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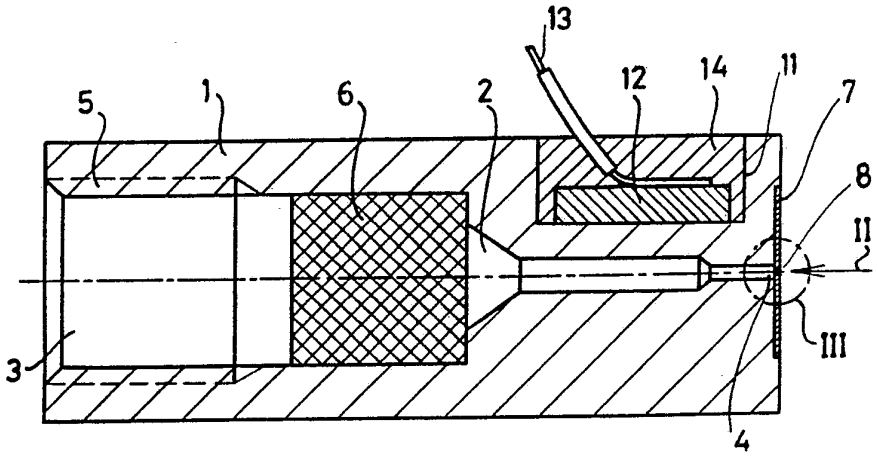

(57) Abstract

A jet nozzle for an ink-jet printer working on the continuous ink jet principle comprises an essentially block-shaped housing (1) of essentially undeformable material, in which an ink supply channel (2) is fitted. The ink supply channel (2) has a relatively small diameter at the outflow end (4). Provision is made in an end wall of the ink supply channel (2) fixed to the housing (1) for an outflow channel (8) which has a very small diameter, and whose length is greater than its diameter. The housing (1) is provided with an ultrasonic vibration element (12) near the outflow end (4) of the ink supply channel (2).

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Titel: Nozzle for an ink jet printing apparatus.

The present invention relates to a jet nozzle for an ink-jet printing apparatus.

An ink-jet printing apparatus generally has at least one jet nozzle and an ink supply system which supplies ink at a suitable pressure to the jet nozzle. The ink is forced out of an outflow aperture and injected in the form of a series of small drops of equal size onto a substrate, such as a sheet of paper. The ink drops pass a charging electrode where the drops are selectively provided with an electric charge, and then pass a pair of deflection plates. The charged drops are deflected as a reaction to a voltage which is applied to the deflection plates, so that the drops either go onto the substrate or are deflected and collected. The collected ink can be recirculated to the supply system.

Ink-jet printers can work according to two different principles, the continuous ink jet principle and the drop on demand principle. In the continuous ink jet principle, an ink jet is generated by forcing ink at high pressure through a jet nozzle. The pressure lies between 20 and 60 bar. This produces an ink jet which by means of excitation is reproducibly converted into ink drops which hit the substrate at high velocity. The number of drops which is generated lies between 100,000 and 2,000,000 drops per second. In the case of the drop on demand principle, an ink jet is not generated under high pressure, but individual drops are generated and discharged onto the substrate. This technique is characterized by a low pressure (2 - 10 bar) which is offered in the form of pulses. The number of drops generated lies between 1,000 and 30,000 drops per second.

In jet nozzles for the continuous ink jet principle, drop formation is generally stimulated by an ultrasonic vibration element which reproducibly provides a high-frequency vibration. The pressure pulse needed for drop formation is 0.1% of the working pressure. For a working pressure of 30 bar, this is approximately 0.03 bar, which is very small compared with ink-jet printers operating by the drop on demand principle, where the pressure pulses are a hundred times that.

The present invention relates to a jet nozzle of an ink-jet printer which works on the continuous ink jet principle.

A known jet nozzle for an ink-jet printer which works on the continuous ink jet principle comprises a glass tube which forms an ink supply channel, and whose end part is in the form of a capillary which tapers at the end and forms the outflow aperture there. The glass tube is surrounded by a metal sleeve to protect the capillary and to shield electric fields.

This known jet nozzle has a number of disadvantages. It is difficult to manufacture and is also fragile. Besides, its stability during use is unsatisfactory.

The object of the present invention is to produce a jet nozzle which does not have these disadvantages.

This object is achieved by a jet nozzle for an ink-jet printer working on the continuous ink jet principle, which comprises an ink supply channel and an outflow channel disposed at the outflow end of the ink supply channel and in line therewith, and which according to the invention is characterized in that the jet nozzle comprises an essentially block-shaped housing made of essentially undeformable material and containing the ink supply channel, which at the outflow end has a

relatively small diameter, the outflow channel is fitted in an end wall of the ink supply channel which is fixed to the housing, and said outflow channel has a very small diameter and is of a length which is greater than its diameter, and near the outflow end of the ink supply channel the housing is provided with an ultrasonic vibration element.

The jet nozzle according to the invention is sturdy, of compact construction, and stable during use. It is also reliable and is easy to clean.

Preferred embodiments of the jet nozzle according to the invention are described in the sub-claims.

The invention will now be explained in greater detail in the example of an embodiment which follows, with reference to the drawings, in which:

Fig. 1 is a longitudinal section of the jet nozzle according to the invention;

Fig. 2 is a front view of the jet nozzle of Fig. 1, in the direction of the arrow II;

Fig. 3 shows the detail III of the jet nozzle of Fig. 1 at the outflow channel, on an enlarged scale; and

Fig. 4 shows an end part of a modified embodiment of the jet nozzle according to the invention.

The jet nozzle shown in Figs. 1 and 2 for an ink-jet printer working on the continuous ink jet principle comprises a slightly oblong-shaped cylindrical housing 1 in which an ink supply channel 2 is fitted concentrically. The ink supply channel 2 has a diameter which decreases in stages from the inflow end 3 towards the outflow end 4. At the inflow end 3 the ink supply channel 2 is provided with, for example, an internal screw thread 5, so that the jet nozzle can be screwed onto an ink supply line (not shown here). A filter 6 for filtering the ink flowing through the channel is fitted

in the ink supply channel 2.

At the outflow end 4 the ink supply channel 2 is provided with an end wall in the form of a separate thin plate 7, which is fixed to the housing 1, and which is provided with an outflow channel 8 of very small diameter which is disposed essentially concentrically relative to the ink supply channel 2. The diameter of the ink supply channel 2 must be small at the outflow end 4, in order to keep the forces on the plate 7 as low as possible during operation. This diameter preferably lies between 0.2 and 1 mm. The diameter of the ink supply channel 2 at the outflow end 4 is, however, many times greater than the diameter of the outflow channel 8 (see also Fig. 3). The diameter of the outflow channel 8 is, for example, between 3 and 30 microns, and is preferably between about 6 and 20 microns. The outflow channel 8 has to be sufficiently long to obtain a stable direction of the ink jet. On the other hand, the outflow channel 8 must be as short as possible in order to prevent high-frequency vibrations, which - as will be discussed in greater detail below - for the formation of drops are transferred to ink flowing through the outflow channel, from being too greatly damped, which would adversely affect the reproducibility of the drop formation.

The housing 1 of the jet nozzle is preferably made of stainless steel. The housing 2 can, however, also be made of less corrosion-resistant material if it is provided with a coating on the inside, for example a coating applied chemically by evaporation. The coating must cover completely, be free from holes, and be corrosion-resistant. Furthermore, this coating must not affect the properties of the ink. The housing could possibly be made of a non-swelling plastic. In addition, a ceramic material can also be used.

In the jet nozzle shown the housing 1 is in the form of a slightly oblong-shaped cylinder. The housing can, however, also be a different shape. It can also be provided with a fitting face (not shown here) for aligning the jet nozzle, and said fitting face can be disposed in the outside wall of the housing by grinding. The housing 1 is, for example, 20 mm long and 8 mm in diameter.

The filter 6 is preferably made of stainless steel with a transmission factor of 3 microns. The filter 6 can, if necessary, also be made of polytetrafluoroethylene or glass.

The thin plate 7 is preferably made of glass, but can also be made of all kinds of other materials, such as ruby, sapphire, stainless steel, nickel, platinum etc. The thickness of the plate 7 is, for example, about 100 microns (0.1 mm).

In view of the small diameter of the ink supply channel, the plate 7 with the outflow channel 8 must be fitted very accurately. The connection of the plate 7 to the housing 1 must be such that the forces on the plate 7 are as low as possible during operation. Great forces lead to deformation of the plate 7, with repercussions for the direction of the jet, or even leading to breaking or cracking of the plate.

In the embodiment of Figs. 1 and 2 the plate 7 is centred in a recess, and fixed on the housing 1 by means of, for example, a thermosetting two-component epoxy adhesive. The adhesive layer must be very thin, while the faces of the housing 1 and the plate 7 to be glued must be very flat. The adhesive must be metered very accurately, in order to:

- prevent adhesive from going into the ink supply channel 2 and blocking the outflow channel,
- keep the surface of plate 7 which is not glued, and

which is exposed to high pressures, as small as possible.

In the embodiment of Fig. 4 the plate 7 is centred by means of a cap 9, in which the plate 7 lies, and which is provided with an aperture 10, in such a way that the outflow channel 8 in the plate 7 lies free. The cap 8 is fixed to the housing 1.

The embodiment of Fig. 4 is an alternative to the fastening form of Fig. 1. Here again the surface area of the plate 7 exposed to the high pressure must be kept as low as possible. If the plate 7 is made of an undeformable material, such as glass, it cannot be clamped, but must be bonded with adhesive. In that case the same requirements as those for the embodiment of Fig. 1 apply for the bonding.

In the jet nozzle shown in Figs. 1 and 2, the housing 1 has formed in it, near the outflow end 4 of the ink supply channel 2, a recess 11 in which an ultrasonic vibration element, for example a piezoelectric crystal 12, is fitted. This vibration element 12 is used to set the ink jet coming out of the outflow aperture 8 in vibration. The piezoelectric crystal can be, for example, a lead/ zirconate/titanate crystal 5 mm in cross section and 1 mm thick. The piezoelectric crystal 12 is provided with electrical connecting wires 13. A thermosetting two-component epoxy adhesive can be used for fixing the piezoelectric crystal 12 on the housing 1. The recess 11 can also be filled with a filler 14, for example epoxy.

Due to the rigid construction of the housing 1, the ultrasonic vibration element 12 can be fitted parallel to the ink supply channel 2, as shown in Fig. 1. This has the following advantages compared with an ultrasonic vibration element which is fitted round the ink supply channel:

- The adhesive connection between the ultrasonic vibration element 12 and the housing 1 can be made very reproducible, because the faces to be bonded can be pressed very well onto each other. The ultrasonic vibration is consequently transferred virtually undamped via the adhesive connection to the housing. (The adhesive layer in fact acts as a damper here.) Good reproducibility of the adhesive connection is essential for good drop formation.

- There is no need to make a hole in the ultrasonic vibration element, something which is necessary in the case of a coaxial position relative to the ink supply channel.

The jet nozzle according to the invention has the following advantages:

- It is compact and short;
- It is sturdy (which is an advantage for handling and cleaning);
- It is relatively cheap to produce;
- It can withstand very high pressure (e.g. 120 bar);
- The front side is easy to polish, which is an advantage for cleaning and provides an improvement in the wetting properties, in particular where a glass plate is used;
- Where a metal housing is used, the electrical shielding of the ink (against electrostatic fields which interfere with the charge) is excellent;
- Due to the easy workability of stainless steel (or other materials from which the housing can be made), variations in the shape (alignment faces) can easily be made; embodiments with very small dimensions are also easy to produce;
- In terms of time, the direction of the ink jet is very stable; after adjustment, re-alignment is no longer necessary;

- The mechanical stability is very good;
- Due to the shape of the ink supply channel, if there is any drying-out of the ink, the residue is very easy to remove.

The overall design of the jet nozzle according to the invention also has the great advantage that the number of drops generated per second, assuming the same electrical vibration offered to the ultrasonic vibration element, is the same within very narrow tolerances for different jet nozzles.

CLAIMS

1. Jet Nozzle for an ink-jet printing apparatus working on the continuous ink jet principle, comprising an ink supply channel and an outflow channel disposed at the outflow end of the ink supply channel and in line therewith, characterized in that the jet nozzle comprises an essentially block-shaped housing (1) made of essentially undeformable material and containing the ink supply channel (2), which ink supply channel (2) at the outflow end (4) has a relatively small diameter, the outflow channel (8) is fitted in an end wall of the ink supply channel (2) which is fixed to the housing (1), and said outflow channel (8) has a very small diameter and is of a length which is greater than its diameter, and near the outflow end (4) of the ink supply channel (2) the housing (1) is provided with an ultrasonic vibration element (12).

2. Jet nozzle according to Claim 1, characterized in that the housing (1) is made of a metal, preferably stainless steel.

3. Jet nozzle according to Claim 1, characterized in that the end wall of the ink supply channel (2) is formed by a separate thin plate (7), which is fixed to the housing (1) at the outflow end (4) of the ink supply channel (2).

4. Jet nozzle according to Claim 3, characterized in that the plate (7) is joined to the housing by means of bonding with adhesive.

5. Jet nozzle according to Claim 1, characterized in that the diameter of the outflow channel (8) lies between 3 and 30 microns, preferably between 6 and 20 microns, and the length/diameter ratio of the outflow channel (8) lies between 3 and 30,

preferably between 4 and 20.

6. Jet nozzle according to Claim 1, characterized in that the diameter of the ink supply channel (2) at the outflow end (4) lies between 0.2 and 1 mm.

7. Jet nozzle according to Claim 1, characterized in that the ultrasonic vibration element (12) is disposed next to and parallel to the ink supply channel (2).

8. Jet nozzle according to Claim 7, characterized in that the ultrasonic vibration element (12) is fixed with adhesive in a recess in the housing (1).

9. Jet nozzle according to one of Claims 1 - 8, characterized in that the housing (1) is provided with a fitting face for aligning the jet nozzle.

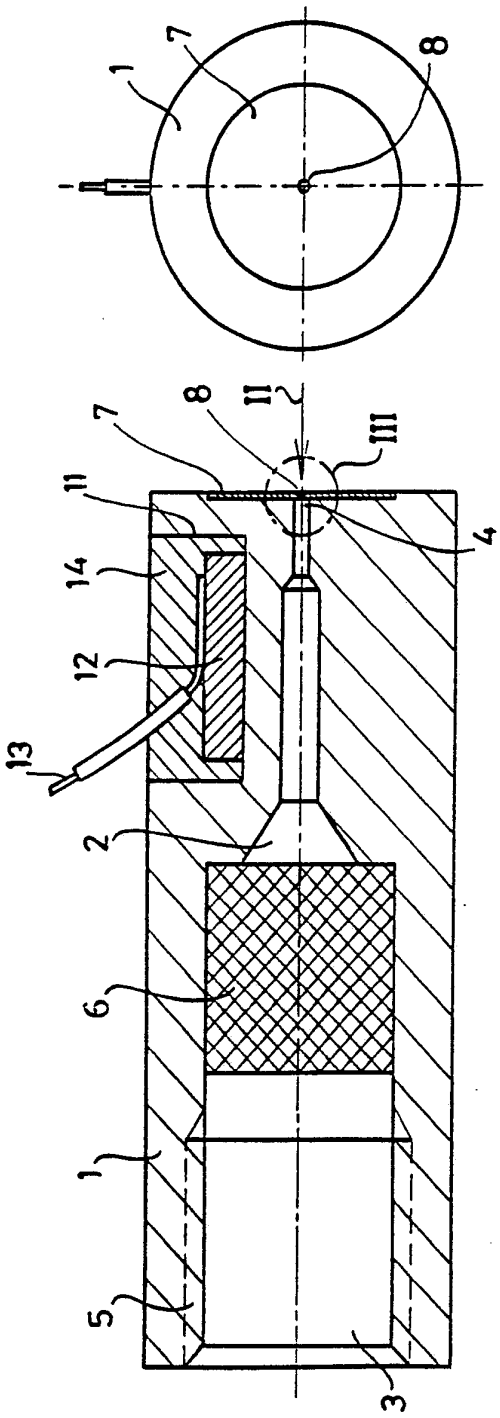

FIG. 2.

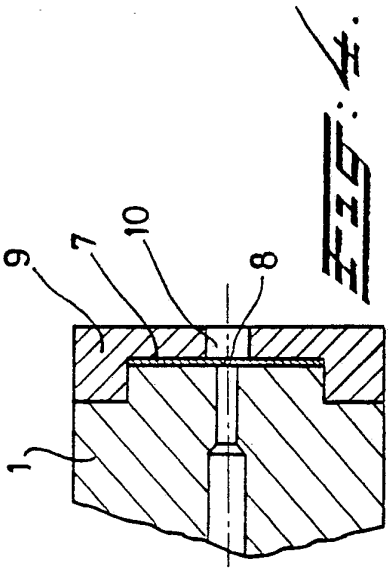

FIG. 4.

FIG. 1.

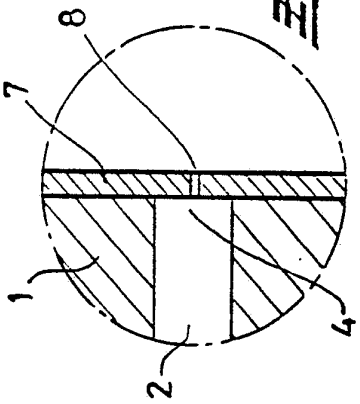

FIG. 3.

INTERNATIONAL SEARCH REPORT

International Application No PCT/NL 90/00006

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 B41J2/14

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	B41J

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category[10]	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
Y	IBM TECHNICAL DISCLOSURE BULLETIN. vol. 20, no. 11a, April 1978, NEW YORK US page 4485 J.M. Huellemeier: "Ink jet nozzle fabrication." see the whole document	1.
A	---	2, 3.
Y	US,A,4228440 (M. HORIKE) 14 October 1980 see column 3, lines 3 - 27; figure 2.	1.
A	---	7, 8.
A	DE,A,3123689 (SIEMENS A.G.) 30 December 1982 see page 5, line 21 - page 6, line 9 see figures 1, 2.	1, 2.

A	US,A,4065774 (C-H. LEE) 27 December 1977 see column 3, line 4 - column 4, line 20; figures 1-5.	1, 3, 4.
	-/--	

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
20 APRIL 1990	16 MAY 1990
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 291 (M-265)(1436) 27 December 1983, & JP-A-58 163667 (A. KIYOSHI) 28 September 1983, see the whole document	1, 3, 4.
A	US,A,4623904 (R. CONTA) 18 November 1986 see column 3, lines 15 - 30 see column 6, lines 24 - 46; figures 2, 5, 8.	5, 6.
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 201 (M-707)(3048) 10 June 1988, & JP-A-63 5949 (S. SEKIMOTO) 11 January 1988, see the whole document	1.
A	US,A,4417255 (I. FURUKAWA) 22 November 1983 see the whole document	1.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

NL 9000006
SA 34101

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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