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The references to the drawing are deemed to be deleted (Rule 43 EPC).

(54) A droplet deposition apparatus with releasably attached nozzle plate

(57) A multichannel droplet deposition apparatus comprising a body (103) with a plurality of channels (104a) terminating in a common channel termination surface (104) and a nozzle plate (102) with through holes (102a) placed on the body at the channel termination surface for providing droplet ejection nozzles for said channels, wherein the nozzle plate is releasably attached to said body.

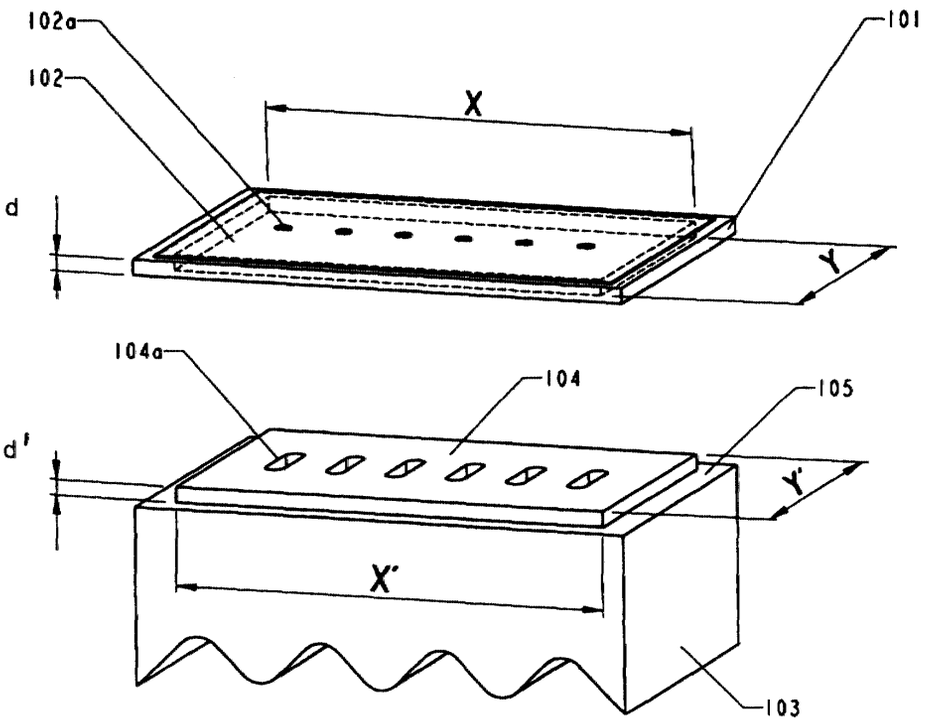

Fig. 1

EP 1 177 897 A1

Description

FIELD OF THE INVENTION

[0001] This invention relates to droplet deposition apparatus and especially to ink jet printheads. In particular it relates to methods for attaching the nozzle plate to the printhead body.

BACKGROUND OF THE INVENTION

[0002] It is known in the art of Ink jet printing that problems with uneven printing, white lines, etc. can occur and that the cause of such printing defect resides frequently in the nozzles through which the ink droplets are propelled towards the ink receiving medium. The printing defects mentioned above can be caused by clogged nozzles, e.g., by drying of the ink in the nozzle or by impurities in the ink, by damaged nozzles, e.g., by the presence of hard pigments in the ink.

[0003] In SOHO (Small Office/Home Office) printers when problems arise the printhead is discarded in its entirety and replace. In larger ink jet printers larger printheads, even page wide printheads are used. A typical example of such printhead has been disclosed in, e.g., **US-A-5 855 713.** In this disclosure printhead is disclosed with a body with a plurality of parallel channels therein, the channels terminating in a common channel termination plane and a nozzle plate mounted on the body at the channel termination plane. In printhead structures as described above the nozzle plate makes less than 20 % of the cost price of the printhead. In that disclosure the body and the nozzle plate are firmly bound together so that when printing problems arise due to defects in the nozzles, the whole printhead has to be discarded, or that the rework, removing the nozzle plate and replacing it with a new, is a very cumbersome task, so that the user is almost forced to discard an expensive printhead of the printer because a fairly inexpensive part of it got a defect.

[0004] Thus the need for a printhead with an easily removable and changeable nozzle plate is still there.

OBJECTS AND SUMMARY OF THE INVENTION

[0005] It is an object of the invention to provide a multichannel droplet deposition apparatus comprising a nozzle plate that can easily be interchanged.

[0006] It is a further object of the invention provide a multichannel droplet deposition apparatus wherein the body of the apparatus comprises registration mark for easy registering of an interchangeable nozzle plate.

[0007] The objects of the invention are realised by providing a multichannel droplet deposition apparatus comprising a body with a plurality of channels terminating in a common channel termination surface and a nozzle plate with through holes placed on said body at said termination surface for providing droplet ejection nozzles for said channels, characterised in that said nozzle plate is releasably attached to said body.

[0008] Preferably said nozzle plate is releasably attached by a force selected from the group consisting of adhesive force, magnetic force and mechanical force.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 shows an exploded view of a first embodiment of a releasably attached nozzle plate.

[0010] Figure 2 shows an exploded view of a second embodiment of a releasably attached nozzle plate.

[0011] Figure 3 shows an exploded view of a second embodiment of a releasably attached nozzle plate.

[0012] Figure 3a shows a detail of figure 3

DETAILED DESCRIPTION OF THE INVENTION

[0013] It was now found that, in a multichannel droplet deposition apparatus - especially in an ink-jet printhead - comprising a body with a plurality of channels terminating in a common channel termination surface and a nozzle plate with through holes placed on said body at said termination surface, it was possible to attach a nozzle plate releasably to the body without having said nozzle plate moving during the operation of the printer, so that the distance nozzle plate/ink receiving medium stayed constant and the registering between nozzle plate and the channels was not diminished. This was even so in printhead structures wherein the outlet of the channel was larger than the opening of the nozzle and where thus, when the ink was propelled through the nozzles by piezo forces, the ink exerts pressure against the nozzle plate.

[0014] In a **first embodiment** of the invention the nozzle plate is attached to a frame and that frame is releasably attached to the body in such a way that the nozzle plate is in contact with the channel termination surface. In figure 1 a possible implementation of this first embodiment is shown. A frame (101) with a thickness, d, and inner dimensions X and Y is provided with a nozzle plate (102) with nozzles (102a). The body (103) is, on the side of the surface (104) where the channels (104a) for providing ink terminate (this surface is further on designated by "channel termination surface"), machined so that the channel termination surface has lowered edges (105) and that the remainder of said surface is elevated above those edges to a thickness d' chosen so that $d' \leq d$. Preferably $d' = d$ so that the nozzle plate attached to the frame rests in contact on the remainder of the channel termination surface. This remainder of the channel termination surface has dimensions X' and Y' chosen so that $X' \leq X$ and $Y' \leq Y$. Preferably X' and Y' are equal to the inner the inner dimensions X and Y, of the frame so that the frame fits snugly over the remainder of the channel termination surface. In this implementation, although registration marks on the channel termination surface can be useful to help the registration of the nozzle plate,

these marks are not strictly necessary, since due to the fit of the frame over the elevated part of the channel termination surface, the nozzles are registered with the exits of the ink channels in the channel termination surface.

[0015] In a **second embodiment** of the invention, the nozzle plate is, as in the first embodiment of this invention, attached to a frame and that frame is releasably attached to the body in such a way that the nozzle plate is in contact with the channel termination surface. In figure 2 this embodiment is schematically shown. In this case, the channel termination surface (104) is not machined and is simply kept flat. A frame (101) carrying a nozzle plate (102) is placed on that flat channel termination surface (104) with the nozzle plate (102) positioned between the frame and the channel termination surface and then the frame is fixed to the body (103) of the droplet deposition apparatus. In this case it is preferred that the body carries at the channel termination surface at least one registration mark, so that the nozzles in the nozzle plate can easily be brought in register with the openings of the channels in the channel termination plate.

[0016] In both the first and second embodiment of the invention, the frame carrying the nozzle plate can be made from any material known in the art, it can be made of stainless steel or of an other metal, e.g., copper, aluminium, nickel, etc), it can be made of rigid plastic (e.g. polyvinylchloride, polyurethane, polycarbonate, etc.).

[0017] In both the first and second embodiment of the invention, the frame carrying the nozzle plate can releasably be fastened to the body by any means known in the art. It can be fastened with screws, with clamps, with a kind of press-studs, with coils springs, etc. In a further implementation of the first and second embodiment of the invention either the frame is releasably attached to the channel termination surface by magnetic forces, e.g., by using a magnetic material to form the frame, or by incorporating permanent magnets either in the frame or in the body or in both.

[0018] In both the first and second embodiment of the invention, the nozzle plate (102) is preferably made of a material that is a chemically resistant ablatable polymer in sheet form, preferably such as polyester, polyether ether ketone or polyimide. Preferably the nozzle plate is made of polyimide. Polyimide has the advantage that it has a relatively low thermal expansion coefficient and that it is obtainable in sheet form in a particularly flat condition approximating to a optically flat or mirror surface, appropriate for the nozzle exit face. The nozzle plate can also be coated with a low energy surface coating as disclosed in US-A-5 010 356.

[0019] The nozzles (102a) can be made in the polyimide with any technique known in the art. A possible way to make the nozzles, when these are around 300 μm is rigorous mechanical drilling. For smaller (i.e. below 200 μm, preferably below 100 μm) aperture diameters laser burning is a fabrication process that is well known to those skilled in the art. is plasma etching. For the production of nozzles with small diameter, plasma etching is a method of choice, since by plasma etching nozzles with very smooth walls can be produced. This smoothness of the walls helps to avoid clogging of the nozzles and misdirection of the ink. A very good method for making the nozzles is the combination laser/plasma etching wherein a method is used of proper focusing and positioning the laser beam whereby an aperture with smaller diameter (than the one finally needed in the nozzle) is burned through the nozzle plate material. After this initial laser burning a plasma etching step follows to enlarge the diameter of the laser burned aperture to the final diameter of the nozzle.

[0020] In a **third embodiment** of the invention, the nozzle plate is micro injection molded. The technique of micro injection molding is well known and makes it possible to manufacture parts with dimensions on micrometer scale with excellent control of tolerances and reproducibility. This technique makes it also possible to use virtually any polymer known in the art to manufacture the nozzle plate, e.g., thermoplastics, fibre reinforced thermoplastics, thermosetting plastics and elastomers can be used for producing a nozzle plate for use in a multichannel droplet deposition apparatus according to this invention. By micro injection molding it is possible to produce "mini nozzle plates" that can be combined together for making one large nozzle plate. The advantage of this system is that when a nozzle is defect, only the "mini nozzle plate" carrying that nozzle has to be replaced.

[0021] In figure 3 such an apparatus is schematically shown. It shows two "mini nozzle plates" (102) each with 4 nozzles (102a). These "mini nozzle plates" are formed so as to fit tightly in a frame (101) that is attached on the body (103) of the droplet ejection apparatus at the surface (104) of the body the ink channels (104a) terminate. The "mini nozzle plates" can beneficially be made as shown in figure 3a, showing a cross-section along the line A-A' of figure 3. The "mini nozzle plates" over their length a notch (102b) and the frame has springs (101a) that fit in the notch when the "mini nozzle plates" are pressed in the frame, so has to keep the "mini nozzle plates" secured in the frame. The "mini nozzle plates" can also beneficially be equipped with a grip for easy removal when necessary.

[0022] The number of nozzles in a "mini nozzle plate" depends on diameter of the nozzles and the pitch and on the dimension that are desired for easy handling of the "mini nozzle plates". So can, e.g., when a nozzle plates with nozzles having a diameter of 100 μm and a pitch of 100 μm is to be made up with "mini nozzle plates", then it can be beneficial to have produce, with micro injection molding, "mini nozzle plates" having something like 25 nozzles in a row, which gives a length of about 0.5 cm for every "mini nozzle plate".

[0023] The frame wherein the "mini nozzle plates" are placed can releasably attached to the body (103) by the

same means as disclosed when describing the first and second embodiment of this invention or it can be an integral part of the body. In this latter case the channel termination surface is machined so as to have raised edges that then act as the frame for accepting the "mini nozzle plates". The former case, wherein the frame is releasably attached to the body, is the preferred implementation of this third embodiment of the invention. When the frame can be removed it is easier to replace a "mini nozzle plate" than when the frame is an integral part of the body.

[0024] In a **fourth embodiment** of the invention, there is no need of a special frame to carry the nozzle plate. The nozzle plate, that is preferably made of a polymeric sheet with through holes, is releasably attached to the flat channel termination surface by an adhesive layer, said adhesive layer being adapted so that, upon detaching said nozzle plate from said body, there is an adhesive break between said adhesive layer and said channel termination surface and no cohesive break within said adhesive layer. The adhesive is preferably a thermo adhesive although pressure sensitive adhesives can be used as well. The adhesive is formulated so that when a force is exerted perpendicular to the bounded nozzle plate, there is no movement or displacement of the nozzle plate, but that upon peeling by a shear force the nozzle plate is removed from the body together with the adhesive layer. Typical chemical formulations for water-based thermo-adhesives, useful in this fourth embodiment of the invention, are, e.g.: UCECRYL BM - trade name of UCB, Belgium for a PolyvinylAcetate-copolymer, NEOCRYL BT24, trade name of Zenica Resins for an acrylate polymer, VINNAPAS dispersion, trade name of Wacker Chemie for[Co(VinylAcetate-Vinyllaurate)], ACRONAL DS3095 trade name of BASF for a copolymer containing acrylate and Vinylacetate moieties, MOWILITH CT5, trade name of Hoechst for [Co(VinylAcetate-crotonic acid)], ACRYSOL WS68, trade name of Rohm & Haas for [Co(R-methylacrylaat)], VINAC XX-210 of 465DEV trade name of Air Products for a copolymer containing vinylacetate moieties, VINNAPAS EV12 trade name of Wacker Chemie and POLYCO 2744 trade name of Borden Inc, both for [Co(ethylacrylate-methylmetacrylate)]. Also adhesive formulations as disclosed in WO-A-96 33246 are useful in this fourth embodiment of the invention.

[0025] "Removable" adhesives that can provide an adhesive layer, wherein upon detaching said nozzle plate from said body, there is an adhesive break between said adhesive layer and said body and no cohesive break within said adhesive layer are disclosed in e. g. WO-A-94 20586 and US-A-5 756 625. Commercially available removable adhesives that can very beneficially used in this fourth embodiment of this invention are, e.g., PRIMAL EP-6120 en PS-61D trade name of Rohm & Haas) and NEOCRYL A-290 trade name of Zeneca Resins.

[0026] When the nozzle plate, in this fourth embodiment of the invention is bound to the body by an adhesive layer, wherein upon detaching said nozzle plate from said body, there is an adhesive break between said adhesive layer and said body and no cohesive break within said adhesive layer, it is preferred to give the nozzle plate corrugations as disclosed in US-A-5 855 713. Micro-cavities and bonding surface lands are formed together in the form of corrugations. The corrugations are typically 2-4 μm deep and of spacing or wavelength 10-20 μm. The lands left between the microcavities have preferably a width in contact with the channel termination surface of between 0.05 times and 0.25 times the width of the micro cavities. By controlling the formulation of the adhesive and the relative dimensions of the lands between the microcavities, the bonding strength of the nozzle plate can be adjusted so as to have a strong adhesion when the fore is perpendicular to the plane of the nozzle plate (this force is exerted mainly by the ink pressure in the channels reaching the nozzle plate) and a sufficiently weak adhesion when a peeling force is exerted to separate the nozzle plate from the body.

[0027] In piezo ink jet printers wherein ink channels - with walls that can exert piezo pressure on the ink in the channels - terminate in a common channel termination surface, it is very beneficial to have a nozzle plate that is releasably attached to the channel termination surface. This is however not to say that in ink jet printheads wherein in k ejection proceeds by, e.g., acoustic waves, bubble generation, thermal expansions, etc. it would not be beneficial to have easily replaceable nozzle plates, in fact in every ink jet printhead the possibility to replace only the nozzle plate and not the whole printhead is a desirable feature, especially in those ink jet printers - independently of the way of ink ejection - wherein the printhead has a wide array, even a page wide, array of nozzles it is interesting to have a releasably attached nozzle plate so that when one nozzle has a defect, it is not necessary to discard the entire (expensive) printhead, only by replacing the (relatively) inexpensive nozzle plate the printer can be brought to optimum performance again.

Parts list

[0028]

101.	Frame
101a	Springs
102	Nozzle plate or "mini nozzle plate"
102a	Nozzles or through holes
102b	Notch in the side of the nozzle plate
103	Body
104	Channel termination plane
104a	Channels
105	Lowered edges

Claims

1. A droplet deposition apparatus incorporating a nozzle plate(102) with nozzles for selectively ejecting liquid drops, **characterised in that** said nozzle plate is releasably attached to said apparatus.

2. A droplet deposition apparatus according to claim 1, wherein said apparatus further comprises a body with a plurality of channels (104a) terminating in a common channel termination surface (104) and a nozzle plate (102) with through holes placed on said body at said termination surface for providing droplet ejection nozzles (102a) for said channels and wherein said nozzle plate is releasably attached to said common channel termination surface.

3. A multichannel droplet deposition apparatus according to claim 2, wherein said nozzle plate is made of a polymeric sheet material and is attached to a frame (101), said frame being releasably attached to said body (103) so as to have said nozzle plate at said termination surface.

4. A multichannel droplet deposition apparatus according to claim 3, wherein said frame is releasably attached to said body by magnetic force.

5. A multichannel droplet deposition apparatus according to claim 3, wherein said frame is releasably attached to said body by clamps.

6. A multichannel droplet deposition apparatus according to any of claims 2 to 5, wherein said body further comprises registration marks for placing said nozzle plate in register with said channels in said termination plate.

7. A multichannel droplet deposition apparatus according to claim 2, wherein said nozzle plate comprises at least two mini nozzle plates (102) releasably fixed in a frame (101).

8. A multichannel droplet deposition apparatus according to claim 7, wherein said frame is an integral part of said body.

9. A multichannel droplet deposition apparatus according to claim 7, wherein said frame is releasably attached to said body.

10. A multichannel droplet deposition apparatus according to claim 2, wherein said nozzle plate is releasably attached to said channel termination surface by an adhesive layer, said adhesive layer being adapted so that, upon detaching said nozzle plate from said channel termination surface, there is an adhesive break between said adhesive layer and said surface and no cohesive break within said adhesive layer.

11. A multichannel droplet deposition apparatus according to any of the preceding claims, wherein said apparatus is a printhead structure for use in ink jet printing.

12. A multichannel droplet deposition apparatus according to any of claims 2 to 10, wherein said channels include means to eject ink at said channel termination surface by piezo pressure.

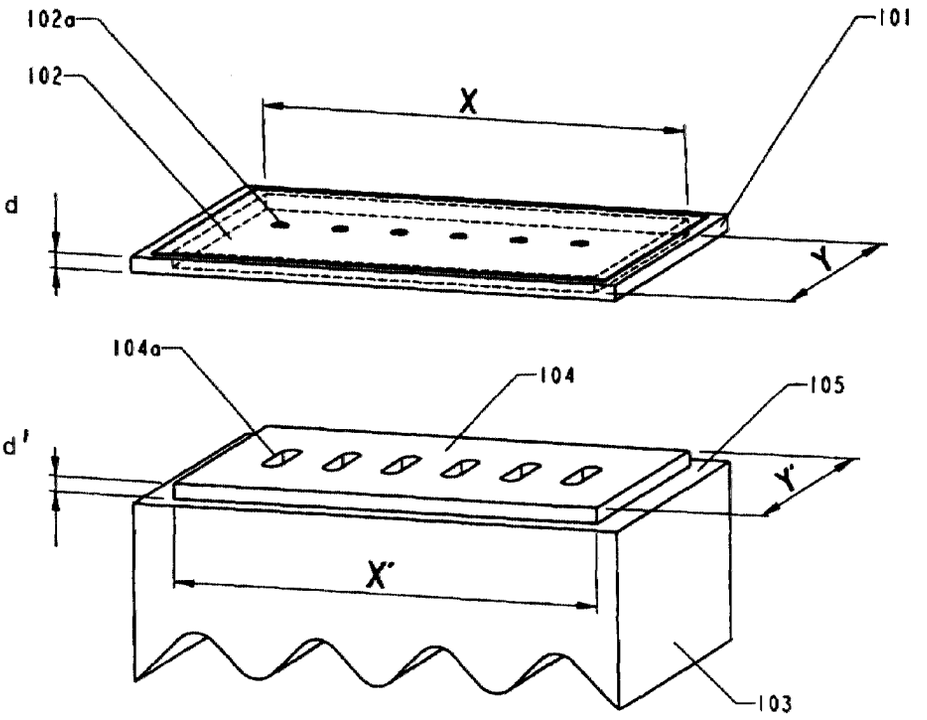

Fig. 1

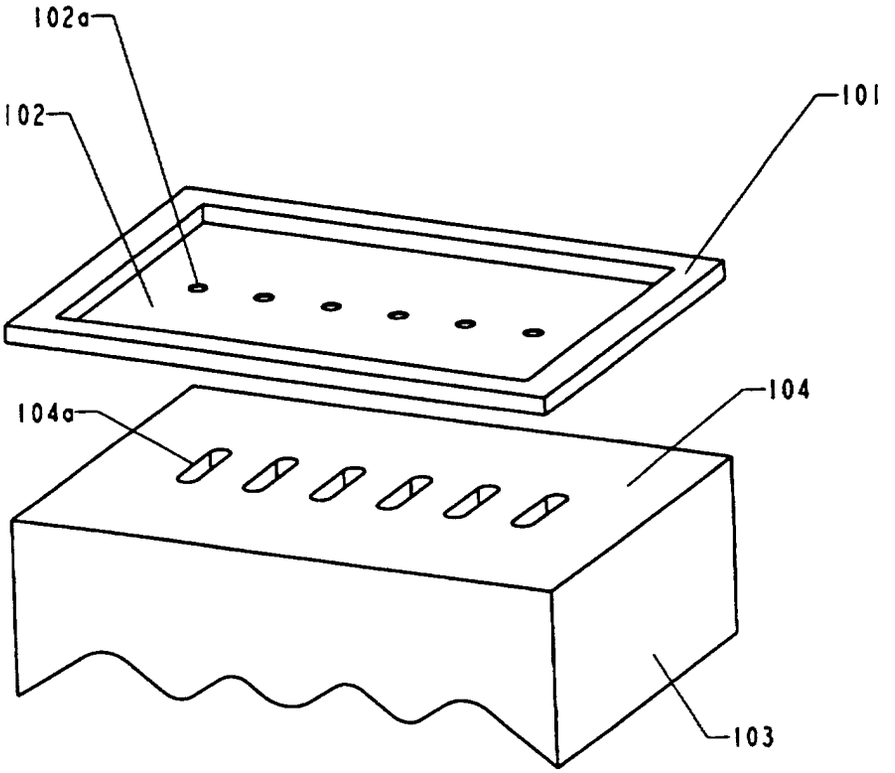

Fig. 2

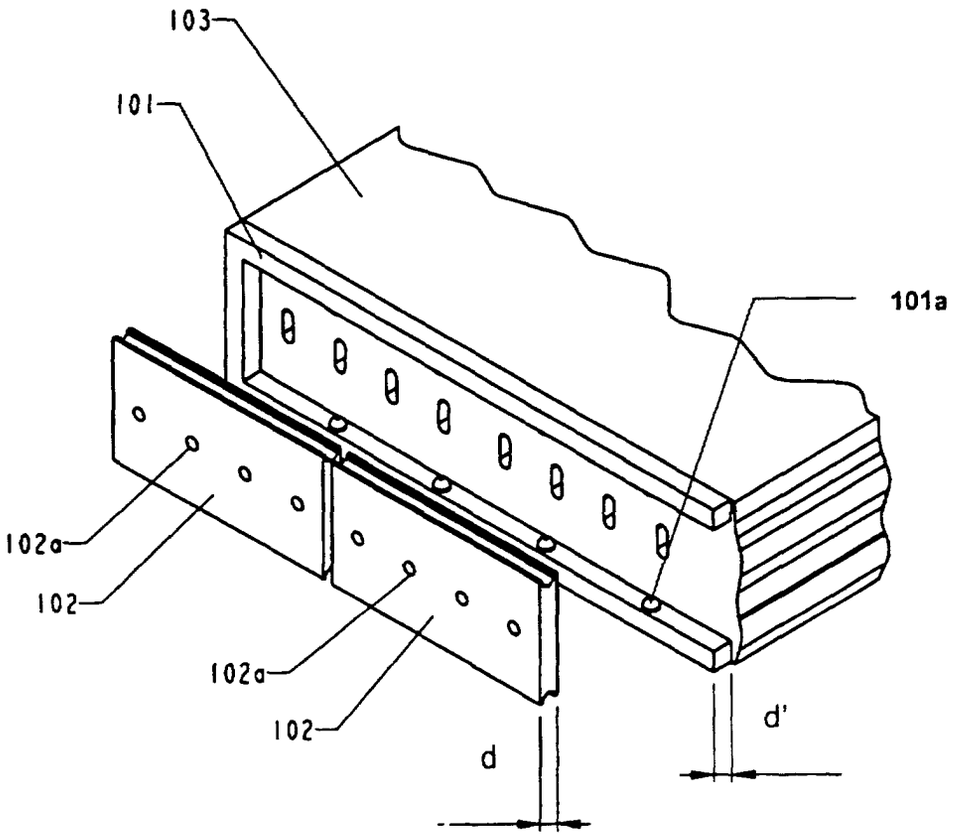

Fig. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 20 2739

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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Y	JP 11 198378 A (CANON INC) 27 July 1999 (1999-07-27) * figures * ---	4	
Y	EP 0 865 923 A (LEXMARK INT INC) 23 September 1998 (1998-09-23) * abstract; figures 6-10 * ---	6	
Y	WO 98 17477 A (XAAR TECH LTD ;ASHE JAMES (GB); LEE ANDREW (GB); SPEAKMAN STUART () 30 April 1998 (1998-04-30) * page 10, line 30 - page 11, line 3 * -----	10	TECHNICAL FIELDS SEARCHED (Int.Cl.7) B41J

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 March 2001	Bardet, M

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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& : member of the same patent family, corresponding document

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