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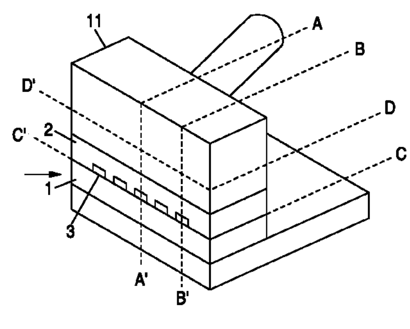
(54) Ink jet print head, ink jet printer and method for maintaining ink jet print head

(57) In an ink supply member including an ink supply passage for supplying ink to a common reservoir , a plurality of gas hold portions are formed to be respectively in communication with only the common reservoir and are capable of holding gas therein. Pressure caused by air bubbles generated in heat elements not only causes ink to be jetted out from nozzles but also is transmitted to the common reservoir, so that the internal pressure of the common reservoir is caused to vary. Also, when ink is refilled, the internal pressure of the common reservoir is caused to vary reversely. These pressure variations are absorbed by the expansion/compression of gas held within the gas hold portions, thereby being able to restrict the pressure variations within the common reservoir as well as prevent generation of undesirable phenomena such as unprinted areas, density variations, and the like.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an ink jet print head which jets out ink from an ink jet port to thereby form an image on a recording medium, an on-demand type of ink jet printer including such ink jet print head, and a maintenance method for maintaining such ink jet print head.

2. Description of the Related Art

Conventionally, as a typical ink jet printer, there are known an ink jet printer using an ink jet print head of a piezoelectric type that a pressure chamber is mechanically deformed by means of piezoelectric material and the resultant pressure is used to jet out ink from its ink jet port, and an ink jet printer using a thermal ink jet print head structured such that a heater disposed in an ink flow passage is electrically energized to vaporize ink and the pressure of the vaporized ink is used to jet out ink from its ink jet port.

The ink jet printers has been developed to increase the number of nozzles which are used to jet out ink in order to improve the quality of a printed image and increase the printing speed thereof. However, if the number of nozzles is increased, then there is increased the pressure that is transmitted from a pressure generation source to a common ink chamber with which a plurality of nozzles are in communication in common. Such increased pressure causes an unstable ink jetting condition, or impedes the ink supply to thereby make it impossible to jet out ink.

Now, Fig. 19 is a graphical representation which shows an example of pressure variations in a common ink chamber used in a conventional ink jet printer. For example, if printing a pattern having a high coverage is started, then pressure for jetting out ink is generated in all of the nozzles. The pressures generated in the respective nozzles are all transmitted to the common ink chamber and, therefore, as a whole, a large pressure is temporarily applied from the nozzles to the common ink chamber. After then, in order to carry out next printing, ink is supplied from the common ink chamber to the nozzles. In such ink supply, due to the flow of the ink, pressure is applied from the common ink chamber to the nozzles. In this manner, the pressure within the common ink chamber, as shown in Fig. 19, is caused to vibrate or vary due to the inertia of the ink. Such pressure variations reach as much as 400 mmH_2O (400x9.8Pa) under the worst condition. These pressure variations cause not only the pressure within the nozzles at the respective printing timings but also the amount of ink supplied to vary, which in turn causes the ink jetting condition to become unstable.

Figs. 20A and 20B are explanatory views of a printed state of the conventional ink jet printer obtained when the image quality thereof is poor. If printing is carried out in such an unstable jetting condition as mentioned above, for example, when a large pressure is applied in a direction to go from the common ink chamber to the nozzles, as shown in Fig. 20A, not only dots are printed by normal ink droplets, but also there occurs a phenomenon that small ink droplets are jetted at a timing different from the normal print timing to thereby increase the density of the printed dots partially. Especially, just as the negative pressure within the common ink chamber reaches its peak, a shortage of ink supply occurs and, for this reason, no ink can be jetted out from the nozzles, with the result that there is produced such an unprinted (missing) portion as shown in Fig. 20B.

In order to solve such problem, for example, in Unexamined Japanese Patent Publication (kokai) No. Sho. 63-128947, there is disclosed a structure in which a damper chamber having an air layer is formed in an ink supply passage. That is, when the pressure is transmitted to the common ink chamber, the pressure advances to the damper chamber and is then relieved by the air layer of the damper chamber. This can reduce variations in the pressure of the interior of the common ink chamber to thereby stabilize the ink jetting condition. However, in this structure, since the opening of the damper chamber is so formed as to face a position where the ink flows violently, the flow of the ink is easy to be produced within the damper chamber, which causes the air within the damper chamber to flow out gradually into the common ink chamber. Consequently, the function of the damper chamber is lowered.

Also, for example, in Unexamined Japanese Patent Publication (kokai) No. Hei. 6-344558, in the rear of a common ink chamber, there is provided an air chamber which is in communication with the common ink chamber. In the structure disclosed in this publication, because the communicating portion between the common ink chamber and air chamber is narrow and the air chamber is wide, it is possible to prevent the outflow of the air from the air chamber due to the inflow of the ink to the air chamber. This in turn makes it possible to keep up a pressure relieving function. However, in this structure, since the air chamber is provided in a second substrate in which the common ink chamber is formed, a print head is increased in size by an amount corresponding thereto.

Further, Unexamined Japanese Patent Publication (kokai) No. Hei. 1-308644 discloses that a pressure-volume converter is provided within an ink chamber. In this structure, since no air is used, there can be obtained a stable pressure relieving function. However, use of a new part, that is, the pressure-volume converter, increases not only the number of steps to produce it but also the cost thereof.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an ink jet printer and an ink jet print head which can jet out ink always stably without increasing the size of the print head or using a new part or the like, and also provide, in such ink jet print head, a maintenance method for maintaining the ink jet print head in such a manner that ink can be always jetted out stably.

In the present invention, an ink jet print head for jetting out ink from a plurality of nozzles to thereby form an image, is comprised of: a plurality of energy generator for causing the ink to be jetted out from the nozzles; a plurality of ink flow passages respectively which is disposed to individually correspond to the energy generator for supplying ink to the energy generator; an ink jet head including an ink reservoir with which the plurality of ink flow passages communicate in common; and an ink supply member including an ink supply passage for supplying ink to the ink reservoir of the ink jet head, the ink supply member further including a plurality of gas hold portions which are respectively in communication with only the ink reservoir and are respectively capable of holding gas therein.

According to the present invention, due to the compression/expansion of gas to be held within a plurality of gas hold portions, pressure transmission within an ink tank and a common reservoir due to the flow of ink in printing can be controlled, so that ink can be always jetted out stably, and thus high image quality can be realized without producing unprinted area or density variations. Also, since the gas hold portions are respectively in communication with the portions of the common reservoir where ink flows only a little, there is eliminated the possibility that the gas within the gas hold portions can be made to flow out therefrom due to the flow of the ink, which can always realize a stable pressure adjust function. Further, because the gas hold portions are formed in the ink supply member, no new parts are necessary and the ink jet print head can be manufactured with no special process, while the size of the print head remains unchanged.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Fig. 1 is a perspective view of an embodiment of an ink jet print head according to the invention;
Fig. 2 is a section view of the embodiment of an ink jet print head according to the invention, taken along the line A-A' shown in Fig. 1;
Fig. 3 is a section view of the embodiment of an ink jet print head according to the invention, taken along the line B-B' shown in Fig. 1;
Fig. 4 is a section view of the embodiment of an ink jet print head according to the invention, taken along the line D-D' shown in Fig. 1;
Fig. 5 is a section view of the embodiment of an ink jet print head according to the invention, taken along the line C-C' shown in Fig. 1;
Fig. 6 is a graphical representation of an example of pressure variations generated in a common reservoir employed in the embodiment of an ink jet print head according to the invention;
Fig. 7 is a section view of a first modification of the embodiment of an ink jet print head according to the invention, taken along the line B-B' shown in Fig. 1;
Fig. 8 is a section view of the first modification of the embodiment of an ink jet print head according to the invention, taken along the line D-D' shown in Fig. 1;
Fig. 9 is a section view of a second modification of the embodiment of an ink jet print head according to the invention, taken along the line B-B' shown in Fig. 1;
Fig. 10 is a section view of the second modification of the embodiment of an ink jet print head according to the invention, taken along the line D-D' shown in Fig. 1;
Fig. 11 is a section view of a third modification of the embodiment of an ink jet print head according to the invention, taken along the line B-B' shown in Fig. 1;
Fig. 12 is a section view of the third modification of the embodiment of an ink jet print head according to the invention, taken along the line D-D' shown in Fig. 1;
Fig. 13 is a section view of a fourth modification of the embodiment of an ink jet print head according to the invention, taken along the line B-B' shown in Fig. 1;
Fig. 14 is a section view of the fourth modification of the embodiment of an ink jet print head according to the invention, taken along the line D-D' shown in Fig. 1;
Fig. 15 is an explanatory view of a concrete experiment conducted in connection with the embodiment of an ink jet print head according to the invention;
Fig. 16 is an explanatory view of the position and shape of gas hold portions formed in an ink jet print head, that is, head No. 1 used in the experiment;
Fig. 17 is an explanatory view of the position and shape of gas hold portions formed in an ink jet print head, that is, head No. 2 used in the experiment.
Fig. 18 is an explanatory view of the position and shape of gas hold portions formed in an ink jet print head, that is, head No. 3 used in the experiment;
Fig. 19 is a graphical representation of an example of pressure variations generated in a common reservoir in a conventional ink jet printer; and,
Figs. 20A and 20B are explanatory views of a printed condition of poor image quality in the conventional in the conventional ink jet printer.

PREFERRED EMBODIMENTS OF THE INVENTION

Preferred embodiments of the present invention will be described as follows referring to the accompanying drawings.

Now, in Figs. 1 to 5, there is shown an embodiment of an ink jet print head according to the invention. In particular, Fig. 1 is a perspective view, Fig. 2 is a section view taken along the line A-A', Fig. 3 is a section view taken along the line B-B', Fig. 4 is a section view taken along the line D-D', and Fig. 5 is a section view taken along the line C-C'. In the drawings, reference numeral 1 designates a heater substrate; 2, a channel substrate; 3, a nozzle; 4, a heating element; 5, an ink flow passage; 6, a common reservoir; 7, recessed portions; 11, an ink supply member; 12, an ink supply passage; and 13, a gas hold portion.

The channel substrate 2 includes a plurality of ink flow passages 5 which are respectively so formed as to correspond to a plurality of nozzles 3, and further includes the common reservoir 6 which is so provided as to communicate in common with the ink flow passages 5. The common reservoir 6 is formed to extend through the channel plate 2. In the present embodiment, a single common reservoir 6 is formed to communicate in common with all of the ink flow passages 5. However, this is not limitative but, instead of a single common reservoir 6, a plurality of common reservoirs may also be formed.

On the other hand, in the heater substrate 1, a plurality of heating elements 4 are provided to respectively correspond to the ink flow passages 5, and as shown in Figs. 2 and 3, a plurality of recessed portions 7 are formed to respectively extend from the upper portions of the heating elements 4 to communicate the ink flow passages 5 with common reservoir 6. Each of the recessed portions 7, as shown in Fig. 5, is formed narrow in part and the wall surface of the recessed portion 7 on the common reservoir 6 side thereof is formed in an arc shape. Such shape of the recessed portion 7 makes it difficult to transmit the pressure generated on the heating element 4 to the common reservoir 6.

When the heater substrate 1 and channel substrate 2 are bonded to each other, a flow passage for ink extending from the common reservoir 6 through the recessed portions 7 to the ink flow passages 5 is formed. Actually, the heater substrate 1 and channel substrate 2 are respectively provided in large number on a wafer and are bonded to each other and, thereafter, they are separated by dicing or the like. While they are bonded, the end portions of the ink flow passages 5 and the through opening of the common reservoir 6 are exposed. In this state, the end portions of the ink flow passages 5 respectively provide the nozzles 3.

The ink supply member 11 is mounted on the through opening of the common reservoir 6. In the ink supply member 11, an ink supply passage 12 and a plurality of gas hold portion 13 are formed. The ink supply passage 12 is used to supply ink from an ink tank (not shown) to the common reservoir 6, and a plurality of gas hold portions 13 are respectively capable of holding gas therein. Each of the gas hold portions 13, as shown in Fig. 3, is formed in a substantially circular hole which is in communication with only the common reservoir 6 but does not extend through the ink supply member 11. After ink is charged, variations in the pressure within the common reservoir 6 can be relieved by the gas retained within the gas hold portions 13. Actually, as shown in Fig. 4, such gas hold portions 13 are arranged at almost equal intervals together with the ink supply passage 12. Since the gas hold portions 13 can be formed together with the ink supply passage 12 when the ink supply member 11 is molded, there is no possibility that formation of the gas hold portions 13 can complicate the manufacturing process of the ink jet print head.

Ink is guided from an ink tank (not shown) through the ink supply passages 12 in the ink supply member 11 to the common reservoir 6. The ink that is guided to the common reservoir 6 is charged into the common reservoir 6 as well as the respective ink flow passages 5 are filled with the thus charged ink. In this state, since the ink is pulled simultaneously by not only a negative pressure generated within the ink tank but also a surface tension which is generated in the interfaces of the ink in the respective ink flow passages 5, there is no possibility that the ink can leak while printing is not in operation. Also, when the ink is fully loaded into the common reservoir 6, gas is retained within the respective gas hold portions 13.

After then, a maintenance operation is carried out to stabilize the respective parts of the ink jet print head. In particular, the maintenance operation is carried out after the initial loading of the ink, or after ink is replaced, or after an ink suction maintenance operation is executed when trouble occurs. As a concrete maintenance operation, for example, after the ink jet print head is heated to, for example, about 60°C, ink is sucked from the nozzle 3 side. In response to such ink suction, gas held within the gas hold portions 13 is expanded as the temperature rises. Then, since the amount of the gas that is expanded due to the temperature rising is discharged into the common reservoir 6, the thus discharged gas is then discharged externally by means of suction of the ink. After this maintenance operation is carried out, even if the temperature of the ink jet print head rises in actual use, the gas held within the gas hold portions 13 is prevented from being discharged into the common reservoir 6, so that printing can be always executed stably. That is, execution of such maintenance operation makes it possible to keep an effect that the variations in the pressure within the common reservoir can be restricted more positively.

While printing, the heating elements 4 which are respectively disposed in the ink flow passages 5 corresponding to the respective nozzles 3 from which ink is jetted out are electrically energized so as to be heated. As a result, due to the pressure of the thus generated air bubbles, the ink is jetted out from the nozzles 3 and is flown onto a recording medium to execute recording. During this operation, the pressure of the air bubbles is also transmitted to the rear portion of the recessed portion 7 and is further transmitted to the common reservoir 6. The pressure is a force which goes in a direction from the ink flow passages 5 to the common reservoir 6. After then, the air bubbles are extinguished as well as the ink is in short supply on the heating elements 4. Therefore, a force in a direction from the common reservoir 6 to the ink flow passages 5 is applied, so that ink is supplied from the common reservoir 6 to the ink flow passages 5.

As described above, during a short period of time from the growth to the extinction of the air bubbles, two kinds of forces which their directions oppose to each other are generated. For this reason, in the conventional ink jet print head having no air bubbles (gas) hold portions 13, as described above, pressure variations shown in Fig. 13 occurs to thereby cause the poor ink jetting or the like. In the present invention, the pressure which is transmitted to the common reservoir 6 when the air bubbles grow is transmitted to the gas hold portion 13 to compress the gas in the gas hold portion 13. Accordingly, the transmitted pressure can be relieved. Also, when the air bubbles are extinguished, the gas within the gas hold portions 13 is expanded to thereby be able to relieve an increase in the negative pressure due to the sudden shortage of ink. In this manner, the gas hold portions 13 function so as to reduce the pressure variations within the common reservoir 6 as much as possible.

Also, when ink is supplied, the ink flows in a direction from the ink supply passages 12 to the recessed portions 7 corresponding to the respective ink flow passages 5. Therefore, a position where the gas hold portion 13 communicates with the common reservoir 6 is a portion where ink flow a little. This makes it possible to restrict the outflow of the gas within the gas hold-portions 13 due to the flow of the ink which occurs in the conventional print head. Accordingly, the pressure variations within the common reservoir 6 can be controlled stably.

Fig. 6 is a graphical representation to show an example of the pressure variations produced in the common reservoir employed in the above embodiment of an ink jet print head according to the present invention. As described above, according to the present embodiment, since the pressure variations within the common reservoir 6 can be restricted by the gas hold portions 13, even when printing is executed under the same condition as the case shown in Fig. 13, as shown in Fig. 6, there cannot be found large pressure variations and thus the printing can also be executed normally.

Now, in Figs. 7 and 8, there is shown a first modification of the above embodiment of the ink jet print head according to the invention. In particular, Fig. 7 is a section view taken along the line B-B' shown in Fig. 1, and Fig. 8 is a section view taken along the line D-D' shown in Fig. 1. In the present modification, the section area of the gas hold portion 13 is increased. If the section area of the gas hold portion 13 is increased in this manner, then the volume of the gas hold portion 13 can be increased and thus the amount of gas to be held within the gas hold portion 13 can be increased. This makes it possible to increase the function to restrict the variations in the pressure within the common reservoir 6. Also, when a sufficient length cannot be secured in the gas hold portion 13, if the section area of the gas hold portion 13 is increased in this manner, then the amount of the gas to be held within the gas hold portion 13 can be secured.

Now, Figs. 9 and 10 show a second modification of the above embodiment of the ink jet print head according to the invention. In particular, Fig. 9 is a section view taken along the line B-B' shown in Fig. 1, and Fig. 10 is a section view taken along the line D-D' shown in Fig. 1. In the present modification, the position of each of the gas hold portions 13 is displaced. In this structure, since the section areas of the communication portions between the respective gas hold portions 13 and the common reservoir 6 are reduced, it is possible to further restrict the inflow of the ink to the gas hold portions 13 as well as the outflow of the gas therefrom, which in turn makes it possible to restrict the pressure variations within the common reservoir 6 more stably. Also, in the present modification, since the position of each gas hold portion 13 is displaced on the opposite side to its corresponding nozzle 3, for example, even in a ink jet printer of a type that the nozzle 3 faces downward and ink droplets are flown downward, the gas within the gas hold portion 13 is prevented from flowing out therefrom and the pressure variations within the common reservoir 6 can be restricted properly.

Figs. 11 and 12 show a third modification of the above embodiment of the ink jet print head of the invention. In particular, Fig. 11 is a section view taken along the line B-B' shown in Fig. 1, and Fig. 12 is a section view taken along the line D-D' shown in Fig. 1. In the present modification, each of the gas hold portions 13 is formed to extend obliquely backward. In the present modification, since the gas is held within the gas hold portion 13 starting at the deepest portion of the gas hold portion 13, even if the ink droplets are jetted in a horizontal direction, or the ink droplets are jetted downward, it can be prevented that the gas within the gas hold portion 13 is replaced by the ink.

Fig. 13 is a section view taken along the line B-B' shown in Fig. 1, and shows a fourth modification of the above embodiment of the ink jet print head of the invention. In the present modification, in the surface of the ink supply member 11, a groove which serves as the gas hold portion 13 is formed and the ink supply member 11 is bonded to the channel substrate 2. In this case, one surface of the gas hold portion 13 provides the surface of the channel substrate 2. The present modification is effective especially when the ink droplets are jetted out downward. In the present modification, since the surface of the channel substrate 2 is used as part of the gas hold portion 13, the channel substrate 2 requires a length which extends backwardly of the common reservoir 6, and also the bonded portion must be airtight. As a further modification of the fourth modification, if possible, the gas hold portion 13 can be formed to be bent in the ink supply member 11.

Fig. 14 is a section view taken along the line D-D' shown in Fig. 1 and shows a fifth modification of the above embodiment of the ink jet print head of the invention. In the present modification, the gas hold portion 13 has a section shape which extends along an opening formed in the common reservoir 6. That is, since the area of the communication portion between the gas hold portion 13 and the common reservoir 6 is increased, the pressure that is transmitted to the interior of the common reservoir 6 can be received in a wide range and can be thereby dampened. Also, since the capacity of the gas hold portion 13 can be increased, the effect to restrict the pressure variations within the common reservoir 6 can be enhanced. However, if the pressure receive area is increased excessively, there is expected a possibility that such wide area cause the flow of the ink and thus the air bubbles within the gas hold portion 13 can flow out into the common reservoir 6. That is, it is necessary to set the pressure receive area in a proper area.

According to the present invention, in addition to the above-mentioned embodiment and the modifications thereof, there are also available other various modifications. For example, although the section shape of the gas bold portion 13 is formed circular or elliptic in the above embodiment and modifications thereof, the gas hold portion 13 can also be formed in other shape, for example, it may be formed in a rectangular shape or in a triangular shape. Also, the shape and position of the gas hold portion 13 can be set freely, provided that they extend along the opening of the common reservoir 6. Further, it is also possible to combine together two or more of the above-mentioned embodiment and modifications thereof.

Also, in the above-mentioned embodiment and modifications thereof, there is shown an ink jet print head including a flow passage structure which communicates the ink flow passages 5 with the common reservoir 6 by means of the recessed portions 7. However, the invention is not limited to this flow passage structure but, for example, it is also possible to employ other various flow passage structures such as a structure including a common slit formed in part thereof or the like, provided that the ink jet print head includes the common reservoir 6.

Further, if the above-mentioned type of ink jet print head is incorporated into a printer, it is possible to structure an ink jet printer which can prevent unprinted (missing) areas or density variations to thereby be able to obtain printed images of high quality.

EXAMPLES

Fig. 15 is an explanatory view of Examples which was conducted in connection with the above embodiment of an ink jet print head according to the invention. Also, Figs. 16 to 18 are explanatory views of the positions and shapes of gas hold portions provided in the examples. In the Examples, an ink jet print head was used in which 125 pieces of nozzles were arranged, and the capacity of the ink droplets to be jetted out from each of the nozzles was 80 pl, while the ink jet print head was driven at a print frequency of 7 KHz. The maximum flow amount of ink in rush print was 125 x 80 pl x 7 KHz = 0.07 cc/sec. = 70 mm^3/sec. Also, the through opening of the common reservoir 6 had a width of 0.5 mm and a length of 10.4 mm. In Fig. 15, there are shown the amounts of gas per ink jet amount which are respectively obtained when the total amounts of gas within a plurality of gas hold portions 13 are divided by the maximum flow amount of ink. Also, head numbers in Fig. 15 identify the ink jet print heads that are employed in the Examples.

An ink jet print head designated by the head No. 0 represents a conventional head in which the gas hold portion 13 is not provided. In this head, as described above, there were produced such density variations or unprinted area as shown in Fig. 20.

An ink jet print head, head No. 1, is an ink jet print head in which there are formed four gas hold portions 13 each having a diameter of 0.4 mm and a depth of 2 mm. In this ink jet print head, as shown in Fig. 16, the gas hold portions 13 are formed two in the neighborhood of each of the two ends of the through opening of the common reservoir 6. In this print head, although there were not found such density variations or unprinted area as in the head No. 0, slight density variations were generated in the neighborhood of the central portion of the present print head in which no gas hold portion 13 is formed.

An ink jet print head, head No. 2, is an ink jet print head in which there are formed eight gas hold portions 13 each having a diameter of 0.4 mm and a depth of 2 mm. In this print head, as shown in Fig. 17, the eight gas hold portions 13 are arranged almost uniformly in the through opening of the common reservoir 6. In this case, no unprinted area or density variations were produced but excellent image quality could be obtained.

As can be understood from comparison of the printed results of the ink jet print heads, head Nos. 0 to 2, by forming the gas hold portion 13, it is possible to reduce the unprinted area or density variations that have been generated in the prior art print heads. Also, comparison between the print heads, head Nos. 1 and 2, shows that, if the gas hold portions 13 are arranged almost uniformly in the through opening of the common reservoir 6, then the unprinted area or density variations can be eliminated over the whole head width and thus excellent image quality can be obtained.

An ink jet print head, head No. 3, is an ink jet print head in which six gas hold portions are formed, each gas hold portion having a diameter of 0.7 mm and a depth of 2 mm. The present ink jet print head corresponds to the above-mentioned first modification of the embodiment of the invention and, as shown in Fig. 18, the six gas hold portions 13 each having a diameter larger than the width of the common reservoir 6 are arranged almost uniformly in the through opening of the common reservoir 6. In this case as well, no unprinted area or density variations were generated but fine image quality could be obtained.

An ink jet print head, head No. 4, is an ink jet print head in which eight gas hold portions each having a diameter of 0.5 mm and a depth of 2 mm are formed, while they are inclined at an angle of 30°C. The present ink jet print head corresponds to the above-mentioned third modification of the embodiment of the invention. In this case as well, no unprinted area or density variations were generated but fine image quality could be obtained.

That is, it can be understood that, according to the above-mentioned various modifications of the embodimentof the invention as well, the unprinted area or density variations can be eliminated but good image quality can be obtained.

Head Nos. 5 to 7 respectively show the results that were obtained when the amounts of gas retained within the gas hold portions 13 of the ink jet print head, head No. 3, were adjusted and the variations thereof were then examined. In particular, in the head No. 5, the interior of the print head No. 3 is made to produce a vacuum therein and ink is then loaded into the vacuum print head, while the total amount of gas retained in the respective gas hold portions 13 is 0.415 mm^3. In the head No. 6, after the gas within the print head is sucked a little, ink is loaded into the print head, while the total amount of gas retained in the respective gas hold portions 13 is 2.05 mm^3. In the head No. 7, after the gas within the print head is sucked slightly, ink is loaded into the print head, while the total amount of gas retained in the respective gas hold portions 13 is 3.39 mm^3. As the result of this experiment, in the head No. 5, there was generated slight density variations, whereas in the heads No. 6 and 7, neither the unprinted area nor density variations were produced but good image quality could be obtained. This shows that, when gas is little present within the gas hold portions 13, similarly to the conventional structure in which no gas hold portion 13 is formed, the density variations or the like are generated, whereas, if a certain amount of gas is held within the gas hold portions 13, the density variations or the like are not generated.

In the head No. 8, similarly to the head Nos. 5 to 7, after the ink jet print head No. 2 is made to produce a vacuum therein, ink is loaded into the vacuous print head, while the total amount of gas retained within the respective gas hold portions 13 is 0.0025 mm^3. In this case, that is, in a condition that gas is little present within the gas hold portions 13, similarly to the conventional print head in which no gas hold portion 13 is formed, the density variations were generated.

From the results of the above experiment, it can be found that, if the gas hold portions 13 are formed within the print head and gas is held within the gas hold portions 13, then generation of undesirable phenomena such as the unprinted area, density variations and the like can be prevented and thus excellent image quality can be obtained. Also, referring to the amount of gas to be held within the gas hold portions 13, in view of the fact that, when it was 0.014 mm^3 per ink jet amount 1 mm^3/sec. for each unit time, there were produced slight density variations, if the gas is held in an amount of 0.015 mm^3 or more, it can be expected that good image quality can be obtained.

Claims

1. An ink jet print head for jetting out ink from a plurality of nozzles to thereby form an image, comprising:

    a plurality of energy generating means for causing said ink to be jetted out from said nozzles;
    a plurality of ink flow passages respectively which is disposed to individually correspond to said energy generating means for supplying ink to said energy generating means;
    an ink jet head including an ink reservoir with which said plurality of ink flow passages communicate in common; and
    an ink supply member including an ink supply passage for supplying ink to said ink reservoir of said ink jet head, said ink supply member further including a plurality of gas hold portions which are respectively in communication with only said ink reservoir and are respectively capable of holding gas therein.

2. An ink jet print head according to claim 1, wherein each of said gas hold portions has a substantially circular section.

3. An ink jet print head according to claim 1, wherein said plurality of gas hold portions are arranged at substantially equal intervals in a direction where said ink flow passages are arranged.

4. An ink jet print head according to claim 1, wherein a total volume of said gas hold portions is 0.015 mm^3 or more per ink amount 1 mm^3/sec. to be jetted out by said energy generating means.

5. An ink jet print head according to claim 1, wherein an area of a communication portion where each of said gas hold portions is directly connected with said ink reservoir is smaller than a section area of a surface of said gas hold portion facing said ink reservoir.

6. An ink jet print head for jetting out ink from nozzles by means of the pressure of thermally generated bubbles to thereby form an image, comprising:

    a first substrate including a plurality of heating resistors for generating heat in order to cause said bubbles;

a second substrate disposed opposed to said first substrate, said second substrate including a plurality of channels for supplying ink onto said heating resistors and a common ink reservoir communicating in common with said plurality of channels; and

an ink supply member including an ink supply passage for supplying ink to said common ink reservoir and a plurality of air hold chambers respectively capable of holding air therein and communicating with only said common ink reservoir.

7. An ink jet printer comprising an ink jet print head for jetting out ink from nozzles by means of the pressure of thermally generated bubbles to thereby form an image, said ink jet print head comprising:

a plurality of energy generating means for causing said ink to be jetted out from said nozzles;

a plurality of ink flow passages respectively which is disposed to individually correspond to said energy generating means for supplying ink to said energy generating means;

an ink jet head including an ink reservoir with which said plurality of ink flow passages communicate in common; and

an ink supply member including an ink supply passage for supplying ink to said ink reservoir of said ink jet head, said ink supply member further including a plurality of gas hold portions which are respectively in communication with only said ink reservoir and are respectively capable of holding gas therein.

8. An ink jet printer according to claim 7, wherein each of said gas hold portions has a substantially circular section.

9. An ink jet printer according to claim 7, wherein said plurality of gas hold portions are arranged at substantially equal intervals in a direction where said ink flow passages are arranged.

10. An ink jet printer according to claim 7, wherein a total volume of said gas hold portions is 0.015 mm^3 or more per ink amount 1 mm^3/sec. to be jetted out by said energy generating means.

11. An ink jet printer according to claim 7, wherein an area of a communication portion where each of said gas hold portions is directly connected with said ink reservoir is smaller than a section area of a surface of said gas hold portion facing said ink reservoir.

12. An ink jet printer comprising an ink jet print head for jetting out ink from nozzles by means of the pressure of thermally generated bubbles to thereby form an image, said ink jet print head comprising:

a first substrate including a plurality of heating resistors for generating heat in order to cause said bubbles;

a second substrate disposed opposed to said first substrate, said second substrate including a plurality of channels for supplying ink onto said heating resistors and a common ink reservoir communicating in common with said plurality of channels; and

an ink supply member including an ink supply passage for supplying ink to said common ink reservoir and a plurality of air hold chambers respectively capable of holding air therein and communicating with only said common ink reservoir.

13. A maintenance method for maintaining an ink jet print head, in which pressure is generated by a pressure generating source, ink is jetted out from an ink jet port due to the thus generated pressure, and pressure vibrations transmitted from said pressure generating source are absorbed by air chambers, wherein:

after ink is filled initially, after ink is replaced, or after ink is sucked, the temperature of said ink jet print head is raised and ink is then sucked from said ink jet port.

FIG. 1

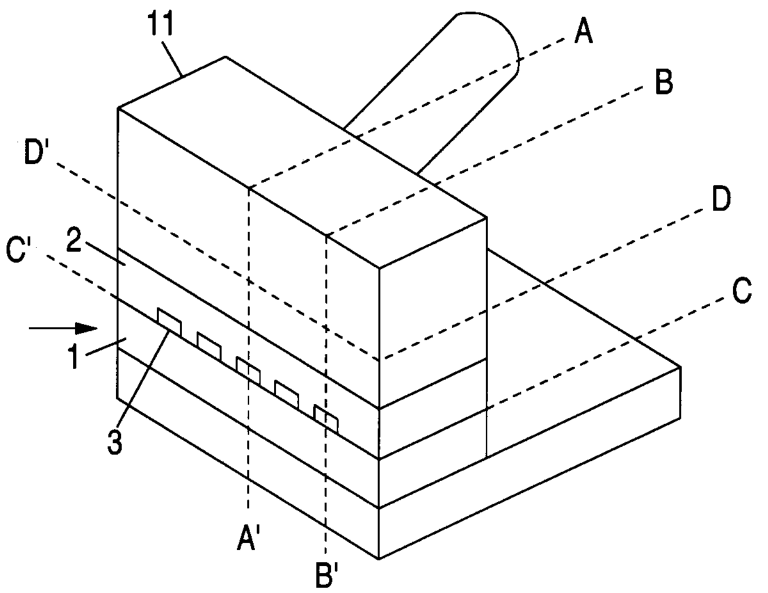

FIG. 2

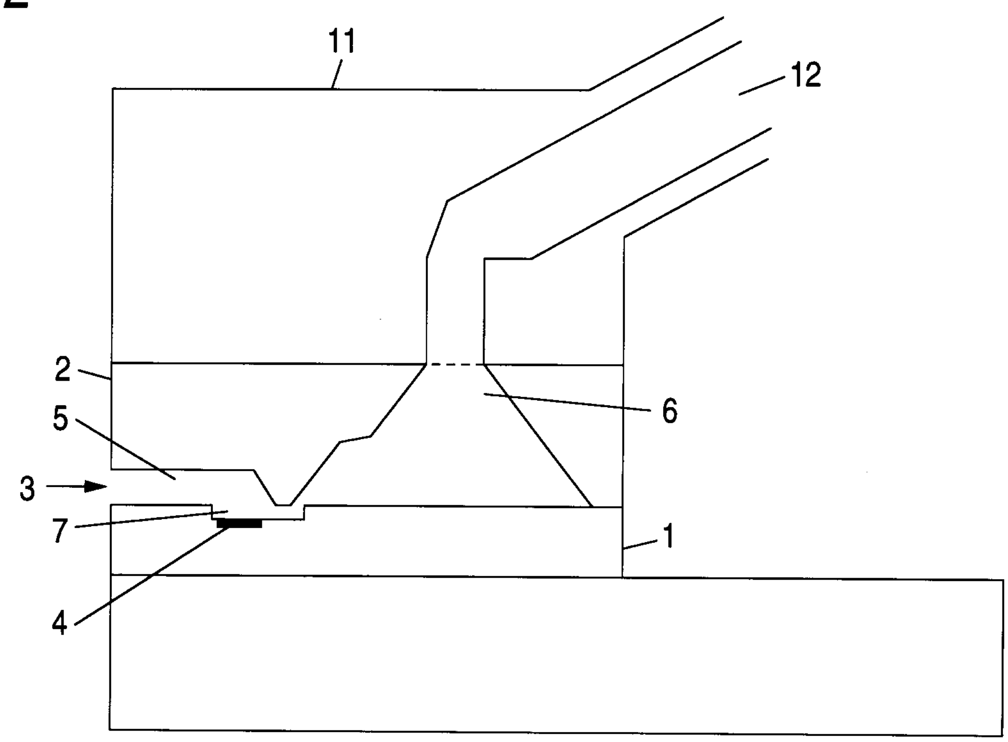

FIG. 3

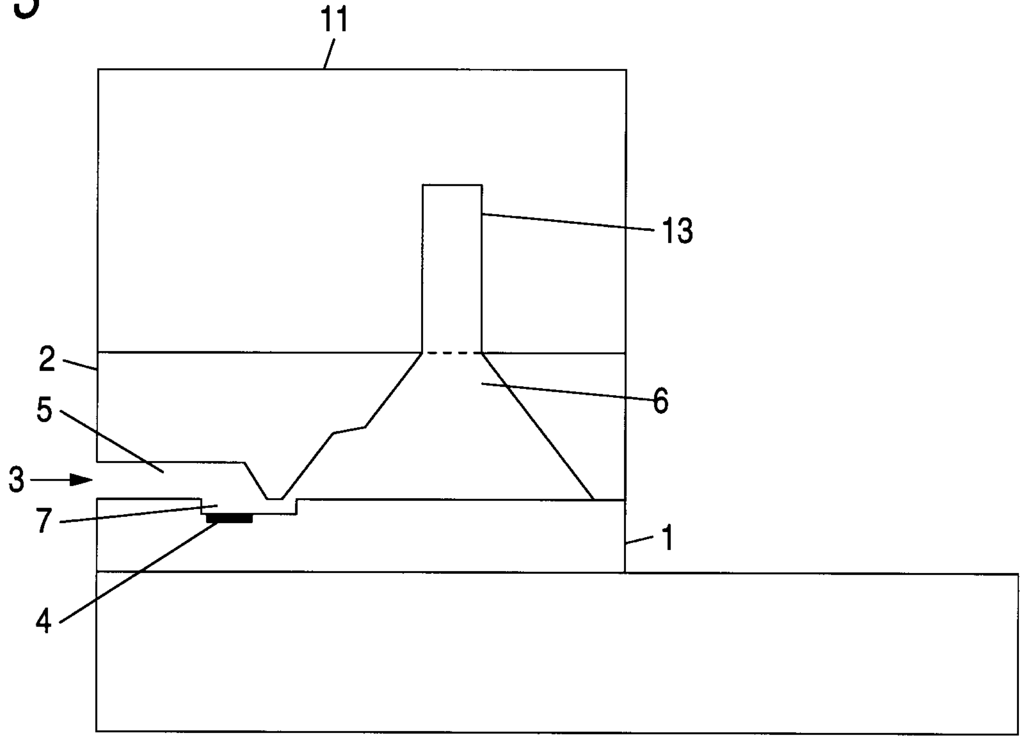

FIG. 4

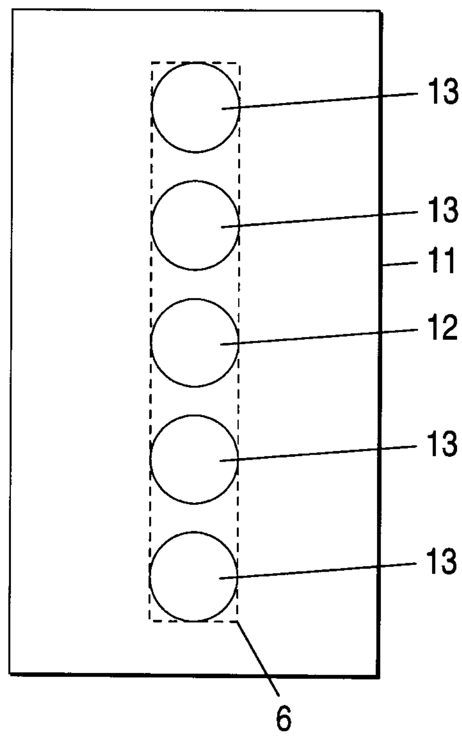

FIG. 5

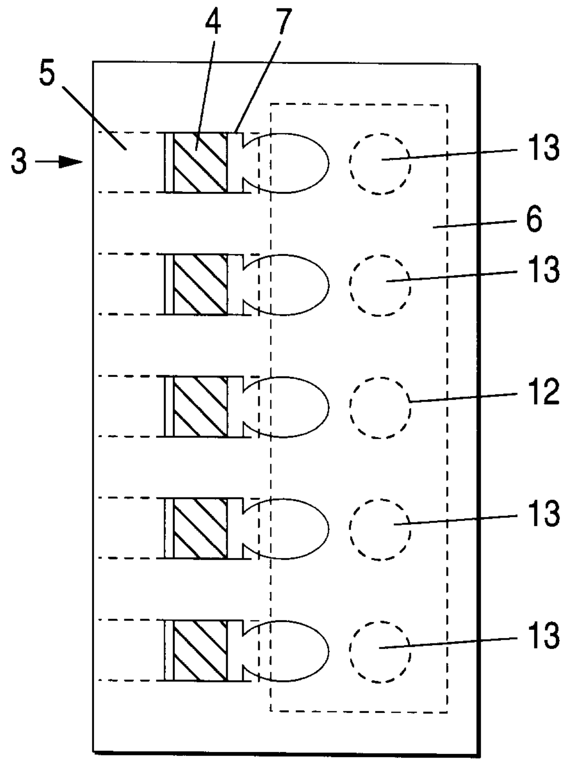

FIG. 6

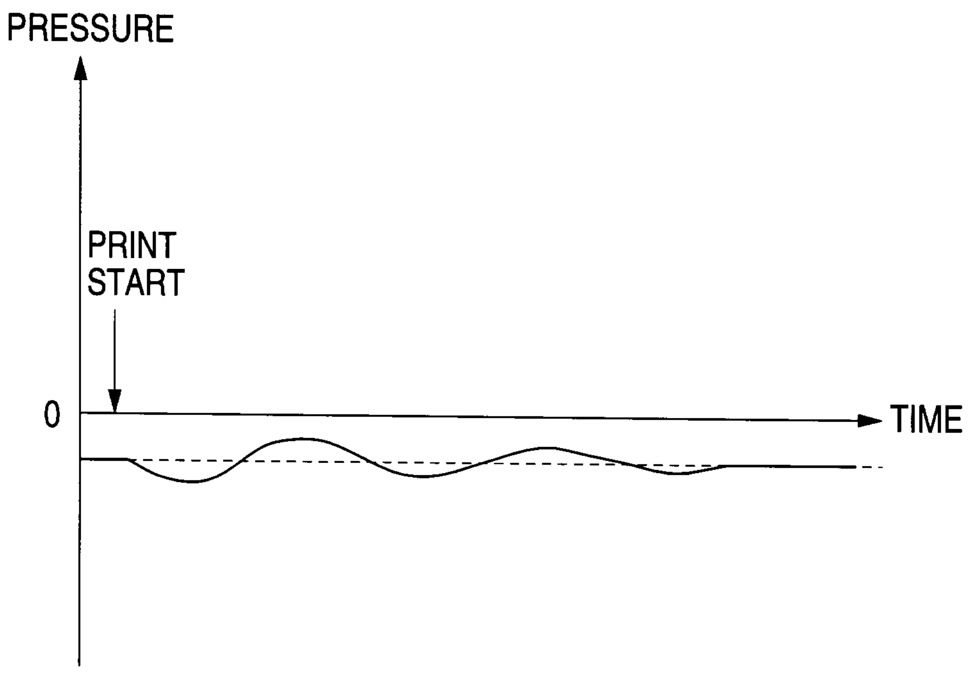

FIG. 7

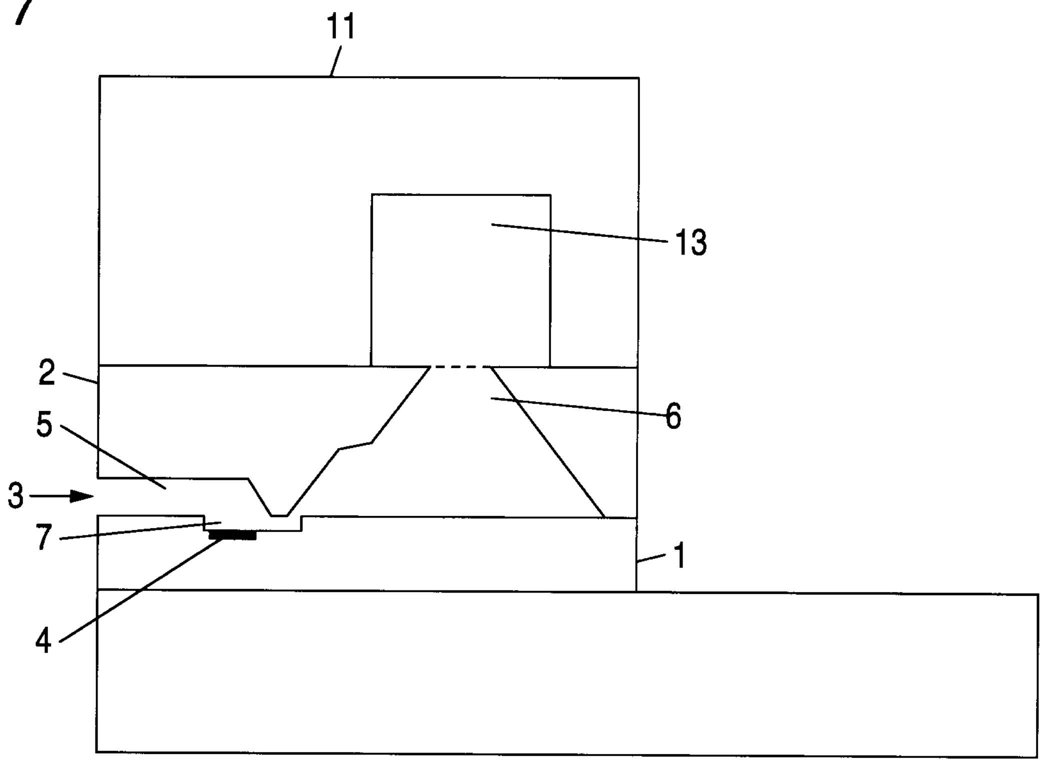

FIG. 8

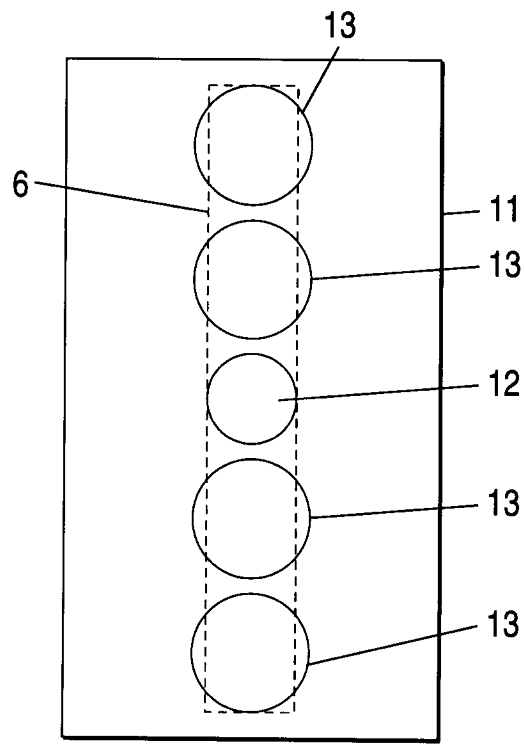

FIG. 9

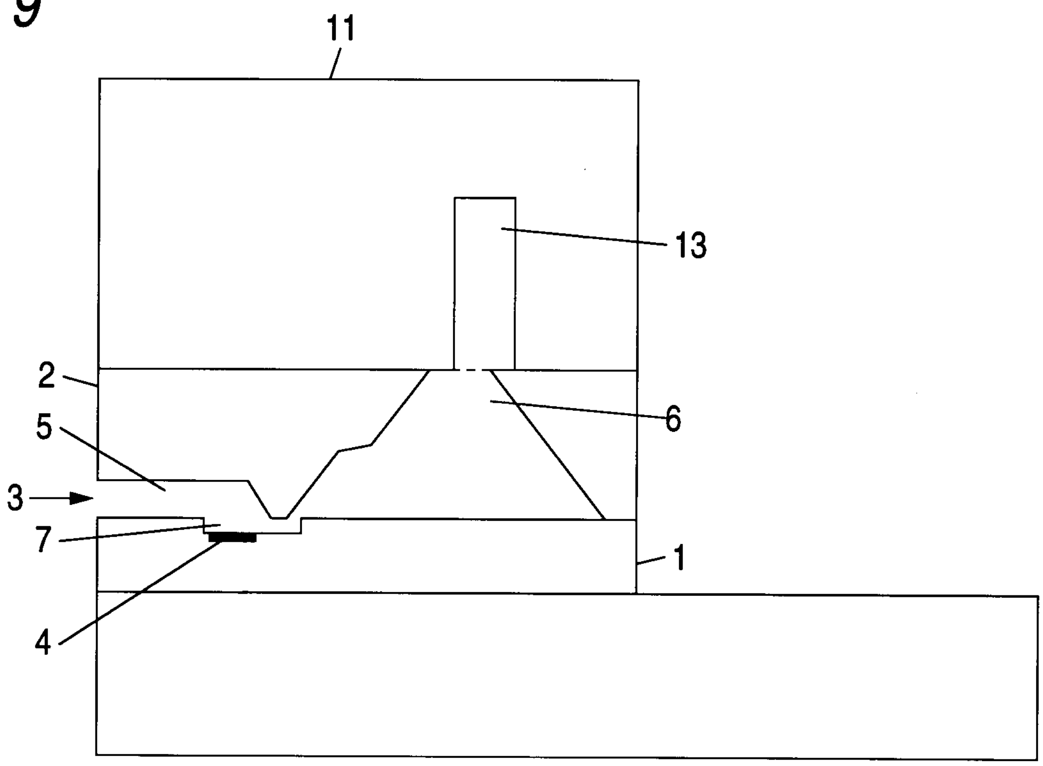

FIG. 10

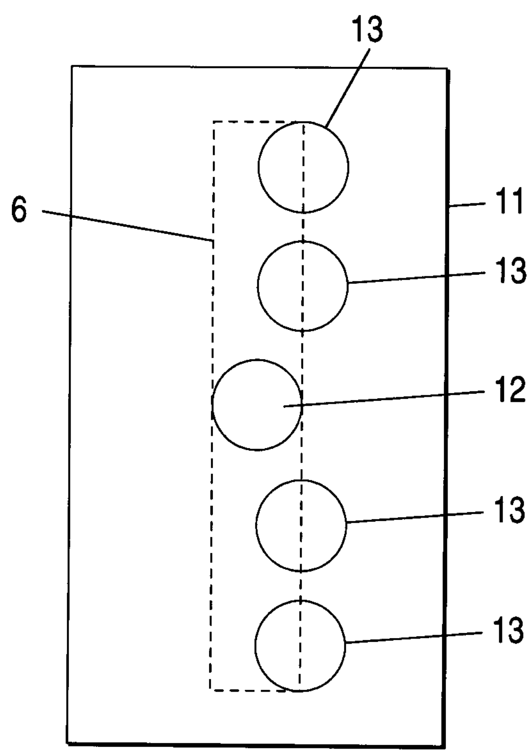

FIG. 11

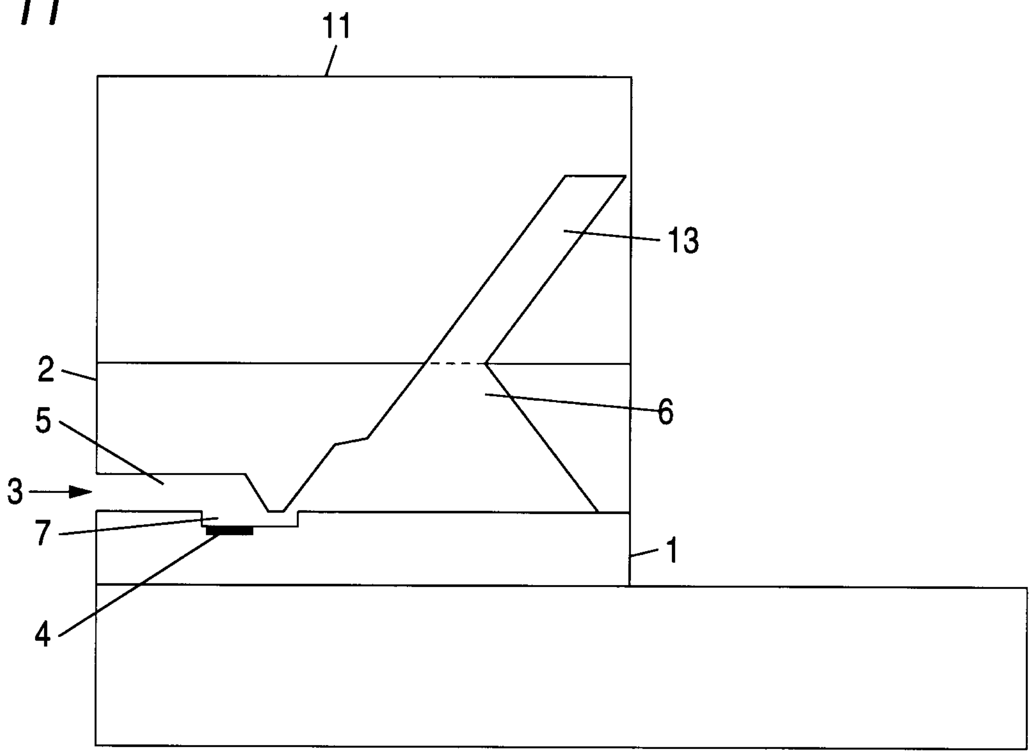

FIG. 12

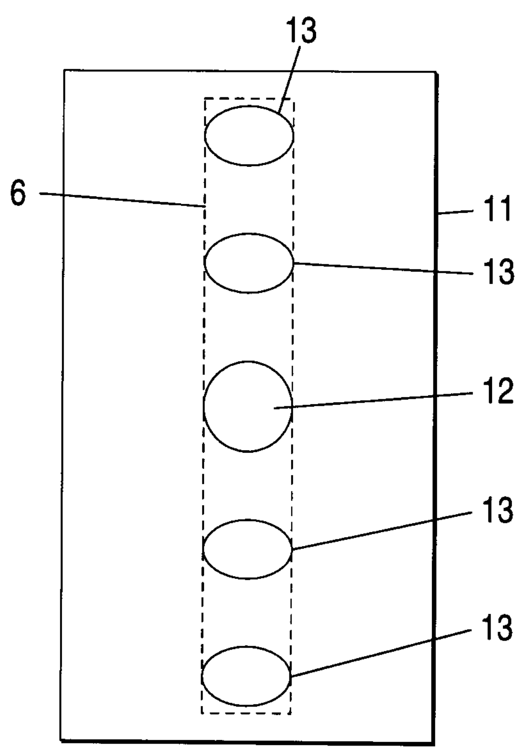

FIG. 13

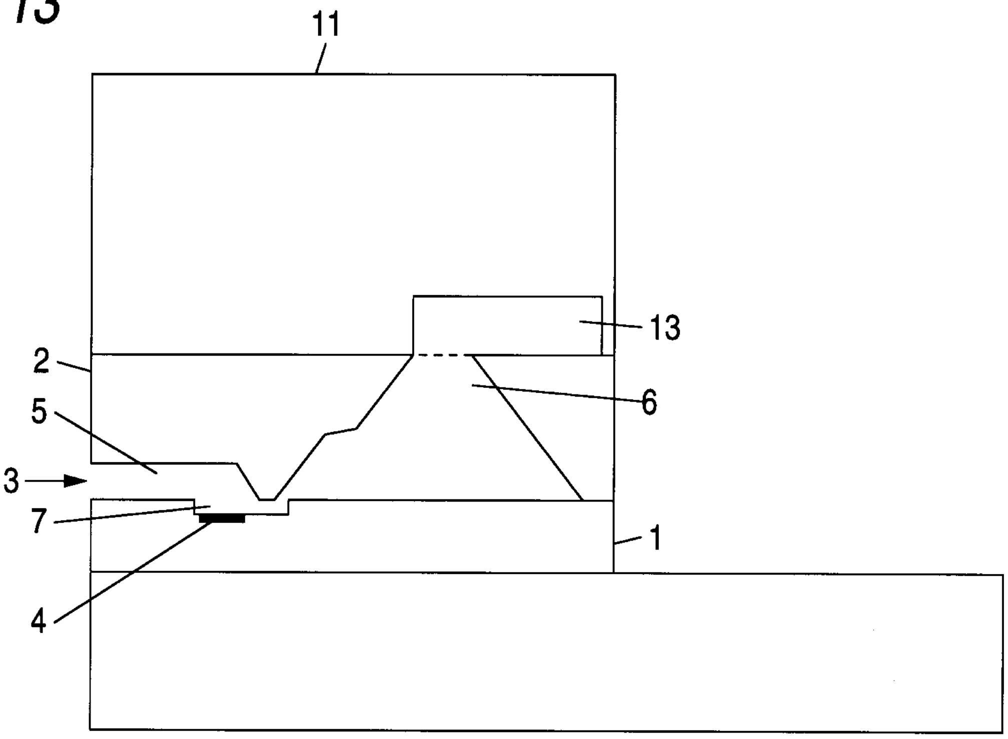

FIG. 14

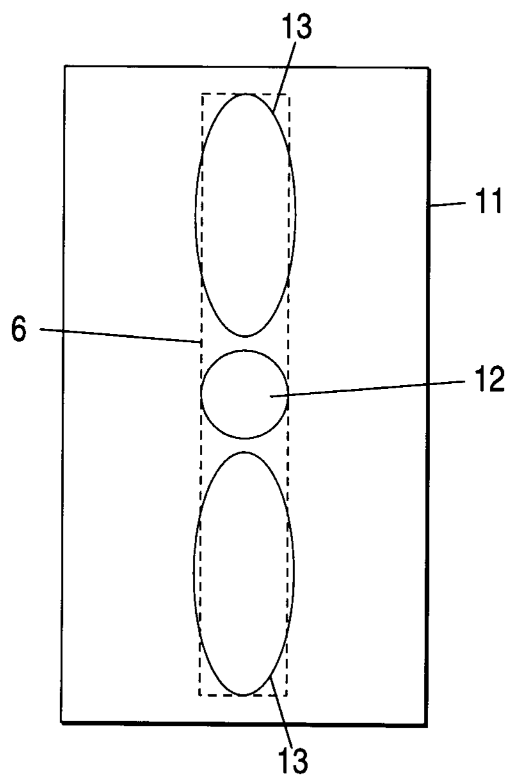

FIG. 15

HEAD NUMBER	{ VOLUME OF GAS HOLDING PORTION (mm^3) } / { INK JET AMOUNT PER SEC. (mm^3/ sec.) }	PRINT CONDITION
0	0	DENSITY VARIATIONS AND / OR UNPRINTED AREA WERE GENERATED
1	0.014	SLIGHT DENSITY VARIATION WERE GENERATED
2	0.029	DENSITY VARIATION WERE NOT GENERATED
3	0.067	DENSITY VARIATION WERE NOT GENERATED
4	0.045	DENSITY VARIATION WERE NOT GENERATED
5	0.0059	SLIGHT DENSITY VARIATION WERE GENERATED
6	0.029	DENSITY VARIATION WERE NOT GENERATED
7	0.048	DENSITY VARIATION WERE NOT GENERATED
8	0.0025	DENSITY VARIATION WERE GENERATED

FIG. 16

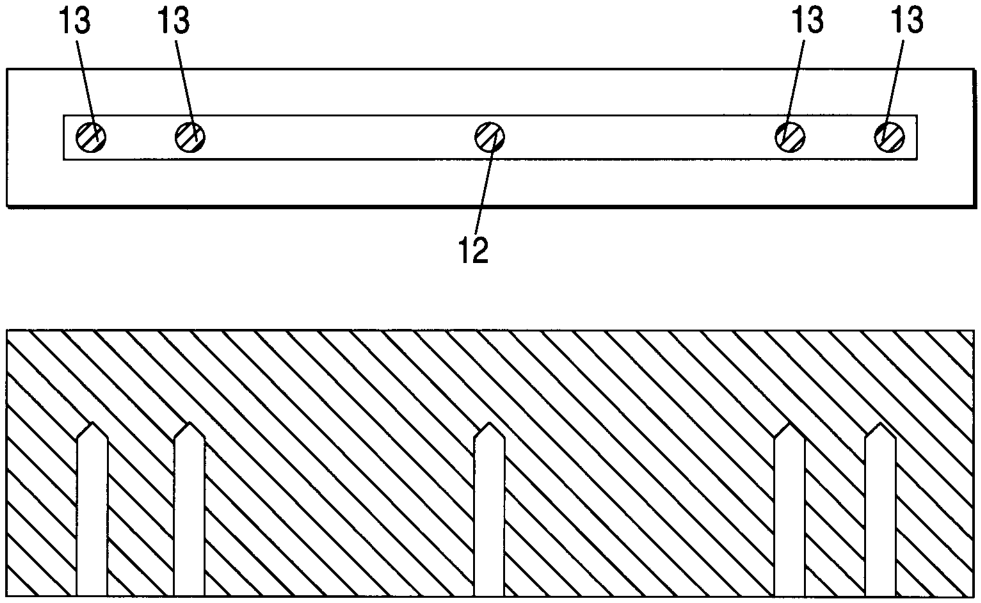

FIG. 17

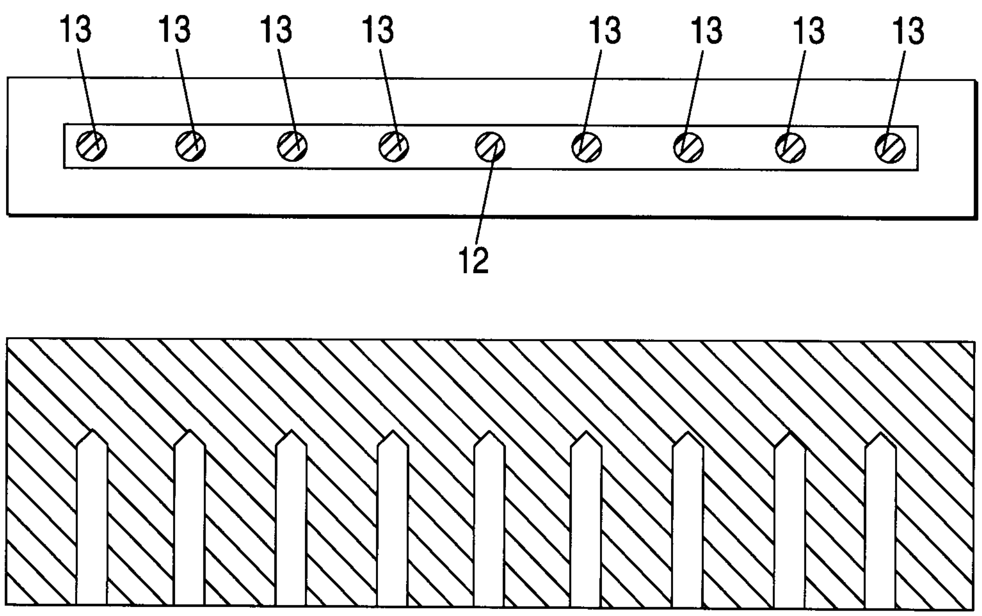

FIG. 18

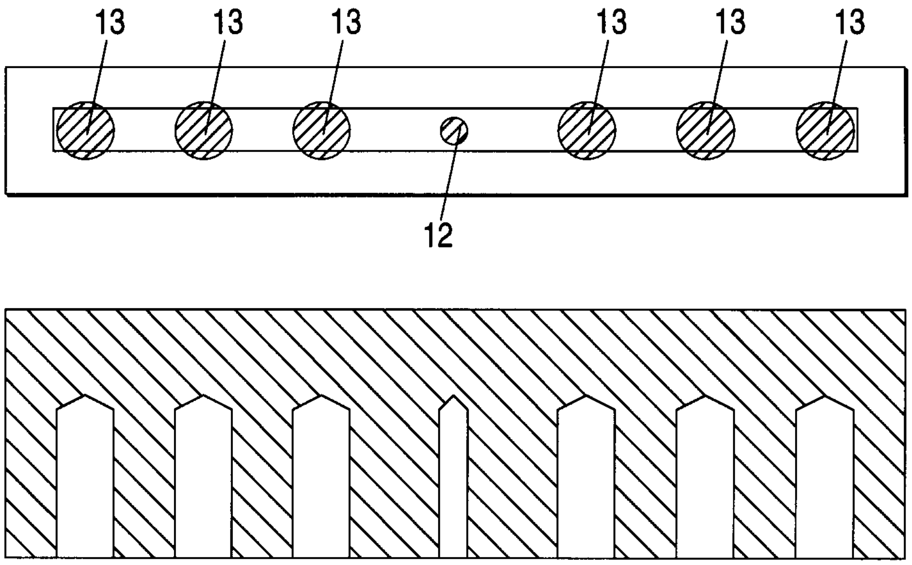

FIG. 19

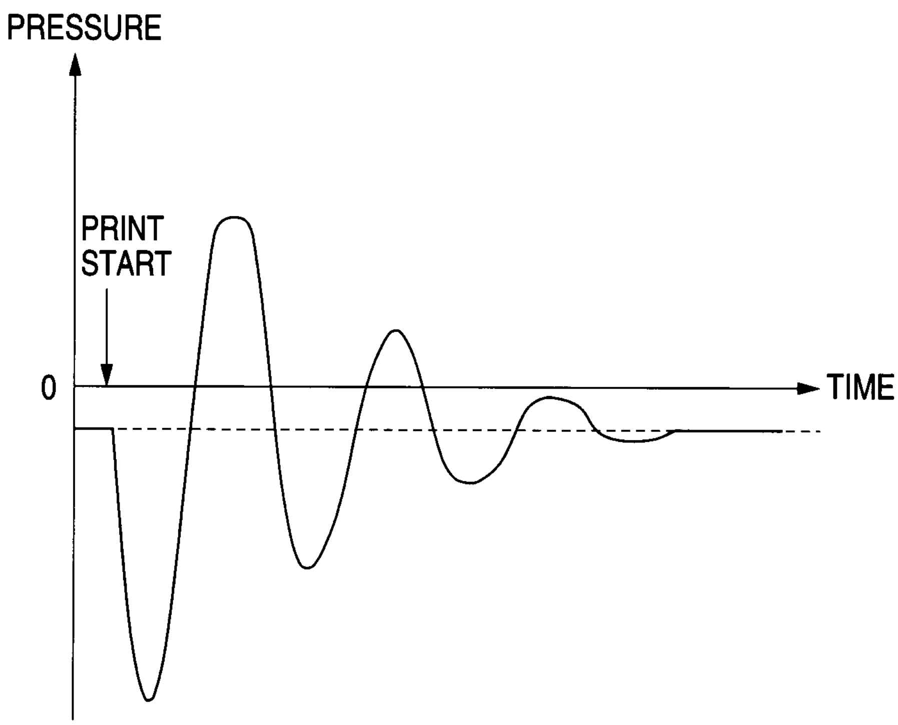

FIG. 20A

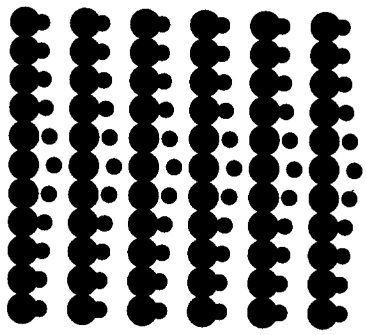

FIG. 20B