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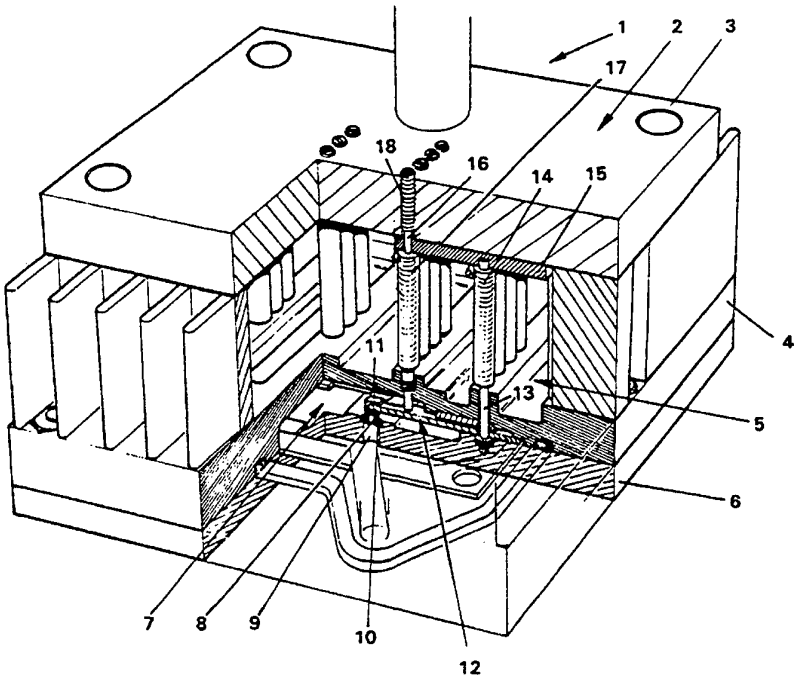

(57) Abstract

A printhead (1) for an ink jet printer includes a chamber (5) for containing marking fluid fed to the head in use. A plurality of orifices (8) open from the chamber (5), a marking fluid being emitted in use through the orifices (8). A corresponding plurality of actuators are provided. Each actuator comprises an arm (12) having at one end means for selectively opening and closing a respective orifice (8); a magnetic circuit (12, 13, 14, 15) of which the arm (12) forms a side; and one or more coils (14) for selectively inducing a magnetic flux in the circuit in order to move the arm (12) between a position in which it closes the respective orifice (8) and a position in which it opens the orifice (8).

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INK JET PRINTER

The present invention relates to ink jet printers of the drop-on-demand type and, more particularly, to printheads for printers of this type.

In our GB-B-2134452, there is shown and described, a printhead in which a plurality of orifices are individually opened and closed by solenoid-actuated, wire-pulled closures. Locating the solenoids remote from the closures enables a fairly close spacing of the nozzles to be achieved. In the type of printhead shown in GB-B-2192590 (amongst others), which is a development of this system, individual nozzles are opened and closed by closure members on the end of rod-like magnetic armatures which are directly driven by respective coils. A problem with this design is that of nozzle spacing, resulting from the diameter of the coils/solenoids used to drive the armatures. If the solenoids are to be sufficiently strong and quick in pulling open the nozzles (hence of significant diameter) and if significant solenoid crosstalk is to be avoided (hence spaced well apart), then the nozzles cannot be located as closely as desired.

The present has the object, amongst others, of enabling a very close nozzle spacing to be achieved, without loss of opening power/speed.

According to the present invention there is provided a printhead for an ink jet printer, the printhead including

a chamber for containing marking fluid fed to the head in use;

a plurality of orifices opening from the chamber and through which a marking fluid can be emitted in use; and,

a corresponding plurality of actuators, each comprising an arm having, at one end, means for selectively opening and closing a respective orifice, a magnetic circuit of which the arm forms a side, and one or more coils for selectively inducing a magnetic flux in the circuit in order to move the arm between a position in

which it closes the respective orifice and a position in which it opens the orifice.

The arm is moved by the induction of the magnetic flux between a position in which a gap is formed between part of the arm and the magnetic circuit and a position in which it closes the magnetic circuit.

Preferably, the arm is formed from spring steel and is mounted in cantilever fashion, flexing under the influence of the applied magnetic flux to open the orifice. The rest of the magnetic circuit is preferably substantially U-shaped.

The arm may vary in width, having a relatively narrow portion in order to provide suitable flexing characteristics, and a relatively wider portion in order to provide a low reluctance path in order to produce the desired degree of flux linking to the part of the circuit on the side of the arm adjacent the gap. A magnetic plate forming part of the magnetic circuit may extend over the narrower portion of the arm where the flexing chiefly occurs and partially over the wider portion in order to enable the required degree of flux linking between the portion of the circuit adjacent the fixed end of the arm and the wider portion of the arm.

In an alternative construction, the arm carries a magnetic plate which is attracted to the adjacent portions of the magnetic circuit on application of current to the coil or coils.

Preferably, the U-shaped portion of the circuit has a pair of coils, one mounted on each leg of the U. This enables adjacent actuators to be more closely spaced as each coil can be smaller in diameter than would be the case if a single coil were to be used and thus maximises copper volume thereby minimising copper losses.

The closeness of the orifices (which is dependent on the coil spacing) can also be improved by having the portion of the arm which closes the orifice extend beyond the leg of the U, so that, if adjacent actuators extend on

opposite sides of the line of nozzles, the nozzles can be more closely located as the coils will be staggered and thus more closely "packed". The actuators may also be flared out from the nozzles to allow maximisation of coil diameter and to minimise spacing.

It is advantageous if the size of the gap between the leg of the circuit and the arm can be adjusted and this can be provided by allowing the leg to be moved axially, through the coil (if there is one) which surrounds it, relatively to the arm.

The adjustment of the leg may be provided by a rod movable relative to the remainder of the circuit or else by allowing the circuit to flex to accommodate such axial movement of the leg as is required.

An example of a printhead according to the present invention will now be described with reference to the accompanying drawings in which:-

Figure 1 is a partially cut-away isometric view through the printhead;

Figure 2 is a complex planar section through the printhead; and

Figures 3 and 4 are cross-sections through the printhead showing an actuator in respectively closing and opening positions.

The printhead 1 comprises a body 2 which has a topplate 3 and a bottom plate 4. Between the plates 3 and 4 is defined a chamber 5 in which are located plural coils of plural actuators as will be described further below. A closure plate 6 is mounted on the bottom plate 4 and defines a chamber 7 to which a marking fluid such as ink is directed in use from a reservoir under pressure. A row of nozzles 8, each of which comprises a channel 9 in the cover plate 6 and an orificed jewel 10, allow ink to pass from the chamber for printing.

Closing each of the nozzles 8 is a synthetic rubber valve member or closure 11 which is mounted on the end of a spring steel, cantilevered, arm 12. Each arm 12 is held

in a cantilevered position between the bottom plate 4 and cover plate 6 and is engaged at its fixed end by a magnetic core 13, around which is positioned a first coil 14. The end of the core 13 remote from the arm 12 is disposed in a flat magnetic plate 15 and, spaced from the first core 13, and passing through the magnetic plate 15, there is disposed a second core 16, around which is provided a second coil 17. Each core 16 has a screw-threaded portion 18 by means of which the axial position of the core 16 is adjustable within the chamber 5, the screw-threaded portion 18 engaging a corresponding screw thread in the top plate 3.

The end of the second core 16 remote from the screw thread 18 is disposed closely adjacent the arm 12 as is best seen in Figure 3. The end of the core 16 is formed with a shaped portion 19 at the point at which the core 16 passes through the bottom plate 4 and into the chamber 7. This enables an O-ring 20 to seal the core 16 and thus avoid ink in the chamber 7 passing into the chamber 5. A second magnetic plate 21 is disposed closely around the end 22 of the core 13 and extends over the arm 12, closely spaced therefrom.

As is best seen in Figure 2, each of the arms 12 has a non-uniform width and has portions 121-124 of different width which will now be described.

The portion at 121 of the arm 12 remote from the respective nozzle 8 is the narrowest portion and extends into a part circular portion 125 which closely surrounds the first core 13. This in turn extends into a portion 122 which is the main area of flex of the arm 12 in use. This in turn extends into a wider portion 123 which in turn leads to a narrower portion 124 on the end of which the rubber closure member 11 is mounted over the nozzle 8. As is clearly illustrated in Figure 2, the magnetic plate 21 overlies the flexing portion 122 of the arm 12 and partially overlies the wider portion 123. This enables magnetic flux in the circuit of the actuator (which is

formed by the core 16, the magnetic plate 15, the core 13 and the plate 21 and arm 12) to link effectively between the remainder of the circuit and the arm 12, the required degree of flex thus not being reduced as would be the case if the portion 123 extended over the length of the arm 12.

In use, when current is applied through the coils 14 and 17, the arm 12 is attracted towards the end of the core 16, lifting the closure 11 from the jewel 10 as shown in Figure 4. Ink under pressure is then emitted as indicated in Figure 4, through the nozzle 8, for printing.

As can be seen from Figures 1 and 2, adjacent nozzles 8 have respective arms 12 which extend in opposite directions, enabling the coils 14 and 17 of adjacent actuators on each side of the row of nozzles to be closely spaced and therefore enabling the nozzles themselves to be more closely spaced than would be the case if all the actuators extended from the same side of the row of nozzles. This increase in the "packing" density of the coils is further enhanced by providing split coils, i.e. two coils 14 and 17, one on each core 13, 16, rather than a single core, although in certain embodiments a single coil may be appropriate.

Adjustment of the axial position of the core 16 can be used to determine the degree of opening of the nozzle 8, but a separate back stop, not shown, may be provided, for example immediately behind the closure 11.

The dimensions of the chamber 7 may be carefully chosen, depending upon the physical properties of the marking fluid, to provide damping to the motion of the arm in use.

Although the example shows that the magnetic circuit of each actuator is formed from discreet components, the two cores 13,16, and the two magnetic plates 15 and 21, it is envisaged that a one-piece laminated component might be used in place of this, in which case the equivalent of the plate 15 may be allowed to flex to accommodate axial

movement of the branch of the circuit closer to the nozzle, for adjustment of the opening and closing of the nozzle.

CLAIMS

1. A printhead (1) for an ink jet printer, the printhead (1) including

a chamber (5) for containing marking fluid fed to the head in use;

a plurality of orifices (8) opening from the chamber (5) and through which a marking fluid can be emitted in use; and,

a corresponding plurality of actuators, each comprising an arm (12) having, at one end, means for selectively opening and closing a respective orifice (8), a magnetic circuit (12,13,14,15) of which the arm (12) forms a side, and one or more coils (14) for selectively inducing a magnetic flux in the circuit in order to move the arm (12) between a position in which it closes the respective orifice (8) and a position in which it opens the orifice (8).

2. A printhead (1) according to claim 1, wherein the arm (2) is formed from steel and is mounted in cantilever fashion, flexing under the influence of the applied magnetic flux to open the orifice (8).

3. A printhead (1) according to claim 1 or claim 2, wherein the part of magnetic circuit (13,14,15) not including the arm is substantially U-shaped.

4. A printhead (1) according to claim 1, claim 2 or claim 3, wherein the arm (12) varies in width, having a relatively narrow portion in order to provide suitable flexing characteristics, and a relatively wider portion in order to provide a low reluctance path in order to produce the desired degree of flux linking to the part of the circuit on the side of the arm (12) adjacent the gap.

5. A printhead (1) according to any of the preceding claims, further comprising a magnetic plate (21) forming part of the magnetic circuit which extends over the narrower portion of the arm (2) and partially over the wider portion in order to enable the required degree of flux linking between the portion of the circuit adjacent the fixed end of the arm and the wider portion of the arm.

6. A printhead (1) according to any of claims 1 to 4, wherein the arm (12) carries a magnetic plate which is attracted to the adjacent portions of the magnetic circuit on application of current to the coil or coils.

7. A printhead (1) according to any of claims 3 to 6, wherein the U-shaped portion of the circuit has a pair of coils (14,17), one mounted on each leg (13,16) of the U.

8. A printhead (1) according to any of claims 3 to 7, wherein the portion of the arm which closes the orifice extends beyond the leg of the U.

9. A printhead (1) according to any of the preceding claims, wherein the actuators flare out from the nozzles (8).

10. A printhead (1) according to any of the preceding claims, wherein the gap between the leg (13) of the circuit and the arm (12) can be adjusted by axial movement of the leg.

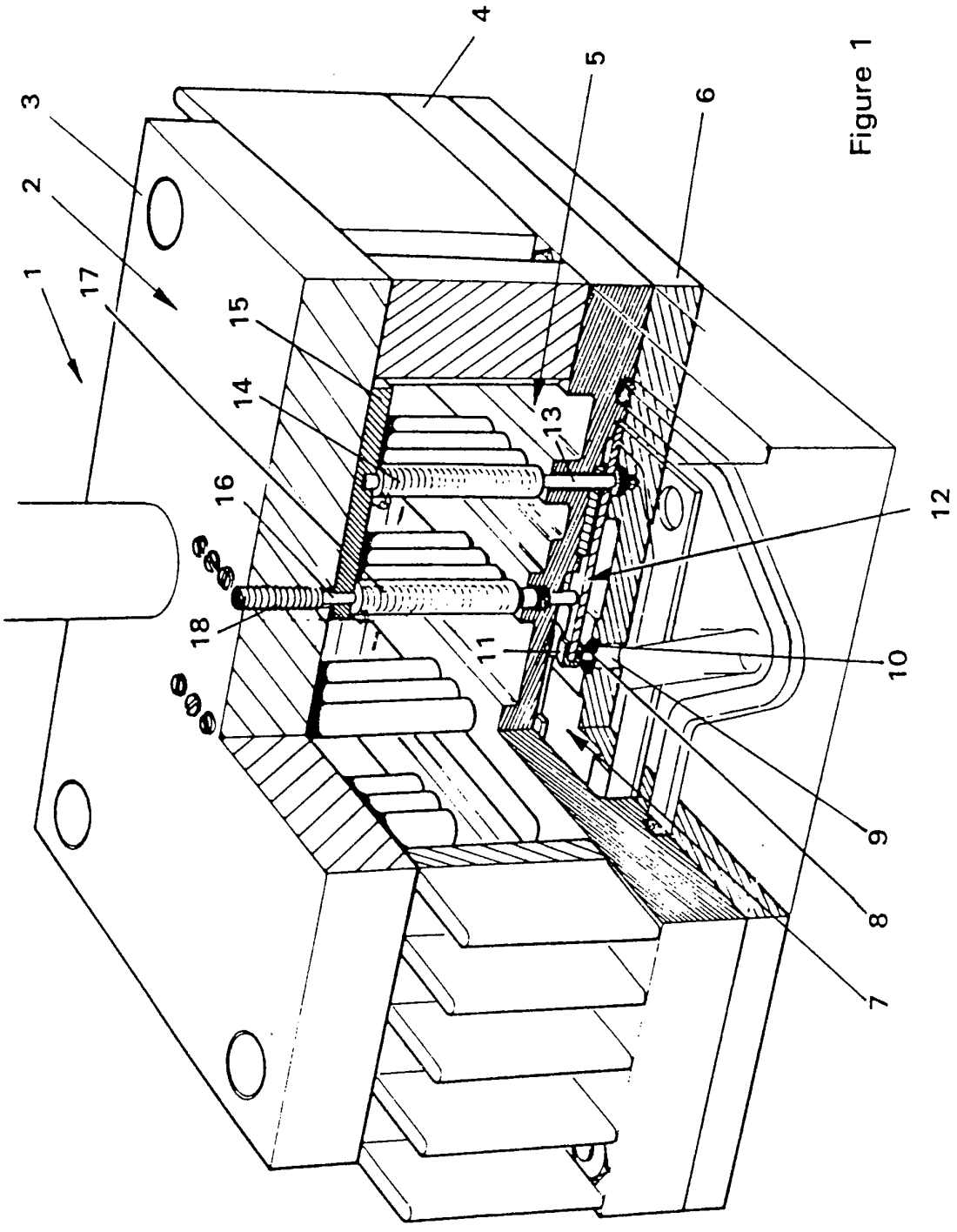

Figure 1

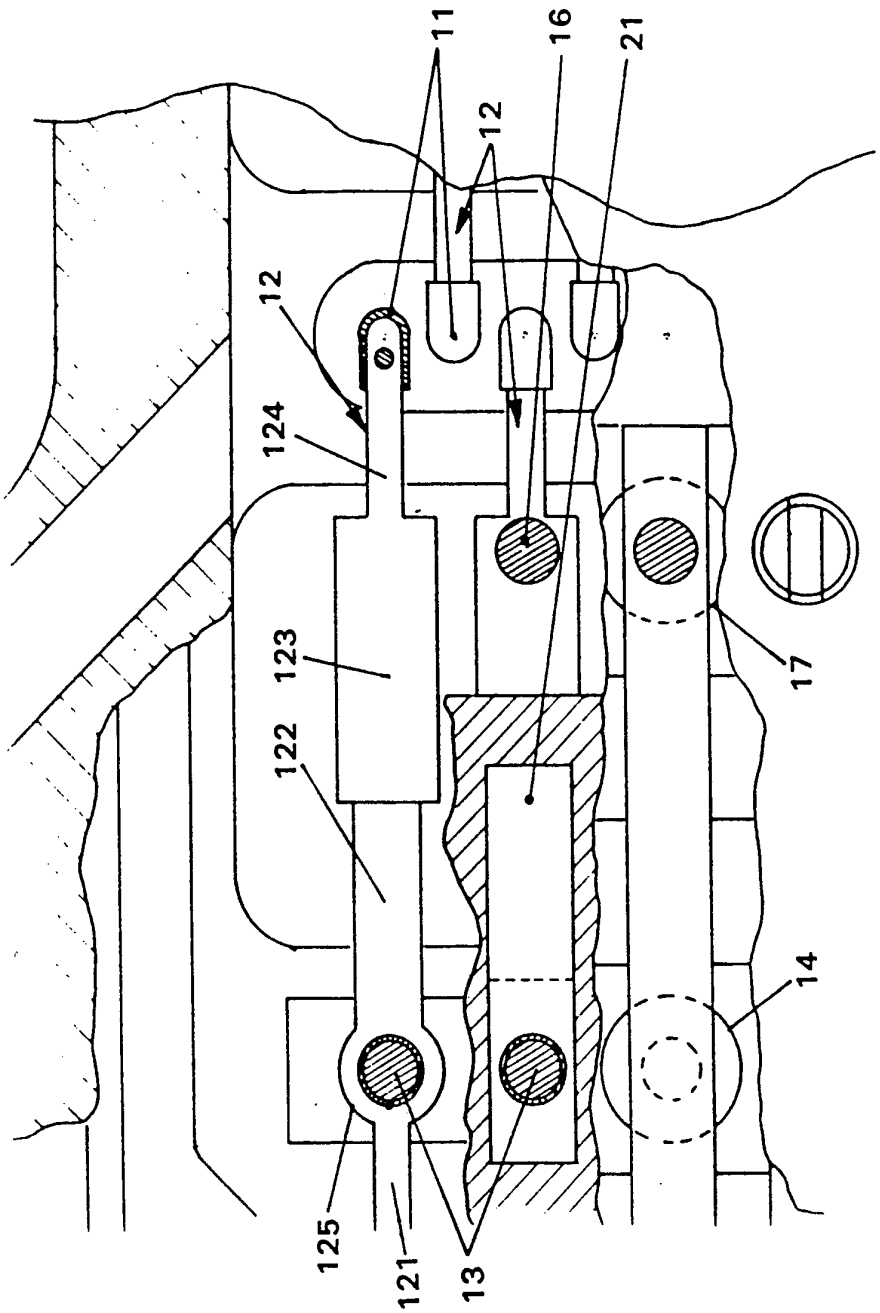

Figure 2

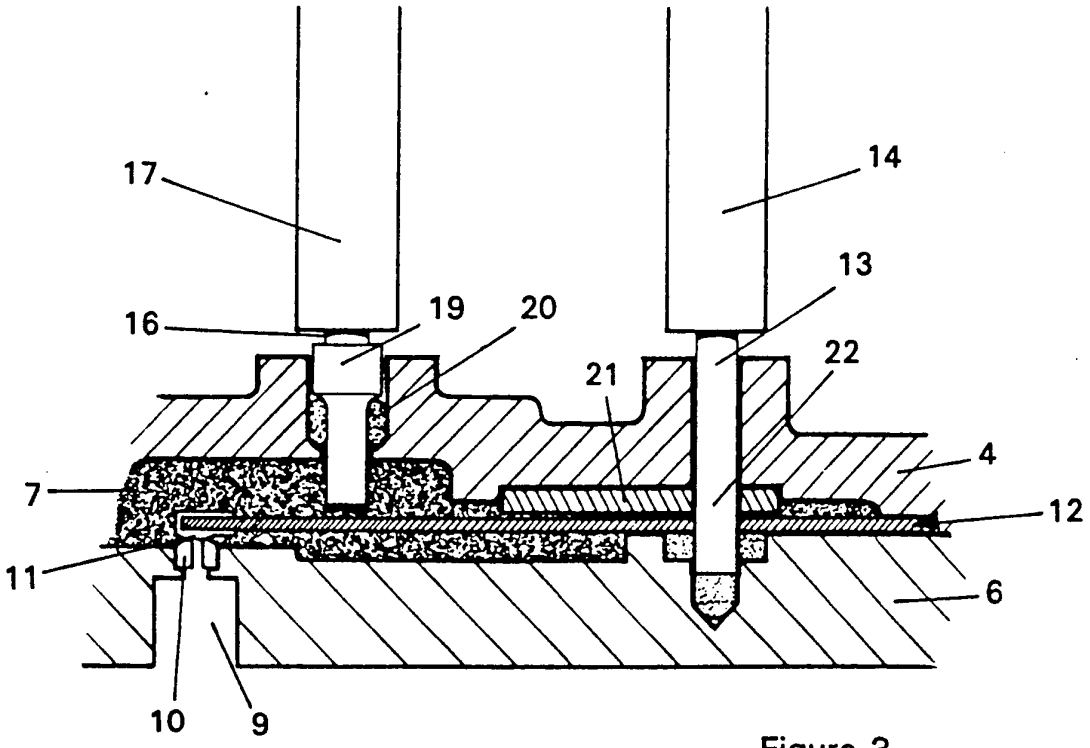

Figure 3

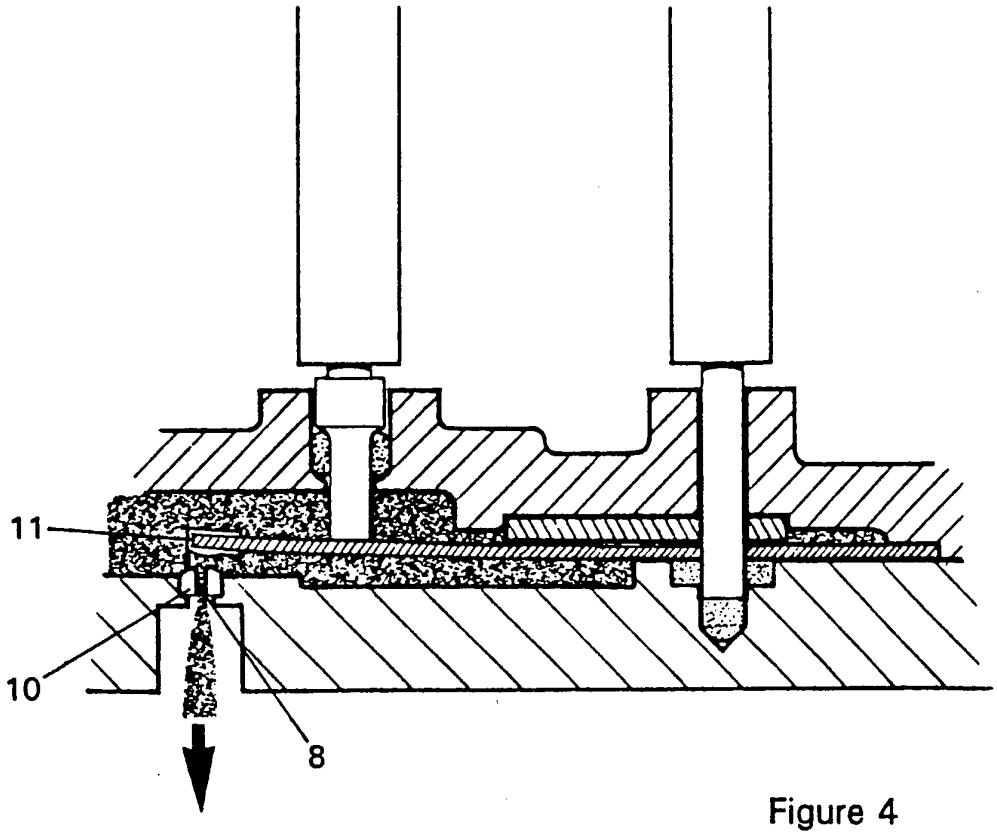

Figure 4

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 94/00155

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 B41J2/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 B41J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,5 126 755 (SHARPE ET AL.) 30 June 1992 see the whole document	1
X	GB,A,2 192 590 (MARKPOINT SYSTEM AB) 20 January 1988 cited in the application	1,3,8,9
Y	see the whole document	2,4-7,10
Y	EP,A,0 510 648 (IVRY, YEHUDA) 28 October 1992 see column 5, line 45 - column 6, line 19; figure 5	2,4
Y	US,A,4 336 544 (DONALD ET AL.) 22 June 1982 see claim 5; figures 1,2,3	2,5,6

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
14 April 1994	02. 05. 94

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 8, no. 270 (M-344) (1707) 11 December 1984 & JP,A,59 142 163 (CANON K.K.) 15 August 1984 see abstract	7
Y	DE,A,24 41 496 (OLYMPIA WERKE AG) 22 January 1976 see column 5, line 21 - column 6, line 22; figure 5	10
A	US,A,4 674 896 (YASUNAGA ET AL.) 23 June 1987 see column 2, line 29 - line 31	5,6

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte. nal Application No
PCT/GB 94/00155

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