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(12) # EUROPEAN PATENT SPECIFICATION

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(54) **Ink jet forming unit.**

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DE-A-2 943 164
DE-A-3 228 887
US-A-4 275 290

(73) Proprietor: **FUJI XEROX CO., LTD.**
No. 3-5, Akasaka 3-chome
Minato-ku Tokyo 107 (JP)

(72) Inventor: **Koike, Takao**
No.2274, Hongo
Ebina-shi Kanagawa (JP)
Inventor: **Tamai, Masayoshi**
No.2274, Hongo
Ebina-shi Kanagawa (JP)
Inventor: **Iyoda, Tetsuo**
No.2274, Hongo
Ebina-shi Kanagawa (JP)
Inventor: **Koizumi, Yukihisa**
No.2274, Hongo
Ebina-shi Kanagawa (JP)

(74) Representative: **Boeters, Hans Dietrich, Dr. et al**
Boeters, Bauer & Partner Thomas-Wimmer-Ring 14
D-8000 München 22 (DE)

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Courier Press, Leamington Spa, England.

Description

Background of the Invention

Field of the Invention

This invention relates to ink jet forming units in an ink jet printer.

Description of the Prior Art

An ink jet printer is advantageous in that it can record data on ordinary sheets, it needs no developing nor fixing, and it generates little noise. Recording systems employed for the printer are roughly classified into (1) a first or continuous type in which ink drops are continuously jetted and are selectively applied to a recording sheet, and (2) a second or pulsed group in which an ink drop is jetted only when printing is effected.

In the continuous group, it is necessary to control the trajectories of ink droplets for instance by a method in which an ink droplet is deflected by charging. Therefore, not only is the control mechanism intricate, but it is also necessary to provide a space for installation of an ink circulation system, so that it is difficult to miniaturize the printer.

The recording systems in the pulsed group can be further classified according to principle of operation of forming the ink jet with an ink jet forming unit.

In an ink jet forming unit for a so-called "magneto-fluid-graphic" system, a magnetic ink is allowed to rise on a controlling recording stylus and it is then attracted by an electric field so that it is jetted. Therefore, in the case where data are recorded in color with the ink jet forming unit, the number of recording colors is limited because the magnetic material has its own color other than the color of the ink and the color of the ink may change as the magnetic material is oxidized.

DE—A—3 228 887, DE—A—2 943 164, and US—A—4 275 290 disclose ink jet forming units which perform recording according to a so-called "bubble jet" system, i.e. the ink is boiled to form bubbles by locally applying heat to the ink in an opening in the ink jet forming unit by means of a resistor or the like. The ink may be completely or partially vaporized, the formation of gas bubbles causing the ink to move out of the opening, or the surface tension of the ink is reduced, again causing the ink to move out of the opening. A variation is further described in above mentioned US—A—4 275 290 and is intended to heat and electrolyze the ink by an electric current flowing directly through the ink. The current is carried by electrodes which are mounted on a vertical wall and are in contact with the ink. Gaseous bubbles are generated at the electrodes and provide the internal pressure required to jet an ink drop through the opening. All these bubble jet systems require that the ink is more or less thermally stable. However, such inks are difficult to prepare.

Summary of the Invention

Accordingly, an object of this invention is to provide an ink jet forming unit which can record data in desired colors and stably and effectively jets ink drops. The foregoing object of the invention has been achieved with an ink jet forming unit in accordance with claim 1. An ink jet forming unit according to the invention comprises inter alia: gas producing means for electrolyzing water of a water-based ink to produce a gas; and a nozzle in which an ink drop is formed by the gas and is jetted by the pressure which is provided as the gas expands.

Brief Description of the Drawings

Fig. 1 is an external view showing a print head using ink jet forming units according to this invention;

Fig. 2 is a perspective view showing essential components of an ink jet forming unit in a nozzle in prior art;

Fig. 3 is an explanatory diagram describing the principle of operation for forming an ink jet with the ink jet forming unit of Fig. 2;

Fig. 4 is a perspective view showing the essential component of the ink jet forming unit of the invention;

Fig. 5 is an explanatory diagram describing the principle of operation for forming an ink jet with the ink jet forming unit of Fig. 4.

Detailed Description of the Preferred Embodiments

The invention will be described with reference to its embodiments.

Fig. 1 shows the external appearance of a print head. The print head 10 has an apperture plate whose length is substantially equal to the width of a recording sheet (not shown). A number of ink jet forming units are arranged on the appertures plate (the nozzle plate). More specifically, the ink jet forming units are arranged at equal intervals and in a line in the longitudinal direction of the ink jetting surface 11. In the case of a printer which records data on a recording sheet of size "A4" paper with a recording density of 8 lines/mm, a nozzle 12 is associated with each ink jet forming unit and has an opening, each side of which is about 60 μm. In this case, 1,728 nozzles 12 are arranged at equal intervals of 60 μm.

Fig. 2 shows essential parts of an ink jet forming unit. The nozzle 12 is an elongated, insulated and hollow part. The nozzle 12 has upper and lower electrodes 14 and 15 at positions on the inner walls which are slightly backward of the external opening and are positioned such that the electrodes 14 and 15 confront each other. A series circuit consisting of a switch 16 and a DC voltage source 17 is connected between the upper and lower electrodes 14 and 15. When the switch 16 is turned on, the water-based ink (not shown) in the nozzle 12 is subjected to electrolysis, so that the ink comes out in a jet. The upper and lower electrodes 14 and 15 are of a metal such a nickel, silver, nickel-plated iron, or gold or silver-plated iron. The electrodes are formed in the nozzle by vacuum deposition or other conventional methods.

Fig. 3 shows the principle of forming an ink jet with the ink jet forming unit according to Fig. 2. Fig. 3(A) shows the standby state of the ink jet forming unit in which the nozzle 12 is filled with ink 18. The ink is supplied from an ink tank (not shown) by capillary action. The ink 18 is prepared by dissolving pigment and electrically conductive material in water. The conductivity of the ink is adjusted to be between 10^{-1} and $10^{-2}\ \Omega^{-1} \cdot cm^{-1}$.

Fig. 3(B) shows the initial state of the ink jet forming unit, in which a recording voltage is applied between the electrodes 14 and 15. When a printing pulse of several volts to several tens of volts is applied between the electrode 14 and 15, hydrogen is produced from the upper electrodes 14 which is used as a cathode, while oxygen is produced from the lower electrode 15 which is used as an anode. These gases form bubbles 21 and 22. The bubbles 21 and 22 grow abruptly into one bubble as shown in Fig. 3(C). As a result, the ink column is separated into two parts near the opening; that is, an ink part 18A is formed and separated from the remaining ink 18 by the bubbles 21, 22. The ink 18A is moved outwardly as bubbles 21 and 22 grow and coalesce, and is finally jetted as an ink droplet 23 as shown in Fig. 3(D).

The above-described operation is accomplished in one microsecond to several hundreds of microseconds in which the printing pulse is applied. The ink droplet 23 strikes a recording sheet which is spaced slightly away from the ink jet forming unit, thus printing one dot. In practice, a number of ink jet forming units of the print head 10 are selectively driven according to a picture signal to record data for one line in a single action. When the recording of one line is achieved, the recording sheet or the print head is moved a distance of one line in the secondary scanning direction, so that the next printing operation can be started. At this time, the ink 18 in the nozzle 12 is restored by capillary action as shown in Fig. 3(A).

With these ink jet forming units, printing can be achieved at a frequency of about 1 kHz if the printing pulse voltage and the size of the ink droplet are set to suitable values. This recording speed is sufficiently high for desired operation. It is unnecessary for the ink to contain magnetic material, and the ink can be used at room temperature. As a result, the ink can be used for a long period of time without any changes in the ink.

Fig. 4 shows the nozzle of the ink jet forming unit according to the invention. The nozzle 25 is made up of the lower electrode 16 and insulated inner walls. A metal plate, or a metal bar, which is made of nickel or the like is arranged in the ink passageway which is linked to the ink tank. The metal plate in the passageway is the other electrode.

Fig. 5, arranged similarly to Fig. 3, shows the principle of operation for forming an ink jet with the ink jet forming unit in Fig. 4. In Fig. 5, those components which have been described with reference to Fig. 3 are therefore designated by the same reference numerals, and their detailed descriptions are omitted. In this modification, the lower electrode 15 is remote from the other electrode, and only the bubble 22 produced from the lower electrode 15 is directly utilized for jetting an ink drop. Accordingly, in order to obtain the same recording speed as that of the above-described embodiment under the same conditions as those of that embodiment, it is necessary to slightly increase the printing pulse voltage. However, the modification is advantageous in that since only the lower electrode 15 is arranged on the inner wall of the nozzle, the ink jet forming unit can be readily manufactured and accordingly the manufacturing cost can be reduced.

The ink jet forming units of the invention are arranged over the entire width of a recording sheet, so that one line of data is recorded in one action. However, when recording should be achieved at an especially high speed, a method may be employed in which one to several tens of ink jet forming units are arranged in a print head, and recording is carried out simultaneously with the parallel ink jet forming units while the print head is moving relative to the recording paper in the main scanning direction. It goes without saying that it is not always required that the nozzle is square or rectangular in section.

As is apparent from the above description, in the invention, the bubbles are formed by electrolysis. Therefore, it is unecessary to preheat the ink jet forming units, and it is possible to quickly start the recording operation. The ink jet forming unit of the invention is simple in construction, low in manufacturing cost and high in reliability when compared with the conventional one in which an ink drop is jetted by a pressure wave which is provided by an electro-mechanical conversion element.

Claims

1. An ink jet forming unit for use with an ink (18) containing water, comprising:

— a nozzle (12) containing said ink and having an openign in the end thereof

— gas producing means for electrolyzing said water in said ink to produce bubbles (21) of gas, which form an ink drop and jet said ink drop through said opening by means of the pressure generated by said bubbles, said gas producing means comprising two electrodes (14, 15) containing said ink,

— a power source (16, 17) connected to said electrodes,

characterized in that only one (15) of said electrodes is arranged horizontally near said opening.

2. An ink jet forming unit, as claimed in claim 1, characterized in that said power source is a controlled power source (16, 17).

3. An ink jet forming unit, as claimed in claims 1

or 2, characterized in that said power source (16, 17) comprises a series circuit consisting of a switch (16) and a DC voltage source (17).

4. An ink jet forming unit, as claimed in any of claims 1 to 3, characterized by the provision of a plurality of said nozzles (12) arranged parallel to one another and a plurality of gas producing means, each associated with a separate nozzle.

Patentansprüche

1. Tintenstrahlbildende Einheit zur Verwendung mit einer wasserhaltigen Tinte (18) mit

— einer Düse (12), welche die Tinte enthält und eine Öffnung am Ende aufweist,

— einem gasbildenden Mittel zum Elektrolysieren des Wassers der Tinte zur Bildung von Gasblasen (21), die einen Tintentropfen bilden und den Tintentropfen durch die Öffnung mit Hilfe des durch die Blasen erzeugten Drucks treiben, wobei das gasbildende Mittel zwei Elektroden (14, 15) umfaßt, die mit der Tinte in Kontakt stehen,

— einer Versorgungsquelle (16, 17), die mit den Elektroden verbunden ist,

dadurch gekennzeichnet, daß nur eine Elektrode (15) der beiden Elektroden horizontal in Nachbarschaft zur Öffnung angeordnet ist.

2. Tintenstrahlbildende Einheit nach Anspruch 1, dadurch gekennzeichnet, daß die Versorgungsquelle eine geregelte Versorgungsquelle (16, 17) ist.

3. Tintenstrahlbildende Einheit nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Versorgungsquelle (16, 17) eine Reihenschaltung aus einem Schalter (16) und einer Gleichspannungsquelle (17) umfaßt.

4. Tintenstrahlbildende Einheit nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß mehrere Düsen (12), die parallel zueinander angeordnet sind, und mehrere gasbildende Mittel vorgesehen sind, die jeweils einer getrennten Düse zugeordnet sind.

Revendications

1. Dispositif pour produire un jet d'encre utilisable avec une encre (18) contenant de l'eau, comprenant:

— une buse (12) contenant ladit encre et pourvue d'un orifice à son extrémité,

— un moyen de production de gaz pour électrolyser ladite eau dans ladite encre afin de produire des bulles (21) de gaz, qui forme une goutte d'encre et projette ladite goutte d'encre au travers dudit orifice sous l'effet de la pression engendrée par lesdites bulles, ledit moyen de production de gaz comprenant deux électrodes (14, 15) entrant en contact avec ladite encre,

— une source de courant (16, 17) reliée auxdites électrodes,

— caractérisé en ce que seulement une (15) desdites électrodes est placée horizontalement à proximité dudit orifice.

2. Un dispositif de production de jet d'encre tel que revendiqué dans la revendication 1, caractérisé en ce que ladite source de courant est une source de courant commandée (16, 17).

3. Un dispositif de production de jet d'encre tel que revendiqué dans les revendications 1 ou 2, caractérisé en ce que ladite source de courant (16, 17) comprend un circuit-série se composant d'un interrupteur (16) et d'une source de tension continue (17).

4. Un dispositif de production de jet d'encre tel que revendiqué dans une quelconque des revendications 1 à 3, caractérisé en ce qu'il est prévu un pluralité desdites buses (12) qui sont disposées parallèlement entre elles et une pluralité de moyens de production de gaz qui sont chacun associés à une buse séparée.

FIG. 1

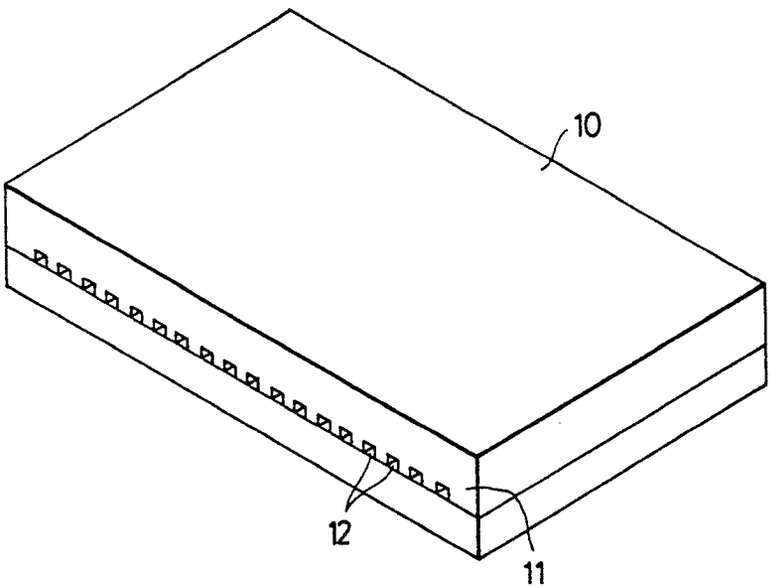


FIG. 2

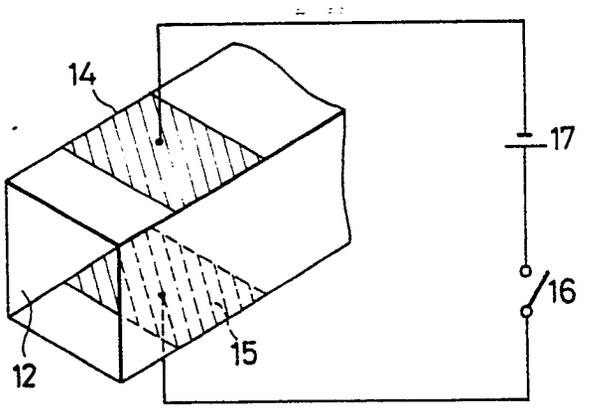


FIG. 4

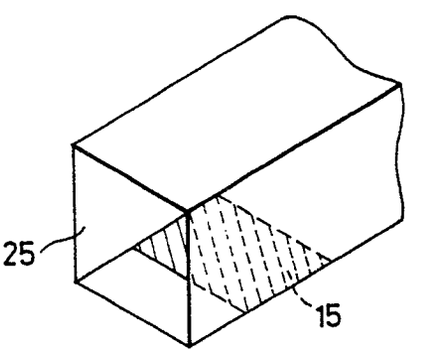


FIG. 3

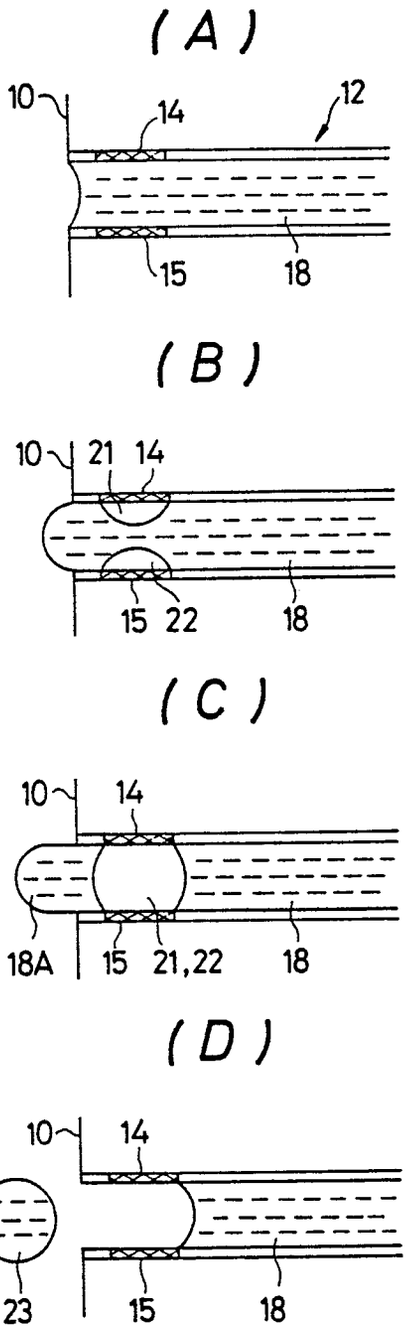
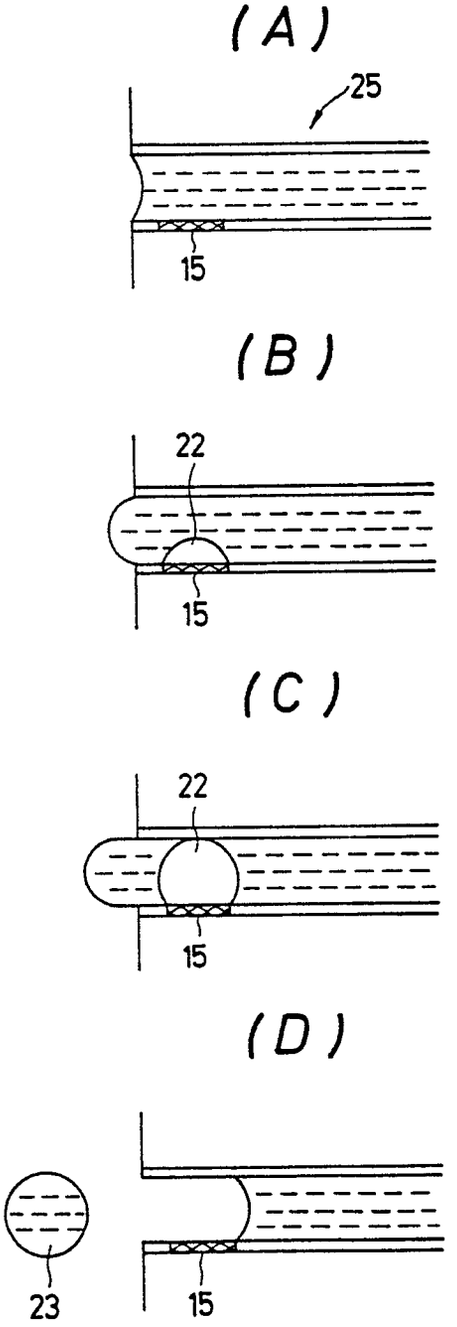

(A)
10
14
12
15
18
(B)
10
21
14
15
22
18
(C)
10
14
18A
15
21,22
18
(D)
10
14
23
15
18

FIG. 5


(A)
25
15
(B)
22
15
(C)
22
15
(D)
23
15