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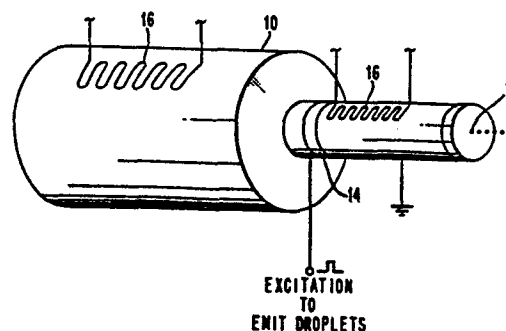
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54 Ink jet recording system.

57 An apparatus for liquid jet recording systems is described for providing drop-on-demand ink from a reservoir wherein the ink contained in the reservoir is a wax-based hot-melt ink which undergoes a liquid-solid phase transition. The apparatus includes an ink reservoir (10), a nozzle (12), and a piezoelectric transducer (14) connected to a source of electrical pulses to provide excitation to cause droplets of ink to be moved from the reservoir and out through the nozzle. A unique meltable wax-based ink (95 percent paraffin wax and 5 percent carnauba wax) capable of undergoing a liquid-to-solid phase transition is contained in the reservoir (10) which includes heaters (16) which are employed to impart thermal energy to the ink to carry out the phase change.



INK JET RECORDING SYSTEM

The invention relates to ink jet recording systems, and more particularly to ink jet recording systems wherein ink is contained in a chamber or reservoir and is discharged through a nozzle orifice and adheres onto the surface of a recording medium.

In liquid jet recording systems wherein ink is contained in a chamber or reservoir and is expelled from the chamber either as droplets or in a continuous stream onto a recording surface, it is known that heating elements may be provided to raise the temperature of the ink. In U.S. Patent 4,184,169, issued January 15, 1980 to Taylor et al, a drop-on-demand ink drop printer is shown including two ink reservoirs having associated heating elements. The heating elements are used to create expanded vapour pressure to force the ink from one reservoir through a printhead and into the second reservoir.

In U.S. Patent 4,251,824, issued February 17, 1981 to Hara et al, heating elements are located along the flow path of ink in a printer to expand and vaporize the liquid ink to produce a pressure used to expel the ink. In U.S. Patent 3,878,519, issued April 15, 1975 to Eaton, an ink jet system is described wherein heat is applied to a stream of ink. The temperature change causes a change in surface tension of the ink, which controls the breakup of the stream into discrete droplets.

U.S. Patent 3,655,379, issued April 11, 1972 to Gundlach, is an example of a system which uses heat energy to produce vapour expansion pressure to propel ink from a drum surface onto a paper.

Other examples of printing systems wherein the viscosity of the ink is changed by application of heat are shown in U.S. Patent 3,369,253, issued February 13, 1968 to Sihvonen, U.S. Patent 3,553,708, issued January 5, 1971 to Carreira et al, and U.S. Patent 4,164,745, issued August 14, 1979 to Cielo et al.

The aforesaid prior art is distinct from the present invention in that the present invention is directed to a wax-based hot-melt ink for an ink jet system incorporating heating elements to cause a liquid-solid phase transition of the ink.

An object of the present invention is to provide a liquid jet recording system employing ink which undergoes a liquid-solid phase transition.

Another object of the present invention is to provide an ink jet recording system using a wax-based hot-melt ink. A further object of the present invention is to provide an ink jet recording system incorporating heating elements, a hot-melt ink, and a piezoelectric element for emitting the ink.

A still further object of the present invention is to provide an ink jet recording system wherein the spreading of liquid ink onto the outside surface of the ink nozzle, is prevented.

Another object of the present invention is to provide a hot-melt ink for an ink jet recording system which avoids long drying times and is therefore useful for high speed.

Still another object of the present invention is to provide a hot-melt ink for an ink jet recording system which is in a solid state when the system is idle.

Accordingly the invention provides ^{an} ink jet recording system comprising a reservoir for holding a supply of ink, a nozzle mounted in said reservoir for permitting ink to exit from said reservoir, an actuating element connected to said nozzle and to a source of electrical excitation signals for causing droplets of ink to be expelled from said reservoir through said nozzle, a quantity of ink disposed in said reservoir, said ink being composed in part of a meltable wax-base which undergoes a liquid to solid phase transition, and heating means

associated with said reservoir to melt said ink into said liquid phase for expulsion from said nozzle.

The invention includes a method of recording data comprising storing in a reservoir an ink having a meltable wax-base which undergoes a thermally reversible liquid to solid phase transition, effecting a solid to liquid or a liquid to lower viscosity liquid transition of the ink in the reservoir by heating the ink, and ejecting a drop of the heated liquid ink from a nozzle connected to the reservoir.

The invention will now be further described with reference to the accompanying drawing. The drawing, referred to as Figure 1 for convenience is a perspective view of an embodiment of an apparatus for retaining and selectively expelling ink according to the principles of the present invention. It is understood that a plurality of such ink drop emitters could be integrated to form an array.

Description of the Preferred Embodiment

Referring to FIG. 1, an illustration of an apparatus for providing drop-on-demand ink from a reservoir wherein the ink contained in the reservoir is a wax-based hot-melt ink which undergoes a liquid-solid phase transition.

The apparatus includes an ink reservoir 10, a nozzle 12, and a piezoelectric transducer 14 connected to a source of electrical pulses to provide excitation to cause droplets of ink to be moved from reservoir 10 and out through nozzle 12. The particular configuration of reservoir 10, nozzle 12 and piezoelectric transducer 14 is not critical, and many variations of such combinations are known in the art. In particular, a plurality of ink channels can be used in serial or line printing applications.

Typically, a piezoelectric transducer is used to provide the piston-like action. A piezoelectric transducer is a device that converts electrical

energy into mechanical energy. It can also do the converse. In U.S. Patent 2,512,743 to C. W. Hansell, issued June 27, 1950, an ink jet was described in which a circular piezoelectric transducer was used in an extensional mode, the extension being along the axis to drive ink. The piezoelectric transducer was arranged coaxially with a conical nozzle, the axial extension being used to create pressure waves causing expulsion of droplets from the nozzle. Several other transducer arrangements have been proposed. A basic arrangement was disclosed in an article, "A Piezoelectric Capillary Injector-A New Hydrodynamic Method for Dot Pattern Generation", by Eric Stemme and Stig-Goran Larsson, IEEE Transactions on Electron Devices, January 1973, pages 14-19. In that disclosure, a system is disclosed in which a bilaminar piezoelectric disk is used to drive ink coaxially with the bilaminar disk. In that system, application of an electrical voltage pulse across the disk causes an inward, that is, towards the ink, center deflection, which forces ink droplets out of an orifice. U.S. Patent 3,946,398, issued March 23, 1976, shows a similar device; however, as disclosed in that patent the center deflection of the disk is used to eject ink through an orifice, the axis of drop ejection being perpendicular to the axis of the disk.

Two other arrangements are shown in U.S. Patent 3,857,049, issued December 24, 1974. In the arrangement shown in FIG. 1 through FIG. 4 of that patent, a tubular transducer surrounds a channel containing the ink, and the transducer, when excited by application of an electrical voltage pulse, squeezes the channel radially to eject a drop. As shown in FIG. 6 of that patent, there is disclosed a system in which the radial expansion of a disk in response to an electrical voltage pulse is used to compress ink in circumferential channels thereby forcing ink droplets out of a nozzle. Other arrangements are also known.

The apparatus of FIG. 1 further includes heaters 16 which are employed to impart thermal energy to a unique wax-based ink which is located in reservoir 10 and is passed through nozzle 12. One embodiment of the heaters 16 may be as heating elements on a thin film which is

incorporated on the reservoir 10 and nozzle 12. One embodiment of a heating element is explained in the previously mentioned U.S. Patent 4,251,824 wherein SiO_2 is sputtered as a base layer onto an Al_2O_3 base plate, followed by lamination of ZrB_2 as the heat generating layer and Al as the electrode, after which the heat generating body is formed by a selective photo-etching, and finally SiO_2 is again sputtered as an insulative protective layer. Other heater embodiments are also available and may be employed in the present invention.

Whereas heated ink reservoirs and electrically controlled ink expelling structures have been employed in various ways in the prior art, in the present invention such techniques are used in combination with a meltable wax-based ink which undergoes a liquid-to-solid phase transition.

The meltable wax-based ink which undergoes a liquid-to-solid phase transition employed in the embodiment of the present invention is specified as having a phase transition temperature within a 60° centigrade to 80° centigrade degree range and a kinematic viscosity between one and forty centistokes. One example of a suitable ink according to the present invention would be composed of 95% paraffine plus 5% carnauba wax which has a viscosity of 14.7 centistokes at 65° centigrade.

The use of such wax-based ink in the present invention provides an advantage relative to the problem of nozzle face wetting. Water-based inks produce wetting of the nozzle face, and spreading of the ink occurs onto the outside surface of the nozzle which is generally exposed to ambient air. This wetting results in impaired drop ejection.

Rather than make the nozzle surface non-wetting, (hydrophobic) in the present invention it is assumed that the nozzle face is hydrophobic and that the properties of the hot-melt ink keep the ink from spreading on the nozzle face. During operation, the meniscus is continuously renewed and is thus kept from spreading. The hot-melt ink requires some warm up

time, but the fact that the hot-melt ink is initially in a solid state has advantages, such as the virtual absence of evaporation when the printer is not active. During use the ink may be in a semi-liquid state and be brought to a proper flowable liquid state only when printing is to be effected.

What has been described is an improved liquid jet recording system employing a hot-melt ink which undergoes a liquid-solid phase transition.

CLAIMS

1. Ink jet recording system comprising a reservoir (10) for holding a supply of ink,

a nozzle (12) mounted in said reservoir for permitting ink to exit from said reservoir,

an actuating element (14) connected to said nozzle and to a source of electrical excitation signals for causing droplets of ink to be expelled from said reservoir through said nozzle,

a quantity of ink disposed in said reservoir, said ink being composed in part of a meltable wax-base which undergoes a liquid to solid phase transition, and

heating means (16) associated with said reservoir to melt said ink into said liquid phase for expulsion from said nozzle.

2. Ink jet recording system as claimed in claim 1, further comprising a recording member in the path of said ink droplets expelled from said nozzle, said ink droplets being disposed on the surface of said recording member and undergoing said liquid to solid phase transition.

3. Ink jet recording system as claimed in claim 1 or 2, wherein said actuating element (14) is a piezoelectric transducer connected to a source of electrical pulses to provide excitation to cause droplets of ink to be moved from said reservoir out through said nozzle.

4. Ink jet recording system as claimed in claim 1, 2 or 3, wherein said heating means (16) is an electrical thin film heater including a laminated heat generating layer and conductive electrodes disposed on said reservoir and said nozzle.

5. Ink jet recording system as claimed in claim 1, 2, 3 or 4, wherein said ink is composed of approximately 95 percent paraffin and 5 percent carnauba wax.

6. A method of recording data comprising storing in a reservoir an ink having a meltable wax-base which undergoes a thermally reversible liquid to solid phase transition, effecting a solid to liquid or a liquid to lower viscosity liquid transition of the ink in the reservoir by heating the ink, and ejecting a drop of the heated liquid ink from a nozzle connected to the reservoir.

