Candidate's Answer Paper
(Examination Paper A - Electricity/Mechanics)

Printing head

The invention relates to a printing head according to the pre-amble of Claim 1. The invention also relates to a printer incorporating such a printing head. The invention further relates to a system of a computer coupled with a printer incorporating such a printer head.

A printer head of said kind is know from document I.

Printers in general can be divided into two groups: the first group consists of so-called impact printers which use what could be described as the hammer principle, whereas the second group consists of so called non-impact printers in which no direct strokes of characters or character elements onto the surface to be printed are performed. Examples of the first group are hammer, chain and needle printers, examples of the second group are electrophotographic printers (laser printers), thermo and ink jet printers.

A broadly applied printing principle which is used for both of the above groups of printers is the matrix printing principle. Matrix printers do not have fixed printing characters. Instead, they use a matrix grid in which dots are either set (printed) or left out (not printed) in order to produce a character to be printed. An example of an impact matrix printer is the well known needle printer in which a plurality of needles corresponds to the dots in the matrix grid. In most matrix printers, a printing head is moved across the surface to be printed and/or vice versa and the control electronics of the printer sets the correct dot or dots in the matrix grid at the correct moment. The advantage of matrix printers is that the character to be printed can be freely chosen within the matrix grid, which allows printing of self-designed characters or graphics.

Impact printers and therefore also matrix impact printers have considerable disadvantages: they are noisy, they make use of colour ribbons which tend to wear out irregularly, their maximum working frequency (and hence their printing speed) is limited and the mechanism of the printing head is sensitive, expensive to manufacture and difficult to service.

Ink jet printers have the following general working principle: liquid ink is ejected from a printing head having a plurality of tiny ink ejecting outlets or nozzles, the arrangement of which corresponds to the above-mentioned matrix grid. The ink is ejected from the outlets in the form of droplets towards the printing paper under the control of the printer electronics. This principle allows a higher density of the printing matrix than is possible with needle printers and therefore a higher printing resolution. Moreover, the printing itself is rapid and quiet, which aspect is of particular importance for PC applications.

The know ink jet printer comprises an arrangement to apply a pressure pulse to the ink in the ink supply passage and a piezoelectric crystal to generate the pressure pulse by supply of a voltage pulse to the piezoelectric crystal. Since the vibration frequency of the crystals is limited, the printing speed of the known ink jet printer is limited.

An object of the invention is to provide a printing head with which higher printing speeds can be achieved.

This object is achieved with a printing head as defined in claim 1.

The pressure pulse resulting from the expanding vapour bubble serves to eject an ink drop exclusively from the respective outlet.

The working frequency and hence the printing speed are higher, since the vibration frequency of the piezoelectric crystals is limited.

Further advantages are obtained by the embodiments of the dependent claim.

In the device of claim 2, it is no longer necessary to take into account the thermal and chemical properties of the ink. It is therefore much easier to produce colour printers using three different inks in one and the same printing head (each colour having its own printing matrix). Another advantage is that a wide selection of working fluids and of materials for the electrical connections and the resistors is permitted without having to worry about wetting characteristics and other problems, in particular chemical problems, associated with the ink composition, such as corrosiveness and the deposition of ink particles on the resistor. Consequently both the ink and the working fluid can be optimised for their individual purposes. A properly selected working fluid ensures a better energy efficiency for the vapour bubble formation than ink compositions.

As regards the working fluid, water based liquids have proved to give satisfactory results. The working fluid is introduced between the heating device and the membrane during the manufacture of the printing head.

The expansion of the vapour bubble causes the membrane to be deformed, resulting in a local displacement thereof and in the transmission of a pressure pulse to the ink in the passage. This pressure pulse then ejects a droplet of ink from the outlet 8. When the voltage pulse is terminated, the vapour bubble will quickly collapse back by recondensation, so that a repeated operation is possible without the necessity of supplying fresh working fluid.

Another object of the invention is to provide a printing head which has a narrow printing resolution.

This object is achieved by a printing head as defined by claim 4.

It is noted that the advantageous effect of providing a capillary channel as the ink supply passage can be achieved separately from the features of the characterising position of claims 1 to 3.

In the device defined in claim 4,

- Due to the absence of pump chambers and other portions having relatively large diameters in the flow path, the ink supply for the printing head according to the invention can - as already mentioned above - be carried out by means of capillary action.

- The device defined as in claim 4 is much easier to manufacture and is therefore cheaper. With the principle described above, it is even possible to integrate the printing head into a disposable ink cartridge which, when empty, is replaced. The printing head of the invention does not have the complicated flow paths present in the printing head of Document I which - because of the size of the pump chambers which is determined by the size of the piezoelectric crystals - have to get narrower downstream of the pump chamber to increase the printing resolution.

- The device of claim 4 requires less space since it is relatively thin. It is possible to form a stack comprising several of the devices described above, whereby several dots can be printed at the same time, the distance between the outlets of neighbouring devices determining the printing resolution.

The channel 6 is preferably about 75 µm x 75 µm in cross-section and corresponds in width to the nonconducting strip 3.

As to a printing head of claim 5, it is to be mentioned here that the voltage U applied to the resistor and the resistance value R of the resistor both determine the current I flowing through the resistor. The relationship is the following: I = U/R (Ohm's Law). Typical values in practice are: U = 1.5 V (Volt) and R = 3 Ω (Ohm) resulting in a current of I = 0.5 A (Ampère). A typical pulse duration is 5 µs (5×10^{-6} s).

In the device defined in claim 12 the passage 6 has two portions of different cross-sectional area: the first is a capillary narrow portion underneath the outlet and the second is a portion with a larger cross-sectional area which serves to ensure a reliable ink supply to the narrow portion.

As to the printing head of claim 14 it is noted that only very little working fluid is required to produce a sufficient vapour bubble to cause ejection of an ink droplet. In this the printing heads shown in this application can be extended in order to provide a plurality of outlets. In this way, a one column printing matrix is created. When several of these arrangements are positioned beside one another, a printing head having a matrix with several columns is obtained.

Claims

1. A printing head for an ink-jet printer comprising

   - an ink supply passage (6) with an inlet (7) and an outlet (8).
   - an arrangement (4, 21, 22) to apply a pressure pulse to ink (13) in the ink supply passage (6).

characterised in that

   - said arrangement (4, 21, 22) comprises a heating device (4) to heat a fluid to form from said fluid an expanding vapour bubble (15) to form said pressure pulse.

2. A printing head as claimed in claim 1, characterised in that

   - the heating device (4) is arranged to heat a working fluid.
   - the printing head comprising a flexible membrane (21) separating the working fluid from the ink (13) in the ink supply passage (6).

3. A printing head as claimed in claim 1, characterised in that

   - the heating device (4) is arranged to heat ink (13) in the ink supply channel.

4. A printing head as claimed in claim 1, 2 or 3, characterised in that

   - the ink supply passage (6) comprises a capillary channel.

5. A printing head as claimed in claim 1, 2, 3 or 4, characterised in that

   - the heating device comprises a heating register (4) with electrodes (11, 12) for receiving a voltage pulse.

6. A printing head as claimed in claims 1, 2, 3, 4 or 5, characterised in that

   - the heating device (4) is located adjacent to the outlet (8) of the ink supply passage (6).

7. A printing head as claimed in claims 1, 2, 3, 4, 5 or 6 characterised in that

   - the outlet (8) is located at an end of the ink supply passage (6).

8. A printing head as claimed in any one of claims 1 to 6 characterised in that

   - the outlet (8) is located sideways with respect to the longitudinal axis of the ink supply passage.

9. A printing head as claimed in any one of claims 4 to 8, characterised in that

   - the printing head comprises
   - a substrate (1).
   - a capillary block (5) with the capillary channel (6) on a side of the capillary block facing the substrate.

10. A printing head as claimed in claim 9, characterised in that

    - the capillary block (5) comprises a through (20) on a side facing away from the substrate and accommodating the outlet (4).

11. A printing head as claimed in any one of claims 1 to 10 characterised in that

    - the outlet (8) of the ink passage (6) has a tapered form.

12. A printing head as claimed in any one of claims 1 to 11, characterised in that

    - the ink supply passage comprises a wide portion (6b) and a narrow portion (6a) adjacent to the outlet (8).

13. A printing head as claimed in claim 2, characterised in that

    - the printing head comprises a cavity (22) covered on at least one side with the flexible membrane (21) for accommodating the working fluid.

14. A printing head as claimed in claim 2, characterised in that

    - the flexible membrane (21) is located directly over the heating device (4) and
    - the flexible membrane comprises a rough surface facing the heating device so that an adequate amount of working fluid is able to be accommodated between the heating device (4) and the flexible membrane.

15. A printing head as claimed in claim 2, characterised in that the flexible membrane consists of silicone rubber.

16. A printing head as claimed in claim 5, characterised in that the electrodes consist of chromium or aluminium.

17. A printing head as claimed in claim 5, characterised in that the heating resistor comprises gold, titanium, tungsten, chromium or aluminium.

18. A printer comprising a printing head as claimed in any one of claims 1 to 17.

19. A system of a computer coupled with a printer as claimed in claim 18.

Note to the Examination Committee

1. The advantageous effects of the capillary ink supply passage viz. obtaining e.g. a higher printing resolution can be achieved also separately from generating a pressure pulse from an expanding vapour bubble.

   The use of a capillary channel as such does not form a single general inventive concept (Art. 82 EPC, R. 30 EPC). Therefore it will be proposed to file a divisional application (Art. 76 EPC) of which the independent claim is formed by the pre-amble of claim 1 of the present application and the characterising portion of claim 4. The remark on 95/A(E/M)/e/4, 2nd paragraph serves to ensure that the subject-matter of the proposed divisional application does not extend beyond the present application.

2. Claim fees are incurred under Rule 31 EPC for claims 11 to 19. If claim fees are to be economised on I would propose to abandon claims 15, 16, 17.