EUROPEAN QUALIFYING EXAMINATION 1995

PAPER B
ELECTRICITY / MECHANICS

This paper comprises:

INSTRUCTIONS TO CANDIDATES

In this paper, you should assume that a European patent application for all the Contracting States comprising the appended documents* has been filed and that the European Patent Office has issued the annexed official communication. The paper may include a client's letter containing instructions about the way your client wishes to prosecute the European patent application.

You should accept the facts given in the paper and base your answers upon such facts. Whether and to what extent these facts are used is your responsibility.

You should not use any special knowledge you may have of the subject-matter of the invention, but are to assume that the prior art given is in fact exhaustive.

Your task is now to draft a full response to the official communication. The response should be a letter to the EPO, accompanied, if appropriate, by an amended set of claims. No amendments to the description should, however, be made.

The claims should afford the broadest protection possible while meeting the requirements of the Convention. In your letter of response you should set out your arguments in support of the patentability of the independent claim(s).

If you consider that any part of the application ought to be made the subject of one or more divisional applications, you should in a note, clearly identify the subject-matter of the independent claim of such divisional application(s) and the justification for this. However, it is not necessary to draft the wording of the independent claim for the or each divisional application.

In addition to your chosen solution, you may – but this is not mandatory – give, in a note, the reasons for your choice of solution, for example, why you selected a particular form of claim, a particular feature for an independent claim, a particular piece of prior art as starting point or why you rejected or preferred some piece of prior art. Any such note should however be brief.

It is assumed that you have studied the examination paper in the language in which you have given your answer. If this is not so, please indicate on the front page of your answer in which language you have studied the examination paper. This always applies to candidates who – after having filed such a request when enrolling for the examination – give their answer in a language other than German, English or French.

* These documents do not necessarily constitute the only or best solution to the task set in Paper A.

Description of the Application

The invention relates to a printing head for use in ink jet printers. These printers apply the following general working principle: liquid ink from an ink reservoir is guided into the printing head having a plurality of tiny ink ejecting outlets or nozzles, the arrangement of which corresponds to a printing matrix. From the outlets, ink droplets are ejected under the control of the printer electronics towards a surface to be printed. This principle allows a high density of the printing matrix, resulting in a high printing resolution. Moreover, the printing itself is rapid and quiet, which aspect is of special importance for PC applications.

Document I discloses a printing head comprising at least one ink supply passage, the or each ink supply passage having at least one outlet, the or each outlet being associated with means for producing a pressure pulse in the ink in the ink supply passage to cause an amount of ink to be displaced towards and ejected out of the respective outlet in the form of a droplet. In Document I, the means for producing a pressure pulse in the ink in the ink supply passage comprises at least one electrorestrictive element which undergoes a deformation when a voltage pulse is applied to it. This deformation is transmitted to the ink in a pump chamber by means of a flexible cover plate. The pump chamber is connected to the outlet, from where the ink is ejected onto a recording medium such as paper.

A problem associated with the above printing head is that - due to the size of the electrorestrictive elements - the printing head is rather bulky. In order to achieve a good printing resolution in spite of the size of the pump chambers, this printing head is provided with flow paths guiding the ink from the pump chambers towards the outlets. Moreover, to ensure a reliable ejection of

the ink droplets from the outlets, fluid diodes are provided upstream of the pump chambers. All these measures result in a rather complicated structure of the printing head.

It is therefore an object of the invention to provide a printing head which has smaller dimensions, whereby a high printing resolution can be achieved, which is easier to manufacture and which nevertheless guarantees a reliable ejection of the ink droplets.

According to the invention, this object is achieved by means of a printing head as set out in Claim 1, in which the or each means for producing a pressure pulse comprises means for forming a vapour bubble acting on the ink in the ink supply passage.

The or each ink supply passage can have an inlet connected to an ink reservoir.

The outlet or outlets can be arranged along the length of the or each ink supply passage.

In order to ensure a reliable supply of the ink, the or each ink supply passage can be a capillary channel.

In an embodiment of the invention, the vapour bubble is formed in the ink and/or the or each means for forming a vapour bubble can comprise an electrical resistor. The or each resistor can be provided in the respective ink supply passage in the vicinity of the respective outlet. The or each resistor advantageously consists of a thin film metallization layer.

The invention is described hereafter with reference to the appended drawings. The basic working principle is explained with reference to Figs. 1 to 4, whereas Figs. 5 to 9 show five embodiments of the invention which are suitable for commercial application. In all the drawings corresponding parts carry the same reference numerals, a list of which is attached at the end of the present description. In the drawings:

Fig. 1 is a schematic exploded view of a printing device illustrating the basic working principle of the invention,

Fig. 2 is a perspective view of the device of Fig. 1,

Fig. 3 is a vertical cross-sectional view on an enlarged scale of the device of Figs. 1 and 2 along the line III-III of Fig. 2,

Figs. 4A to 4F depict a sequence of events involved in the production of an ink droplet,

Figs. 5A and 5B are disassembled and assembled views respectively of an "end-shooter" printing head (first embodiment),

Figs. 6A and 6B are disassembled and assembled views respectively of a "side-shooter" printing head (second embodiment),

Figs. 7 is a perspective view of another "side-shooter" printing head (third embodiment) and

Figs. 8 and 9 show in perspective cross-section two further "side-shooter" printing heads of the invention (fourth and fifth embodiments).

Figs. 1 and 2 show an ink jet printing device having a single ink ejecting outlet. Part of one surface of a substrate 1 of electrically nonconducting material is covered with a thin film metallization layer 2. This is a metal layer which is extremely thin and which is applied by evaporation of a metal under a vacuum onto the substrate, masks being used to create metallization patterns on the substrate. The thin film metallization layer is configured to provide a narrow nonconducting strip 3 of width D1 of 75 µm (= 0.075 mm) and a conducting strip of width D2 of 75 µm. This conducting strip - due to its limited cross-sectional area of

conducting material - creates an electrical resistor 4 in the metallization layer 2. Alternatively, the resistor can be created by a different material which may also be applied by evaporation. In a typical configuration, the resistor 4 is located at a distance D3 of 150 µm from an edge of the substrate 1. Fixed to the upper surface of the metallization layer 2 is a capillary block 5, typically made of glass, having an ink supply passage in the form of a capillary channel 6 with an inlet 7 and an outlet 8. The channel 6 is about 75 µm x 75 µm in cross-section and corresponds in width to the nonconducting strip 3.

Behind the capillary block 5 and on top of the substrate 1 is a wall 9 (depicted schematically only) for holding ink in a reservoir 10 (see Fig. 2). The channel 6 draws ink by capillary action from the reservoir 10 to the outlet 8. As can be seen in Fig. 2, the printing device has two electrodes 11 and 12 which are attached to the metallization layer 2 for applying a voltage pulse across the resistor 4. Fig. 3 shows the relative configurations of the ink 13, the capillary block 5, the resistor 4 and a surface 14 to be printed. In operation, the distance D4 between the outlet 8 and the surface 14 is of the order of 0.75 mm.

Figs. 4A to 4F show in cross-sectional view a sequence of events during one cycle of operation of the printing device. When a voltage pulse is applied to the electrodes 11 and 12, the current flowing through the resistor 4 has a sufficient heating effect to superheat the ink and thereby to create a vapour bubble 15 over the resistor 4 as shown in Fig. 4A. The vapour bubble expands rapidly as shown in Fig. 4B. By controlling the electrical energy supplied to the resistor 4, the size of the vapour bubble 15 is determined. Care must be taken to ensure that the total amount of energy absorbed by the ink is not so great as to expel vapour from the outlet 8. The momentum imparted to the ink from the vapour bubble expansion in the direction of the outlet 8 acts to propel a

droplet of ink out of the channel 6. The vapour bubble then begins to collapse back as shown in Fig. 4C. After the ink droplet has left the outlet 8, as shown in Fig. 4D, the vapour bubble completely collapses back on or near its starting location, voltage no longer being applied to the resistor 4. The ink begins to refill the channel 6 by capillary action (Fig. 4E) and the ink droplet subsequently lands on the surface to be printed (not shown). Fig. 4F shows the channel 6 filled to its original condition, ready for the next cycle. Printing is accomplished by successively applying voltage pulses to the resistor 4 in an appropriate sequence, while the printing device and the surface to be printed are moved relative to each other so as to create the desired printing pattern.

In the above explanation of the basic working principle of the invention, the preferred ink supply by capillary action has been used. It should however be noted that any other suitable kind of ink supply could be provided. For example, the ink in the reservoir could be under a slight overpressure. This also applies to the embodiments to be described below.

Comparing the printing device described above which constitutes a basic printing head with the printing head disclosed in Document I it is observed that:

- The present device 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 present device 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.

- Due to the absence of pump chambers and other portions h relatively large diameters in the flow path, the ink supply t the printing head according to the invention can - as already mentioned above - be carried out by means of capillary action.
- The vapour bubble is preferably generated in the vicinity of the outlet, so that the impedance to flow of the ink towards the outlet is very low in comparison with that towards the reservoir and no fluid diodes have to be provided to guarantee ink flow in the desired direction.
- The working frequency and hence the printing speed are higher, since the vibration frequency of the piezoelectric crystals is limited.

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 $R = 3\ \Omega$ (Ohm) resulting in a current of $I = 0.5$ A (Ampère). A typical pulse duration is 5 µs (5×10^{-6} s).

The pulses to be applied to the resistor are not generated in the printing head, which usually is exchangeable or even of the single-use type but by suitable control electronics provided in the printer.

Figs. 5A and 5B show an ink jet printing head according to a first commercial embodiment of the invention. The printing head has a plurality of outlets which create a one column printing matrix. The so-called "end-shooter" printing head shown in Figs. 5A and 5B comprises a substrate 1 and a capillary block 5 having several capillary chan-nels 6. Typical materials for the substrate 1 are insulators such as glass, ceramics and silicon, while the material used for the capillary block 5 can be chosen for its ease of manufacture in regard to the formation of the capillary chan-nels 6. For example, the capillary block 5 is made of moulded glass, etched silicon or etched glass. The substrate 1 and the

capillary block 5 are bonded together by epoxy resin. The ... tances D5 and D6 corresponding to the channel spacings and wi... are determined by the desired separation and size of the outlet... thus determining the printing resolution. A filling channel 16 supplies ink to the capillary channels 6 from a remote ink reservoir (not shown).

A plurality of resistors 4 is provided on the substrate 1, each resistor consisting of a pad of thin film titanium-tungsten on the bottom of each capillary channel 6. Also provided is a number of electrical connections 17 made of thin film gold for supplying a voltage pulse to the resistors 4. Other typical materials for the connec-tions 17 are chromium or aluminium, whereas the resistor 4 can also consist of platinum or silicon. As indicated by the rupture line in Figs. 5A and 5B, the printing head can be extended so as to include the desired number of outlets.

The name "end-shooter" printing head has been selected for this embodiment because the printing head described above ejects the ink at the ends of the channels.

Figs. 6A and 6B show a second embodiment of the invention, a so-called "side-shooter" printing head. It comprises a substrate 1 which carries two electrical connections 17 and a resistor 4. Two plastics spacers 18 separate the substrate 1 from a cover 19, whereby a channel 6, preferably a capillary channel, is provided for the ink. The cover 19 is composed of silicon and has an etched tapered outlet 8 for the ink droplets. The outlet 8 is located directly opposite the resistor 4. The size of the outlet is typically 0.1 mm x 0.1 mm. In this side-shooter printing head, the ink droplets are ejected not from the end of the channel 6 (as in the end-shooter printing head) but sideways out of the channel.

Fig. 7 shows a third embodiment of the invention, which is a side-shooter printing head. A substrate 1 carries two glass spacers 18 for holding ink 13 in a channel 6. A silicon cover 19 is provided having a series of etched tapered outlets as exemplified by outlet 8. Each outlet 8 is recessed in a trough 20 formed in the cover 19 so that a thicker cover can be used to provide better structural stability. As can be seen from Fig. 7, the channel 6 has two portions of different cross-sectional area: the first is a capillary narrow portion 6a underneath the outlet 8 and the second is a portion 6b with a larger cross-sectional area which serves to ensure a reliable ink supply to the portion 6a. A filling tube 16 connects the portion 6b to a remote ink reservoir (not shown).

The printing heads shown in Figs. 6A, 6B and 7 can be extended in the direction of the arrows E shown in Figs. 6A and 7 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. For the side-shooter printing heads, it is to be mentioned that the pressure pulse resulting from the expanding vapour bubble serves to eject an ink droplet exclusively from the respective outlet opposite the resistor, since the surrounding ink blocks the pressure pulse in the other directions to the extent that an ejection of ink from any neighbouring outlets in the column is avoided.

Figs. 8 and 9 show fourth and fifth embodiments of the invention which - although slightly more complicated to manufacture - provide a number of additional advantages. In these embodiments, the vapour bubble is not formed directly in the ink as is the case in the embodiments of Figs. 1 to 3 and 5 to 7, but in a separate working fluid.

The side-shooter printing head shown in Fig. 8 includes a cover 19 having an outlet 8 for ejecting ink. The cover 19 is separated from a flexible membrane 21 by means of spacers 18 so as to provide an ink supply passage in the form of a channel 6. Directly below the flexible membrane 21 there is a cavity 22 for containing a working fluid. The cavity 22 is bounded below by a resistor 4 and on the sides by walls 23, the resistor 4 and the walls 23 being carried by a substrate 1. Also shown are two electrical connections 17 for supplying a voltage pulse to the resistor 4.

As in the embodiments described above, in operation, a voltage pulse is applied to the resistor 4 to cause heating and a sudden vaporization of a portion of the working fluid in the cavity 22, whereby a vapour bubble is formed under the flexible membrane 21. 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 channel 6. 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.

The spacers 18 provide only a small separation of the membrane 21 from the outlet 8 to permit adequate energy transfer to the ink and to ensure filling of the channel 6 by capillary action. A typical outlet diameter is 75 µm and the same materials can be used as in the previous embodiments. The flexible membrane 21 consists advantageously of a thin film of silicone rubber, although other materials having the necessary elasticity may be used.

Fig. 9 shows a fifth embodiment of the invention in which only very little working fluid is required to produce a sufficient vapour bubble to cause ejection of an ink droplet. In this

embodiment the walls 23 of Fig. 8 are eliminated and a flexible membrane 21 is placed directly over a resistor 4. In order to create sufficient space between the resistor 4 and the membrane 21, at least one of these two parts has to have a rough surface so that an adequate volume of working fluid is provided therebetween for a proper vapour bubble formation. This is illustrated in Fig. 9 by showing a vapour bubble 15 creating a local deformation of the membrane 21, whereby an ink droplet (not shown) is ejected from the outlet 8 in the channel 6. Also shown in Fig. 9 are electrical connections 17 for the resistor 4.

As regards the working fluid, water based liquids have proved to give satisfactory results. The working fluid is introduced between the resistor 4 and the membrane 21 during the manufacture of the printing head.

In the fourth and fifth embodiments described with respect to Figs. 8 and 9, 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.

The embodiments described with respect to Figs. 8 and 9 are side-shooter printing heads. However, the described separate working fluid concept is also applicable to end-shooter printing heads.

List of reference numerals used

substrate..... 1
metallization layer..... 2
narrow nonconducting strip..... 3
resistor..... 4
capillary block..... 5
capillary channel..... 6
channel portions..... 6a, 6b
inlet..... 7
outlet..... 8
wall..... 9
reservoir..... 10
electrodes..... 11, 12
ink..... 13
surface to be printed..... 14
vapour bubble..... 15
filling channel, filling tube... 16
electrical connections..... 17
spacers..... 18
cover..... 19
trough..... 20
membrane..... 21
cavity..... 22
walls..... 23

Claims

1. A printing head comprising at least one ink supply passage (6), the or each ink supply passage (6) having at least one outlet (8), the or each outlet (8) being associated with means (4) for producing a pressure pulse in the ink (13) in the ink supply passage (6) to cause an amount of ink to be displaced towards and ejected out of the respective outlet (8) in the form of a droplet, characterised in that the or each means for producing a pressure pulse comprises means (4) for forming a vapour bubble (15) acting on the ink in the ink supply passage (6).

2. A printing head as claimed in Claim 1, characterised in that the or each ink supply passage (6) has an inlet (7) connected to an ink reservoir (10).

3. A printing head as claimed in Claim 1 or 2, characterised in that the outlet or outlets (8) is or are arranged along the length of the or each ink supply passage (6).

4. A printing head as claimed in any of Claims 1 to 3, characterised in that the or each ink supply passage is a capillary channel (6).

5. A printing head as claimed in any of Claims 1 to 4, characterised in that the vapour bubble (15) is formed in the ink (13).

6. A printing head as claimed in any of Claims 1 to 5, characterised in that the or each means for forming a vapour bubble comprises an electrical resistor (4).

7. A printing head as claimed in Claim 6, characterised in that the or each resistor (4) is provided in the respective ink

supply passage (6) in the vicinity of the respective outlet (8).

8. A printing head as claimed in Claim 6 or 7, characterised in that the or each resistor (4) consists of a thin film metallization layer.

9. A printer comprising a printing head as claimed in any of Claims 1 to 8.

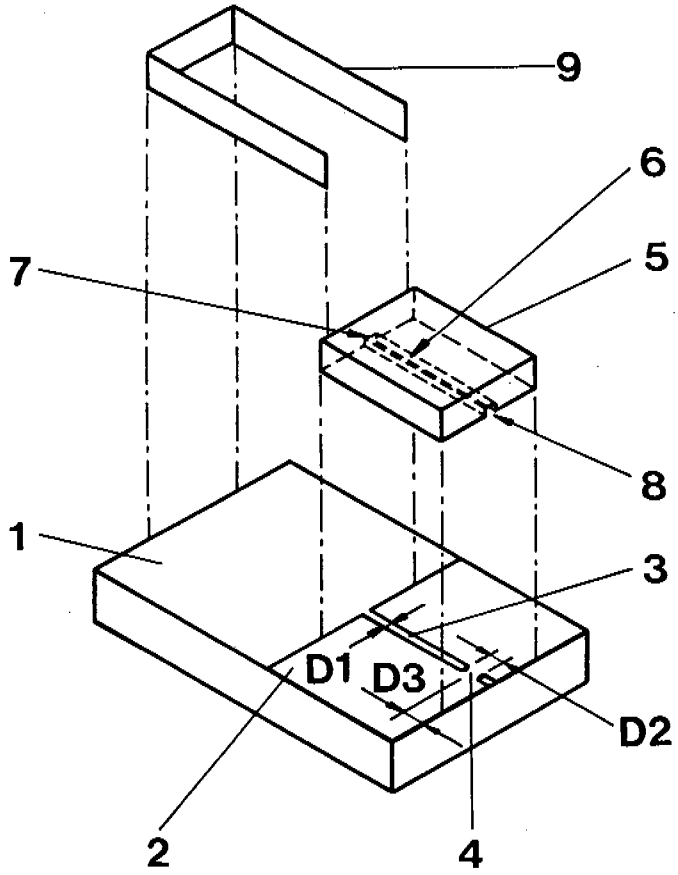


Fig. 1

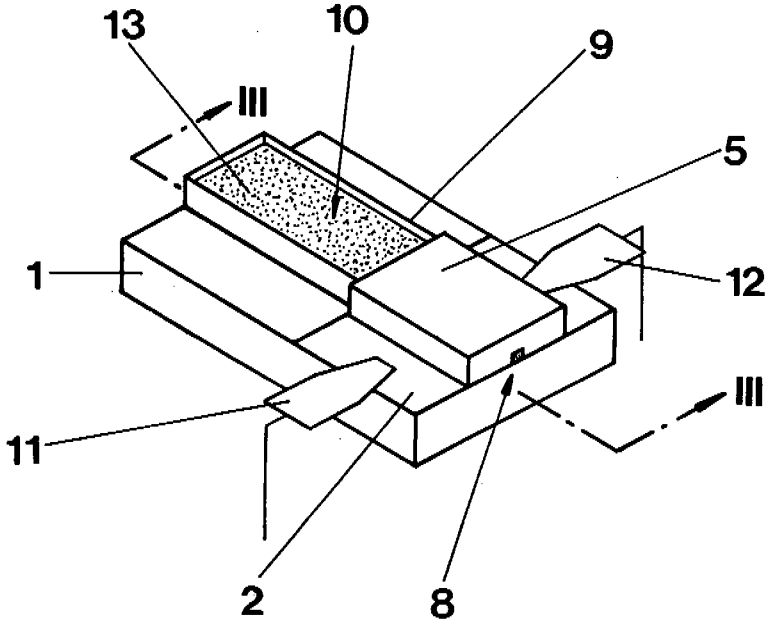


Fig. 2

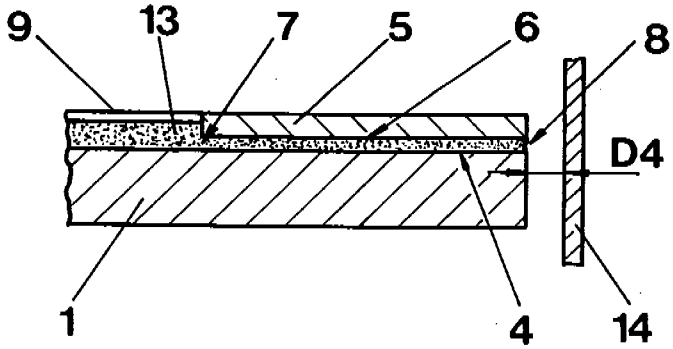


Fig. 3

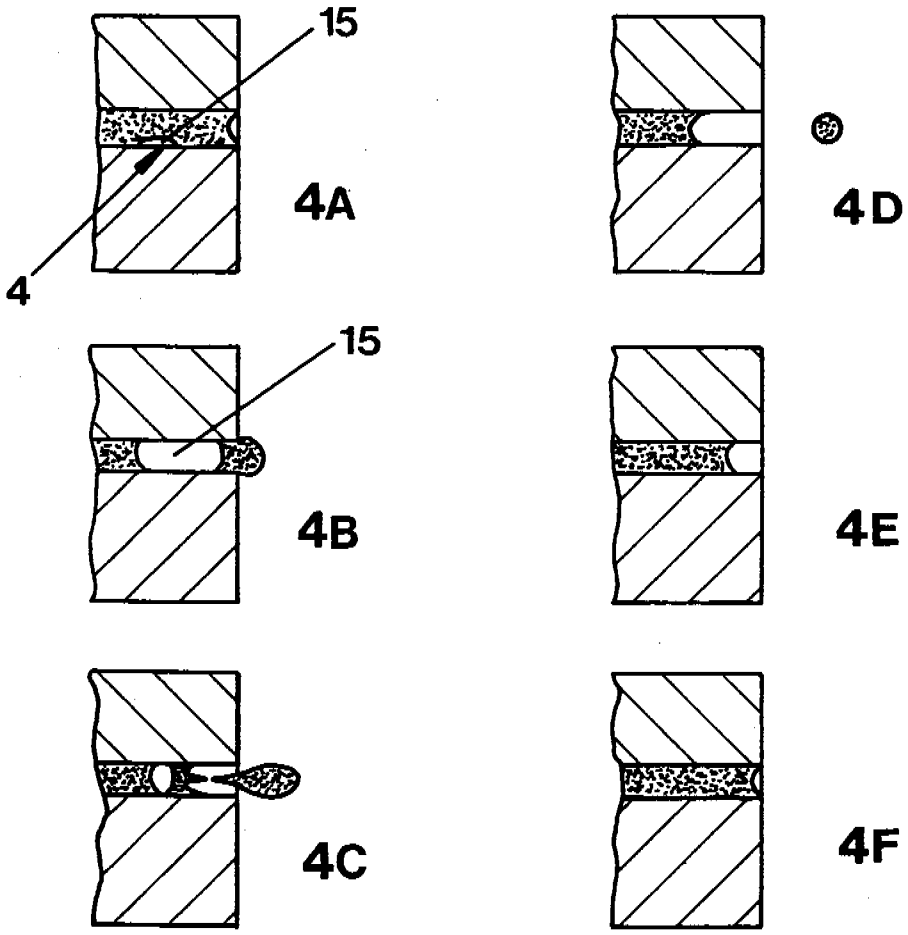


Fig. 4

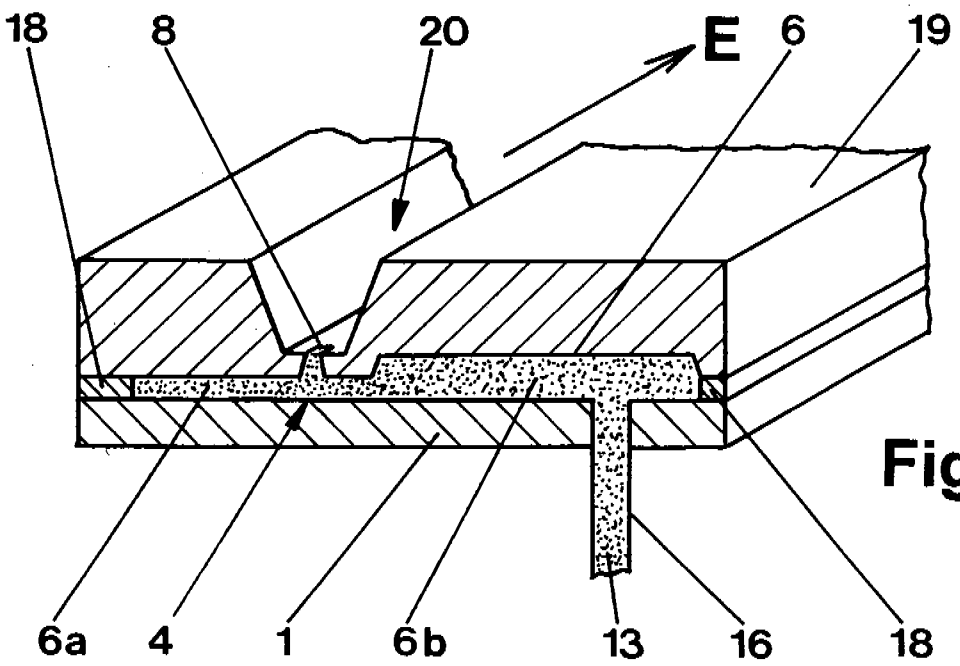


Fig. 7

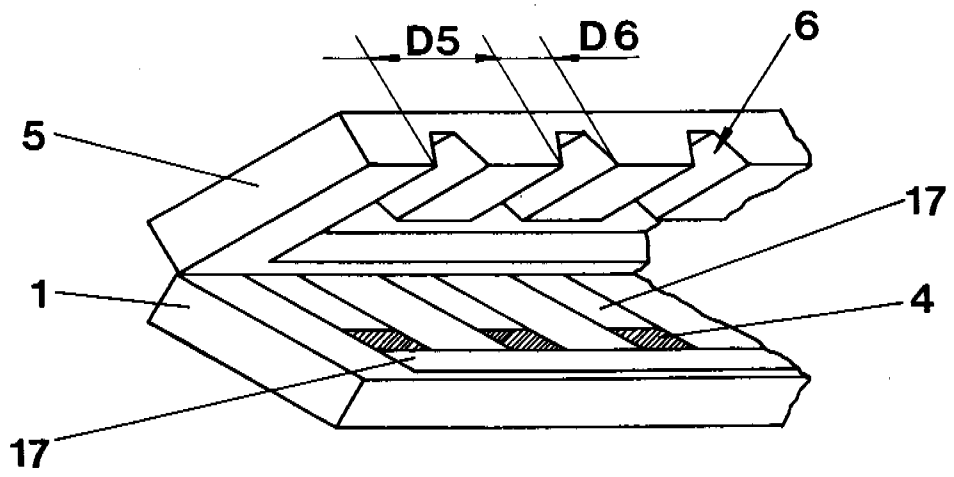


Fig. 5A

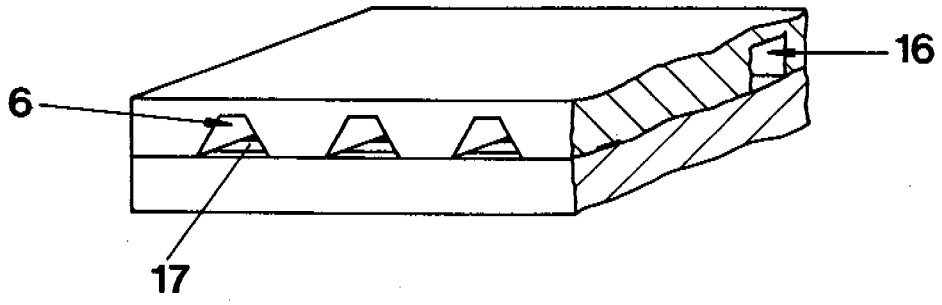


Fig. 5B

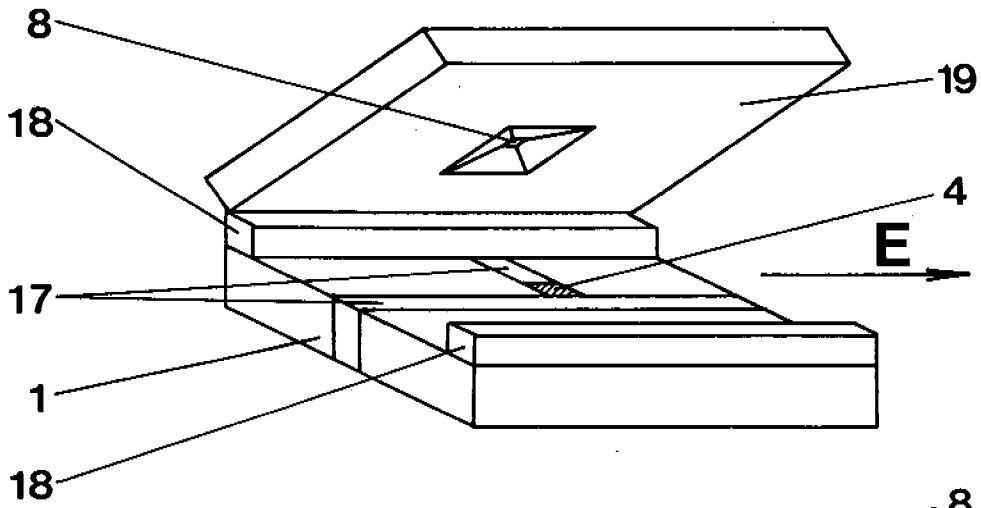


Fig. 6A

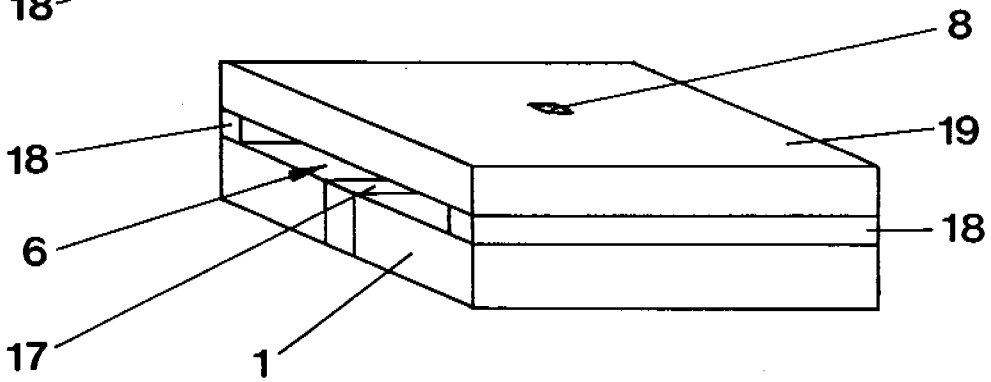


Fig. 6B

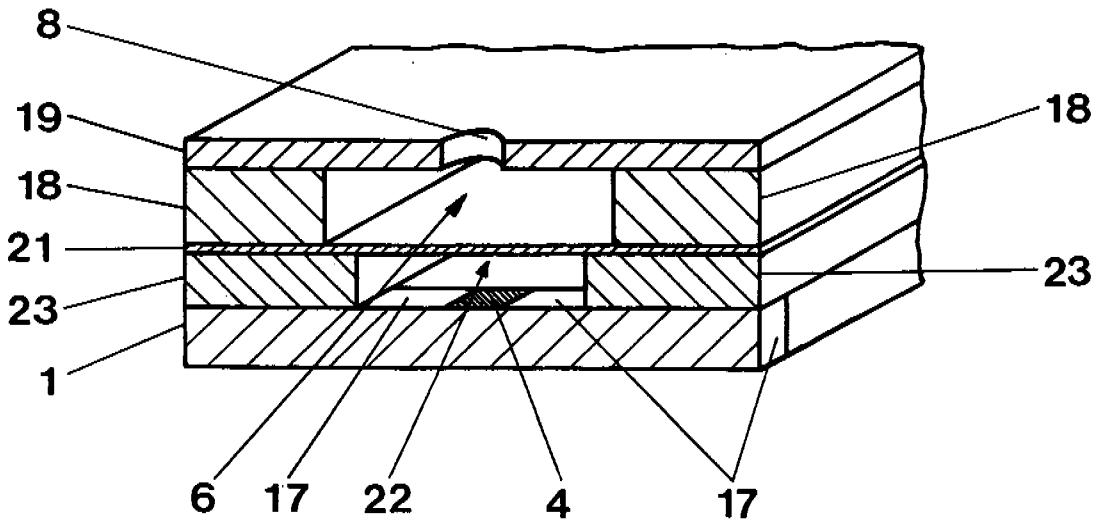


Fig. 8

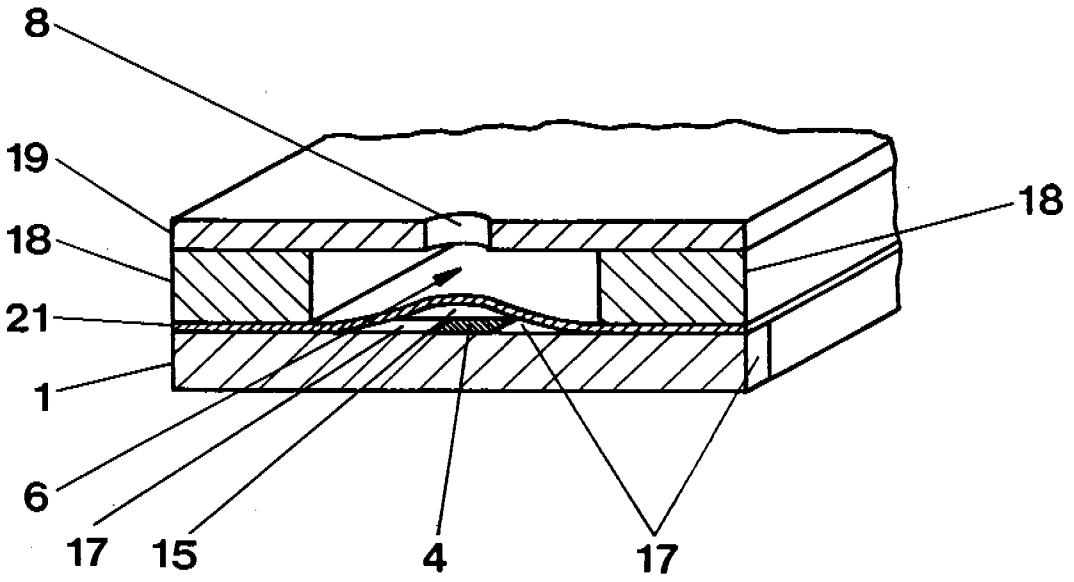


Fig. 9

Communication

1. Document II, which was published before the date of filing of the present application, is referred to in this Communication.

2. Using the terminology of present Claim 1, Document II, which represents the most relevant state of the art, discloses a printing head comprising at least one ink supply passage (35, 46-1 to 46-n), the or each ink supply passage (35, 46-1 to 46-n) having at least one outlet (39), the or each outlet (39) being associated with means (33, 45-1 to 45-n) for producing a pressure pulse in the ink in the ink supply passage (35, 46-1 to 46-n) to cause an amount of ink to be displaced towards and ejected out of the respective outlet (39) in the form of a drop-let (5), the or each means for producing a pressure pulse comprising means (33, 45-1 to 45-n) for forming a vapour bubble acting on the ink in the ink supply passage (35, 46-1 to 46-n); (see Figs. 1 to 3 and the corresponding description).

   It is to be noted that Document II also mentions the "side-shooter" aspect, in which an ink supply passage is provided with a plurality of outlets along the length thereof (see last paragraph of Document II).

   Consequently the subject-matter of Claim 1 lacks novelty in view of Document II. Hence Claim 1 cannot be allowed (Art. 52 (1) and 54 (1, 2) EPC).

3. The features specified in Claim 2 are disclosed in Document II in combination with those of Claim 1 (see the channel 35 in Fig. 1). Since Document II also mentions "side-shooter" devices (see last paragraph thereof), in which the outlet or outlets is or are arranged along the length of the or each ink supply passage, the features of Claim 3 are also disclosed therein. Thus the subject-matter of Claims 2 and 3 also lacks novelty.

4. Document II similarly discloses the features set out in Claims 4 to 6: the capillary ink supply is mentioned in the second half of the 6th paragraph and from Fig. 1 and the 7th paragraph it is clear that the vapour bubble is formed in the ink by means of an electrical resistor 33. The subject-matter of Claims 4 to 6 therefore also lacks novelty.

5. From Figs. 1 to 3 of Document II it is clear that the or each resistor is provided in the respective ink supply passage in the vicinity of the respective outlet as specified in Claim 7 and that the or each resistor can consist of a thin film metallization layer (see middle of the 7th paragraph). Consequently the subject-matter of Claims 7 and 8 also lacks novelty.

6. Document II indicates that the printing head disclosed therein is intended for use in a printer (see 10th paragraph). Thus the subject-matter of Claim 9 also lacks novelty.

7. In view of the above, none of Claims 2 to 9 is allowable under Art. 52 (1) and 54 (1, 2) EPC.

8. For the sake of completeness the following should be noted: although not a subject of the claims, the embodiments disclosed in Figs. 8 and 9 do not appear to be anything more than a straightforward combination of the idea disclosed in Document II of producing a pressure pulse in the ink by means of a vapour bubble and the printing head of Document I (mentioned in the opening part of the present description), in which a pressure pulse is applied via a membrane (the flexible plate 3 in Document I) to the ink in order to eject ink droplets from the outlet(s). Such a combination is considered obvious in particular in view of the 8th paragraph of Document II which clearly suggests a solution to the problem of making the resistor insensitive to the chemical properties of the ink, consisting in arranging a foil between the resistor and the ink.

DOCUMENT I (State of the Art)

The present invention relates to an ink jet printer and in particular to a nozzle head therefor. In the nozzle head to be described herein, the volume of a pump chamber containing ink is abruptly changed in response to an electric signal such that ink droplets are ejected from a nozzle hole.

The invention will be more closely described with respect to the appended drawings, in which:

Fig. 1 is a side view, partially in cross-section, of the nozzle head according to the invention,

Fig. 2 is a front view of the nozzle head according to the invention and

Fig. 3 is a schematic representation of an ink channel in cross-section along the line III-III of Fig. 1.

The nozzle head 1 consists of a base plate 2 and a flexible covering plate 3. In the base plate 2 there is formed an ink supply path 6 for supplying ink from a slightly pressurised ink tank (not shown) to an ink reservoir 5 through a supply pipe 4. From the ink reservoir 5 the ink reaches pump chambers 7 through flow paths 11 including fluid diodes 10. The fluid diodes 10 permit an ink flow towards the pump chambers 7 and prevent an ink flow from the pump chambers back to the reservoir. The pump chambers 7 are connected to nozzle holes 9 by means of flow paths 11a. The flexible covering plate 3 is joined onto the base plate 2 and electrorestrictive elements 12 such as piezo-

electric crystals are mounted on the outer surface of the c
plate 3 at positions corresponding to the pump chambers 7.

When - under the control of the printer electronics - a voltage pulse +U as shown schematically in Fig. 3 is applied to one of the electrorestrictive elements 12, the element undergoes a deformation (which is indicated in Fig. 3 in chain-dotted lines). This deformation is transmitted to a portion of the flexible covering plate 3, whereby a pressure pulse is applied to the ink in the corresponding pump chamber 7. In this way, a progressive wave is generated in the ink in the pump chamber 7, one half of which heads towards the ink reservoir 5 but is blocked by the fluid diode 10, whilst the other half heads towards the nozzle hole 9 and ejects the ink in the form of a droplet 8 through the nozzle hole 9.

Each fluid diode 10 provided between the ink reservoir 5 and the respective pump chamber 7 consists of a heart-shaped barrier 13 which creates an impedance to flow towards the ink reservoir 5 which is considerably higher than that towards the nozzle hole 9. In this way, an efficient ejection of ink droplets out of the nozzle holes 9 is guaranteed.

It should be noted that two or more of the "one column matrix" nozzle heads of the type shown in Figs. 1 to 3 can be joined together in order to create a printing matrix with a higher number of nozzle holes.

DRAWINGS OF DOCUMENT I (State of the Art)

FIG. 1

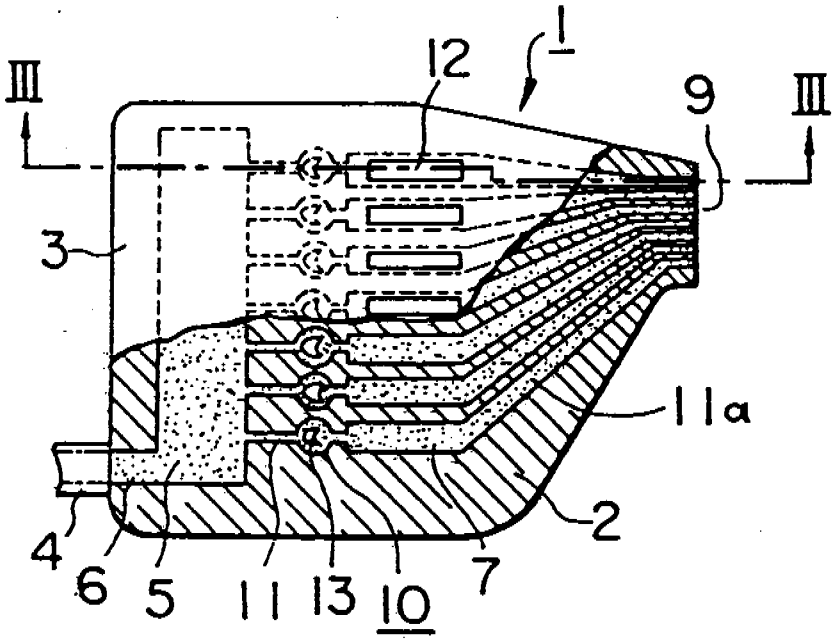


FIG. 2

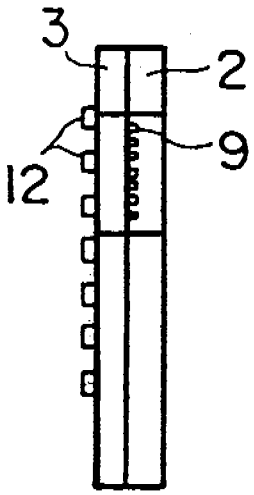
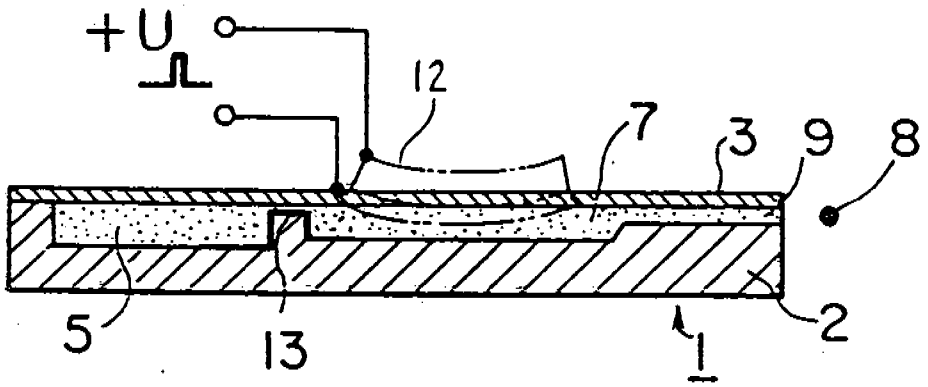


FIG. 3



DOCUMENT II (State of the Art)

The present invention refers to ink jet printing devices and ensures a safe, rapid and reliable ejection of the droplets.

The invention will be described with reference to the appended drawings, in which:

Fig. 1 is a schematic view of a printing device according to the present invention,

Fig. 2 is a perspective view of the printing device shown in Fig. 1 and

Fig. 3 is an exploded view of a multiple jet printing head according to the present invention.

Reference is now made to Figs. 1 and 2, showing the basic structure of the present invention in which droplet formation is achieved by thermal energy. Ink is supplied from an ink supply tank 38 maintained under a predetermined elevated pressure P3 to a printing channel 35 via a conduit 37. As an alternative to a pressurised ink tank, the printing channel 35 can be a capillary channel similarly ensuring a reliable ink feed from a tank towards a printing opening 39. The printing channel 35 is formed by a planar base plate 34 and a cover plate 36 provided with an appropriate groove.

From the printing opening 39, ink droplets 5 are ejected onto a recording medium 42 such as paper by means of an electrothermal transducer, for example an electrical resistor 33. In a preferred embodiment, the resistor 33 consists of a thin film metal layer on the base plate 34. When a suitable voltage pulse is applied to the resistor 33, the temperature of the ink in the vicinity of the

resistor exceeds its boiling point and an ink vapour bubble is formed. This explosively expanding bubble serves to eject an ink droplet 5 out of the printing opening 39.

If desired, the resistor 33 can be covered by a thermoconductive foil (not shown) which is in close contact therewith and which protects the resistor against thermal burnout into the ink. Moreover, such foil makes the resistor insensitive to the chemical properties of the ink used.

When a pressurized ink supply system is used, a drainage system for leaking ink as shown in Fig. 1 is useful. Any excess ink leaving the printing opening 39 is drawn by a reduced pressure P4 into an intake aperture 40. A lateral cover 41 is provided to form the intake aperture 40. Typical dimensions of the intake aperture are about 10 to 500 µm (for printing opening diameters of 20 to 1000 µm).

Fig. 3 shows a one column matrix printing head for an ink jet printer, the head having n printing openings. A base plate 44 carries n resistors 45-1 to 45-n of approximately 150 Ω each. Each single resistor is connected at one end to a common ground electrode 55, the other ends of the resistors being connected to electrodes 56-1 to 56-n. The base plate 44 is bonded to a cover plate 48 provided with grooves which cooperate with the base plate 44 to define printing channels 46-1 to 46-n of 40 µm in width which all terminate in a common ink reservoir 47. The ink reservoir 47 is covered by a plate 51 provided with an air vent tube 50 and ink supply tubes 49-1, 49-2 connected to an ink supply tank (not shown).

The printing head is provided with a drain system consisting of an intake plate 52 having a slot 53 of a width of 30 µm which is

connected to a drainage chamber 54, the latter being maint under a reduced pressure in use.

In operation, voltage pulses are applied between the common groun electrode 55 and one or more of the individual electrodes 56-1 to 56-n, whereby matrix printing is carried out as the printing head and the recording medium are moved relative to each other.

The present invention has been described with reference to a device in which each printing opening is created by an end of a respective printing channel. It is, however, equally suited for devices in which the printing openings are provided along the length of one or more printing channels, whereby the ink droplets are ejected sideways out of the channel(s).

DRAWINGS OF DOCUMENT II (State of the Art)

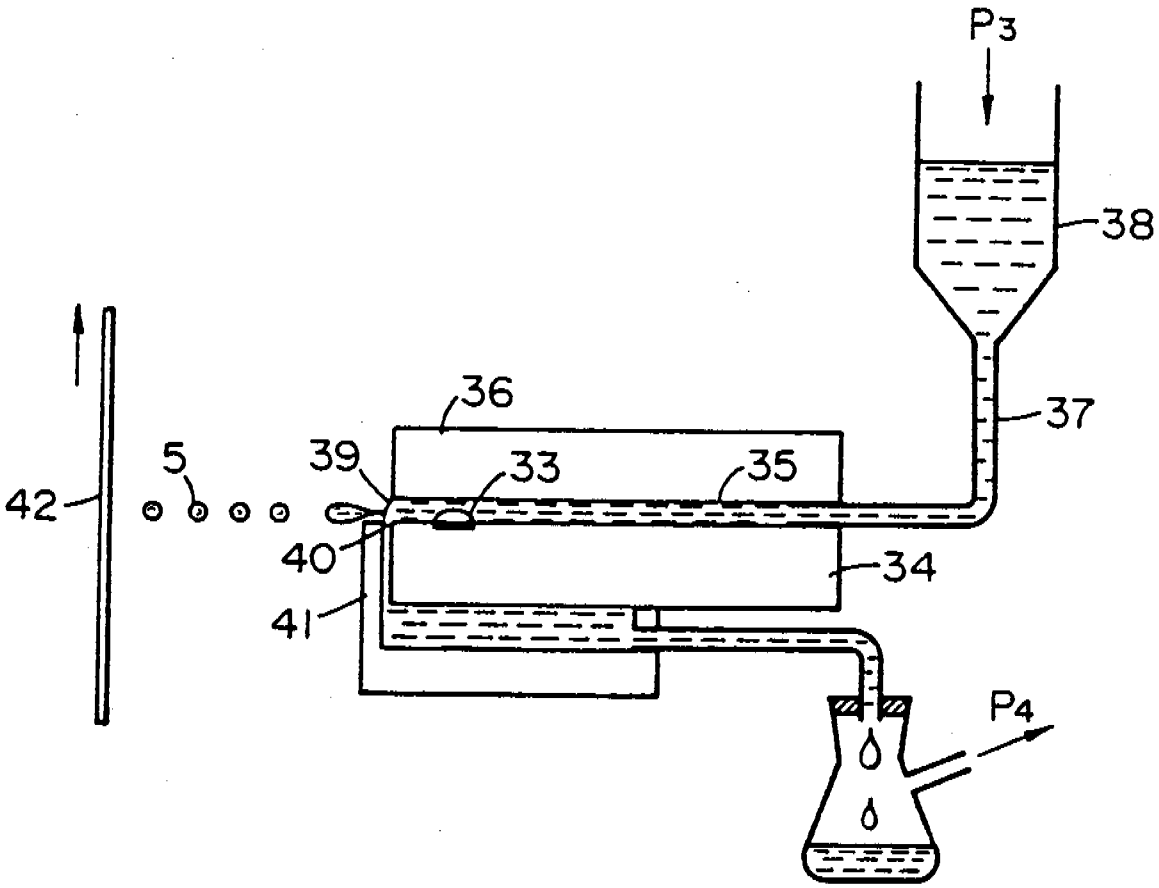


FIG. 1

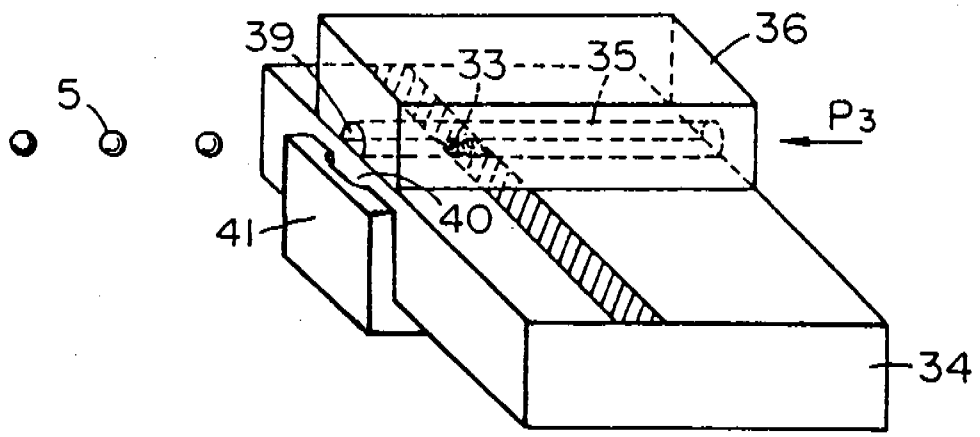


FIG. 2

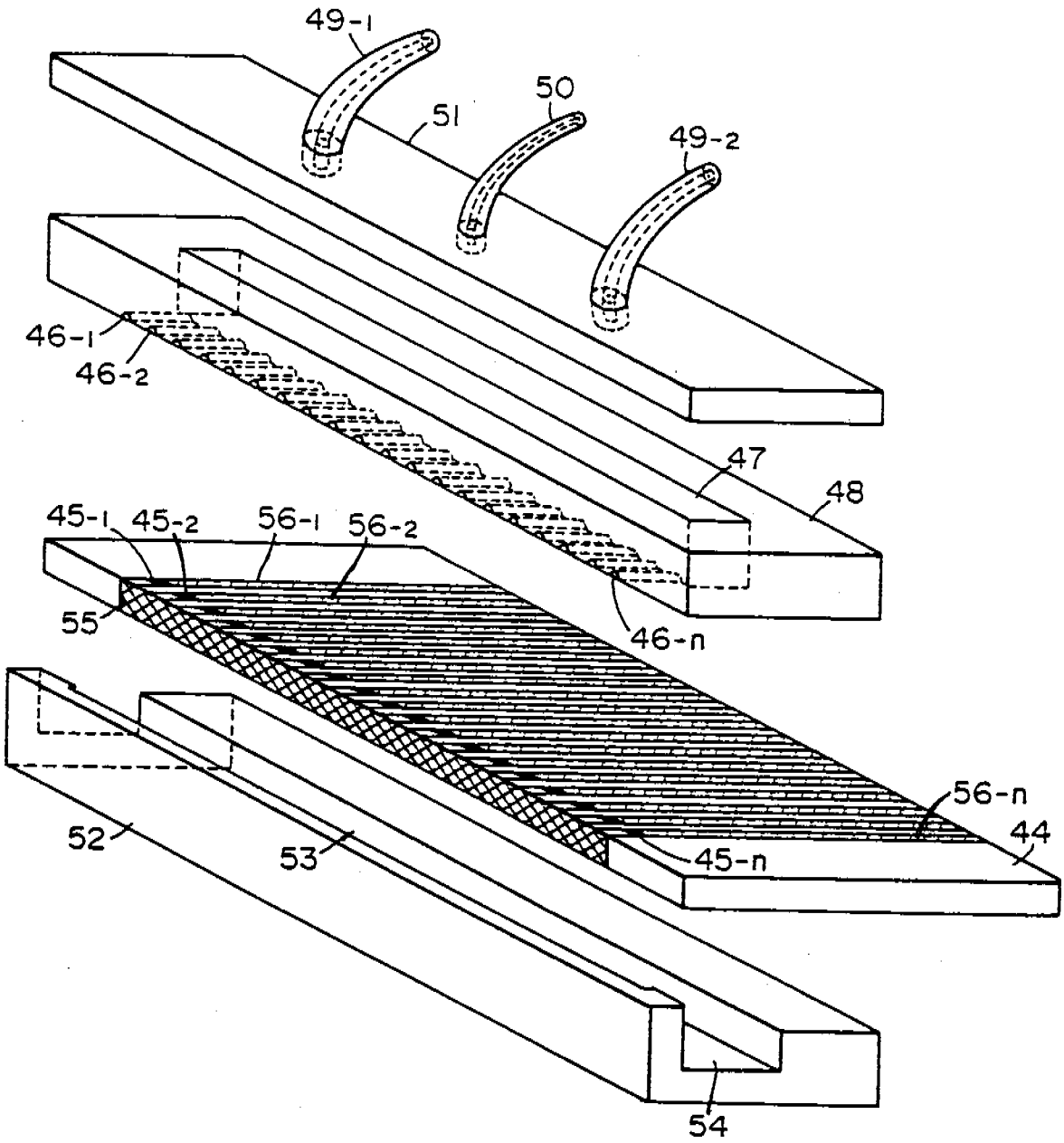


FIG. 3

Client's Letter

Thank you for providing us with a copy of the Communication of European Patent Office. We have taken note of the cited prior art and the objections raised by the Examining Division.

We ask you to draft a response to the Communication in due time and we would like to inform you as follows:

We are no longer particularly interested in obtaining protection of the embodiments described with reference to Figs. 1 to 7. Our main interest lies in the fourth and fifth embodiments of the invention described with reference to Figs. 8 and 9.

Please take the necessary steps to prosecute our European patent application taking care to ensure patent protection at least for the embodiments of Figs. 8 and 9.