Laminated ink jet head and printer apparatus.

A laminated type ink jet head for a printer is described which is given a multi-nozzle structure and a color nozzle structure by laminating a plurality of sets of nozzle plates (M) and lead plates alternately to form one block and by stacking a plurality of blocks vertically to form a building head structure. Each nozzle plate is formed on its one face (3) with ink passages (4), nozzles (5), ink chambers (6) and so on and is equipped on its other face with piezoelectric elements (7). On the other hand, each lead plate has its one face equipped with terminals for the piezoelectric elements (7) and its other face formed merely into a flat plane.
BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a head for an on-demand type ink jet printer and, more particularly, to a head of an ink jet printer making use of piezoelectric elements.

Description of the Prior Art

In the ink jet printer of the prior art, the heads of thermal type and piezoelectric type have been developed and have become marketable. Especially, the thermal ink jet printer has grown remarkable because of its advantages in its printing quality, cost, quietness and low power consumption. However, this type requires large-scaled facilities and vast investments for its development because it has to be finely worked but is troubled by its short lifetime due to the cracking of a thin film resistance caused by the heat shocks. Thus, the thermal type has found it difficult to be composed of a multiplicity of, e.g., several hundreds of nozzles. On the other hand, a head of the piezoelectric ink jet printer is exemplified in U.S.P. No. 4,216,483, as shown in Fig. 29. In Fig. 29, reference numeral 210 designates a ceramic or glass smooth substrate, which is recessed to have an ink supply chamber 211, a compression chamber 212, an ink injection nozzle 213 and an ink communication passage 214 by means of corrosion or the like. As shown in Fig. 30, moreover, there is adhered to the underlying smooth substrate 21 a corresponding upper plate 221, on which a piezoelectric element 222 is mounted to correspond to the compression chamber 212. With the structure thus made, the ink is supplied from the ink communication passage 214 through the ink supply chamber 211 to the compression chamber 212 and is injected from the ink injection nozzle 213 to a matter to be printed, as the compression chamber 212 has its capacity reduced by the motion of the piezoelectric element 222.

With this structure, the number of the compression chambers 112 having a wider area than that of the nozzles is increased with the nozzle number so that an intrinsic limit resides in the increase in the nozzle number. Thus, the nozzle number at present is several to several tens at most, and the piezoelectric ink jet printer is inferior in the printing speed and quality to the thermal ink jet printer or a laser printer so that its application to higher grade application including business applications is restricted. Moreover, the head of this structure can naturally find it impossible to accomplish the color printing.

SUMMARY OF THE INVENTION

It is, therefore, a major object of the present invention to provide a piezoelectric ink jet head which is enabled to have a multi-nozzle structure by solving the above-specified problems, which is superior in economy and performance to the head of the existing printer and which can accomplish a color printing operation.

Another object of the present invention is to provide a piezoelectric ink jet head for a printer, which head comprises a multiplicity of ink jet plates each including: a substrate having a multiplicity of nozzles, ink passages and ink chambers formed in its one face; a multiplicity of piezoelectric elements mounted on said substrate in positions corresponding to said ink chambers; and a multiplicity of lead terminals connected individually with said piezoelectric elements, said nozzles being arranged equidistantly and in the longitudinal direction of a nozzle face, wherein the improvement resides in that said ink jet plates are laminated such that said nozzles are offset at a printing pitch.

Thus, the ink introduced from the outside via the ink passages to the ink chambers is injected for the printing operation when the capacities of the ink chambers are abruptly reduced by the actions of the piezoelectric elements mounted in the positions corresponding to the ink chambers. Those piezoelectric elements are driven by the pulse signals which are inputted from the outside through lead terminals.

Still another object of the present invention is to provide a laminated type ink jet head for a printer, which comprises: a multiplicity of nozzle plates each including: a plurality of ink passages formed in one face of the substrate of each nozzle plate for providing communications between an ink reservoir and a plurality of nozzles; a plurality of ink chambers individually formed midway of said ink passages; and a plurality of piezoelectric elements mounted on the other face of said each nozzle plate and in positions corresponding to said ink chambers; and a multiplicity of lead plates each including: a plurality of grooves formed in one face of the substrate of each lead plate for housing said piezoelectric elements; a plurality of piezoelectric element terminals individually mounted in said grooves; and a plurality of lead-out terminals individually connected with said piezoelectric element terminals, the other face of said each lead plate being made smooth, wherein the improvement resides in that said nozzle plates and said lead plates are alternately laminated.

Thus, the multi-nozzle structure can be achieved by laminating the ink jet plates to form the head of one block. The line type head can be constructed by arranging a plurality of such blocks...
in a horizontal direction. Moreover, a serial type color ink jet head can be obtained by stacking a plurality of those blocks vertically and by changing the ink colors for the individual blocks. Still moreover, a line type color ink jet head can be obtained by arranging a plurality of vertically stacked blocks in a horizontal direction.

A further object of the present invention is to provide a piezoelectric ink jet head which comprises: a plurality of laminated nozzle plates each including: a thin substrate having a plurality of ink passages leading from an ink supply face to a nozzle face formed with a plurality of nozzles, and a plurality of piezoelectric elements mounted on said substrate in positions corresponding to said ink chambers; and two end plates laminated on the two end faces of the structure of said laminated nozzle plates such that their sealing faces are made liquid-tight.

As a result, the ink supplied from the ink supply face in the nozzle plate flows through the ink passages and reaches the ink chambers which are formed midway of the ink passages. The ink chambers have their capacities reduced by the actions of the piezoelectric elements mounted to correspond to the ink chambers, so that the ink in the ink chambers is injected from the nozzles in the nozzle face. Since the nozzle plates for such operations are made thin and flat, a plurality of nozzle plates can be laminated. Moreover, these laminated nozzle plates are made liquid-tight by laminating the end plates on the two end faces of the laminated nozzle plates and by molding the sealing faces integrally. As a result, the ink jet head can be given the multi-nozzle structure.

A further object of the present invention is to provide a printer apparatus which comprises: a head body made rotatable between a used position and an unused position and prepared: by laminating a plurality of nozzle plates each including a thin substrate having a plurality of ink passages leading from an ink supply face to a nozzle face formed with a plurality of nozzles, and a plurality of piezoelectric elements mounted on said substrate in positions corresponding to said ink chambers; by laminating two end plates on the two end faces of the structure of said laminated nozzle plates and by molding the sealing faces of said nozzle plates liquid-tight; capping means for sealing said nozzles when said head body is unused; and wiper means for wiping said nozzles in the course of said head body from the used position to the unused position.

Other objects, features and advantages of the present invention will be apparent from the detailed description which follows.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described in greater detail in the following with reference to the drawings, in which:

- Fig. 1 is a top plan view showing a nozzle plate constituting a head according to the present invention;
- Fig. 2 is a side elevation of Fig. 1;
- Fig. 3 is a top plan view showing the back of Fig. 1;
- Fig. 4 is an enlarged top plan view showing an ink passage, an ink chamber and a nozzle of Fig. 1;
- Fig. 5 is a side elevation of Fig. 4;
- Fig. 6 is a top plan view showing a lead plate constituting a head according to the present invention;
- Fig. 7 is a side elevation of Fig. 6;
- Fig. 8 is a top plan view showing the back of Fig. 6;
- Fig. 9 is a side elevation showing an ink jet head, which is constructed of one block formed by laminating nozzle plates and lead plates alternately, and taken from the nozzle face;
- Fig. 10 is a top plan view of Fig. 9;
- Fig. 11 is a schematic diagram showing a head of line type, which is formed by arraying the blocks of Fig. 9 horizontally;
- Fig. 12 is a schematic diagram showing a serial color head which is formed by stacking the blocks of Fig. 9 vertically;
- Fig. 13 is a schematic diagram showing a line color head which is constructed by arraying the heads of Fig. 12 horizontally;
- Fig. 14 is a schematic top plan view showing a building block type line printer;
- Fig. 15 is a side elevation showing one embodiment of the head according to the present invention;
- Fig. 16 is a section taken along line A - A of Fig. 15;
- Fig. 17 is a top plan view showing the surface of a nozzle plate constituting a head according to the present invention;
- Fig. 18 is a side elevation of Fig. 17;
- Fig. 19 is a top plan view showing the back of the nozzle plate of Fig. 17;
- Fig. 20 is a top plan view showing the surface of a nozzle plate making a pair with the nozzle plate of Fig. 17;
- Fig. 21 is a side elevation of Fig. 20;
- Fig. 22 is a top plan view showing the back of the nozzle plate of Fig. 20;
- Fig. 23 is a diagram for explaining a nozzle forming state;
- Fig. 24 is an enlarged top plan view showing an ink passage formed in a nozzle plate;
Fig. 25 is a side elevation showing the depth of the ink passage formed in Fig. 24; Fig. 26 is an enlarged side elevation showing a piezoelectric element of a nozzle plate; Fig. 27 is a section showing one embodiment of a printer having a head according to the present invention installed therein; Fig. 28 is a side elevation of Fig. 27; Fig. 29 is a top plan view showing a substrate of an on-demand type ink jet printer of the prior art; and Fig. 30 is a section taken along line B - B of Fig. 29.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described in the following in connection with the embodiments thereof with reference to the accompanying drawings. First of all, a first embodiment will be described with reference to Figs. 1 to 14. In Figs. 1 to 3, there is shown a nozzle plate M which is constructed, as follows. Reference numeral 1 designates a substrate which is formed of an extremely thin (e.g., 0.25 mm) sheet of plastics, glass, metal or the like. The substrate 1 is formed in its one face, as shown in Fig. 1, with an ink reservoir 2 which extends along one widthwise end portion. A plurality of ink passages 4 are formed generally in parallel to extend from the ink reservoir 2 to a nozzle face 3 forming the other widthwise end portion. Those ink passages 4 are individually formed with nozzles 5 at the exits of the nozzle face 3. Moreover, ink chambers 6 are individually formed midway of the ink passages 4. To the back of the nozzle plate M, as shown in Fig. 3, there are individually mounted piezoelectric elements 7 which are positioned to correspond to the ink chambers 6 in the surface.

Incidentally, the aforementioned ink passages 4 and so on are shown in more detail in Figs. 4 and 5. Each entrance from the ink reservoir 2 to the ink passage 4 is equipped with a baffle 8 for adjusting the flow of ink. The ink chamber 6 formed at the central portion of the ink passage 4 is set about two times as wide as the ink chamber 6 and about one half as deep as the nozzle plate M, as indicated by a broken line in Fig. 5. The nozzle 5 forming the exit of the ink passage 4 is restricted to a predetermined diameter. On the back of the ink chamber 6, moreover, there is mounted the piezoelectric element 7 across about one half of the thickness of the nozzle plate M.

In Figs. 6 to 8, there is shown a lead plate N which is constructed, as follows. Reference numeral 11 designates a substrate which is formed, like the substrate 1 of the nozzle plate M, of an extremely thin sheet of plastics, glass, metal or the like. As will be described hereinafter, the lead plates N and the nozzle plates M are laminated to form a head such that the nozzle face 3 of the latter M and one end face 12 of the former N extend in a flat plane. A plurality of separate ink reservoir holes 13 extending through the substrate 11 are formed in the portions corresponding to the ink reservoir 2 of the nozzle plate M.

Incidentally, when the lead plate N and the nozzle plate M are to be molded of plastics, they can be thermally contact-bonded with excellent results either directly or through a thin plastic sheet.

In the portion corresponding to the piezoelectric elements 7 mounted on the back of the nozzle plate M, on the other hand, there is formed a groove 14 which is deepened to house the piezoelectric elements 7. The groove 14 is extended from one end portion to the other of the substrate 11 of the lead plate N. The groove 14 is formed in its bottom with terminals 15 for the piezoelectric elements 15, which are respectively connected with lead-out terminals 16 for the piezoelectric elements 7, as located at the other end face of the substrate 11. This substrate 11 is formed on its back with nothing but merely into a flat face, which is laminated in contact on the surface of another nozzle plate, i.e., the face formed with the ink passages and so on, thus completing the ink reservoir, ink passages, ink chambers and nozzles of the nozzle plate.

Figs. 9 and 10 show an ink jet head which is constructed of one block X formed by laminating individual twelve sheets of the aforementioned nozzle plates M and lead plates N alternately. In case of an ink jet head constructed of one set of one sheet of nozzle plate M and one sheet of lead plate N, the sets are individually arranged and laminated one by one such that the individual nozzles 5 are sequentially offset pitch by pitch of the printing in the longitudinal direction of the two plates. Moreover, end plates 21 and 22 are respectively laminated on the uppermost and lower most faces of the block. Like the back of the lead plate N, the back of the end plate 21 laminated in contact on the surface of the nozzle plate M completes the ink reservoir, ink passages, ink chambers and nozzles of the uppermost nozzle plate M. Incidentally, numeral 23 designates an input support port for supplying the ink to the ink reservoir 2.

Next, the operations of the ink jet head thus constructed will be described in the following. The ink supplied from an external ink tank to the ink reservoir 2 flows through the ink passages 4 to fill up the ink chambers 6. On the back of the ink chambers 6, there are mounted the piezoelectric elements 7, which are fed with electric pulse signals from the outside through the piezoelectric ele-
ment lead-out terminals 16 and the piezoelectric terminals 15. As a result, the piezoelectric elements 7 are abruptly distorted so that the ink chambers 6 have their capacities abruptly changed to build up liquid pressures. Then, the ink in the ink chambers 6 is quickly injected in the form of liquid droplets from the opened nozzles of the nozzle face 3, thus effecting the printing operation. In case the ink jet plates composed of the nozzle plates M and the lead plates N for the actions described above are laminated, as shown in Figs. 9 and 10, a total nozzle number of 360 is obtained if the nozzle number of each plate is 30 and if the lamination is composed of twenty plates. If, moreover, the nozzle pitch of each nozzle plate is 1.5 mm and if the twelve sets of ink jet plates are joined with a longitudinal offset of 0.127 mm per each set, the block X obtained can have 200 DPI (Dots Per Inch). Thus, a high speed 200 DPI serial printer can be completed by carrying that block X at a right angle with respect to a paper feeding direction a.

As shown in Fig. 11, a line type printer having a size of A4 can be constructed by forming its head such that the aforementioned five blocks X are arranged in the longitudinal direction. In this case, the pitch of the nozzles at the joint portions between the blocks X is set at 1.5 mm like that of the nozzles of one sheet of nozzle plate. As a result, a nozzle pitch of 0.127 mm can be maintained in the five blocks X to provide a line type printer of 200 DPI. At the printing time, the printing operation is performed by feeding the paper in the direction b with the head being fixed.

If a head (of building block type) is constructed by stacking three blocks X, Y and Z in the vertical direction, as shown in Fig. 12, a serial color printer can be provided by feeding inks of three primaries individually to the blocks X, Y and Z. Another block may naturally be added to feed black ink. The color printer is constructed such that the ink feed and the drive voltage application to those blocks are wholly accomplished from the back of the nozzle face 3. Thus, the individual blocks can be arranged in close contact to one another. At the printing time, moreover, the head is reciprocally carried in a direction c, and the paper is fed in a direction d and in parallel with the nozzle face 3.

As shown in Fig. 13, moreover, another line color printer can be provided by arranging five heads each composed of the three blocks X, Y and Z of Fig. 12 in the longitudinal direction and by feeding the three primary inks to the blocks X, Y and Z individually. At the printing time, the paper is fed in parallel with the nozzle face 3 with the heads being fixed.

Fig. 14 is a schematic top plan diagram showing a line printer in which the building block type head shown in Fig. 11 is packaged. The piezoelectric element lead-out electrodes 16 of the lead plate N are classified into two groups and arranged on the back of the nozzle face 3 of the block X, and the ink supply ports 23 are formed between the groups. The lead-out terminals 16 are connected through connectors 24 and cables 25 to a printed board 26 for driving and controlling the piezoelectric elements. The ink supply ports 23 are connected through a lead pipe 27 to an ink tank 28 which is disposed at the outside. Reference numeral 29 designates a nozzle cap which is driven by a not-shown drive unit to seal the nozzle face 3 at the non-printing time.

With the structure thus described, at the printing time, the cap 29 is moved at first by the drive unit from the nozzle face 3 to a position in which it raises no trouble against the printing operation. The printing ink is fed at all times from the ink tank 28 through the lead pipe 27 so that it flows from the ink supply ports 23 via the ink passages of the nozzle plate to fill up the ink chambers, as has been described hereinbefore. The pulse signals issued from the control circuit of the printed board 26 are fed to the piezoelectric elements so that the piezoelectric elements are distorted to reduce the capacities of the ink chambers abruptly thereby to inject the ink in the ink chambers quickly in the form of droplets from the nozzles.

Although the embodiment has been described in the combination of the lead plate and the nozzle plate, the lead plate may be eliminated, and the wiring lines and terminals for the piezoelectric elements may be mounted directly on the nozzle plate.

Next, a second embodiment of the present invention will be described in the following with reference to Figs. 15 to 28. In this case, the description will be made by exemplifying a printer which applies the present invention to a line printing head.

Figs. 27 and 28 are schematic diagrams showing a printer on which a piezoelectric ink jet head according to the present invention is mounted. Reference numeral 101 designates an ink jet head body which is constructed mainly by laminating a multiplicity of nozzle plates, as will be described hereinafter. Numeral 102 designates body stands for supporting the body 101 rotatably partially in the directions a and b, and numeral 103 designates an ink case which is fed with ink from an ink box 104 disposed apart from the printer by way of a tube 105. Numeral 106 designates a paper bed for supporting a sheet of paper P to be printed, movably in a direction e, for example.

Numeral 107 designates a flexible printed board for leading out lead wires from the head body 101. Numeral 108 designates a wiper made of a rubber plate, which is made movable in the
direction c, after having rotated the head body 101 in the direction a, to wipe or clean the nozzle face of the head body 101. Numerical 109 designates a nozzle face cap which is made movable in the direction d, after having rotated the head body 101 in the direction b, to cap the nozzle face of the head body 101 so that it may prevent the ink on the nozzle face from drying and accordingly the quality at the printing time.

Fig. 15 is a side elevation showing the head body from the nozzle face. The head body 101 is constructed by laminating the nozzle plates M and N, as will be described in detail, alternately, by arranging end plates 111 and 112 at the two ends of the lamination, and by fixing them integrally and firmly by means of fixing bolts 113. In this case, neither any special adhering nor bonding means need to be used, but the joint faces may be held in contact and fixed from the outside, as described above. Numerical 114 designates four nozzles which are arranged at each of the nozzle plates M and N. Two nozzle plates M and N are grouped, in which eight nozzles are staggered in oblique rows.

In case each sheet of nozzle plate is equipped with four nozzles, as in the present embodiment, the total nozzle number is 3,456, if 864 sheets of nozzle plates each set to have a thickness of 1/100 inches are laminated. Then, a line head of 400 DPI (Dots Per Inch) can be constructed for the paper of A4 size.

Fig. 16 is a section taken along line A - A of Fig. 15. Reference numerals 115 and 115 designate ink supply faces which are supplied with the ink from the ink case 103; numerical 116 designates a nozzle face; and numerals 117 and 117' designate lead terminal portions from one face of the piezoelectric element, as will be described hereinafter. Numerical 118 designates a molding portion which molds liquid-tight a shield face 119 formed all over the surface excepting the ink supply faces 115 and 115, the nozzle face 116 and the lead terminal portions 117 and 117', thereby to prevent the ink from leaking to the outside.

In Figs. 17 to 19 showing one sheet of the nozzle plate M: Fig. 17 presents a surface side; Fig. 18 presents a side face showing the nozzle face; and Fig. 19 presents the back of the same. The nozzle plate M is formed of a thin sheet having a thickness of 1/100 inches, as described above, and a suitable material therefor is plastics such as the PPS (Poly Phenylene Sulfite) resin or the PBT (Poly Butylene Terephthalate) resin. The nozzle plate M is shaped by cutting a cube deeply at four corner portions 121, 122, 123 and 124 and by further cutting an intermediate portion 125 of the ink supply face 115 in a semicircular form. This shaping is performed for leaving the uncut portions as the ink supply faces 115 and 115, the nozzle face 116 and the lead terminal portions 117 and 117', as described above, for forming the molding portion 118 in the cut portions 121, 122, 123, 124 and 125, and for allowing three bolts for fixing the alternately laminated nozzle plates M and N to extend through the molding portion 118 at the cut portions 122, 123 and 125 (as shown in Fig. 16).

As shown in Fig. 17, the nozzle plate M is formed in its surface side with two ink passages 128 and 129 which lead generally in parallel from the ink supply face 115 located at the upper right-hand of the Drawing to the nozzle face 116 through ink chambers 128 and 127 formed at the center portion. As indicated by broken lines, the back side of the nozzle plate M is also formed with similar ink passages 130 and 131, and piezoelectric elements 134 and 135 shown in Fig. 17 are mounted on the back sides of ink chambers 132 and 133 which are formed midway of those ink passages 130 and 131, as shown in Fig. 19. Those piezoelectric elements 134 and 135 are individually connected with common electrodes 136 and 137. Sideways of the piezoelectric element 135, there is formed a recess 138 for housing the piezoelectric elements to be mounted on the back of the nozzle plate N, as will be described hereinafter. In this recess 138, there are mounted piezoelectric element lead terminals 145 which are lead to the lead terminal portions 117.

In Figs. 19 is a top plan view showing the back of the nozzle plate M. Numerals 141 and 142 designate piezoelectric elements which are located on the back sides of the ink chambers 126 and 127 (of Fig. 17) formed midway of the ink passages 128 and 129. Those piezoelectric elements 141 and 142 are individually connected with common electrodes 143 and 144. Numerical 139 designates a recess in which the piezoelectric element lead terminals 145 are mounted and led to the lead terminal portions 117.

In Figs. 20 to 22 showing the nozzle plate N: Fig. 20 presents a surface side of the nozzle plate N; Fig. 21 presents a side face showing the nozzle face; and Fig. 22 presents the back of the same. The nozzle plate N is given the same shape and structure as those of the nozzle plate M, but the surface of the plate M corresponds to the back of the plate N whereas the back of the plate M corresponds to the surface of the plate N. As a result, when the nozzle head 101 is to be formed by laminating the nozzle plates M and N alternately, as shown in Fig. 15, the surface of each plate M and the back of each plate N come into contact, and the back of the plate M and the surface of the plate N come into contact. Moreover, the individual lead terminal portions 117 and 117' of the plates M and N are staggered at opposite positions. As has been described hereinbefore, the
eight nozzles 114 for each set of the nozzle plates M and N, as opened in the nozzle face 116, are staggered in an oblique row.

Fig. 23 is an enlarged diagram showing essential portions of the nozzle face 16 of the nozzle plate M and nozzle plates N1 and N2 to be held in close contact with the two sides of the nozzle plate M. As described above, the nozzle plate M is arranged in its nozzle face 116 with four nozzles 114a, 114b, 114c and 114d which are arrayed in the oblique row. The nozzle 114a is formed by covering the groove, which is formed directly in the surface of the nozzle plate M, with the contacting nozzle plate N1. The nozzle 114b, as located at the lower lefthand of the nozzle 114a in the Drawing, is formed in the following manner. Specifically, the nozzle plate M is formed in its surface with a groove 151b having a larger diameter than that of the nozzle 114b, and the groove 151b is further formed with a groove in its bottom. On the other hand, a projection 152i sized and shaped to correspond to that groove 151b is formed on the nozzle plate N1. When this nozzle plate N1 is brought into contact with the nozzle plate M, that projection 152i is fitted in the groove 151b of the nozzle plate M to define the nozzle 114b.

Like before, the nozzle 114c, as located at the lower lefthand of the nozzle 114b in the Drawing, is formed by fitting a projection 152j, which is formed on the contacting nozzle plate N2, in a groove which is formed in the bottom of the groove 153c. Moreover, the nozzle 114d, which is located at the lower lefthand of the nozzle 114c and in the back of the nozzle plate M, is formed by covering a groove, which is formed directly in that back, with the contacting nozzle plate N2.

Fig. 24 is an enlarged diagram showing the ink passages 128 and 129 which are formed in the nozzle plate M, for example. As has been described hereinbefore, the ink passages 128 and 129 are formed to extend generally in parallel from the ink supply face 115 to the nozzle face 116 through the ink chambers 126 and 127 which are formed in the central portion. The entrances from the ink supply face 115 to the ink passages 128 and 129 are equipped with baffles 156 and 157 for adjusting the ink flows. The ink passages 128 and 129 are constricted at their exits to form the nozzles 114 having a predetermined diameter. The ink chambers 126 and 127 formed at the central portions of the ink passages 128 and 129 are made about two times as wide as that of the ink passages and about one half as thick as that of nozzle plate, as indicated by a broken line in Fig. 25. Moreover, the piezoelectric element 141 is mounted over the ink chamber 126 across about one half thickness of the nozzle plate M.
outside from the opened nozzles 114 of the nozzle face 116, thus accomplishing the printing operation.

A considerable number of nozzle plates for such operations can be laminated by thinning the nozzle plates, and the laminated nozzle plates can be made liquid-tight by laminating the end plates on the two end faces of the laminated nozzle plates and by molding the sealed faces. The total nozzle number is the product of the number of the nozzles in one nozzle plate and the number of the laminated nozzle plates. Let the case be assumed, in which each nozzle plate is equipped with four nozzles, for example, as in the present embodiment thus far described. If, in this case, 864 sheets of nozzle plates are laminated each having its thickness set to 1/100 inches, the total nozzle number is as large as 3,456 so that a line head having 400 DPI (Dots Per Inch) can be constructed for the A4 size paper.

The line head body thus given multiple nozzles has its width equalized substantially to the paper width so that the line is printed by fixing the nozzle face of the head body toward the paper surface and by feeding the paper in the longitudinal direction. In this case, the piezoelectric elements are driven at a time difference corresponding to the paper feeding rate and the inter-row distance of the nozzles to inject the ink from the nozzles which are staggered in the eight rows.

If, on the other hand, the nozzle plate is set to have a thickness of 1/100 inches and if 864 nozzle plates each having two nozzles are laminated, the total nozzle number is 1,728 so that a line head having 200 DPI can also be constructed for the A4 size paper.

Although the description thus far made is directed to the case in which the present invention is applied to the line heads, the present invention can also be applied to a serial head, as follows. Specifically, the direction of laminating of the nozzle plates is set to the paper feeding direction. If the dot density is set to 400 DPI, for example, and if seventeen nozzle plates having a thickness of 1/100 inches are laminated, the nozzle number is sixty eight, and the printing length is 4.2 mm. This body is scanned in the paper width direction to print a height of 4.2 mm. Then, the entire paper can be printed by feeding the paper sequentially at a step of 4.2 mm.

Next, the following description is directed to a printer protecting device according to the present embodiment, namely, a wiping device for cleaning the nozzle face of the head body and a capping device for sealing the nozzle face, when the printer is not used, to prevent the nozzle face from getting dry and the printing operation from being deteriorated. In Figs. 27 and 28, reference numeral 101a designates spindles connected to the two ends of the head body 101. These spindles 101a are borne midway on the body stands 102 through the not-shown bearings. On the leading end of one spindle 101a, there is fixed a gear 181 which meshes with a gear 183 connected to a motor 182 fixed on the body stand 102.

To the spindle 101a at the side of the head body 101, on the other hand, there are attained moving members 184 and 191 for moving both the wiper 108 for cleaning the nozzle face and the cap 109 for sealing the nozzle face toward the center of the head body 101. Numerals 185 and 192 designate stoppers for stopping the moving members 184 and 191 to change their positions relative to the head body 101. Moreover, numeral 193 designates a lead pipe which is connected to a not-shown vacuum pump or the like.

If the wiping device is to be operated with the construction thus far made, the motor 182 is driven forward to rotate the head body 101 in the direction of arrow a through the gears 183 and 181 and the spindles 101a so that the wiper 108 may have its edge sliding on the nozzle face of the head body 101 to clean the contamination of ink.

If the capping device is to be operated, the motor 182 is rotated backward to rotate the head body 101 likewise in the direction of arrow b so that the nozzle face of the head body 101 and the cap 109 are brought to face each other. Next, the moving member 191 is moved toward the center of the head body 101 to bring the nozzle face and the cap 109 into abutment against each other. During the non-use, the nozzle portion is sealed up with the cap 109. If necessary, moreover, the air in the cap 109 is sucked through the lead pipe 193 by the vacuum pump to feed the ink whereby to clean the insides of the nozzles. Incidentally, while the printer is being used, the operations may be reversed to those described above, to direct the nozzle face toward the paper.

Claims

1. A piezoelectric ink jet head for a printer, comprising a multiplicity of ink jet plates each including: a substrate having a multiplicity of nozzles, ink passages and ink chambers formed in its one face; a multiplicity of piezoelectric elements mounted on said substrate in positions corresponding to said ink chambers; and a multiplicity of lead terminals connected individually with said piezoelectric elements, said nozzles being arranged equidistantly and in the longitudinal direction of a nozzle face, wherein the improvement resides in that said ink jet plates are laminated such that said nozzles are offset at a printing pitch.
2. A laminated type ink jet head for a printer, comprising:
   a multiplicity of nozzle plates each including: a plurality of ink passages formed in one face of the substrate of each nozzle plate for providing communications between an ink reservoir and a plurality of nozzles; a plurality of ink chambers individually formed midway of said ink passages; and a plurality of piezoelectric elements mounted on the other face of said each nozzle plate and in positions corresponding to said ink chambers; and
   a multiplicity of lead plates each including: a plurality of grooves formed in one face of the substrate of each lead plate for housing said piezoelectric elements; a plurality of piezoelectric element terminals individually mounted in said grooves; and a plurality of lead-out terminals individually connected with said piezoelectric element terminals, the other face of said each lead plate being made smooth,
   wherein the improvement resides in that said nozzle plates and said lead plates are alternately laminated.

3. An ink jet head according to Claim 1 or 2, wherein said piezoelectric element lead terminals and an ink supply port are mounted on the back of the face in which said nozzles are opened.

4. An ink jet head according to any of the Claims 1 to 3, wherein said nozzle plates and said lead plates are molded of plastics and are thermally contact-bonded either directly or through plastic thin films.

5. An ink jet head according to any of the Claims 1 to 3, wherein a plurality of blocks each composed of the ink jet head, which is formed by laminating said ink jet plates or said nozzle plates and said lead plates alternately, are arranged in the longitudinal direction.

6. An ink jet head according to any of the Claims 1 to 4, wherein a plurality of blocks each composed of the ink jet head, which is formed by laminating said ink jet plates or said nozzle plates and said lead plates alternately, are stacked in the vertical direction.

7. An ink jet head according to any of the Claims 1 to 5, wherein a plurality of blocks each composed of the ink jet head, which is formed by laminating said ink jet plates or said nozzle plates and said lead plates alternately, are stacked in the vertical direction, and wherein a plurality of blocks each composed of said stacked blocks are arranged in a horizontal direction.

8. A piezoelectric ink jet head comprising:
   a plurality of laminated nozzle plates each including: a thin substrate having a plurality of ink passages leading from an ink supply face to a nozzle face formed with a plurality of nozzles, and a plurality of piezoelectric elements mounted on said substrate in positions corresponding to said ink chambers; and
   two end plates laminated on the two end faces of the structure of said laminated nozzle plates such that their sealing faces are made liquid-tight.

9. An ink jet head according to Claim 8, wherein the ink passages and the ink chambers formed in said substrate and the nozzles formed in said nozzle face are defined by both a groove formed in the substrate of one of said nozzle plates and a projection formed in the substrate of another nozzle plate to be laminated on the former nozzle plate or the surface of the latter substrate.

10. An ink jet head according to Claim 8 or 9, wherein the substrates of said nozzle plates are made of plastics.

11. An ink jet head according to Claim 8 or 9, wherein the nozzles formed in said nozzle face are arranged stepwise.

12. An ink jet head according to Claim 8, wherein said piezoelectric elements have their lead-out portions made of a thin metal film formed on the surface of each of said nozzle plates and an insulating film formed on said metal film.

13. A printer apparatus comprising:
   a head body made rotatable between a used position and an unused position and prepared: by laminating a plurality of nozzle plates each including a thin substrate having a plurality of ink passages leading from an ink supply face to a nozzle face formed with a plurality of nozzles, and a plurality of piezoelectric elements mounted on said substrate in positions corresponding to said ink chambers; by laminating two end plates on the two end faces of the structure of said laminated nozzle plates; and by molding the sealing faces of said nozzle plates liquid-tight;
   capping means for sealing said nozzles when said head body is unused; and
   wiper means for wiping said nozzles in the course of said head body from the used posi-
tion to the unused position.

14. A printer apparatus according to Claim 13, wherein said head body is fixed to have its nozzle face toward a paper holding bed thereby to establish a space in the portion of said paper holding bed corresponding to said nozzle face, and wherein said capping means and said wiper means pass through said space to seal and wipe said nozzles, respectively, when said head body is unused.

15. A printer apparatus according to Claim 13, further comprising conveyor means for moving said head body freely.
FIG. 12

Z
Y
X

c

d
3
FIG. 23

152
114c
114d
153c
1522
151b
114a
M
N1
N2
<table>
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<th>Category</th>
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<td>1, 2, 8, 13</td>
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**TECHNICAL FIELDS SEARCHED (Int. Cl.)**

B 41 J  
G 01 D

The present search report has been drawn up for all claims

**Search**

VIENNA

**Date of completion of the search**

22-09-1992

**Examiner**

MEISTERLE

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