

INK JET TYPE RECORDING HEAD

TECHNICAL FIELD

The present invention relates to an ink jet type recording head of an on-demand type for jetting ink droplets in response to a printing signal to form an ink image on a recording medium such as recording paper. More specifically, the present invention concerns an array of nozzles and a shape of an ink chamber for jetting a droplet of ink.

TECHNICAL BACKGROUND

Recently, there has been needs for ink jet type recording apparatuses capable of outputting an image recorded in high density. JP-A-60-147348 discloses such an ink jet type recording head capable of realizing higher recording density than the linear array density of the nozzles. In the ink jet type recording head described in this publication, the recording head having the linearly arranged nozzles along a single straight line is obliquely disposed with respect to the main scanning direction to increase the recording density. However, the structure of this recording head owns such problems that pitch fluctuation occurs in recording pixels, which is caused by dimensional errors or the like such as

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dimensional errors occurred when the recording head is mounted on the carriage. Accordingly, printing qualities are greatly influenced.

To the contrary, in accordance with the ink jet type recording head described in JP-A-4-312895, as shown in Fig. 12, the nozzles are arranged on a plurality of slanted straight lines in a zigzag form, and therefore, the printing quality could be improved irrelevant to accuracy in the mounting dimension.

To realize high density recording by the ink jet type recording head described in JP-A-4-312859, the pitches between the respective nozzles must be narrowed, namely the angle α should be made small. However, this angle setting is essentially restricted in order to prevent an occurrence of crosstalk or the like, which is caused by interference among the ink chambers at the bending portions of the slanted straight lines. Also, since this recording head is so constructed as to have a plurality of bending portions, permeance depths in ink are different from each other between the recorded image at the bending portion and the recorded image at the peripheral portion. Then, as illustrated in Fig. 13, a plurality of fluctuation will be produced in the entire recorded image.

As a consequence, it is an object of the present



invention to provide an ink jet type recording head capable of realizing high recording density and high printing quality, which is made highly integrated.

DISCLOSURE OF INVENTION

An ink jet type recording head according to the present invention is characterized in that nozzles for jetting ink droplets are arranged substantially along a V-shaped line which is opened toward the main scanning direction of the recording head.

Also, the ink jet type recording head according to the present invention is characterized in that the nozzles are arranged substantially along combination lines of inclined line segments which are opened toward the main scanning direction, and such nozzles arranged along at least one inclined line segment among the nozzles located along the inclined line segments which are mutually adjacent to each other, are shifted along the main scanning direction.

Further, the ink jet type recording head according to the present invention is characterized in that the nozzles are arranged substantially along combination lines of inclined line segments which are opened toward the main scanning direction, and a part of the nozzles arranged along the inclined line segments are shifted along the main scanning



direction.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is an explanatory diagram with respect to a nozzle arrangement and an ink chamber arrangement of an ink jet type recording head according to the present invention.

Fig. 2 schematically shows a printing condition of a first embodiment of the present invention.

Fig. 3 is an enlarged diagram for representing a portion of nozzles according to the first embodiment of the present invention.

Fig. 4 is a graph showing positional shifts in pixels according to the first embodiment of the present invention.

Fig. 5 is a perspective view for explaining a mounting condition of the ink jet type recording head according to the present invention.

Fig. 6 is a perspective view showing a transporting mechanism of the ink jet type recording head according to the present invention.

Fig. 7 schematically shows a printing pattern of the first embodiment of the present invention.

Fig. 8 schematically shows an ink jet type recording head according to another embodiment of the present invention.

Fig. 9 schematically represents an ink jet type recording



head according to another embodiment of the present invention.

Fig. 10 schematically shows an ink jet type recording head according to a further embodiment of the present invention.

Fig. 11 is an explanatory diagram of the ink jet type recording head according to the present invention.

Fig. 12 is an explanatory diagram for explaining the conventional nozzle arrangement and the conventional ink chamber arrangement.

Fig. 13 is an explanatory diagram for indicating the conventional printing condition.

BEST MODE TO CARRY OUT INVENTION

The present invention will now be described more in detail with reference to the accompanying drawings.

Fig. 1 is an explanatory diagram of a nozzle arrangement and an ink chamber arrangement of an ink jet type recording head according to an embodiment of the present invention. In Fig. 1, the recording head according to this embodiment is provided with nozzles 190 to 197 for jetting a droplet of ink, and ink chambers 170 to 177 communicated with these nozzles. Although partially omitted from this figure, the recording head is equipped with each ink chamber communicated with 32

nozzles along one line, i.e., 64 nozzles in total. In this figure, the nozzles are arranged at a constant interval in such a manner that these nozzles are positioned along line segments L1 and L2 corresponding to such straight lines inclined to opposite directions with respect to the X direction, namely the main scanning direction (moving direction of the recording head mounted on a carriage). This line segment is inclined at an angle of α in such a manner that the pitch P1 of each nozzle along the sub-scanning direction becomes 1/360 inches, and the line segment L1 and the line segment L2 constitute a substantially V shape.

The ink chambers are arranged outside the V-shaped area formed by the line segments L1 and L2. A width "d4" of the respective ink chambers is made so wide as to be able to obtain a sufficient ink jetting amount, i.e., 450 micrometers, and a depth thereof is made so deep as to be able to secure ^{sufficient} an _{ink flow} ink flowability, i.e., 150 micrometers.

As a pressure applying means for applying pressure to the ink chambers constructed in the above-described manner, such a pressure applying means may be employed in which a piezoelectric element is laminated to a vibrating plate that constitutes the wall of the ink chamber, or a piezoelectric element is printed on a vibrating plate and the resultant object is sintered.



The dimensions of the overall nozzle according to this embodiment were $w=d_1 \times 24=13.55\text{mm}$, and $h=p_1 \times 47=3.32\text{mm}$.

In accordance with the recording head of the present invention, since the arrangement of the nozzles is formed in a V shape, the following problems of the conventional recording head as described in JP-A-4-312859 could be solved. That is, in the prior art recording head, dark/light ink fluctuation occurs in plural places. To the contrary, in accordance with the recording head of the present invention, as shown in Fig. 2, such a place where printing density becomes high is suppressed only to the area near the nozzle 192 at the central portion, and printing density around the edge nozzle 190 can be made uniform, so that the printing density fluctuation could be suppressed to the minimum place, i.e., one place over the entire printing width "b". Accordingly, even when a bit image such as a graphic is recorded by using the recording head of this embodiment, it is possible to print out a high quality image without deteriorating texture.

In this embodiment, it was so arranged as shown in Fig. 1 that among the nozzles along the mutually adjacent inclined line segments L1 and L2, the nozzles along the inclined line segment L2 (namely, nozzles 191, 195, 196, 197 in this drawing) were positionally shifted with respect to the position of the nozzle 192 along the main scanning direction



(namely, X direction as shown in this drawing) by a shift amount of $d2=d1 \times 2.5=P1 \times 20$, and furthermore, a distance "P2" between the nozzle 192 and the nozzle 191 along the sub-scanning direction, located at the edge portions of the line segment L1 and the line segment L2, was made equal to P1, i.e., the same pitch. Another pitch between the nozzle 194 and the nozzle 191 was selected to be $P1 \times 3$. In Fig. 3, there is shown a partial enlarged diagram of such a bending portion that these nozzles were positionally shifted. As illustrated in the drawing, in accordance with this embodiment, the nozzle array along the line segment L2 is positionally shifted from the nozzle array along the line segment L1 by an amount of 2.5 times as large as one nozzle pitch along the "-X" direction. Further, the nozzle 191 along the line segment L2 is arranged at a position of $d1/2$ between the nozzle 193 and the nozzle 194 along the line segment L1. Since, as described above, these nozzles are positionally shifted by the shift amount of $d2=d1 \times 2.5=P1 \times 20$, the minimum distance between the nozzles 191 and 194 which are mutually positioned at the nearest place from each other can be made long, while maintaining sufficiently high printing density. Also, a sufficient rigidity of the wall between the ink chamber 171 and the ink chamber 174 can be achieved. As a consequence, it is possible to eliminate adverse influence given to ink jetting such as



crosstalk.

Since the shift amount "d2" is set to be an integer times as large as the printing pitch P1 such as $d2=d1 \times 2.5 = P1 \times 20$, the printing timing of the nozzles (namely, nozzles 191, 195, 196, 197 shown in drawing) shifted along the main scanning direction can be correctly obtained by counting the reference timing (interval of reference timing corresponds to pitch p1 in this embodiment) along the main scanning direction by an integer (for instance, nozzle 191 is shifted from nozzle 192 by 20 reference timings). The reference timing along the main scanning direction may be directly obtained from either outputs of linear encoders arranged along the same direction, or pulse numbers of a stepping motor for driving the recording head. In accordance with this embodiment, with such a construction, the pixels could be formed accurately also from the nozzle groups which were shifted along the main scanning direction without additionally employing a specific timing generating mechanism, whereby higher printing qualities could be achieved.

Moreover, in accordance with this embodiment, the shape of the ink chamber positioned near the nozzle is made not by a curved surface with a simple R, but by a curved surface having a smaller R at the portion nearer to the nozzle, so that the distance between the nozzles located adjacent to each other



may be widened. Thus, there are such excellent merits that interference such as crosstalk can be more firmly avoided, and the better bubble exhausting characteristic can be achieved since R of the curved surface near the nozzle is stepwise made small.

In this embodiment, the minimum distance ($d_5=352.8$ micrometers) is longer than a total value ($d_6=r_1+r_2=200$ micrometers) of a distance ($r_1=100$ micrometers) between the center of the nozzle 191 and an outer periphery of the ink chamber 171, and also a distance ($r_1=100$ micrometers) between the center of the nozzle 194 and an outer periphery of the ink chamber 174, and then r_3 can be made wide, i.e., longer than 100 micrometers, and so rigidity of the wall between the ink chambers can be maintained very high.

In accordance with the recording head of the present invention, there is substantially no risk that printing qualities are deteriorated which are caused by the mounting errors and the like. This reason will now be described in detail.

Since the printing pitch P_1 is selected to be $1/360$ inches ($=70.6$ micrometers) in this embodiment, the diameter of a single pixel on the recording medium 1 is preferably on the order of 100 to 120 micrometers, taking account of such a fact that the recording medium can be completely covered. As to



such a pixel dimension, the positional shifts of 20 to 30 micrometers in the pixels could be visually recognized, resulting in deterioration of printing qualities. In accordance with this embodiment, the positional shift of the nozzle 195 by the angle θ is expressed as $\Delta x = h \times \pi \times \theta / 180$ along the X direction and $\Delta y = d3 \times \pi \times \theta / 180$ ($h = P1 \times 47 = 3.32\text{mm}$, $d3 = d1 \times 2.5 = 1.41\text{mm}$). The actual positional shift with respect to the angle θ is represented in Fig. 4. Generally speaking, the angle θ is on the order of 0.1 degree involving play of various components and part precision or the like, and the positional shifts are small such as $\Delta x = 6$ micrometers and $\Delta y = 2.5$ micrometers. Thus, it is possible to apply this angle while maintaining sufficient printing qualities.

The recording head of the present invention can be readily mounted on such an ink jet type recording apparatus capable of easily replacing the recording head by the user without paying any care to mounting accuracy to the carriage, because of the above-described reasons.

The recording head may be easily mounted even if such a recording apparatus is a recording apparatus arranged by such a simple supporting mechanism with an arm 360 and a pin 361 as shown in Fig. 5. In this recording apparatus, the recording head 9 is relatively transported along the main scanning direction (x-direction in this figure) relative to the



recording medium while droplets of ink 50 are jetted from the nozzle 190 and so on, thereby forming pixels on the recording medium 1. After the above-described pixel formation along the main scanning direction has been accomplished, the recording medium 1 is transported along the sub-scanning direction (y-direction in this figure) perpendicular to the main scanning direction. Subsequently, the recording operation is continued by performing such a process that pixels are formed on an empty portion of the recording medium 1 along the main scanning direction (x-direction in this figure). This transportation of the recording head is performed by driving a belt 6 via a pulley 5 by a stepping motor 10, as illustrated in Fig. 6. Even when errors are produced in a feeding amount along the main scanning direction due to eccentricity of the pulley 5, or vibrations or expansion and contraction of the belt 6 caused by external environments, smoothing and continuous patterns are printed out as shown in Fig. 7 by employing the recording head of this embodiment. Therefore, the printing using the recording head of this embodiment is advantageous in that there is substantially no visual observation of disturbance in the vertical lines or the like, thereby providing high quality printing.

Fig. 8 shows another embodiment of the present invention. This embodiment is characterized in that a part of the nozzles

(a nozzle 192 in this figure) positioned along the inclined line L1 is positionally shifted along the main scanning direction (x-direction in this figure). In this manner, the nozzle 192 is greatly shifted by an amount ($d7=d1 \times 3$), as compared with the nozzle 191 which will subsequently jet ink. Thus, a droplet of ink is jetted from the nozzle 192 at the earlier stage onto the recording medium and then is dried, thereby forming pixels at the earlier stage. Accordingly, even when the ink droplets jetted from the next nozzle 191 are overlapped on the image formed by the ink droplets jetted from the nozzle 192, since the image formed by the nozzle 192 has been dried, it could be prevented that the ink droplets are partially collected, whereby fluctuation of ink density at the central printed portion could be furthermore suppressed. While only the nozzle 192 is positionally shifted in this embodiment, the effect as to the ink density fluctuation may be further improved when a plurality of nozzles are positionally shifted.

Fig. 9 shows a further embodiment of the present invention. In this embodiment, the nozzles are so arranged that they are positioned along a plurality of line segments L1, L2, L3 and L4. As an example, different colors are allocated to the respective line segments in such a manner that a black color is allocated to the line segment L1, a cyan



color is allocated to the line segment L2, a magenta color is allocated to the line segment L3, and a yellow color is allocated to the line segment L4. The line segments L1 and L4 are separated from the line segments L2 and L3 along the main scanning direction (x-direction), respectively, so that a distance between the nozzles 190 and 191 is made large, and another distance between the nozzles 192 and 193 is made large. Accordingly, it is prevented that other different colors would flow into the nozzles 190, 191, 192, 193 to produce color mixture and muddy colors.

Fig. 10 shows a further embodiment of the present invention. This recording head is formed in a lozenge shape by combining two sets of V-shaped nozzle arrangements. In accordance with this nozzle arrangement, after the thinning printing operation has been carried out by one set of the V-shaped nozzle arrangement along the main scanning direction during the recording operation, the printing operation by the other set of the V-shaped nozzle arrangement is carried out in order to fill the pixel between the printed pixels by the thinning manner. As a consequence, it is possible to solve problems such as ink blurring.

As a structure of an ink jet type recording head in order to realize the above-explained ink jet type recording head according to the present invention, as shown in Fig. 11, a



stacked type ink jet type recording head is preferably utilized. In accordance with this recording head, stacked flow path ports in a flow path from an ink chamber 17 to a nozzle 2 may be gradually shifted with ease. As a result, since the position of the nozzle 2 may be shifted outside the ink chamber rather than the edge portion of the ink chamber 17, the location of the ink chamber can be lowered as compared with that of the nozzle. When such a structure is employed in the nozzle arrangement having such a bending portion as explained in the embodiment of the present invention, the distances between the adjacent ink chambers can be made sufficiently long. Thus, crosstalk can be sufficiently prevented, and also the distances between the nozzles can be shortened. It is therefore possible to arrange the nozzles at high density. In Fig. 11, it is so constructed that the ink is supplied from a common ink chamber 11 to the ink chamber 17, and then is jetted from the nozzle 2 via the flow path by pressuring vibrating plates 19 stacked on the ink chamber 17 by way of a piezoelectric element 20.

As described above, in accordance with the present invention, it is possible to provide a highly integrated ink jet type recording head capable of printing out an image at high recording density, and of suppressing printing fluctuation, while printing qualities are not adversely



influenced by mounting errors.

UTILIZATION IN INDUSTRY

As described above, the ink jet type recording head of the present invention is suitable to be utilized in such recording apparatuses as a printer, a facsimile, and a copying machine.

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CLAIMS

1. An ink jet type recording head having a plurality of nozzles for jetting ink droplets, wherein

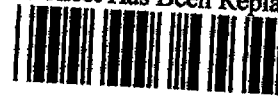
said plurality of nozzles are arranged in such a manner that the nozzles are positioned on straight lines at an interval, which are inclined mutually to opposite directions with respect to a main scanning direction corresponding to a transport direction of the recording head, and nozzle arrays are formed in a substantially V-shape.

2. An ink jet type recording head as claimed in claim 1 wherein at least one nozzle array positioned on the inclined straight line is positionally shifted along the main scanning direction with respect to the other nozzle array.

3. An ink jet type recording head as claimed in claim 2 wherein a shift amount along the main scanning direction is set in such a manner that each of the nozzles of said the other nozzle array is arranged between the nozzles of said one nozzle array.

4. An ink jet type recording head as claimed in claim 2 or 3 wherein said shift amount along the main scanning direction is 2.5 times as large as or equal to an interval between the





nozzles.

5. An ink jet type recording head as claimed in claims 1 to 4 wherein the nozzle is provided at a position separated by a space from an edge portion of said nozzle array on the inclined straight line on a bending portion side thereof.

6. An ink jet type recording head as claimed in claims 1 to 5 wherein an ink chamber communicated with said nozzle is fabricated by such a multisteppped curved surface near said nozzle that a diameter of the curved surface is made smaller near said nozzle.

7. An ink jet type recording head as claimed in claims 1 to 6 wherein said nozzle arrays are arranged in a lozenge shape.

8. An ink jet type recording head as claimed in claims 1 to 7 wherein said ink jet type recording head is of a stacked type that the positions between the ink chambers and the nozzles are variable.

