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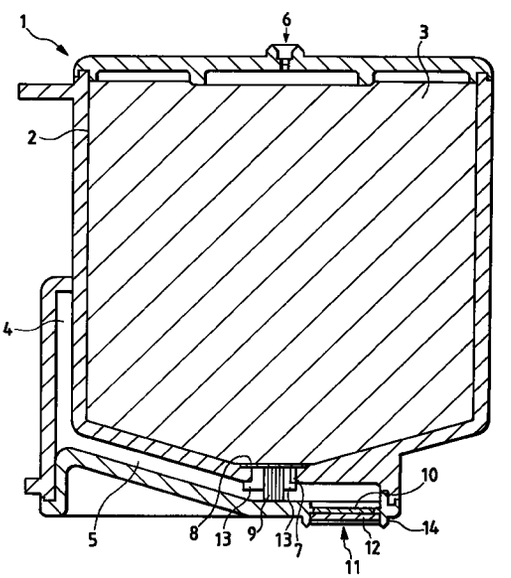
(54) Ink supply unit

(57) A main ink chamber 2 for housing a capillary member 3 and an intermediate ink chamber 4 are provided, between which a first meniscus formation member 8 is disposed. An ink guide member 9 is in contact with the bottom face of the first meniscus formation member 8 for supplying ink to the first meniscus formation member 8. The ink guide member 9 is held by ink guide member retainers 13 extending toward the ink guide member 9 from the wall of a communication hole 7 and is kept in contact with the first meniscus formation member 8. A larger number of the ink guide member retainers 13 are placed on the side of a joint port 11 and a smaller number thereof are placed on the side of the intermediate ink chamber 4 for guiding bubbles entering from the first meniscus formation member 8 to the side of the intermediate ink chamber 8 for preventing a move of the bubbles to the joint port 11 and the mixing of the bubbles into a print head.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an ink supply unit for supplying ink to an ink jet head in an ink jet recorder.

2. Description of the Related Art

In a conventional ink supply mechanism used with an ink jet recorder, an ink tank contains a porous member with one end coupled to a print head via a filter and the other end formed with an air inlet, for example, as described in Japanese Patent Examined Publication No. Hei 3-41351. In such an ink supply mechanism, air may enter the filter through the space between the porous member and the inner wall of the ink tank, inhibiting ink supply to the ink tank.

To solve such a problem, for example, in Japanese Patent Unexamined Publication No. Hei 2-34354, such a rib abutting an ink absorber is placed on the inner wall face of an ink tank for preventing bubbles from entering a head. However, also in this method, adhesion of the head to a sponge may be poor and air still enters the head along the inner wall face of the ink tank.

As alternative solution means, for example, an air gathering chamber containing a porous member is disposed in an ink flow path connecting a print head and an ink vessel for gathering bubbles, as disclosed in Japanese Patent Unexamined Publication No. Sho 57-2786. However, in such a structure, flow path resistance of the porous member itself is large and when bubbles build up on full surfaces of the porous member, flow path resistance increases and ink supply does not keep pace with ink required for responding to high-speed printing.

Further, for example, a filter cloth is stuck on one face of an elastomer plate having a through hole for gathering bubbles on the filter face, as disclosed in Japanese Patent Unexamined Publication No. Sho 59-95152. However, also in this structure, when bubbles build up on full surfaces of the filter cloth, flow path resistance increases and ink supply does not keep pace with ink required for responding to high-speed printing, as in the above-mentioned structure.

Further, for example, a hollow needle is used for a joint connecting an ink tank and a head and a porous substance is disposed in the hollow needle for preventing the entry of bubbles or dust, as disclosed in Japanese Patent Unexamined Publication No. Hei 3-189157. However, in this structure, the inner diameter of the hollow needle needs to be made small virtually to provide a good connection property of the joint. That is, since the opening area of the porous member contained in the hollow needle lessens, flow path resistance increases and ink supply does not keep pace with ink required for responding to high-speed printing.

In such a structure wherein bubbles are trapped on the faces of the porous substance or the filter, it is also possible to enlarge the filter particle size of the porous substance or the filter to decrease the flow path resistance. In this case, for example, if a large amount of ink is consumed because of maintenance, etc., bubbles pass through the porous substance or the filter and enter the print head, causing print failure, etc.

As another art, a method wherein ink is stored in a subtank disposed between an ink tank and a head and is supplied from the subtank to the head is disclosed, for example, in Japanese Patent Laid-Open No. Sho 60-262654. The subtank is opened to the atmosphere and bubbles and ink are separated in the subtank for supplying only ink to the head. However, in this structure, there is a possibility that ink will leak from the atmospheric release port of the subtank and further there is a restriction on design that the head is placed above the subtank to maintain ink pressure at negative pressure.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an ink supply unit for preventing the entry of bubbles into a print head without increasing flow path resistance in an ink supply process from an ink chamber to the print head.

According to the invention, there is provided an ink supply unit for supplying ink to a print head comprising a main ink chamber formed with an atmospheric communication port and a communication hole for supplying ink, a capillary member being housed in the main ink chamber for holding ink, a meniscus formation member being disposed on the communication hole, placed in contact with the capillary member, and formed with a plurality of minute holes, a subordinate ink chamber having a supply part being connected to the communication hole for supplying ink to the print head and an inner wall slanting upward from the connection part to the communication hole, an ink guide member being made of a porous member in contact with the bottom face of the meniscus formation member and extending toward the bottom of the subordinate ink chamber, and a holding member for holding the ink guide member.

In the ink supply unit, the holding member is made up of a plurality of protrusion members extending radially from a side wall of the communication hole and being placed so that the number of the protrusion members placed on the side of the upward slanting inner wall of the subordinate ink chamber is smaller than that of the protrusion members placed on its opposite side.

In the ink supply unit, the supply part is disposed on an opposite side to the upward slanting inner wall with the connection part to the communication hole between.

According to the invention, there is provided an ink supply unit for supplying ink to a print head comprising a main ink chamber formed with an atmospheric communication port and a communication hole for supplying ink, a capillary member being housed in the main ink

chamber for holding ink, a meniscus formation member being disposed on the communication hole, placed in contact with the capillary member, and formed with a plurality of minute holes, a subordinate ink chamber being formed with a supply part being connected to the communication hole for supplying ink to the print head and having an inner wall on an opposite side to the supply part with the connection part to the communication hole between slanting upward from the connection part to the communication hole, an ink guide member being made of a porous member in contact with the bottom face of the meniscus formation member and extending toward the bottom of the subordinate ink chamber, and a wall member hanging between the connection part to the communication hole and the supply part.

In the ink supply unit, a wall face between the connection part to the communication hole and the supply part may slant upward from the supply part.

According to the invention, in a state in which the ink supply unit is attached to a recorder, ink is held by the capillary member for keeping negative pressure in a print head. When ink is consumed through the print head, the ink held by the capillary member passes through the meniscus formation member and is supplied from the communication hole through the supply part of the subordinate ink chamber to the print head. If bubbles enter the main ink chamber, they are trapped by the meniscus formation member.

For clogging, etc., normally ink and dust are sucked from the nozzle side. The negative pressure occurring at this time becomes large as compared with the negative pressure occurring in a normal ink supply. At this time, the bubbles on the meniscus formation member may pass through the meniscus formation member together with ink on rare occasion by the large negative pressure. However, since the side wall of the subordinate ink chamber slants upward from the connection part to the communication hole, the bubbles mixed into the ink from the main ink chamber rise along the slant side wall by their buoyant force and are collected. Thus, only the ink is supplied to the print head and no bubbles are mixed into the print head; recording can be continued with a good image quality.

When ink is furthermore consumed and the main ink chamber becomes empty of ink, negative pressure is kept by ink meniscuses formed on the minute holes of the meniscus formation member. That is, as the negative pressure increases, the ink meniscuses are pressed and air passes through as bubbles. The negative pressure decreases as much as the volume of the bubbles. Thus, the negative pressure is kept almost constant. The bubbles passing through the meniscus formation member move along the slant wall face of the subordinate ink chamber by the buoyant force of the bubbles and are collected as described above; no bubbles are mixed into the print head.

At this time, if the bubbles remain on the bottom face of the meniscus formation member, both faces of the meniscus formation member are exposed to air and there is a possibility that the ink amount will decrease, breaking the meniscuses. However, the ink guide member sucks up ink from the subordinate ink chamber and supplies it to the meniscus formation member, whereby the meniscuses formed on the minute holes of the meniscus formation member are not broken.

The ink guide member is placed so as not to close the communication hole so that it does not produce a bottleneck of ink passage or bubble occurrence. Thus, it would fall down very easily without any measures. However, the ink guide member, which is held by the holding member, is kept in contact with the meniscus formation member so as to continue supplying ink to the meniscus formation member.

Although bubbles are trapped by the meniscus formation member, the bubbles passing through the meniscus formation member are collected in the intermediate ink chamber. Therefore, such flow path resistance required for completely preventing the entry of bubbles as before does not exist, and the entry of bubbles into the print head can be prevented without increasing the flow path resistance.

Also, according to the invention, the holding member for holding the ink guide member is made up of a plurality of protrusion members extending radially from the side wall of the communication hole. The protrusion members are placed so that the number of the protrusion members placed on the side of the upward slanting inner wall of the subordinate ink chamber is smaller than that of the protrusion members placed on its opposite side. The bubbles passing through the meniscus formation member and entering the subordinate ink chamber tend to be guided to the side with a smaller number of the protrusion members; such placement causes bubbles to be guided to the side of the slant inner wall and rise along the slope for collection. Thus, the holding member does double duty of holding the ink guide member and guiding bubbles.

Further, according to the invention, the supply part disposed in the subordinate ink chamber is located on the opposite side to the inner wall slanting upward with the connection part to the communication hole between. As described above, bubbles move toward the slanting inner wall by the ink guide member, but the supply part is located on the opposite side to the move direction, whereby the ink flow and the bubble flow can be separated and the mixing of bubbles into the print head can be furthermore decreased.

Still further, according to the invention, in the structure wherein the supply part is disposed on the opposite side to the inner wall slanting upward from the connection part to the communication hole, the wall member hangs between the connection part to the communication hole and the supply part. It can block bubbles attempting to move to the connection part, decreasing the mixing of bubbles into the print head. Of course, the wall member can also be applied to the above-mentioned ink supply units.

Still further, according to the invention, the wall face

between the connection part to the communication hole and the supply part is also slanted upward from the supply part, whereby bubbles entering from the supply part can also be moved along the slant wall face for collection. Particularly, in the construction allowing the ink supply unit to be separated from a recorder, when the ink supply unit is attached to the recorder, bubbles can be taken into the ink supply unit from the supply part by a pressurization force at the attachment above and other objects and features of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings.
time for decreasing the air amount into the print head.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Figure 1 is a sectional view showing a first embodiment of an ink supply unit of the invention;
Figure 2 is a perspective view in section showing the first embodiment of the ink supply unit of the invention;
Figure 3 is a plan view of a communication passage top face in the first embodiment of the ink supply unit of the invention;
Figure 4 is a perspective view for explaining an ink guide member retainer in the first embodiment of the ink supply unit of the invention;
Figure 5 is a sectional view showing a second embodiment of an ink supply unit of the invention;
Figure 6 is a plan view of a communication passage top face showing a modified example in the first and second embodiments of the ink supply unit of the invention;
Figure 7 is a plan view of a communication passage top face showing another modified example in the first and second embodiments of the ink supply unit of the invention;
Figure 8 is a perspective view showing a state before a print head unit is attached in an example of a carriage to which the ink supply unit of the invention is attached;
Figure 9 is a perspective view showing a state before the ink supply unit is attached in the example of the carriage to which the ink supply unit of the invention is attached;
Figure 10 is a perspective view showing a state of the carriage after the ink supply unit of the invention is attached;
Figure 11 is a sectional view showing the state of the carriage after the ink supply unit of the invention is attached;
Figure 12 is an external view showing one example of a recorder; and
Figure 13 is a sectional view showing a third embodiment of an ink supply unit of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the accompanying drawings, a description will be given in detail of preferred embodiments of the invention.

Figure 1 is a sectional view showing a first embodiment of an ink supply unit of the invention. Figure 2 is a perspective view in section showing the first embodiment of the ink supply unit of the invention. Figure 3 is a plan view of a communication passage top face in the first embodiment of the ink supply unit of the invention. Figure 4 is a perspective view for explaining an ink guide member retainer in the first embodiment of the ink supply unit of the invention. In the figures, numeral 1 is an ink tank, numeral 2 is a main ink chamber, numeral 3 is a capillary member, numeral 4 is an intermediate ink chamber, numeral 5 is a communication passage, numeral 6 is an atmospheric communication port, numeral 7 is a communication hole, numeral 8 is a first meniscus formation member, numeral 9 is an ink guide member, numeral 10 is a second meniscus formation member, numeral 11 is a joint port, numeral 12 is an absorption material, numeral 13 is ink guide member retainers, and numeral 14 is a joint outer peripheral portion. This embodiment shows an ink supply unit of separation type from a print head. In Figure 2, the side wall on the front and the capillary member 3 are excluded.

The ink tank 1 contains the main ink chamber 2 and the intermediate ink chamber 4 on the side thereof. A material which has rigidity and is good in ink resistance for enabling long-term ink holding is selected for the cabinet of the ink tank 1. The ink tank 1 is connected to a print head (not shown) at the joint port 11. Ink in the main ink chamber 2 passes through the communication passage 5 and is supplied via the joint port 11 to the print head.

The communication hole 7 is made in the bottom of the main ink chamber 2, which communicates with the intermediate ink chamber 4 and the joint port 11 via the communication passage 5. The communication hole 7 can be shaped in cross section like a circle, an ellipse, a polygon, a star, a cross, a slit, or the like. The bottom face of the main ink chamber 2 is formed as a slope such that the communication hole 7 is the lowest part.

The capillary member 3 is placed in the main ink chamber 2 for holding ink by a capillary force and maintaining negative pressure. It can be made of a fiber material having a two-dimensional structure, a porous material having a three-dimensional structure, felt comprising a fiber material spun into a three-dimensional form, a nonwoven cloth material, or the like. Specifically, for example, polyester felt comprising polyester fibers spun into a three-dimensional form or a filling material comprising polyester fibers bundled in one direction can be used as the material of the capillary member 3. A material having a density of 0.04 g/cm^3-0.1 g/cm^3 can be used; a material having a density of the order of such value is preferred from the viewpoints of the capillary

force and fluid resistance with respect to ink. The material is not limited to polyester fibers and any other material can be used in accordance with ink if it has a proper capillary force and resists ink.

The surrounding shape of the capillary member 3 is the same as the inside shape of the main ink chamber 2 and the capillary member 3 is inserted into the main ink chamber 2 so that the surroundings of the former come in intimate contact with the side walls of the latter, thereby preventing air introduced from the atmospheric communication hole 6 from entering the main ink chamber 2 along the side walls thereof. The bottom face of the capillary member 3 is formed with a slope having a larger lean than the lean α of the slope made on the bottom face of the main ink chamber 2. Further, only the portion of the capillary member 3 coming in contact with the first meniscus formation member 8 is formed convexly. The capillary member 3 of such a shape is inserted into the main ink chamber 2 so as to come in contact with the whole bottom face of the main ink chamber 2. Then, it is crushed particularly on the first meniscus formation member 8 and the density of the capillary member 3 raises, and lowers gradually with distance from the first meniscus member 8, thereby furthermore blocking air attempting to pass through between the inner face of the main ink chamber 2 and the capillary member 3 and enter the main ink chamber 2 for decreasing the amount of air arriving at the surface of the first meniscus formation member 8 in a state in which ink remains in the main ink chamber 2. A structure wherein the capillary member 3 is not pressed into contact with the first meniscus formation member 8 is also possible, but the capillary member 3 needs at least to be in contact with the first meniscus member 8.

The atmospheric communication port 6 through which the capillary member 3 can communicate with the atmosphere is made in the top of the main ink chamber 2. In the embodiment, the diameter of the atmospheric communication port 6 is made larger than the hole of the capillary member 3 or the gap between fibers. The capillary member 3 communicates with the atmosphere on the top and is released with the atmospheric pressure. When ink is supplied to the print head, the ink in the capillary member 3 is pressed by the atmospheric pressure and is derived from below the capillary member 3 to the communication passage 5 by negative pressure, so that it can be used efficiently. At this time, the negative pressure in the print head is held constant by the capillary force of the capillary member 3. The atmospheric communication port 6 can also be provided with a sheet not passing ink and allowing air to pass through so that ink do not jump out of the atmospheric communication hole 6. Alternatively, it can also be formed with a large number of minute holes through which ink does not flow out.

The first meniscus formation member 8 is placed on the communication hole 7 made in the bottom face of the main ink chamber 2. The bottom of the capillary member 3 is pressed into contact with the first meniscus formation member 8 for placement. The first meniscus formation member 8 can use a mesh substance such as a wire net or resin net, a porous substance, etc., for example. A metal mesh filter, a filter using as a base material a substance comprising metal fibers, for example, SUS fine wires formed like felt and further compressed and sintered, an electro forming metal filter, etc., can be used as specific examples of the mesh substance. For example, a filter of a knitted item of metal or resin fibers like tatami twill or a filter having a highly precise hole diameter made by laser beam machining, electron beam machining, etc., can be used. The form is a circle, a rectangle, or any other form if it can cover the communication hole 7.

When the capillary member 3 is impregnated with ink, the ink passes through the first meniscus formation member 8 and moves to the intermediate ink chamber 4. The first meniscus formation member 8 also prevents unnecessary air from entering the intermediate ink chamber 4 if the capillary member 3 becomes empty of ink. When the ink is furthermore consumed, air coming in through the atmospheric communication port 6 passes through the capillary member 3, pushes meniscuses of ink covering the minute holes made in the first meniscus formation member 8 in contact with the capillary member 3 by an increase in negative pressure in the main ink chamber 2, overcomes the surface tension, and passes through the meniscuses, forming bubbles. The bubbles moves through the communication passage 5 to the intermediate ink chamber 4. The pressure when the bubbles occur (bubble point pressure) depends on the filter particle size of the first meniscus formation member 8. The filter particle size is made optimum, whereby the negative pressure in the ink tank 1, namely, the ink supply pressure to the print head can be held constant. The filter particle size of the first meniscus formation member 8 can range from 40 μm to 70 μm or so, for example.

The ink guide member 9 is placed on the lower face of the first meniscus formation member 8 so as to come in contact with the lower face. It has a cross-sectional dimension smaller than the diameter of the communication hole 7. If bubbles build up on the lower face of the first meniscus formation member 8 and an air layer is formed or the main ink chamber 2 becomes empty of ink and the ink level becomes lower than the height of the communication passage 5, the ink guide member 9 sucks up the ink from the bottom of the communication passage 5 and supplies it to the first meniscus formation member 8, whereby the first meniscus formation member 8 can always be kept in a wet condition and negative pressure can be maintained, whereby the best condition can be maintained until all ink is consumed. The ink guide member 9 may be of any form like a slit, a rectangular parallelopiped, a prism such as a triangle pole, a cylinder, or an elliptic cylinder. More than one ink guide member 9 can also be provided. The ink guide member 9 may be made of any material if the material is capable of pulling up ink to the first meniscus formation member

8 by a capillary force; for example, a filling material comprising polyester fibers bundled in one direction, a porous member of polyurethane, melamine foam, etc., or a two- or three-dimensional fiber structure can be used.

As described above, the ink guide member 9 has a cross section dimension smaller than the diameter of the communication hole 7 so as not to close the communication hole 7 and further extends to the bottom of the communication passage 5. Thus, it is very unstable without any measures and may fall down due to vibration, etc., at the manufacturing or operating time. If the ink guide member 9 falls down, no ink is supplied to the first meniscus formation member 8 and the ink tank 1 becomes unable to be used before ink in the intermediate ink chamber 4 is all consumed.

To circumvent such a problem, the ink guide member 9 is held by a plurality of ink guide member retainers 13 extending in the center direction of the communication hole 7 from the side wall thereof, as shown in Figures 3 and 4. Here, three ink guide member retainers 13 are placed as one example. From the viewpoint of pressing the ink guide member 9, it is desirable to form the ink guide member retainers 13 so as to press the ink guide member 9 as long as possible in the length direction thereof. However, to provide the ink flow path, a gap is made between the retainer 13 and the bottom of the communication passage 5. To retain the strength, the ink guide member retainers are also extended to the top face of the communication passage 5 together with the side wall of the communication hole 7. Further, to guide bubbles occurring on the joint port 11 side of the communication hole 7 and bubbles entering through the joint port 11 to the intermediate ink chamber 4, the ink guide member retainers 13 are formed so as not to come in contact with the side walls of the communication passage 5 for providing a bubble flow path. Specifically, when the ink guide member 9 is about 7 mm long, the ink guide member retainer 13 is set to about 5 mm long and the spacing between the retainer 13 and the bottom of the communication passage 5 can be set to about 2 mm. The thickness is set to about 0.5 mm and to ensure the strength, a reasonable width is provided within the communication passage 5. The ink guide member retainers 13 can be molded integrally with the cabinet of the ink tank 1.

To dispose the ink guide member retainers 13, a larger number of the retainers 13 may be placed on the side of the joint port 11 and a smaller number of the retainers 13 may be placed on the side of the intermediate ink chamber 4. Here, one is placed on the side of the intermediate ink chamber 4 and two are placed on the side of the joint port 11 so that the angle between the ink guide member retainer 13 placed on the side of the intermediate ink chamber 4 and the ink guide member retainers 13 placed on the side of the joint port 11 becomes 130° and that the angle between the ink guide member retainers 13 placed on the side of the joint port 11 becomes 100°. Bubbles occurring in the communication hole 7 enter the communication passage 5 through wide spaces between the ink guide member retainers 13. Thus, a smaller number of the ink guide member retainers 13 are disposed on the side of the intermediate ink chamber 4, whereby more bubbles enter the side of the intermediate ink chamber 4 and move to the intermediate ink chamber 4 along the slope of the communication passage 5 described below. In contrast, a larger number of the ink guide member retainers 13 are placed on the side of the joint port 11, whereby the entry of bubbles into the joint port 11 side of the communication passage 5 can be decreased. Thus, ink and bubbles can be well separated by adjusting the placement of the ink guide member retainers 13.

The intermediate ink chamber 4, the main ink chamber 2, and the joint port 11 are made to communicate with each other in order via the communication passage 5. As shown in Figure 1, the upper wall of the communication passage 5 is slanted so as to gradually raise toward the intermediate ink chamber 4 from the communication passage 7, whereby bubbles occurring in the communication hole 7 can be moved smoothly to the intermediate ink chamber 4. Although the bottom of the communication passage 5 may be level, in the embodiment only the section connecting the intermediate ink chamber 4 and the main ink chamber 2 is formed as a slope to reduce the remaining ink amount as much as possible. The joint port 11 may be made at the lowest part of the communication passage 5.

As described above, the bubbles occurring in the communication hole 7 through the first meniscus formation member 8 move to the intermediate ink chamber 4 along the slant top face of the communication passage 5. The bubble move direction at this time is a direction toward the intermediate ink chamber 4 from the communication hole 7. On the other hand, the move direction of ink supplied to the print head is a direction toward the joint port 11 from the communication hole 7. Since the bubble move direction and the ink move direction are opposite to each other, the ink and bubbles can be reliably separated for lessening the mixing of bubbles into the print head in conjunction with the ink guide member retainers 13.

The intermediate ink chamber 4 is filled with ink in the initial state. Bubbles passing through the first meniscus formation member 8 from the main ink chamber 2 and entering the communication passage 5 are collected. The intermediate ink chamber 4 may be sized to enable collection of bubbles entering on rare occasion by the time the main ink chamber 2 becomes empty of ink; it can be made of a small chamber. To collect bubbles, the top face of the intermediate ink chamber 4 needs to be formed so as to become above the communication hole 7 of the main ink chamber 2.

The amount of bubbles collected in the intermediate ink chamber 4 does not much increase while the capillary member 3 holds ink, but if the ink held in the capillary member 3 runs out and air enters through the first meniscus formation member 8 as bubbles, the

amount of collected bubbles increases rapidly. Thus, if the ink held in the capillary member 3 runs out, the liquid level in the intermediate ink chamber 4 lowers rapidly. At least a part of the intermediate ink chamber 4 is formed of a transparent substance and lowering of the ink level is sensed, whereby a condition in which the ink tank 1 becomes almost empty of ink can be detected. Of course, the entire ink tank 1 can also be formed of a transparent or semitransparent substance. Various methods such as a visual inspection method and an optical detection method can be used to detect the ink level. A reference line can also be made for convenience of visual inspection.

The joint port 11 is formed with the second meniscus formation member 10 and the absorption material 12 in order. In a state in which the ink tank 1 is detached and left standing, surface tension of ink formed in minute holes made in the second meniscus formation member 10 prevents ink in the intermediate ink chamber 4 and the communication passage 5 from leaking from the joint port 11. When the ink tank 1 is attached to a recorder, air remaining in the joint port 11 due to pressure at the attaching time is passed through an ink film of the second meniscus formation member 10 and is moved to the intermediate ink chamber 4. Thus, the mixing of bubbles into the print head can be reduced. Further, when the ink tank 1 is attached, the second meniscus formation member 10 prevents vibration and shock applied to the ink tank 1, pressure fluctuation caused by acceleration, and the mixing of bubbles from the nozzles of the print head. A filter using as a base material an SUS mesh or a substance comprising SUS fine wires formed like felt and further compressed and sintered, a metal or resin fiber knitted item, etc., can be used as a material of the second meniscus formation member 10 like the first meniscus formation member 8. The filter particle size of the second meniscus formation member 10 is determined by the interfacial tension with used ink and the wet angle as well as the designed bubble point pressure. Specifically, it can range from 5 μm to 60 μm or so. The bubble point pressure in the second meniscus formation member 10 may be set to such a degree that internal ink does not leak and air does not enter with the ink tank 1 detached.

The absorption material 12 disposed in the joint port 11 prevents ink deposited on the joint port 11 from dropping when the ink tank 11 is detached. A material excellent in ink absorption power is used as the absorption material 12; for example, it can be made of a sponge, a filling material comprising polyester fibers bundled in one direction, or the like. It is desirable that the absorption material 12 is low in flow path resistance.

The joint outer peripheral portion 14 of the joint port 11 is shaped at the tip like a convexity. For example, a donut-shaped elastic member is placed in the connection portion of the print head (not shown) to the joint port 11 corresponding to the portion with which a joint outer peripheral portion 19 of the ink tank 1 comes in contact. The joint outer peripheral portion 14 is pressed against the elastic member, thereby sealing the ink flow path in the connection part for preventing ink leakage in the portion.

Next, the operation in the first embodiment of the ink supply unit of the invention will be discussed. In the initial state, the main ink chamber 2 is filled with ink to the limit of ink that can be held by the capillary force of the capillary member 3. It is desirable as the use start condition that the main ink chamber 2 is filled with ink as much as possible from the viewpoint of ink use efficiency. However, the capillary member 3 requires a reasonable portion filled with no ink to generate negative pressure by the capillary force of the capillary member 3. The intermediate ink chamber 4 is filled with ink. In the description to follow, the initial state of ink pressure in the print head can be set to -20 mmH_2O, for example. In the initial state before the ink supply unit is attached, the ink pressure is provided by the capillary force of the capillary member 3 for holding ink. Ink in the intermediate ink chamber 4 and the communication passage 5 also becomes negative pressure, which is held by an ink interface formed in the minute holes of the second meniscus formation member 10. Before use, an airtight seal can be put on the joint port 11 and the atmospheric communication port 6. In this state, the ink tank 1 is packaged. To use the ink tank 1, the airtight seal is peeled off before the ink tank 11 is attached to a recorder.

When the ink tank 1 is attached, some air may remain in the joint port 11. The remaining air pushes the ink interface formed on the second meniscus formation member 10 by pressure at the ink supply unit attachment time and enters the communication passage 5 as bubbles. The bubbles entering the communication passage 5 pass through beside the ink guide member retainer 13 and move along the slant of the top face of the communication passage 5 by the buoyant force of the bubbles themselves and are collected in the intermediate ink chamber 4.

When printing is started after the ink tank 1 is attached, ink is consumed at the print head. Then, air as much as the consumed ink gradually spreads into the capillary member 3 from the atmospheric communication port 6. As the ink held in the capillary member 3 decreases, the water head of ink decreases and negative pressure gradually increases, but hovers within the allowable range. Even if the ink lessens, it can be supplied at stable negative pressure by the capillary force of the capillary member 3. The ink held in the capillary member 3 moves smoothly through the first meniscus formation member 8 to the communication passage 5.

In ink supply at the normal print operation, air entering through the atmospheric communication port 6 attempts to enter the first meniscus formation member 8 along the side wall of the main ink chamber 2, but a very small quantity of air arrives at the surface of the first meniscus formation member 8 because of press into contact with the capillary member 3 on the bottom face of the main ink chamber 2. If slight air arrives at the sur-

face of the first meniscus formation member 8, it remains trapped on the first meniscus formation member 8 and ink continues to move. If bubbles mixed in the ink pass through the capillary member 3 and air comes in contact with the top face of the first meniscus formation member 8, it also remains trapped on the first meniscus formation member 8 and ink continues to move by setting the filter particle size of the first meniscus formation member 8 finer than that of the capillary member 3. The ink move from the main ink chamber 2 to the intermediate ink chamber 4 is made until the ink held in the capillary member 3 is almost consumed.

As maintenance operation to avoid nozzle clogging, etc., ink may be sucked from the nozzle tips in a state in which bubbles are trapped on the surface of the first meniscus formation member 8. In this case, since the ink is forcibly sucked from the nozzle tips, a larger negative pressure than usual occurs. When a large amount of ink is consumed as in printing all over, negative pressure may become larger than usual. At such time, bubbles trapped on the surface of the first meniscus formation member 8 are pulled into the communication passage 5 together with ink through the minute holes on rare occasion. The bubbles pulled into the communication passage 5 side of the first meniscus formation member 8 grow together with other bubbles, overflow the communication hole 7, and move along the slant top face of the communication passage 5 to the intermediate ink chamber 4 by the buoyant force of the bubbles, then are collected in the upper part of the intermediate ink chamber 4. If the face of the first meniscus formation member 8 on the communication passage 5 side is covered with bubbles, negative pressure is held by the surface tension of the ink interface formed in the minute holes of the first meniscus formation member 8.

When the ink held in the capillary member 3 is almost consumed, air comes in contact with the top of the first meniscus formation member 8. In this state, the minute holes of the first meniscus formation member 8 are formed with ink interface or ink meniscuses. As the ink is furthermore consumed, negative pressure gradually increases. When a given negative value (bubble point pressure of ink determined by the filter particle size of the first meniscus formation member 8) is applied to the first meniscus formation member 8, fine bubbles of air occur on the communication passage 5 side of the first meniscus formation member 8 through the ink interface or ink meniscuses formed on the first meniscus formation member 8. The fine bubbles move along the slope of the communication passage 5 to the inside of the intermediate ink chamber 4 by the buoyant force of the bubbles. At this time, a smaller number of the ink guide member retainers 13 are placed on the side of the intermediate ink chamber 4, whereby more bubbles move to the side of the intermediate ink chamber 4 and further move along the slant of the top face of the communication passage 5, whereby the bubbles are smoothly moved to the intermediate ink chamber 4. The bubbles moved to the intermediate ink chamber 4 remain therein gradually. The subsequent ink dynamic pressure is controlled by the first meniscus formation member 8 and is held almost constant until ink runs out.

After the ink held in the capillary member 3 runs out, both faces of the first meniscus formation member 8 are exposed to air. That is, the main ink chamber 2 side of the first meniscus formation member 8, when the main ink chamber 2 becomes empty of ink, is exposed to air introduced through the atmospheric communication port 6. The communication passage 5 side of the first meniscus formation member 8, where a minute air layer is formed by bubbles entering via the first meniscus formation member 8, is also exposed to air. However, the ink guide member 9 sucks up the ink in the communication passage 5 to the first meniscus formation member 8 for always holding the first meniscus formation member 8 in a wet condition. Thus, the first meniscus formation member 8 is continuously formed with an ink film and the negative pressure control operation after bubbles occur is performed effectively. The ink guide member 9, which is pressed by the ink guide member retainers 13, is held in contact with the first meniscus formation member 8. Thus, the pressure is controlled to stable ink supply pressure until the ink in the intermediate ink chamber 4 and the communication passage 5 almost runs out.

By the way, if an environmental change such as an external pressure or temperature change occurs, the atmospheric pressure received by the capillary member 3 from the atmospheric communication port 6 is the same as that received by the nozzle tips of the print head 1. Thus, even if the atmospheric pressure changes, the pressure balance is kept and the effect is small. If air is collected in the intermediate ink chamber 4, the collected air expands or shrinks as the external temperature or pressure changes. If the air in the intermediate ink chamber 4 shrinks, negative pressure rises, thus the change is canceled by similar operation to that performed when ink is consumed. If the air in the intermediate ink chamber 4 expands, ink in the intermediate ink chamber 4 and the communication passage 5 is absorbed by the capillary member 3 through the first meniscus formation member 8 and the negative pressure in the communication passage 5 is kept. In either case, however, the intermediate ink chamber 4 contains a small amount of air and the volume of the main ink chamber 2 is far larger than that of the intermediate ink chamber 4, thus no problem arises.

Figure 5 is a sectional view showing a second embodiment of an ink supply unit of the invention. Parts identical with those previously described with reference to Figure 1 are denoted by the same reference numerals in Figure 5. In the second embodiment, the top face of the section from a joint port 11 of a communication passage 5 to a first meniscus formation member 8 is also made a slope. That is, the top face of the communication passage 5 is formed so as to gradually rise from the joint port 11 to an intermediate ink chamber 4. For example, when an ink tank 1 is attached to a

recorder, as described above, air in the connection part of the ink tank 1 and the recorder enters through the joint port 11 as bubbles. The bubbles entering the communication passage 5 float to the top face of the communication passage 5 by the buoyant force of the bubbles themselves. Since the top face of the communication passage 5 becomes a slope to the intermediate ink chamber 4, the bubbles move along the slope to the intermediate ink chamber 4 and are collected therein. Although ink guide member retainers 13 hang from the top face of the communication passage 5 on the way, the bubbles pass through between the side face of the communication passage 5 and the ink guide member retainer 13 and move to the intermediate ink chamber 4.

Most of the bubbles entering from the main ink chamber 2 are guided to the intermediate ink chamber 4 by the ink guide member retainers 13 as described above, but bubbles also occur on the side of the joint port 11. These bubbles cannot move in the direction of the joint port 11 because the top face of the communication passage 5 descends toward the joint port 11; in contrast, the bubbles move to the intermediate ink chamber 4 through the gap between the ink guide member retainer 13 and the side wall of the communication passage 5.

Thus, according to the second embodiment of the invention, the bubbles entering through the communication hole 7 or the joint port 11 are moved to the intermediate ink chamber 4, so that no bubbles remain in the vicinity of the joint port 11 and the mixing of bubbles into a print head can be prevented.

Figure 6 is a plan view of a communication passage top face showing a modified example in the first and second embodiments of the ink supply unit of the invention. Parts similar to those previously described with reference to Figure 1 are denoted by the same reference numerals in Figure 6 and will not be discussed again. In Figure 6, numeral 15 is a wall, which hangs from the top face of a communication passage 5 in the surroundings of the joint port 11 side of a communication hole 7. The bottom end of the wall 15 is not in contact with the bottom face of the communication passage 5, providing a gap therebetween used as an ink flow path.

In the first and second embodiments, the bubbles occurring on the bottom face of the first meniscus formation member 8 occur not only on the intermediate ink chamber 4 side, but also on the joint port 11 side. The wall 15 prevents the bubbles occurring on the joint port 11 side from moving toward the joint port 11. In Figure 6, the wall 15 is placed so as to couple two ink guide member retainers 13 disposed on the joint port 11 side, improving mutual strength. However, the wall 15 is not limited to the form and can also be formed as an independent protrusion. Of course, it may be molded integrally with the cabinet of the ink tank 1. In the first embodiment and the modified example, three ink guide member retainers 13 are placed, but two or four or more retainers can also be placed.

Figure 7 is a plan view of a communication passage top face showing another modified example in the first and second embodiments of the ink supply unit of the invention. Parts similar to those previously described with reference to Figure 6 are denoted by the same reference numerals in Figure 7. In the first and second embodiments, the ink guide member 9 is inserted between the ink guide member retainers 13 when the ink tank 1 is assembled. However, in addition, for example, the ink guide member 9 can also be attached directly to the first meniscus formation member 8 for use as an assembly of the first meniscus formation member 8 and the ink guide member 9, or the first meniscus formation member 8 and the ink guide member 9 can also be integrally molded of the same material, in which case the ink guide member 9 can be made unnecessary. At this time, as shown in Figure 7, a structure wherein a wall 15 is hung from the top face of a communication passage 5 in the surroundings of the joint port 11 side of a communication hole 7 can be adopted to guide bubbles overflowing the communication hole 7 to an intermediate ink chamber 4.

Bubbles entering the communication passage 5 from a main ink chamber 2 are suppressed in a move in the direction of the joint port 11 and promoted in a move to the intermediate ink chamber 4. Thus, the mixing of bubbles into a print head through the joint port 11 can be prevented. Since ink toward the joint port 11 moves between the wall 15 and the bottom face of the communication passage 5, the ink flow is not hindered. Further, bubbles entering through the joint port 11 pass through between the wall 15 and the side wall of the communication passage 5 and move to the intermediate ink chamber 4; no bubbles remain in the vicinity of the joint port 11.

Figures 8 to 10 are perspective views showing an example of a carriage to which the ink supply unit of the invention is attached. Figure 11 is a sectional view. In the figures, numeral 21 is a carriage, numeral 22 is a print head unit, numeral 23 is an ink tank, numeral 24 is a shaft hole, numeral 25 is a guide plate receptacle, numeral 26 is an opening, numeral 27 is a protrusion receptacle, numeral 28 is a plate spring, numeral 29 is a print head retaining lever, numeral 30 is a print head abutment part, numeral 31 is contact pins, numeral 32 is an ink tank retainer, numeral 33 is a protrusion, numeral 34 is a print head fixing part, numeral 35 is boards, numeral 36 is ink guide parts, numeral 37 is a black head, numeral 38 is a color head, numeral 39 is a fit part, numeral 40 is a shaft, numeral 41 is a spring, numeral 42 is a contact board, numeral 43 is a connector, numeral 44 is a position sensor, and numeral 45 is a timing fence.

The carriage 21 is formed with the shaft hole 24 and the guide plate receptacle 25 so as to be movable by a main shaft and a guide plate of the main unit of a recorder. To incorporate the print head unit 22 into the carriage 21, the carriage 21 is formed with the opening 26 at the center, the protrusion receptacles 27 on both side walls, and the plate spring 28 on the rear bottom

face. As shown in Figure 11, the print head retaining lever 29 is fixed on both ends pivotably to the shaft 40 and is energized by the spring 41. When the print head unit 22 is attached to the carriage 21, the print head retaining lever 29 presses the print head unit 22 slantingly against the print head abutment part 30 and energizes it in the Z direction and -Y direction in the figures, as indicated by the heavy arrow in Figure 11. When the print head unit 22 is attached, the print head abutment part 30 abuts the print head fixing part 34 of the print head unit 22 for positioning the print head unit 22. In Figure 8, a part of the print head retaining lever 29 is cut away so that the internal print head abutment part 30 can be seen.

As shown in Figure 11, the contact board 42 is disposed in the rear of the carriage 21 and is electrically connected to the recorder main unit by a flexible cable, etc. The connector is attached to the contact board 42. The contact pins 31 of the connector 43 are provided for electric connection to the print head unit 22 and supplying power and various signals supplied from the recorder main unit to the print head unit 22. The contact board 42 further includes the position sensor 44 for detecting a mark put on the timing fence 45.

The ink tank retainer 32 is fitted in the fit part 39 of the ink tank 23 for locking the ink tank 23. The ink tank 23 is pressed against the ink guide part 36 of the print head unit 22 by the press force of the ink tank retainer 32 for sealing the connection part of the print head unit 22 for liquid communication. A dent as wide as the width of the fit part 39 is made in the proximity of the ink tank retainer 32 and the fit part 39 is inserted into the recess, thereby positioning in the X direction and -Y direction in the figures.

The print head unit 22 is provided with ink guide parts 36 connected liquidly to ink tanks 23 for receiving supplied ink for each color. Here, ink guide parts 36 for receiving black ink and ink of other three colors are disposed. Black ink received at the corresponding ink guide part is supplied to the black head 37 and ink of other colors received at the corresponding ink guide parts is supplied to the color head 38. The black head 37 and the color head 38 comprise a large number of nozzles arranged in the Y direction in the figures. With the black head 37, all arranged nozzles can be used for recording in black. With the color head 38, the arranged nozzles are separated into three groups and the nozzles in each group are used for recording in the corresponding color. Unused nozzles may be provided. On the other hand, the print head unit 22 is provided with the boards 35 on which drive circuits for driving the black head 37 and the color head 38 are mounted. The boards 35 are electrically connected to the contact pins 31 of the carriage 21. Here, two boards are provided corresponding to the heads. The boards can be made of, for example, metal and are also used as heat sinks for heat radiation of the black head 37 and the color head 38. The print head unit 22 are formed with the protrusions 33 on side faces and the print head fixing part 34 on the top for use when the print head unit 22 is attached to the carriage 21. The protrusions 33 are fitted into the protrusion receptacles 27 of the carriage 21 for holding and positioning the print head unit 22. The print head fixing part 34 abuts the print head abutment part 30 of the carriage 21 and is pressed and fixed by the print head retaining lever 29.

To attach the print head unit 22 to the carriage 21, the print head retaining lever 29 is lifted up and pivoted and the print head unit 22 is inserted into the carriage 21 from the top thereof so that the black head 37 and the color head 38 of the print head unit 22 are exposed from the opening 26 of the carriage 21. At this time, it can be inserted slightly slantingly for easy insertion. The protrusions 33 of the print head unit 22 are inserted into the protrusion receptacles 27 of the carriage 21 and abut the deepest parts for positioning the front side of the print head unit 22. Further, the print head fixing part 34 of the print head unit 22 is abutted against the print head abutment part 30 of the carriage 21 and the print head retaining lever 29 is released for pressing the carriage 21 in the Z direction and -Y direction by the energy of the print head retaining lever 29. The force directions at this time are indicated by the heavy arrows in Figure 11. On the other hand, the print head unit 22 is placed on the plate spring 28 of the carriage 21 and is energized in the -Z direction by the elastic force of the plate spring 28 for fixing the print head unit 22 in conjunction with the print head retaining lever 29.

Further, the contact pins 31 of the carriage 21 are electrically connected to a contact section (not shown) of the print head unit 22. At this time, for stable electric connection, the contact pins 31 require a press force against the contact section of the print head unit 22. The reaction force of each contact pin 31 at this time requires about 80 gf. For example, if 15 signal lines exist, the reaction force of the contact pins 31 requires about 1.2 kgf in total. After the protrusions 33 of the print head unit 22 are inserted into the protrusion receptacles 27 of the carriage 21, the print head unit 22 is fixed by the print head retaining lever 29, whereby the contact section of the print head unit 22 is pressed by a given force by the contact pins 31 for providing stable electric coupling. In Figure 11, the press force by the contact pins 31 is indicated by the heavy arrow.

Generally, to position and incorporate one part, it is known that the most stable composition is accomplished by positioning at three points on the first reference plane, positioning at two points on the second reference plane, and positioning at one point on the third reference plane. In the example, the print head fixing part 34 of the print head unit 22 and the print head abutment part 30 of the carriage 21 are used for positioning and the protrusions 33 on both sides of the print head unit 22 and the protrusion receptacles 27 on both sides of the carriage 21 are used for positioning with respect to the Y direction by using the press force of the print head retaining lever 29 and the reaction force of the contact pins 31. The print head retaining lever 29

generates a force in a direction forming an angle of about 30° from the Z direction to the -Y direction for pressing the print head unit 22 in the Z direction and -Y direction for securing the abutment between the print head fixing part 34 of the print head unit 22 and the print head abutment part 30 of the carriage 21 for positioning and for pressing the protrusions 33 of the print head unit 22 against the lowest parts of the protrusion receptacles 27 of the carriage 21 for positioning in the Z direction. The protrusions 33 of the print head unit 22 are stably pressed against the protrusion receptacles 27 of the carriage 21 in the Y direction by the reaction force of the contact pins 31 for positioning in the Y direction in the parts. Thus, precise positioning is performed in the Y and Z directions. Positioning in the X direction is performed by the protrusions 33 and the side faces of the carriage 21.

Figure 9 shows a state in which the print head unit 22 is incorporated in the carriage 21. After the print head unit 22 is incorporated, the ink tanks 23 are attached. Here, a black ink tank and ink tanks of other three colors are attached. The ink tanks shown in the embodiments discussed above can be used as the ink tanks. Each ink tank 23 is formed with the fit part 39. To attach the ink tank 23, it is inserted into a predetermined position with the holding part of the ink tank 23. Then, the fit part 39 of the ink tank 23 is fitted into the ink tank retainer 30 of the carriage 21 and the ink tank 23 is pressurized in the Z direction with respect to the print head unit 22. The joint port made in the bottom face of the ink tank 23 is pressed against the corresponding ink guide part 36 of the print head unit 22 by the pressurization force for defining a sealed ink flow path.

The front lower part of the ink tank 23 abuts the front of the carriage 21 for positioning in the Y direction. The positioning in the Y direction is also performed by means of a wall formed at the depth of the ink guide part 36 of the print head unit 22 and a recess made in the proximity of the ink tank retainer 30 of the carriage 21. Further, positioning in the X direction is performed by means of a partition disposed surrounding the ink guide part 36 of the print head unit 22 and a recess made in the proximity of the ink tank retainer 30 of the carriage 21. In the example, the ink tank 23 is also pressed and fixed by a nail disposed on the face of the carriage 21 facing the bottom face of the ink tank 23. Figure 10 shows a state in which four ink tanks 23 are attached.

Figure 12 is an external view showing an embodiment of a recorder. In the figure, numeral 51 is a recorder, numeral 52 is a lower case, numeral 53 is an upper case, numeral 54 is a tray insertion slot, numeral 55 is a dip switch, numeral 56 is a main switch, numeral 57 is a paper receptacle, numeral 58 is a panel console, numeral 59 is a manual insertion slot, numeral 60 is a manual tray, numeral 61 is an ink tank insertion lid, numeral 62 is an ink tank, numeral 63 is a paper feed roller, numeral 64 is a paper tray, numeral 65 is an interface cable, and numeral 66 is memory cards.

A cabinet of the recorder 51 mainly consists of the upper case 52 and the lower case 53, wherein electric circuitry, drive parts, etc., (not shown) are housed. The lower case 52 is provided with the tray insertion slot 54 through which the paper tray 64 storing record paper is inserted for loading paper into the recorder 51.

The dip switch 55 and the main switch 56 are fitted to the lower case 52. The dip switch 55 is used to set a part of the operation of the recorder 51 and is assigned function settings less frequently changed. When not used, the dip switch 55 is covered with a cover. The main switch 56 is a switch for turning on and off the power of the recorder 51. The lower case 52 is further provided with an interface connector (not shown), insertion slots of the memory cards 56, etc. The interface cable 65 is connected to the interface connector for transferring data to and from an external computer, etc. The memory card 66 is used as an extended memory when the recorder 51 operates; it may store font for use at the recording time.

The upper case 53 is formed with the paper receptacle 57 for discharging recorded paper. It is also provided with the panel console 58 comprising input means frequently used for the user to set a record mode and give commands of paper feed, paper discharge, etc., display means of messages from the printer, and the like. Further, the manual insertion slot 59 and the manual tray 60 are provided, enabling the user to manually feed paper from here.

The upper case 53 is also provided with the ink tank insertion lid 61. The user can attach or detach the internal ink tank 62 by opening the lid. The ink supply units of the invention as shown in the embodiments discussed above can be used for the ink tanks 62. Here, four ink tanks are attached. As shown in Figures 8 to 11, the print head unit is fitted to the carriage and further the ink tanks 62 are attached.

Sheets of paper stored on the paper tray 64 are taken out one by one and transported by an internal transport system (not shown) and fed along the circumference of the paper feed roller 63. The record head (not shown) to which the ink tank 62 is attached moves in a direction perpendicular to the paper transport direction for recording data for each strip area. The sheet of paper is fed to the record position of the next strip area in the length direction of the sheet by the paper feed roller 63. This operation is repeated for recording data on the sheet. Then, the sheet is discharged to the paper receptacle 57 of the upper case 53.

In Figures 8 to 12, we have discussed the example for using black and other three colors for recording. However, the invention is not limited to the example and three colors except black may be used or five or more ink supply channels may be used. Of course, the invention can also be applied to a monochrome recorder. Further, print heads can also be provided in a one-to-one correspondence with colors in addition to the 2-head composition of the black head 37 and the color head 38 shown in Figures 8 to 11.

Figure 13 is a sectional view showing a third

embodiment of an ink supply unit of the invention. Parts identical with or similar to those previously described with reference to Figure 1 are denoted by the same reference numerals in Figure 13 and will not be discussed again. In Figure 13, numeral 71 is a print head and numeral 72 is a supply passage. The embodiment shows an example in which the print head 71 and an ink tank 1 are of one-piece construction.

The print head 71 is surrounded by a heat sink (not shown) to which the print head 71 is fitted, a printed wiring board (not shown) for supplying an electric signal to the print head 71, etc. The print head 71 is formed with a large number of nozzles (not shown) at a high density. For example, 128 nozzles can be formed at a density of 300 spi. Each nozzle is provided with a heating element (not shown) for generating bubbles upon energization for jetting ink drops. In Figure 13, ink drops are jetted downward.

The inside of the ink tank 1 is divided into a main ink chamber 2 and an intermediate ink chamber 4. The intermediate ink chamber 4 in the embodiment is used as an ink storage chamber rather than an ink chamber for only collecting unnecessary bubbles as in the first and second embodiments. Thus, it can be formed so as to have a size equal to or larger than the main ink chamber 2. In the first and second embodiments, the ink tank 1 can store only the ink amount almost as much as the ink amount that can be held by the capillary member 3 in the main ink chamber 2. In the third embodiment, however, the intermediate ink chamber 4 can store almost 100% ink, so that the entire volume efficiency of the ink tank 1 can be improved.

In the embodiment, ink is supplied from the intermediate ink chamber 4 via the supply passage 72 to the print head 71. That is, a communication passage 5 only connects a communication hole 7 made in the lower part of the main ink chamber 2 and the intermediate ink chamber 4. The top face of the communication passage 5 is formed so as to rise gradually from the communication hole 7 to the intermediate ink chamber 4 as in the first and second embodiments, whereby bubbles entering through a first meniscus formation member 8 from the main ink chamber 2 move along the slope of the communication passage 5 to the intermediate ink chamber 4 and are collected on the top of the intermediate ink chamber 4. In this structure, the bubble move direction is the same as the ink move direction, but the bubbles float to the top of the intermediate ink chamber 4 by the buoyant force of the bubbles before arriving at the supply passage 72. Thus, the bubbles are scarcely mixed into the print head 71.

Further, a plurality of ink guide member retainers 13 are provided for supporting an ink guide member 9 so that a smaller number of the ink guide member retainers 13 are placed on the side of the intermediate ink chamber 4 and that a larger number of the retainers 13 are placed on the opposite side, thereby ensuring connection of the ink guide member 9 and the first meniscus formation member 8 and guiding the bubbles entering from the main ink chamber 2 to the intermediate ink chamber 4.

A second meniscus formation member 10 is disposed in the connection part of the communication passage 5 and the supply passage 72, but has only a filter function of preventing pressure change by vibration or shock applied to the ink tank 1 or acceleration and the mixing of bubbles from the nozzles of the print head 31, removing dust, etc., because the print head 71 and the ink tank 1 are not separated. Since no ink tanks are attached or detached, an absorption material 12 does not have an ink absorption function and only removes final dust, bubbles, etc. Either or none of the second meniscus formation member 10 and the absorption material 12 can be provided.

The operation of the third embodiment of the ink supply unit of the invention is similar to the operation after the ink tanks are attached in the first or second embodiment. In the third embodiment, a connection part like a joint part does not exist at an intermediate point of the ink flow path from the main ink chamber 2 to the print head 31, so that air or dust is not mixed at attachment or detachment and good recording can be executed. In a state in which the ink supply unit is detached from a recorder, negative pressure is kept on a balance between the capillary force of the nozzles made in the print head 31 and that of a capillary member 3 in the main ink chamber 2 and trouble such as ink leakage does not occur.

Since the intermediate ink chamber 4 has a large volume and a large amount of air is also collected therein in the structure of the third embodiment, if an environmental change such as an external pressure or temperature change occurs, internal air expands or shrinks and the effect cannot be ignored. The operation when such an environmental change occurs will be discussed briefly.

First, when the intermediate ink chamber 4 is filled with ink and ink is supplied from the main ink chamber 2, the atmospheric pressure received by the capillary member 3 from an atmospheric communication port 6 is the same as that received by the nozzle tips of the print head 71. Thus, even if the atmospheric pressure changes, the pressure balance is kept and the effect is small.

Next, an example wherein an air layer is formed in the intermediate ink chamber 4 will be considered. When the external pressure falls or the external temperature rises, the volume of the air layer on the top of the intermediate ink chamber 4 expands and therefore the negative pressure value in the intermediate ink chamber 4 attempts to become relatively small. Thus, ink in the intermediate ink chamber 4 passes through the first meniscus formation member 8 via the communication hole 7 and is absorbed by the capillary member 3 in the main ink chamber 2, whereby the differential pressure between the pressure in the intermediate ink chamber 4 and the atmospheric pressure is kept and ink does not leak.

When the external pressure rises or the external temperature falls, the air layer on the top of the intermediate ink chamber 4 shrinks and therefore the negative pressure value in the intermediate ink chamber 4 attempts to become relatively large. In this case, as with the ink consumption time, air passes through the capillary member 3 from the atmospheric communication port 6 and further passes through the first meniscus formation member 8 and is introduced via the communication hole 7 into the intermediate ink chamber 4, whereby the differential pressure within the intermediate ink chamber 4 is kept constant. When the main ink tank 2 contains ink, a move of ink to the intermediate ink chamber 4 occurs for keeping the negative pressure in the intermediate ink chamber 4. In either case, ink does not leak.

The third embodiment shows the one-piece construction of the ink supply unit and print head different from the first or second embodiment, but the ink supply unit and print head in the first or second embodiment can also be formed as one-piece construction.

As seen from the description given so far, according to the invention, the entry of bubbles into the print head can be prevented without increasing flow path resistance for recording with good picture quality. Since the ink guide member is pressed by the ink guide member retainers and ink is reliably supplied to the meniscus formation member, a problem wherein the ink guide member falls down and it is made impossible to consume all ink in the intermediate ink chamber is solved. Further, placement of the ink guide member is adjusted or a wall is provided, thereby suppressing a move of bubbles to the print head and preventing image quality degradation by the entry of bubbles into the print head for providing a stable and high image quality.

The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and modifications and variations are possible in light of the above teachings or may be acquired from practice of the invention. The embodiment was chosen and described in order to explain the principles of the invention and its practical application to enable one skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto, and their equivalents.

Claims

1. An ink supply unit for supplying ink to a print head, comprising:

   a main ink chamber formed with an atmospheric communication port and a communication hole for supplying ink;

   a capillary member being housed in said main ink chamber for holding ink;

   a meniscus formation member being disposed on said communication hole, placed in contact with said capillary member, and formed with a plurality of minute holes;

   a subordinate ink chamber having a supply part being connected to said communication hole for supplying ink to the print head and an inner wall slanting upward from the connection part to said communication hole;

   an ink guide member being made of a porous member in contact with a bottom face of said meniscus formation member and extending toward a bottom of said subordinate ink chamber; and

   a holding member for holding said ink guide member.

2. An ink supply unit as claimed in claim 1 wherein said holding member is made up of a plurality of protrusion members extending radially from a side wall of said communication hole and being placed so that the number of said protrusion members placed on a side of the upward slanting inner wall of said subordinate ink chamber is smaller than that of said protrusion members placed on its opposite side.

3. An ink supply unit as claimed in claim 2 wherein said supply part is disposed on an opposite side to the upward slanting inner wall with the connection part to said communication hole between.

4. An ink supply unit as claimed in claim 2 further comprising a wall member hanging between the connection part to said communication hole and said supply part.

5. An ink supply unit as claimed in claim 1 wherein a gap is defined between said holding member and the bottom of said supply part.

6. An ink supply unit as claimed in claim 1 wherein said holding member are formed so as not to come in contact with the side walls of said supply part for providing a bubble flow path.

7. An ink supply unit for supplying ink to a print head comprising a main ink chamber formed with an atmospheric communication port and a communication hole for supplying ink, a capillary member being housed in said main ink chamber for holding ink, a meniscus formation member being disposed on said communication hole, placed in contact with said capillary member, and formed with a plurality of minute holes, a subordinate ink chamber being formed with a supply part being connected to said communication hole for supplying ink to the print head and having an inner wall on an opposite side to said supply part with the connection part to said

communication hole between slanting upward from the connection part to said communication hole, an ink guide member being made of a porous member in contact with a bottom face of said meniscus formation member and extending toward a bottom of said subordinate ink chamber, and a wall member hanging between the connection part to said communication hole and said supply part.

8. An ink supply unit as claimed in claim 3 or 7 wherein a wall face between the connection part to said communication hole and said supply part slants upward from said supply part.

9. An ink recording apparatus comprising:

a print head;

an ink supply unit for supplying ink to said print head, said ink supply unit comprising:

a main ink chamber formed with an atmospheric communication port and a communication hole for supplying ink;

a capillary member being housed in said main ink chamber for holding ink;

a meniscus formation member being disposed on said communication hole, placed in contact with said capillary member, and formed with a plurality of minute holes;

a subordinate ink chamber having a supply part being connected to said communication hole for supplying ink to the print head and an inner wall slanting upward from the connection part to said communication hole;

an ink guide member being made of a porous member in contact with a bottom face of said meniscus formation member and extending toward a bottom of said subordinate ink chamber; and

a holding member for holding said ink guide member.

10. An ink recording apparatus as claimed in claim 9 wherein said holding member is made up of a plurality of protrusion members extending radially from a side wall of said communication hole and being placed so that the number of said protrusion members placed on a side of the upward slanting inner wall of said subordinate ink chamber is smaller than that of said protrusion members placed on its opposite side.

11. An ink recording apparatus as claied in claim 10 wherein said supply part is disposed on an opposite side to the upward slanting inner wall with the connection part to said communication hole between.

12. An ink recording apparatus as claimed in claim 10 further comprising a wall member hanging between the connection part to said communication hole and said supply part.

13. An ink recording apparatus as claimed in claim 11 wherein a wall face between the connection part to said communication hole and said supply part slants upward from said supply part.

FIG. 1

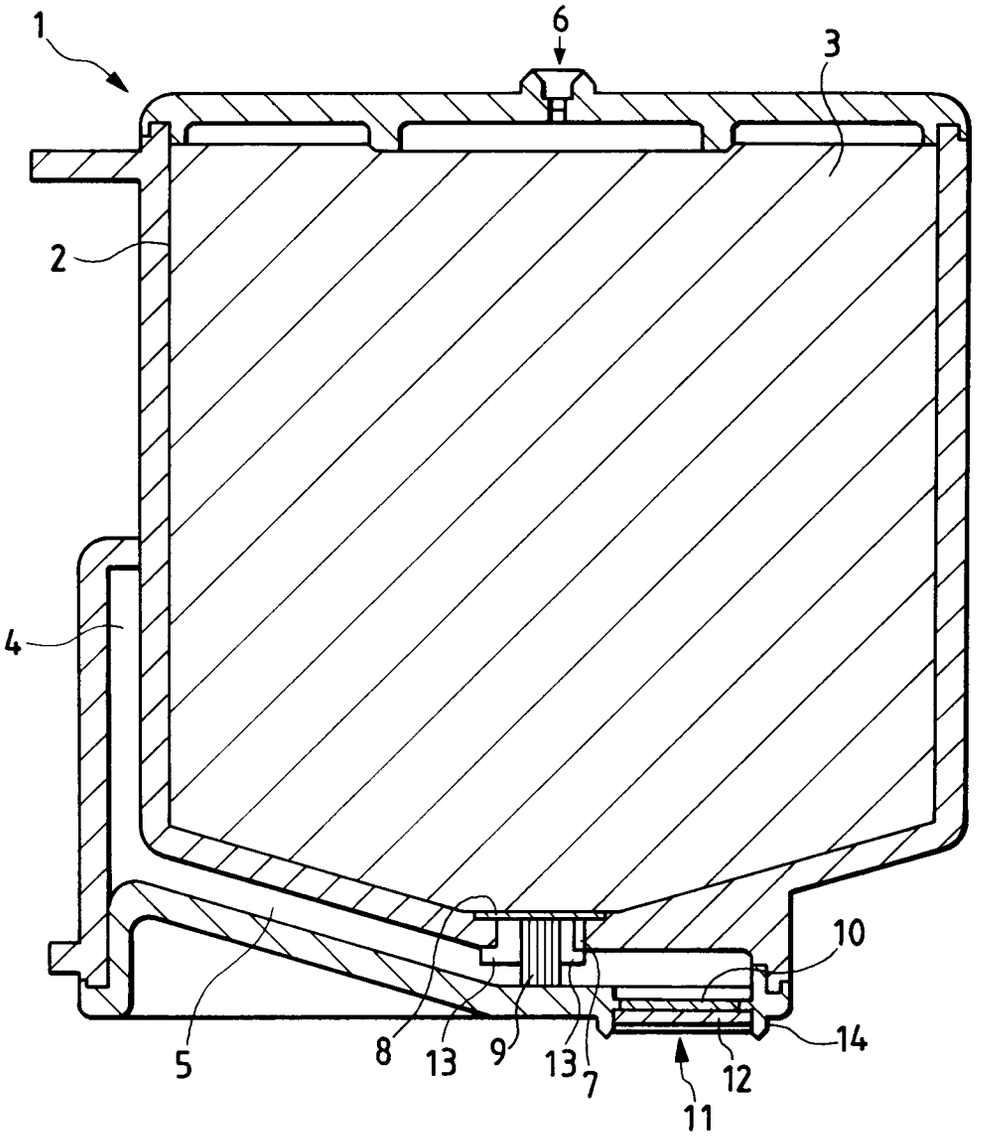

FIG. 3

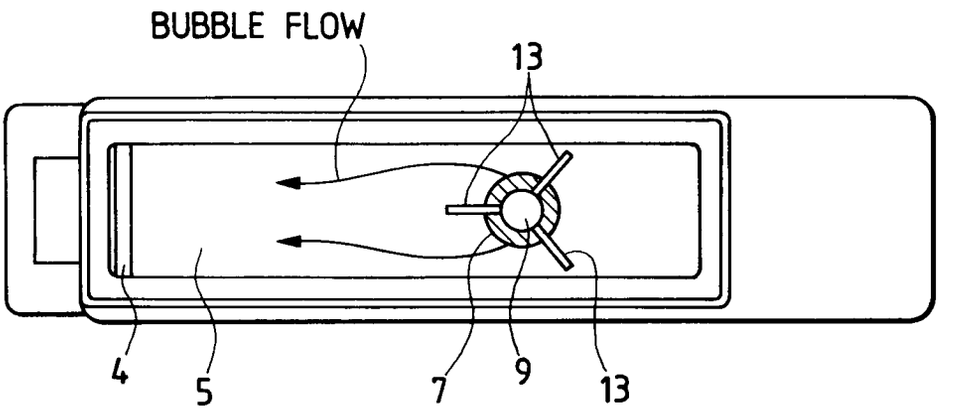

FIG. 2

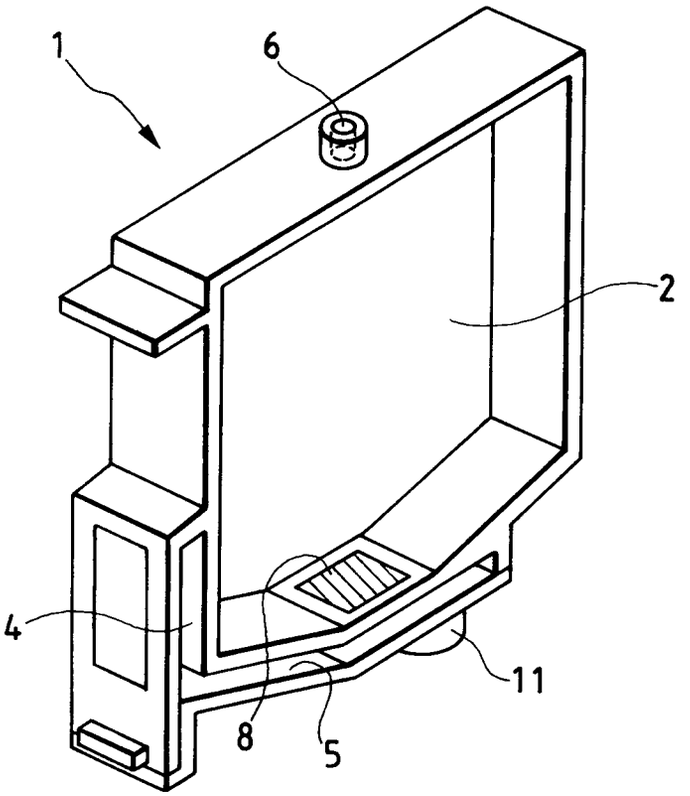

FIG. 4

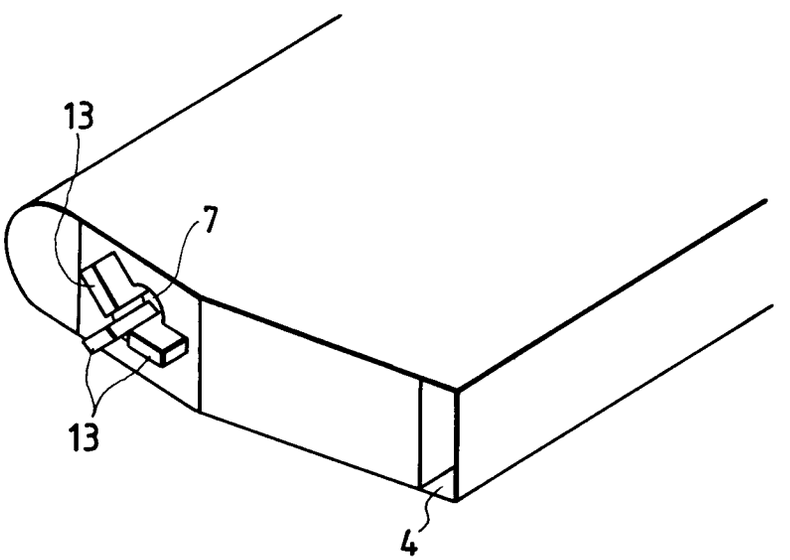

FIG. 5

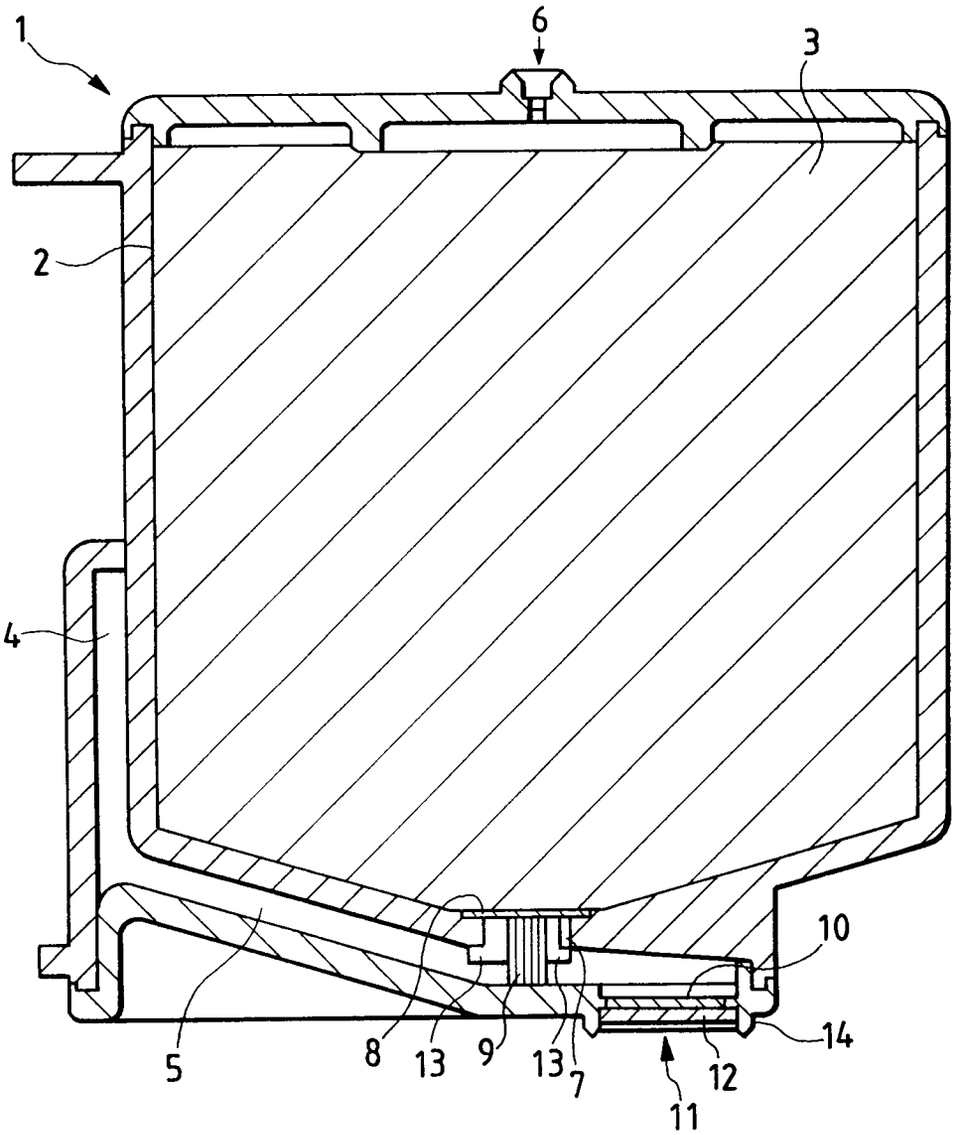

FIG. 6

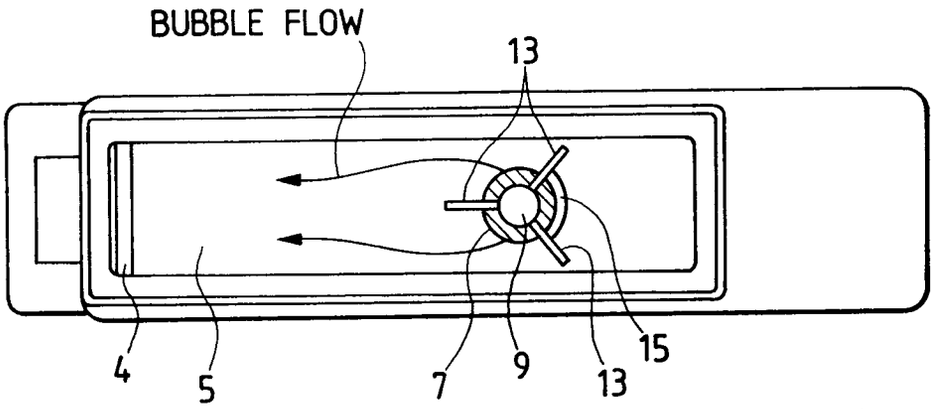

FIG. 7

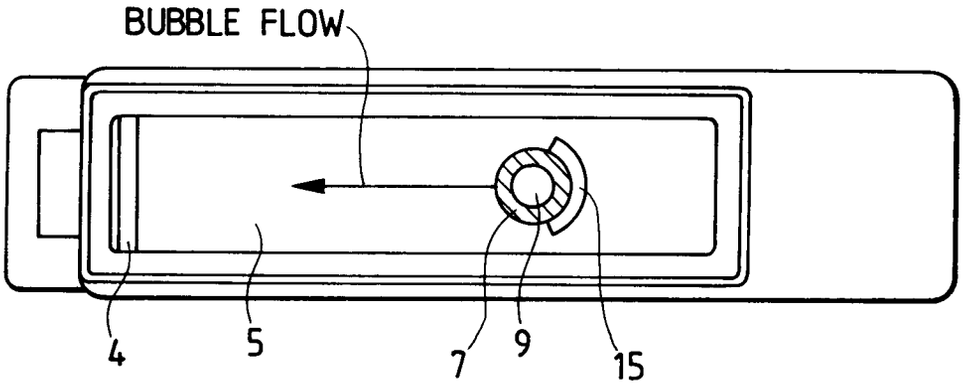

FIG. 10

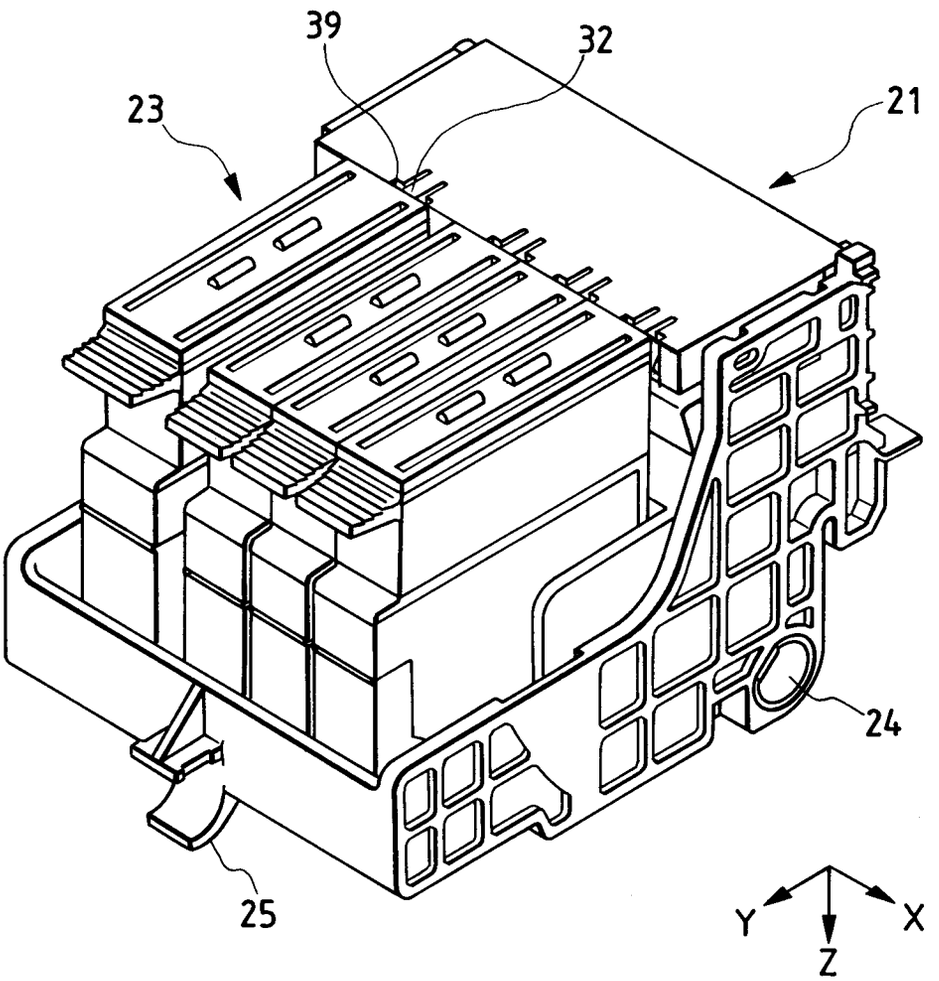

FIG. 8

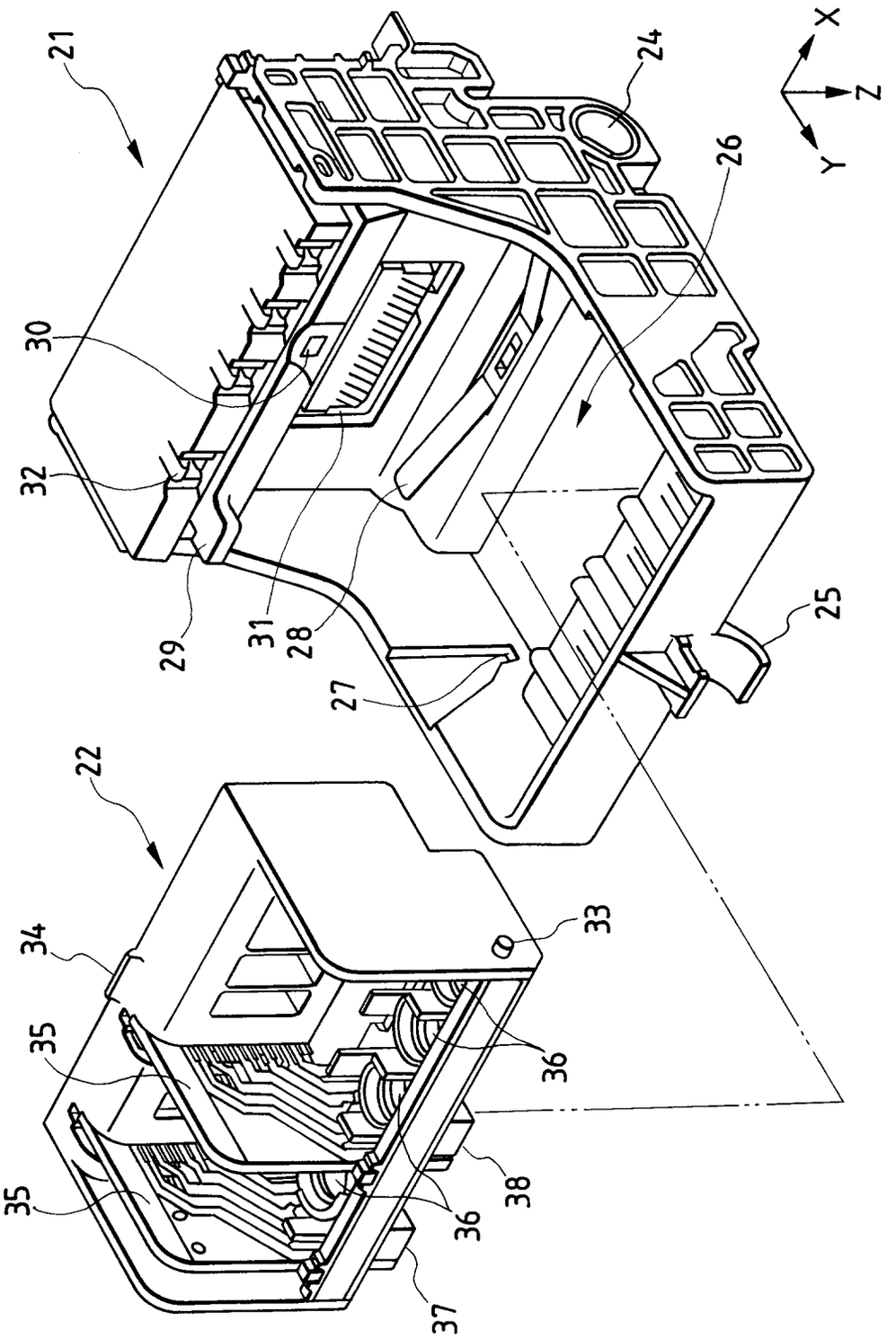

FIG. 9

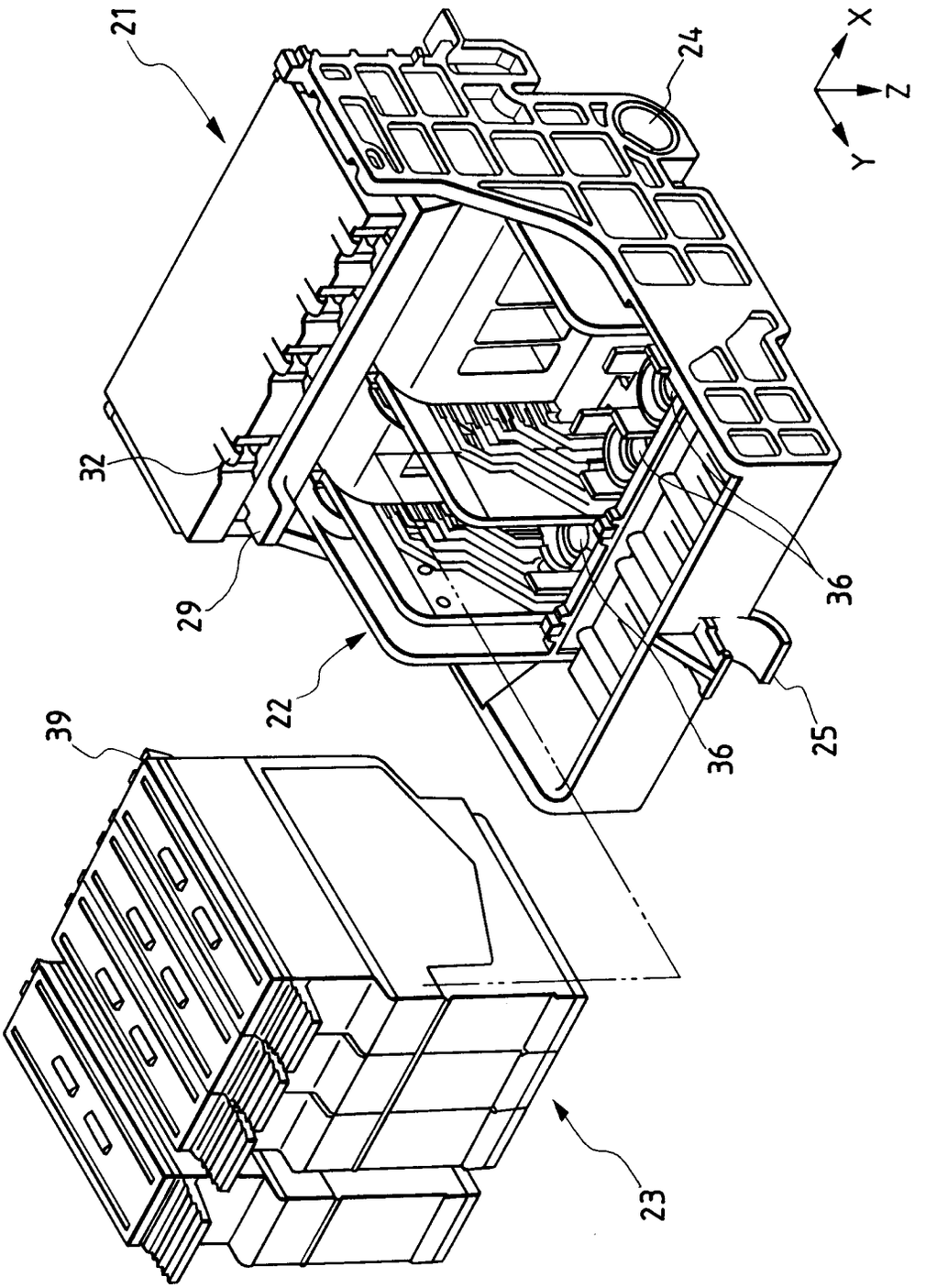

FIG. 11

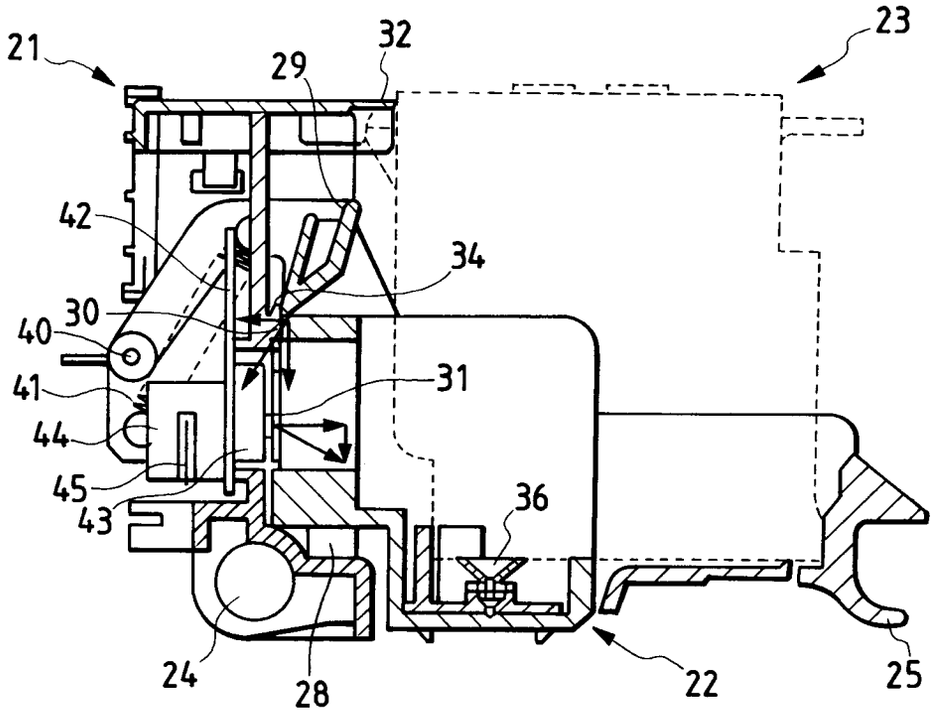
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FIG. 12

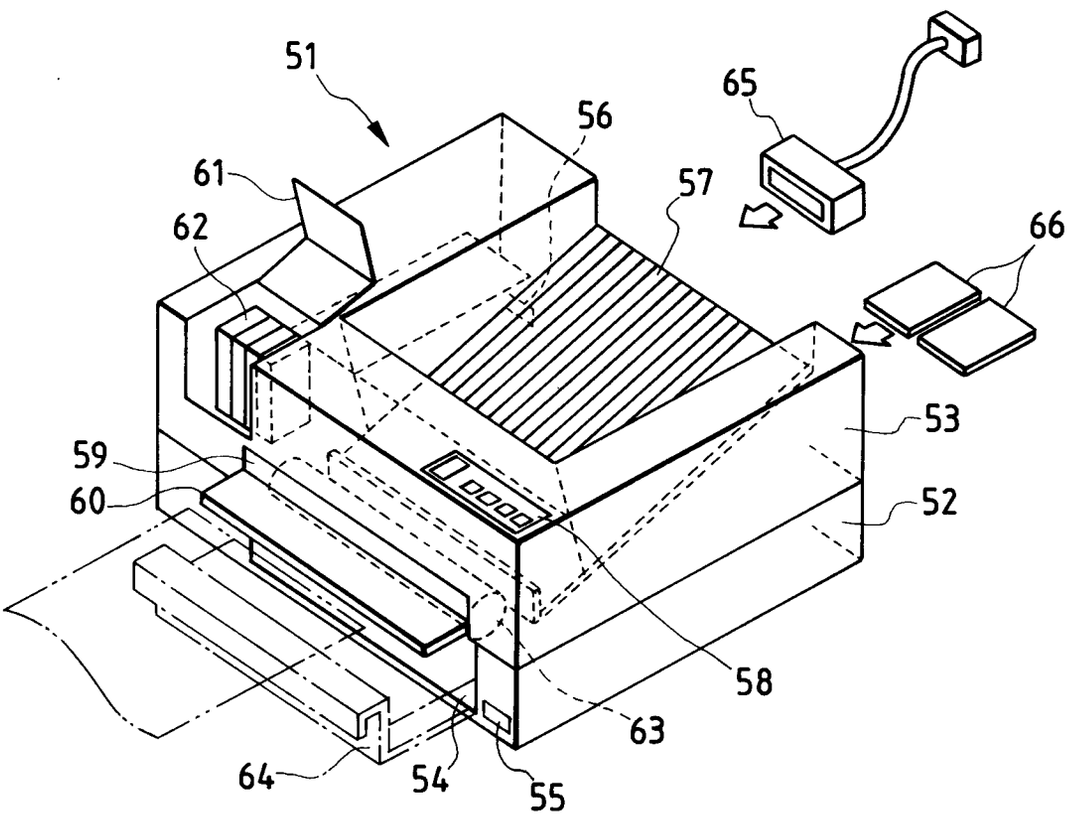
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FIG. 13