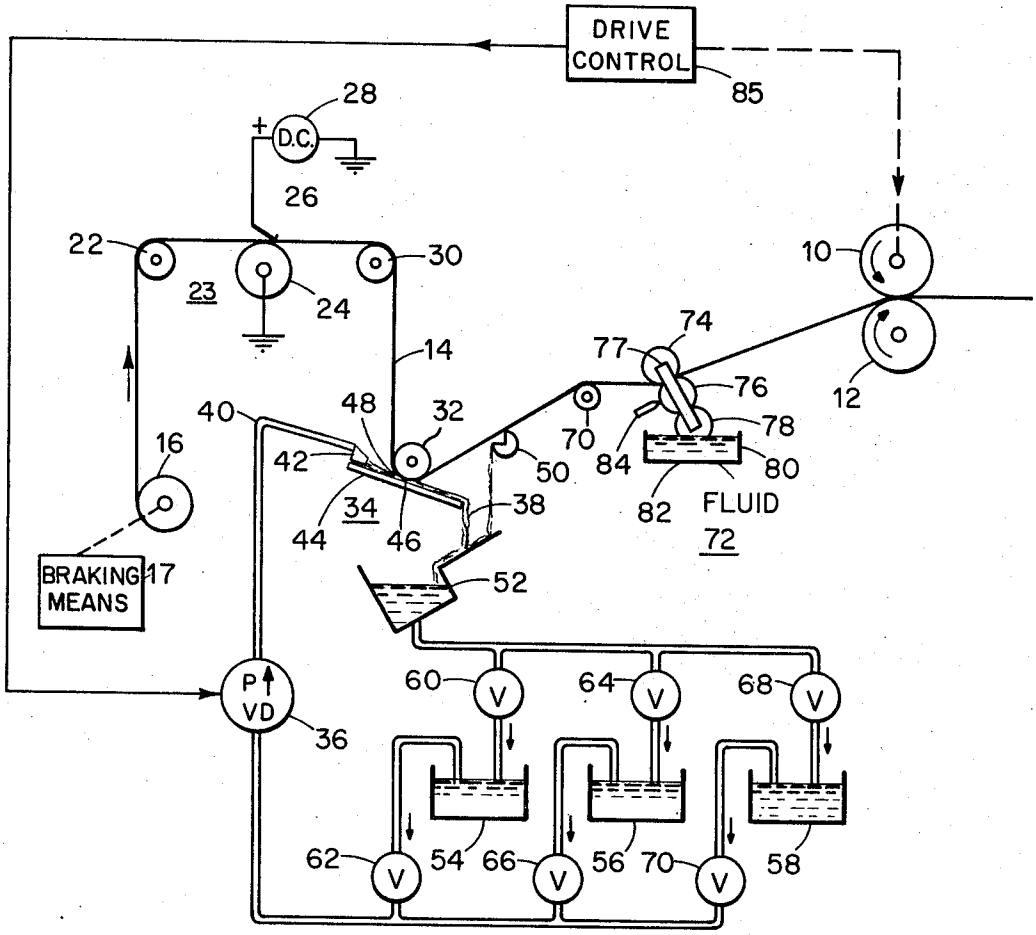


Fig. 1.



Fig. 2.

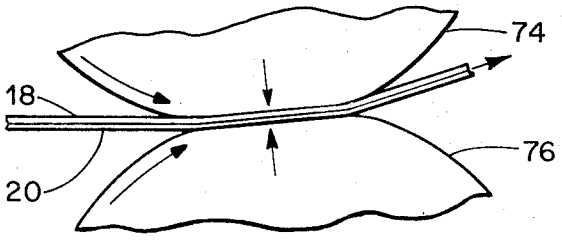


Fig. 4.

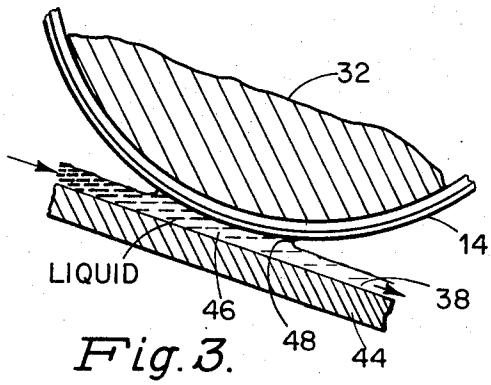


Fig. 3.

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PRINTING SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to an apparatus for printing upon a recording medium and particularly to an apparatus for printing permanent images electrographically upon a paper medium at comparatively high speeds such as are required in a computer read-out.

Presently the output of computers is printed out by impacting paper with print hammers. The movement of such print hammers limits the speed at which the read-out can be handled. Such hammers are also noisy and difficult to maintain. To increase the speed it has been proposed that the print-out be accomplished with so called non-impact printing such as electrographic printing. The latter accomplishes its result upon a paper medium composed of a conductively treated paper base that supports a plastic dielectric coating. The medium is positioned between an electrode that contacts the conductive base and a second electrode whose surface is shaped to conform to the image to be printed. A high voltage applied between the two electrodes excites the paper medium and establishes an electrostatic field across the dielectric coating. The coating retains a residual electrostatic field that constitutes a charged latent image of the shape to be printed.

The latent image is developed, that is made visible, by subjecting the paper medium to charged toning particles. These particles are applied while suspended in a liquid toning carrier. The latter softens or liquefies the particles and forms a so-called toning liquid with the particles. The residual electrostatic field of the dielectric surface attracts these particles and holds them. This makes the image visible.

The image is then fixed, i.e. made permanent. This is done by vaporizing the liquid carrier with heat. When the liquid carrier is removed the particles remain, harden, and bond themselves to the coating.

Vaporizing the liquid carrier creates problems. It produces vapors which, if generated at rapid rates and accumulated in large quantities, may be irritating or harmful. The rate of evaporation the environment can tolerate thus limits the speed of printing. Attempts to limit the rate and amount of generated vapors have hitherto been unsuccessful. They have resulted in printing of poor quality.

SUMMARY OF THE INVENTION

The invention obviates these deficiencies of non-impact printing. According to a feature of the invention, after the medium has been excited and developed by a toning liquid the medium is dried not by vaporization, but by squeezing it between two engaging means at least one of which has an externally curved surface and one of which has a compressible porous absorbent surface. Simultaneously the medium is moved so that as it advances longitudinally the engagement means squeeze continuously successive portions of the medium. The absorbent surface then releases the medium and absorbs liquid on the carrier. Scraping means squeeze the liquid out of the absorbent surface and scrape the liquid away.

According to another feature of the invention, the engagement means comprise two rolls, one of which is absorbent, that squeeze the medium between them.

The scraping means compress the portion of the absorbent roll that has absorbed liquid to release the liquid therein and regenerate the roll for further absorbent action.

According to yet another feature of the invention both rolls are absorbent.

According to still another feature of the invention the toning liquid is applied only to one surface of the medium, namely the dielectric surface of the medium.

According to still another feature of the invention the engagement means have surfaces made from respective porous elastomers.

According to still another feature of the invention cleaning means contact the absorbent engagement means for removing impressions left by the medium. The scraping means squeeze the surface of said engagement means after the cleaning means apply cleaning fluid to the surface.

By virtue of the invention most of the liquid is removed by absorbent means and recovered for further use in toning. Only small quantities of the liquid pass beyond the engagement means and these evaporate quickly but not at rates great enough to accumulate in disagreeable quantities even at high printing speeds.

These and other features of the invention are pointed out in the claims. Other objects and advantages of the invention will become obvious from the following detail description when read in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram illustrating a printing system embodying features of the invention;

FIG. 2 is a cross-section of the carrier in FIG. 1;

FIG. 3 is a cross-sectional detail of the developing portion of FIG. 1; and

FIG. 4 is a detail cross-section of the drying portion of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT

In FIG. 1, a pair of peripherally engaging elastomeric capstan rolls **10** and **12**, rotating as shown, pinch a web of electrographic paper **14** and draw it from a supply roll **16** upon which the paper is wound. A cross section of the paper appears in FIG. **2**. The paper is composed of a conductively treated paper-fibrous base **18** which supports a plastic dielectric coating **20**. The paper is rolled on the roll **16** so as to place the coating **20** on the inside.

The paper **14** constitutes the recording medium. It is referred to as paper although only a portion is composed of paper fibers. The base **18** may for example be 0.003 inch thick and the coating 0.0005 inch thick. The thickness of the paper is somewhat exaggerated in the drawing for clarity.

Braking means **17** places the paper **14** under longitudinal tension as the capstan rolls **10** and **12** pull it. This keeps it taut. The bearings in roll **16** may exhibit sufficient friction to constitute the braking means **17**.

The paper **14** leaving the supply roll **16** passes over an idler roll **22** with the dielectric coating **20** contacting the roll. An excitation station **23** then excites the paper. In the excitation station **23** the paper **14** passes between the peripheral surface of an idling image roll **24** which contacts the coating **20** and an electrode **26**

which is biased to frictionally contact the conductive base paper 18. The periphery of the roll 24 is etched so as to project outwardly to form the image of writing which is to be printed on the paper. The print roll is only an example of a printing electrode. The electrode may be in the form of variable projecting types controlled by a computer to perform computer print-out. Essentially this makes the image roll a print roll.

A 700 volt direct current source 28 applies an excitation voltage between the electrode 26 and the image roll 24 which is grounded. This forms an electrostatic field across the coating 20 at those portions of the periphery on the roll 24 that project and contact the layer 20, and the conductive base 18. The image roll 24 rotates as the paper 14 passes between it and the electrode 26. The roll 24 and the electrode 26 are slightly narrower than the width of the paper.

The coating 20 retains across it a residual electrostatic field corresponding to the exciting field and the image on the periphery of the image rolls 24. This constitutes a latent image.

The paper 14 emerging from between the roll 24 and electrode 26 passes over an exit idler roll 30 and around a steel toning roll 32 of a developing or toning station 34. The roll 32 guides the paper and is preferably as narrow or slightly narrower than the paper. The plastic coating 20 of the paper 14 faces outwardly of the roll 32. Since the capstan roll 10 and 12 draw the paper 14 against the braking force at the supply roll 16, the longitudinal forces on the paper produce radial forces directed inwardly to the axis of the roll 32. This assures substantially firm contact between the roll 32 and the base 18 of the paper 14.

During this process the plastic dielectric coating 20 of the paper 14 continues to retain across its thickness the latent electrostatic field that constitutes the latent image of the projections on the periphery of the image roll 24. In order to develop this latent image, a pump 36 drives a toning liquid. The latter comprises a high resistance carrier, such as kerosene, which has a resistance of 10^{16} ohms per cubic centimeter, and a suspension of charged colored thermoplastic resin particles which forms the printing material. The pump 36 drives the liquid 38 through a flexible pipe 40 to a fan nozzle 42. The latter spreads the liquid laterally over a flat steel inclined plate 44 to form a shallow laminar liquid flow. The plate 44 is as narrow or slightly narrower than the width of paper 14. It is spaced from the freely turning toning roll 32 so as to form a gap between the coating 20 and the plate 44 of from 0.005 to 0.020 inch. When the liquid 38 flows through the gap 46, it contacts the coating 20 and forms a meniscus 48. The meniscus appears more particularly in FIG. 3 which shows an enlarged cross section of the roll 32, the paper 14, the plate 44, the meniscus 48, and the liquid 38 in FIG. 1.

As stated, the toning liquid 38 flows by gravity to the toning area where it contacts the paper 14 due to the closeness of the roller 32 and the flat plate 44. As the liquid 38 contacts the paper 14, the meniscus 48 is formed at the coating 20. The meniscus is formed and kept intact by the forces of adhesion between the molecules of the flowing liquid 38 and the coating 20 of the paper 14. It extends transversely across the roll 32 and clings peripherally from one side of the gap, at its narrowest portion, to the other. The gap 46 is sufficiently small to form such a meniscus but large enough to allow passage of toning liquid 38.

The thermoplastic resin particles suspended in the kerosene of the liquid 38 are charged and adhere to the portions of the surface 20 which are oppositely charged. This makes the image visible. That is, it develops the image. As the paper 14 is drawn away from the capstan rolls 10 and 12 it shears off the top portion of the meniscus 48 and retains a portion of the liquid and the thermoplastic resin particles. The flow that supports the meniscus is maintained by the constant pumping action of the pump 36. The flow is adjusted so the paper 14 just contacts or kisses the liquid. This helps assure even distribution of liquid and a distribution of particles that depends almost exclusively on the electrostatic field. A uniformly developed image results.

The particles continue to adhere to the now-wet surface of the coating 20. A wiper 50 in the shape of a longitudinally notched rod removes some of the liquid 38 on the dielectric coating 20. The remaining liquid 38 flowing out of the meniscus 48 is caught in a trough 52 and fed back to a selected one of three reservoirs 54, 56 and 58 containing toner liquid of different colors.

The liquid 38 in each reservoir 54, 56 and 58 has suspended therein thermoplastic resin particles of different colors so as to print in different colors. Six pairs of electrically actuated flow valves 60, 62, 64, 66, 68, and 70 select which of the fluids 38 are drawn by the pump 36 from their respective reservoirs. The valves 60, 62, 64, 66, 68, and 70 are arranged so that two pairs are closed and one pair open to fluid flow.

The tightness of the paper about the roll 32 helps assure uniform distribution of liquid over the coating 20. It also helps prevent liquid 38 from the meniscus 48 from contacting the more absorbent base 18 of the paper 14. Such contact would cause the base to absorb a good deal of the liquid and make drying difficult. The particles in the liquid on the paper are concentrated in those areas carrying the electrostatic field.

The steel roll 32 and the steel plate 44 are in close proximity across the gap. In the vicinity of the gap they thus tend to align the residual electrostatic field across the dielectric 20 to be substantially perpendicular to the dielectric. Such alignment prevents fringing. It assures a sharp visible image. It prevents fuzziness that fringing may introduce. The smaller the gap the sharper the image.

An idler roll 70 directs the paper into a drying apparatus 72 where the image is fixed. In this drying apparatus the paper passes between an elastomeric backup roll 74 that contacts the base of the paper 14 and a second elastomeric absorption roll 76 that contacts the wet toner-carrying coating 20 of the paper 14. Both of the rolls idle and move with the paper 14. Mountings 77 that support rolls 74 and 76 bias the rolls one toward the other by springs, pneumatic or hydraulic cylinders or other known pressure devices to apply pressure against the paper 14.

As the paper passes through the rolls 74 and 76 compress not only the paper but a portion of the peripheral surface of the elastomeric material. The elastomeric material of the absorption roll 76 is such as to be absorbent of the liquid 38. As the roll 76 has its periphery

compressed near the engagement point with the roll 74, any air in the absorptive surface or any other fluid in the absorptive surface is squeezed out. As the paper passes through and emerges between the pinch of the rolls, the portion of the roll 76 that has been compressed begins to expand and absorb the kerosene carrier in the liquid 38 on the surface of the coating 20 of the paper 14. Those particles which are attracted by their electrophoretic condition to the charged portions of the coating 20 remain on and in the crevices of the coating 20. The removal of the surrounding liquid hardens or solidifies the particles so they secure themselves to the paper. This produces permanent printing upon the paper 14 and fixes the image.

The paper when squeezed may also transfer a portion of the particles onto the roll 76. These particles may then be transferred to a successive section of the moving paper. To prevent this, a rotating cleaning brush 78 that dips into a cleaning fluid 80 of a trough 82 applies the cleaning fluid to the surface of the elastomer roll 76. This removes any imageforming particles on the roll 76.

A scraper 84 compresses the surface of the roll 76 after its contact with the brush 78. The scraper 84 squeezes the surface of the elastomeric roll between itself and the axis of the roll. This squeezes out any toning liquid or cleaning fluid that may exist in the absorptive pores of the roll 76. At the same time it scrapes toning liquid and the cleaning fluid that was on the surface of the roll and substantially dries it. This presents a substantially dry roll surface to the paper which in turn dries the paper. The paper then passes between the capstan rolls 10 and 12 and out to a utilizing station. The scraper avoids the effect of a squeeze roller which would, as it turned, reapply the liquid squeezed out.

A drive control 85 that senses the speed of the capstan rolls 10 controls the flow of the pump 36 so that more or less fluid 38 can pass out the nozzle 42 in dependence upon the speed of the paper 14. In this manner if the paper speed 14 at the gap 46 is so fast as to shear off large amounts of liquid in the meniscus 48 in a short period of time sufficient fluid is provided to replace the liquid in the meniscus.

The roll 74 and 76 and the scraper 84 prevent significant amounts of liquid from clinging to the carrier 14. This obviates the need for drying the carrier on the basis of evaporation. Thus, the printing speed can be increased while sparing operators of the apparatus from disagreeable fumes. By virtue of the invention so-called non-impact printing upon paper is possible without the danger of excessive fumes.

The diameter of the roll 32 is between ½ inch and 3 inch and preferably 1 inch. Other sizes may of course be used.

While an embodiment of the invention has been described in detail it will be obvious to those skilled in the art that the invention may be embodied otherwise without departing from its spirit and scope.

What is claimed is:

1. An apparatus for printing on a flat flexible medium, comprising driving means for moving said medium along a path, excitation means along the path for sensitizing the medium, developing means along the path for applying a toning liquid to the sensitized medium, and drying means along the path for removing excess toning liquid from the medium; said drying means including first and second rotatable roll means for engaging opposite faces of said medium between them, each of said roll means having externally curved surfaces so as to permit rolling engagement therebetween when the medium is moved between them, said first and second roll means having compressible porous absorbent surfaces composed of an elastomer, pressure means biasing said first and second roll means one toward the other for pressing the moving medium between said roll means so that as said medium advances longitudinally said roll means squeeze continuously successive portions of the medium and compress the absorbent surfaces and then release the medium and the compressed absorbent surfaces so that the absorbent surface absorb liquid on said medium, brush roll means engaging the first roll means, cleaning reservoir means for holding a cleaning fluid in contact with said brush roll means whereby as said first roll means rotates said brush roll means rotates with it and applies cleaning fluid to it, and compression means located along the periphery of said first roll means after engagement with said brush roll means for compressing the absorbent surface of said first roll means so as to scrape the surface thereof after the surface has been cleaned.

2. In apparatus for printing on a flat flexible medium, comprising driving means for moving said medium along a path, excitation means along the path for sensitizing the medium, developing means along the path for applying a toning liquid to the sensitized medium, and drying means along the path for removing excess toning liquid from the medium; said drying means including first and second engaging means for engaging opposite faces of said medium between them, at least one of said engaging means having an externally curved surface so as to permit rolling engagement between said engagement means when the medium is moved between them, said first engaging means having a compressible porous absorbent surface and said second engaging means having a surface, pressure means biasing said first and second engagement means one toward the other for pressing the moving medium between said engagement means so that as said medium advances longitudinally said engagement means squeeze continuously successive portions of the medium and compress the absorbent surface and then release the medium and the compressed absorbent surface so that said absorbent surface absorbs liquid on said medium, compression means for compressing the previously squeezed portion of the absorbent surface and brush roll means engaging the curved surface of said one engaging means, cleaning liquid reservoir means for holding a cleaning fluid in contact with said brush roll means whereby as said curved surface of said one engagement means rotates said brush roll means rotates with it and applies cleaning fluid to its surface, said compression means being disposed at a location along the periphery of said curved surface of said one engagement means so as to scrape the surface thereof after the surface has been cleaned.

3. An apparatus as in claim 2 wherein said engagement means each include rotatable roll means adapted to engage opposite faces of the same portion of the medium and squeeze the carrier between them.

4. A device as in claim 3 wherein both of said roll means have compressible absorbent surfaces.

5. A device as in claim 2 wherein both of said engagement means have compressible absorbent surfaces.

6. A device as in claim 2 wherein said engagement means have surfaces made from respective porous elastomers.

7. A device as in claim 2 wherein said drying means further comprise cleaning means contacting said first engagement means for removing impressions left by the medium and wherein said squeezing means squeeze said surface at a point after said cleaning means apply cleaning fluid to said surface.

8. Apparatus as in claim 2 wherein said developing means wet only one surface of the medium.

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