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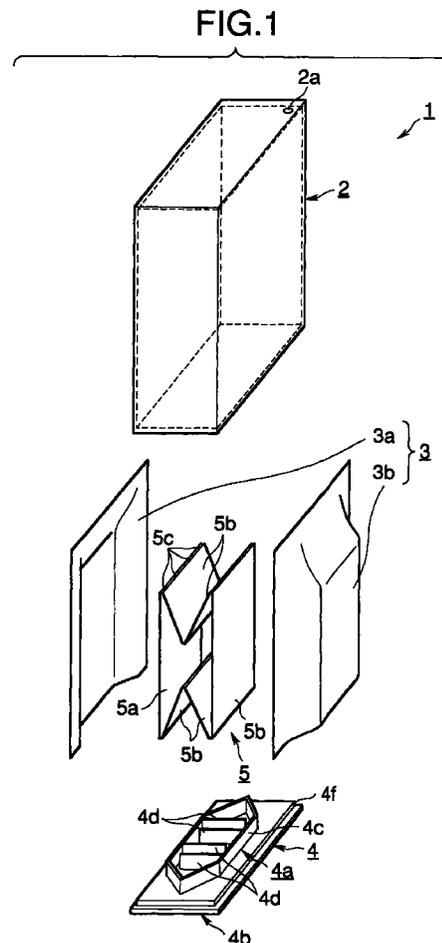
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(54) Ink container

(57) An ink container (1, 51) has an ink-holding space (9a, 89) maintained at substantially constant negative pressure until the ink contained in the ink-holding space (9a, 89) has been exhausted. The ink container (1, 51) includes a flexible wall (3, 55) and an urging member (5, 59, 76). The flexible wall (3, 55) forms a part of the ink-holding space (9a, 89) and the outer surface of the flexible wall (3, 55) is exposed to the atmospheric pressure. The urging member (5, 59, 76) takes the form of, for example, a spring. The urging member (5, 59, 76) is incorporated in the ink-holding space (9a, 89) and urges the flexible wall (3, 55) outwardly of the ink-holding space (9a, 89). The atmospheric pressure is exerted on the flexible wall (3, 55) so that the flexible wall (3, 55) is displaceable inwardly of the ink-holding space (9a, 89) as the ink is supplied from the ink-holding space (9a, 89) to an external device. The urging member (5, 59, 76) operates substantially in a plastic deformation region thereof.



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Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to an ink container that is kept at a pressure lower than the atmosphere to hold ink.

DESCRIPTION OF THE RELATED ART

[0002] With ink containers for use in on-demand type ink jet printers, various constructions have been proposed for maintaining the interior of the ink container at a negative pressure with respect to the atmospheric pressure. One such conventional ink container is of the construction that an ink absorbing material is accommodated in the ink container and the negative pressure of the ink absorbing material serves to hold ink therein. However, this construction is not effective in utilizing a limited space of the container. One of the most effective constructions appears to be one that the ink container is sealed against the atmosphere and a negative pressure in the container serves to hold ink in the container.

[0003] Constant negative pressure in the ink container is one of the important characteristics required of this type of ink container. However, the negative pressure in the ink container varies in accordance with the remaining amount of ink and environmental conditions such as temperature and atmospheric pressure. Therefore, a variety of constructions for the negative-pressure type ink container have been proposed in order to maintain as constant a negative pressure as possible.

[0004] For example, Japanese patent Preliminary Publication KOKAI No. 6-226993 discloses a liquid ink cartridge that includes an ink container with a pair of resilient side walls. The ink container accommodates a metal spring therein, which urges the side walls from the inner side to the outside of the ink container. The inside of the ink container is maintained at a negative pressure. With ink containers of the construction, the resilient side walls deform inwardly to compress the spring as the ink is supplied to an external device, thereby gradually decreasing the volume of the ink container. Thus, the construction does not allow air to enter the ink container from outside, thereby significantly reducing effects of the environmental changes such as temperature and atmospheric pressure on the negative pressure in the ink container.

[0005] With the aforementioned conventional ink container, the spring simply deforms resiliently. When the side walls exert forces on the spring in such a direction as to compress the spring, the force of the spring acting on the side walls proportionally increases. If the negative pressure increases beyond a predetermined value, the ink is sucked inwardly too strongly, so that the ink cannot be ejected properly or not ejected at all.

[0006] One of the solutions to this problem is to reduce the spring constant of the spring, thereby decreasing changes in negative pressure. However, this approach requires a large initial deformation of the spring in order to achieve an initial negative pressure of the ink container. Therefore, the volume of the ink container cannot be effectively used.

SUMMARY OF THE INVENTION

[0007] An object of the invention is to provide an ink container whose ink-holding space is maintained at a substantially constant negative pressure until the ink contained in the ink-holding space has been exhausted.

[0008] An ink container (1, 51) has an ink-holding space (9a, 89) which holds ink (89) therein. The pressure in the ink-holding space is held negative with respect to an atmospheric pressure. The ink container includes a flexible wall (3, 55) and an urging member (5, 59, 76). The flexible wall (3, 55) forms a part of the ink-holding space. The urging member takes the form of, for example, a spring. The urging member (5, 59, 76) is incorporated in the ink-holding space and urges the flexible wall (3, 55) outwardly of the ink-holding space. An atmospheric pressure is exerted on the flexible wall (3, 55) so that the flexible wall (3, 55) is displaceable inwardly of the ink-holding space as the ink is supplied from the ink-holding space to an external device. The urging member (5, 59, 76) operates substantially in a plastic deformation region thereof.

[0009] Another ink container includes a frame (52, 84), a flexible wall (55), and an urging member (59, 77). The frame (52, 84) defines an ink-holding space which holds ink (89) therein. The pressure in the ink-holding space is held negative with respect to an atmospheric pressure. The flexible wall (55) forms a part of the ink-holding space and one side thereof receives the atmospheric pressure. The flexible wall (55) has a periphery (56) securely assembled to the frame to close the ink-holding space. The flexible wall (55) is displaced inwardly of the ink-holding space as the ink (89) is supplied from the ink-holding space to an external device. The urging member (59, 77) is incorporated in the ink-holding space and urges the flexible wall (55) outwardly of the ink-holding space. The urging member (59, 77) is substantially in a plastic deformation region thereof.

[0010] Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present invention will become more fully understood from the detailed description given herein-below and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Fig. 1 is an exploded perspective view of an ink container according to a first embodiment;

Fig. 2 is a cross-sectional view of the ink container of the first embodiment before the ink container is mounted to the ink jet head;

Fig. 3 is a cross-sectional view of the ink container mounted to the ink jet head, after some of the ink has been used;

Fig. 4 illustrates the spring of the first embodiment when expanded into a sheet;

Fig. 5 illustrates the spring of the first embodiment when assembled into a three dimensional structure;

Figs. 6 and 7 illustrate the characteristics of the spring the first embodiment;

Fig. 8 illustrates changes in the negative pressure of the ink container as the ink is supplied from the ink container to an external ink path;

Fig. 9 is an exploded perspective view of an ink container according to a second embodiment;

Fig. 10 is an illustrative diagram of a spring of the second embodiment before it is folded into a structure;

Figs. 11A-11C are a top view, a side view, and a front view of the spring of the second embodiment, respectively;

Figs. 12 and 13 illustrates the properties of the spring of the second embodiment;

Figs. 14 and 15 are cross-sectional views of an ink outlet path according to the second embodiment;

Figs. 16-18 are cross-sectional views of the ink container, illustrating the operation of the ink container;

Fig. 19 illustrates changes in the negative pressure of the ink container according to the second embodiment as the ink is supplied from the ink container to an external ink path;

Fig. 20 illustrates a part of an ink container according to a third embodiment;

Fig. 21 is a cross-sectional view of the ink container of the third embodiment;

Fig. 22 is an exploded perspective view of an ink container according to a fourth embodiment;

Fig. 23A illustrates a spring of the fourth embodiment as it is stamped from a sheet material;

Fig. 23B is a fragmentary cross-sectional view taken along the lines 23B-23B of Fig. 23A;

Figs. 24A-24C are a top view, a front view, and a side view of the spring of the fourth embodiment, respectively;

Figs. 25-27 are cross-sectional views illustrating the

operation of the ink container according to the fourth embodiment;

Fig. 28 is an exploded perspective view of an ink container according to a fifth embodiment; and

Fig. 29 is a cross-sectional view of the ink outlet path of the ink container of Fig. 28.

DETAILED DESCRIPTION OF THE INVENTION

[0012] Embodiments of the present invention will be described in detail with reference to the accompanying drawings.

First embodiment

[0013] Fig. 1 is an exploded perspective view of an ink container according to a first embodiment of the invention.

[0014] Fig. 2 is a cross-sectional view of the ink container before the ink container is mounted to the ink jet head.

[0015] Fig. 3 is a cross-sectional view of the ink container mounted to the ink jet head, after some of the ink has been used.

[0016] Referring to Fig. 1, an ink container includes a tank cover 2, and an ink bag 3 accommodated in the ink tank cover 2, and a tank base 4.

[0017] The ink bag 3 includes ink bag elements 3a and 3b. The ink bag elements 3a and 3b are made of a film on which aluminum is vapor-deposited, or of a multilayer film that contains aluminum. The elements 3a and 3b are placed together in such a way that the ink bag elements 3a and 3b oppose each other to define a space therebetween having an opening at one end. The elements 3a and 3b are, for example, heat-welded together at their three sides for liquid tight seal. The ink bag 3 incorporates a spring 5 therein. The spring 5, which will be described later in detail, abuts inner surfaces of the opposed side walls of the ink bag elements 3a and 3b to urge the side walls in directions as to increase the volume of the ink bag 3. The opening of the ink bag 3 is connected to a tank base 4.

[0018] The tank base 4 has two opposed surfaces, one 4a of which forming an inner surface 4a of the ink bag when the ink bag 3 has been assembled to the tank base, and the other 4b of which being exposed to the environment. Walls 4c rise from the inner surface 4a over which the ink bag 3 fits. Walls 4d also rise from the inner surface 4a to support the spring 5 thereon. The tank base 4 is formed with a through-hole 4e therein through which the interior of the ink bag 3 communicates with the environment, and a filter 6 (Fig. 2) placed on the inner surface 4a to close the through-hole 4e. The tank base 4 has an ink-filling hole, not shown, through which ink is filled after assembly of the ink container. After filling the ink, the ink-filling hole is closed by a sealing cap. Then, a small amount of the ink is drawn through the through-hole 4e so that the spring 5 is

deformed. Thereafter, the packing 8 is placed and is fixedly retained by the annular flange 4g. The ink bag 3 holds ink 9 therein and the ink 9 is supplied from the ink container 1 through the filter 6.

[0019] When the tab 8a is pulled outwardly in a direction shown by arrow A, the through hole 4e opens.

[0020] The tank base 4 is formed with a stepped portion 4f all around the tank base 4 so that a tank cover 2 fittingly engages the tank base 4. The tank cover 2 is formed with a hole 2a therein through which air is introduced from the atmosphere as the ink is supplied from the ink container 1 to an external ink path 7.

[0021] The spring 5 will be described in detail with reference to Figs. 4 and 5.

[0022] Fig. 4 illustrates the spring 5 when expanded into a sheet.

[0023] Fig. 5 illustrates the spring 5 when the sheet of Fig. 4 has been assembled into a three dimensional structure.

[0024] As described above, the ink bag 3 holds both the spring 5 and ink 9 therein. The spring 5 is formed of, for example, a stainless steel or the like which is corrosion resistant and occupies a minimum space in the ink bag 3. The spring 5 includes two pressure-receiving members 5a, links 5b, and folded portions 5c that connect the pressure-receiving members 5a and the links 5b together and progressively are deformed as the ink 9 is supplied to the external device. The sheet shown in Fig. 4 is folded at portions 5c as shown in Fig. 5 and ends 5d are connected together at locations 5e by, for example, spot welding or laser welding.

[0025] The folded portions 5c include a plurality of small straps spaced apart by a predetermined distance and connect links 5b to their adjacent links 5b, and flat part 5a to links 5b. Thus, the folded portions 5c have less rigidity than the pressure receiving members 5a and links 5b. When a pressure is exerted on the spring 5 in such directions that the pressure-receiving members 5a are pressed toward each other, the folded portions 5c are further deformed.

[0026] Figs. 6 and 7 illustrate the characteristics of the spring 5 according to the first embodiment. Fig. 7 shows the relationship between the force F applied to the spring 5 and the deformation or compression δ of the spring 5. The spring 5 will be further described with reference to Figs. 6 and 7.

[0027] As shown in Fig. 7, the spring 5 of Fig. 6 exhibits a characteristic represented by straight line A and curve B as the force F applied to the spring 5 is increased. Line A shows that the spring 5 is elastically deformed. In other words, the compression δ is proportional to the force F applied to the spring 5, i.e., $F=k \cdot \delta$ where k is a spring constant. Curve B implies that the spring 5 is in the plastic deformation region and therefore the spring will not regain its original shape after the force F has been removed.

[0028] As is clear from Curve B, the force F is substantially constant in the plastic deformation region irrespec-

tive of the deformation δ . If the force F is gradually decreased at point B1 in the plastic deformation region, the deformation decreases along dot-dash line C. It is to be noted that the spring 5 does not regain its original shape even after the force F has been decreased to zero, leaving a plastic deformation D. In other words, line C shows that the spring 5 still retains some resiliency after the spring 5 has entered its plastic deformation region.

[0029] Further, the force F decreases slightly as the deformation δ increases in the vicinity of point B1 in the plastic deformation region. This occurs for the following reason. The deformation is concentrated on the folded portions 5c. The deformation of the folded portions 5c become larger as the deformation δ increases so that angles between adjacent links 5b greatly varies (Fig. 6). Therefore, the forces act on the pressure-receiving members 5a, links 5b, and folded portions 5c in different ways from when the spring 5 is in the elastic deformation region.

[0030] The magnitudes of deformation δ and the force F at which the spring 5 enters from the elastic deformation region into the plastic deformation region can be adjusted at will by selecting the material and thickness of the spring 5, and the length and width of the folded portions 5c.

[0031] The operation of the ink container with the aforementioned spring built in will be described in terms of the operation of changes in negative pressure with reference to Fig. 8. Fig. 8 illustrates changes in the negative pressure of the ink container as the ink is supplied from the ink container to the external device.

[0032] When the ink bag 3 has just been filled with ink 9, the spring 5 in the ink bag 3 is not compressed yet. After some amount of the ink 9 has been supplied from the ink container 1 to the external device, the ink bag 3 contracts in such a direction as to compress the spring 5. It is assumed in the embodiment that the initial compression of the spring 5 is on line A of Fig. 7, somewhat before the boundary between the elastic deformation region and the plastic deformation region. It is also assumed that the negative pressure of the ink container 1 is initially at point M and moves along curve E of Fig. 8 within a normal ejection region.

[0033] The ink container 1 is coupled to the ink path 7 of the ink jet head and a printing is then performed. The ink bag 3 contracts (Fig. 3) as the remaining amount of the ink 9 decreases, the inner wall surfaces of the ink bag 3 causing the two pressure-receiving members 5a of the spring 5 to move toward each other. At this time, the biasing force of the spring 5 urges the inner wall of the ink bag 3 outwardly against the contraction force of the ink bag 3, thereby maintaining the negative pressure in the ink bag 3. When the ink bag 3 further contracts as a result of continued printing operation, the spring 5 eventually enters the plastic deformation region, i.e., the spring shifts from curve A to curve B.

[0034] The biasing force of the spring 5 becomes

smaller in the plastic deformation region than in the elastic deformation region. The force F in the plastic deformation region decreases only at a slow rate regardless of the deformation δ , so that the negative pressure changes slowly at a minimum rate as shown by curve E.

[0035] If the spring 5 remains in the elastic deformation region shown by curve A in Fig. 7 just as in the conventional art, then the negative pressure will change along the straight portion G of a dash-dash curve in Fig. 8. As the ink bag 3 contracts, the biasing force F of the spring 5 increases proportionally, so that the negative pressure of in the ink container 1 increases more rapidly than curve E. As a result, the negative pressure in the ink container 1 increases beyond the normal ejection region before the ink 9 in the ink bag 3 has been exhausted, leaving some unused ink in the ink bag 3.

[0036] In the aforementioned first embodiment, the spring 5 operates chiefly in its plastic deformation region during its useful lifetime. Thus, when the spring 5 plastically deforms as the ink 9 is supplied into the ink path of the ink jet head, the spring force of the spring 5 retards the change in negative pressure in the ink container 1, thereby suppressing the changes in the negative pressure of the ink container 1.

[0037] The changes in the volume of the ink container 1 and environmental conditions such as temperature and atmospheric pressure cause changes in the force F applied by the ink bag 3 and changes in the negative pressure of the ink container 1. Therefore, the width and length of the folded portion 5c and thickness of the material of the spring 5 can be carefully selected to adjust the rigidity of the spring 5, thereby achieving an optimum negative pressure of the ink container.

[0038] The spring 5 can be of any shape and material as long as the spring 5 has the aforementioned properties and is liquid tight.

Second embodiment

(Construction of ink-holding section)

[0039] Fig. 9 is an exploded perspective view of an ink container 51 according to a second embodiment.

[0040] Fig. 10 is an illustrative diagram of a spring according to the second embodiment before it is folded into a three-dimensional structure.

[0041] Figs. 11A-11C are a top view, a side view, and a front view of the spring, respectively.

[0042] Figs. 12 and 13 illustrate the properties of the spring.

[0043] Referring to Fig. 9, a frame 52 has a substantially rectangular cross-section and is a short cylinder in overall shape. The frame 52 forms a side wall of an ink container 51. The frame 52 has substantially rectangular openings at the opposed ends thereof, and is formed with a hole 53 therein that communicates with an ink outlet path 69. The ink outlet path 69 is connected to an

ink-receiving path of the ink jet printer when the ink container 51 is mounted to the ink jet printer. One of the openings is closed by a flexible side wall 55 and the other is closed by a rigid wall 65. The frame 52 has a tongue 54 on its one outer surface. The tongue 54 serves to fix the ink container 51 when the ink container 51 is attached to the ink jet printer. The frame 52 is formed with a stepped portion 57 in the edge portion of one of the openings, the stepped portion 57 extending all around the opening.

[0044] The flexible side wall 55 is a substantially rectangular in shape and has a periphery 56, which extends all around the flexible side wall 55 and is configured to the stepped portion of the frame 51. The side wall 55 is fixed at its periphery 56 to the stepped portion 57 by, for example, welding, thereby sealing the frame 52. The side wall 55 is of three-layer construction of polypropylene, deposited aluminum, and PET. The flat part 55a of the side wall 55 is of substantially the same shape as the opening of the frame 52 and somewhat smaller than the opening. Thus, the flat part 55a moves into the frame 52 as the ink is supplied to outside through the hole 53, so that the flat part 55a substantially closes the entire cross-section of the frame 52. The frame 52 is formed with a cutout 58 which opens to the atmosphere upon assembly of the entire ink container 1 (Fig. 16). The cross-sectional view of the side wall 55 of Fig. 9 is best shown in Figs. 16-18.

[0045] A spring 59 is assembled in the frame 52 and sandwiched between the flexible side wall 55 and the rigid wall 65. The spring 59 is positioned so that it urges the flexible side wall 55 outwardly. Referring to Fig. 10 and 11A-11C, the spring 59 includes a flat part 60, two dog-legged part 63a-63b and 63c-63d, folded portions 64 that connect the flat part 60, dog-legged parts 63a-63d, and feet 62 together.

[0046] The spring 59 shown in Fig. 10 is folded into a three-dimensional structure shown in Fig. 11. Of the flat part 60, two feet 62, doglegged parts 63a-63b and 63c-63d, and folded portions 64, the folded portions 64 has the smallest rigidity. The folded portions 64 may be formed in a narrow shape or may be made thinner than the other parts to achieve the smallest rigidity.

[0047] The spring 59 is fixed to the rigid wall 65 with posts 66 extending through the holes 61 in the feet 62. The rigid wall 65 is formed with positioning ribs 67 thereon by which the rigid wall 65 is positioned with respect to the opening of the frame 52. The rigid wall 65 seals against the frame 52 so that the assembled structure is liquid tight.

[0048] The characteristics of the spring 59 will now be described. Fig. 12 illustrates the spring 59 when the force F is applied with the feet 62 fixed. Fig. 13 illustrates the relationship between the force F and deformation δ . When a force is exerted on the flat portion 60 of the assembled spring 59 in such a direction as to compress the spring causes the spring 59, the deformation δ is concentrated on the folded portions 64.

[0049] The force F exerted on the spring 59 shown in Fig. 12 varies along curves E, G, and J. The straight portion of line E indicates that the spring 59 is in its elastic deformation region where the force F is proportional to the deformation δ , i.e., $F=k\delta$. The curve G (G1-G4) indicates that the spring 59 is in its plastic deformation region where the spring 59 will not regain to its original shape even if the force F is reduced to zero. When the spring is on line J, the spring 59 is completely broken.

[0050] In the plastic deformation region as shown by curve G, the force F is substantially constant irrespective of the deformation δ . When the force F is reduced gradually at point G3 in the middle of the plastic deformation region, the deformation δ decreases along line H. The deformation will reach $\delta=L$ after the force F has been reduced to zero. In other words, line H shows that the spring 5 has not completely lost its resiliency after it has entered the plastic deformation region.

[0051] When the force F acts on the flat part 60 of the spring 5 as shown in Fig. 12, the folded portions 64 are first deformed since the folded portions 64 have less rigidity than any other parts of the spring 5. The folded portions 64 have a narrow elastic deformation region. The force F increases as the deformation δ increases (Fig. 13, point 0 to point G1). When the force F further increases, the folded portions 64 enter the plastic deformation region (Fig. 13, points G1-G2-G3-G4). When the force F increases still further, the folded portions 64 are crushed completely with the result that the force F rapidly increases (Fig. 13, point G4-J1).

[0052] In the first embodiment, as shown in Fig. 7, when the spring 5 is in the plastic deformation region, the force F gradually decreases with increasing deformation δ . In the second embodiment shown in Fig. 13, when the spring 5 is in the plastic deformation region, the force F gradually increases as the deformation δ increases. This is because the springs 5 and 59 are different in shape.

(Construction of the ink container)

[0053] Referring again to Fig. 9, a cover 68 is mounted to the ink container 51 to protect the side wall 55 from the environment. The cover 68 is welded to the stepped portion 57 of the frame 52. Upon assembling the cover 68 to the frame 52, an inner space 90 defined between the cover 68 and the side wall 55 communicates with the atmosphere through the cutout 58 so that the air enters the space 90 in accordance with the movement of the side wall 55 toward the rigid wall 65.

[0054] The ink outlet path 69 of the ink container 51 will be described. Figs. 14 and 15 are cross-sectional views of the ink outlet path 69 according to the second embodiment.

[0055] Referring to Fig. 14, the ink outlet path 69 includes a filter 70, a packing 71, and a cap 72. The cap 72 is fixedly mounted to the frame 52 by, for example, welding in order to hold the filter 70 and packing 71 in

position. The packing 71 is in the shape of a hollow circular cylinder with a portion 71a in the shape of a frustum of a right circular cone that tapers inwardly of the cylinder. The portion 71a engages an inlet pipe 74a of an ink path 74 in a sealing relation when ink is supplied into the ink path 74. A sealing film 73 is fixedly mounted to the end of the cap 72 by, for example, welding, thereby providing a sealed environment for the ink until ready to use.

[0056] Referring to Fig. 15, immediately before using the ink, the user peels off the sealing film 73 and the ink container 51 is coupled to an ink path 74 of the ink jet head.

[0057] The operation of the ink container 51 will be described with reference to Figs. 16-19 with respect to changes in negative pressure in the ink container 51 when the ink is drawn from the ink container 51 into the ink path 74.

Figs. 16-18 are cross-sectional views of the ink container 51, illustrating the operation of the ink container 51. The remaining ink decreases in the order of Figs. 16, 17, and 18. Fig. 19 illustrates changes in the negative pressure of the ink container 51 as the ink is supplied into the ink path 74.

[0058] Referring to Fig. 19, the negative pressure necessary for the ink to be supplied from the ink container 51 lies from point G1 to point G5. The ink 89 can be normally supplied from the ink container 51 when the negative pressure is between point G1 and point G4. It is to be noted that Fig. 8 (first embodiment) represents the characteristic after the pressure in the ink container 1 has reached a useable negative pressure while Fig. 19 shows the characteristic before and after the pressure in the ink container has reached a useable negative pressure.

[0059] The spring 59 is assembled to the rigid wall 65 with no initial compressive load at all. Then, the cover 68 is fixedly assembled to the frame 52 so that the flat portion 60 of the spring 59 urges the side wall 55 outwardly. At this time, the characteristic of the spring 59 is between point G1 and point G2 where the spring 59 is in the plastic deformation region. Of course, the ink container 51 may be designed such that the spring 59 is initially between point 0 and point G1 where the spring 59 is in the elastic deformation region. The ink 89 is introduced into the ink-holding section 89a of the container 51 through an inlet, not shown, formed in a part of the frame 52 till there is no air in the ink holding section. When the ink holding section has just been filled with the ink 89, the pressure of the ink holding section ink 89 is the same as the atmospheric pressure (point 0 of Fig. 13).

[0060] Then, using an ink-draining jig, a certain amount of the ink 89 is drained from the ink container 51 to develop a negative pressure, thereby ensuring that the ink 89 is held in the ink-holding section 89a (Fig. 16, point G2 of Fig. 13). When the ink-draining jig is removed, the ink in the ink outlet path 69 is sucked into

the ink container 51 to the filter 70 shown in Fig. 14 due to the negative pressure, so that the surface tension of the filter 70 and the negative pressure in the ink-holding section 89a are balanced. Then, the sealing film 73 is attached to seal the ink container 51.

[0061] The cover 68 may be welded to the frame 52 after the negative pressure has been developed.

[0062] Prior to using the ink in the ink container 51, the user peels off the sealing film 73 and then connects the ink container 51 to the ink path 74 as shown in Fig. 15. Then, the ink 89 is sucked from the ink container 51 through the ink path 74.

[0063] As the ink 89 is supplied from the ink container 51 through the ink path 74, the force F of the spring 59 changes along the curve G in the plastic deformation region shown Fig. 13 through points G2, G3, and G4, and the negative pressure in the ink container 51 changes along the curve shown in Fig. 19 through points G2, G3, and G4. As shown in Fig. 17, the side wall 55 is compressed away from the cover 68 as the ink 89 decreases, causing the spring 59 to be compressed toward the rigid wall 65.

[0064] As the spring 59 is further compressed, the folded portions 64 are further plastically deformed. Finally, the spring 59 is completely collapsed as shown in Fig. 18, so that the force F exerted on the spring 59 rapidly increases along line J from point G4 to point J1 as shown in Fig. 13. As a result, the negative pressure characteristic of the ink container 51 changes from point G4 to point J1 of Fig. 19 beyond the range of demanded pressure, failing to supply ink any further. Thus, the ink container 51 reaches the end of its life and there is little or no ink 89 left in the ink container 51.

[0065] The spring 59 plastically deforms to be permanently crushed, and therefore even if the ink container 51 is again filled with the ink 89, the negative pressure will not be developed again.

[0066] In the second embodiment, the spring 59 is of the construction where the spring 59 is in the plastic deformation region when the ink is normally supplied into the ink path 74. The construction is capable of suppressing changes in the negative pressure in the ink container 51 as the remaining ink decreases, so that changes in the negative pressure are minimized till the ink has nearly been exhausted. The negative pressure can easily be set to a desired value by selecting the shape of the spring 59, thereby improving ink-utilizing efficiency of the ink container 51.

[0067] The ink container 51 cannot be refilled, preventing the user from using ink that is not accepted to the ink container. This prevents troubles of the printhead resulting from the use of non-accepted ink.

[0068] The ink container 51 according to the second embodiment is easy to assemble compared to the ink container 1 according to the first embodiment.

[0069] In the second embodiment, the spring 59 has been in the plastic deformation region before the ink container 51 starts to supply ink. Alternatively, the ink

container 51 may be designed so that the spring 59 is still in the elastic deformation region as long as the negative pressure is such that the ink 89 may be held in the container 51.

Third embodiment

[0070] Fig. 20 illustrates a part of an ink container according to a third embodiment. Fig. 21 is a cross-sectional view of the ink container according to the third embodiment.

[0071] Referring back to Fig. 9, the side wall 55 of the second embodiment is formed from a flat sheet material, which is folded into a three dimensional structure. The side wall 55 is fixedly connected at its periphery to the stepped portion 57 of the frame 52 by, for example, welding. As a result, the corners of the side wall 55 are wrinkled as shown in Fig. 20. These wrinkles 75 become more stiff than the other parts of the side wall 55, resisting against the deformation of the side wall 55 when the flat part 55a of the side wall 55 is displaced into the ink container 51 as shown in Figs. 16-18. This causes changes in negative pressure. In order to reduce the effects of the wrinkles 75 on the negative pressure, the inner wall 88 of the frame 52 and the flat portion 60 of the spring 59 may be spaced apart by a larger distance, but the ink holding capacity of the ink container will be decreased.

[0072] The third embodiment solves the drawback of the second embodiment. In the third embodiment, the corner radius R1 of the inner wall 88 and the corner radius R2 of the flat portion 60 are related by Equation (1) as follows:

$$R2 \cong R1 \quad (1)$$

[0073] The side wall 55 is made of a very soft, flexible material so that the side wall 55 is configured to the shape of the flat part 60 of the spring 59. By satisfying Equation (1), the side wall 55 that covers the corners of the flat part 60 of the spring 59 is gradually curved, alleviating the adverse effect of the wrinkles 75 on the deformation of the side wall 55.

[0074] The rest of the construction is the same as that of the second embodiment.

[0075] The operation of the side wall 55 when the ink is supplied from the ink container 51 will be described.

[0076] As shown in Figs. 16-18, the side wall 55 is gradually compressed toward the rigid wall 65 as the remaining ink decreases. Equation (1) provides a sufficient space in which the areas of the side wall 55 near the wrinkles 75 can be smoothly deformed, so that the somewhat rigid wrinkles 75 will not significantly affect the change in negative pressure.

[0077] Equation (1) alleviates the adverse effect of the wrinkles 75 on changes in negative pressure without substantially spacing the edges 60a of the flat part 60 of the spring 59 apart from the edges 52a of the frame 52.

[0078] Instead of an arcuate shape, the corners of the flat part 60 may be chamfered, a combination of obtuse angles, or a combination of an arcuate shape and obtuse angles. Fourth embodiment

[0079] Fig. 22 is an exploded perspective view of an ink container according to a fourth embodiment. Fig. 23A illustrates a spring as it is stamped from a sheet material. Fig. 23B is a fragmentary cross-sectional view taken along the lines 23B-23B of Fig. 23A. Figs. 24A-24C are a top view, a side view, and a front view of the spring.

[0080] The ink container 51 according to the second embodiment is of the construction where the interior of the ink container 51 is maintained negative in pressure. Therefore the side wall 55 is pressed at all times against entire the flat part 60 including the peripheral edge portion of the flat part 60 and the edge portions of the folded portions 64. Therefore, the side wall 55 may be broken due to vibration and long term storage.

[0081] To prevent such a problem, a spring 76 according to the fourth embodiment is shaped as shown in Figs. 22-24. In other words, the flat part 77 is continuous with connectors 81 via a plurality of first folded portions 78. The flat part 77 has a cutout 78a on both sides of each of the first folded portions 78, so that the first folded portions 78 are behind the outer edge of the flat part 77 of the spring 76 as shown in Fig. 23.

[0082] The flat part 77 has a roll over 79 formed all around the periphery by, for example, drawing except the folded portions 78 and cutouts 78a. The roll over 79 is rolled downward away from the flat part 77 so that when the ink container has been assembled, the outer edge of the roll over 79 will not be in contact with the flat part 55a of the side wall 55. The spring 76 further includes holes 80, connectors 81, second folded portions 82, and feet 83, which are of the same construction as those of the second embodiment and the description thereof are omitted. The rest of the construction of the ink container 51 is the same as that of the second embodiment.

[0083] The operation of the ink container 51 will now be described with respect to that different from the second embodiment. Figs. 25-27 are cross-sectional views illustrating the operation of the ink container according to the fourth embodiment.

[0084] As shown in Figs. 25-27, the roll over 79 prevents the side wall 55 from pressing the sharp edge of the flat part 77 of the spring 76. The edges of the first folded portions 78 are located behind the roll over 79 so that the side wall 55 is not pressed against the edges of the first folded portions 78.

Fifth embodiment

[0085] Fig. 28 is an exploded perspective view of an ink container according to a fifth embodiment.

[0086] Fig. 29 is a cross-sectional view of the ink outlet path of the ink container 51.

[0087] With the ink container 51 according to the second embodiment, The side wall 55 is urged inwardly toward the rigid wall 65 as the ink 89 is supplied into the ink path 74. Then, the side wall 55 may close the hole 53, blocking normal ink flow through the hole 53.

[0088] In order to eliminate such a problem, as shown in Figs. 28 and 29, the inner wall 88 of the frame 84 is provided with ribs 86 which surround a hole 85 and extend in a direction in which the side wall 55 is displaced into the frame 84. The ribs 86 prevent the side wall 55 from completely closing the hole 85, providing ink paths even if the side wall 55 is displaced over the hole 85.

[0089] The shape of the spring 76 is the same as that of the fourth embodiment. The frame 84 has corners with a radius R1 and the flat part 77 of the spring 76 has corners with a radius R2, given by Equation (1), i.e., $R2 \geq R1$. The rest of the construction is the same as that of the second embodiment and the description thereof is omitted.

[0090] The operation of the ink container 51 according to the fifth embodiment will be described.

[0091] As shown in Fig. 29, the side wall 55 is compressed as the ink is supplied into the ink path 74. The side wall 55 then passes over the hole 85. However, the ribs 86 keep the side wall 55 away from the hole 85 ensuring paths for the ink 89 to flow into the hole 85. Thus, the ink 89 continues to be smoothly supplied to the ink jet head until the ink 89 is completely exhausted.

[0092] In stead of providing the ribs 86, the inner wall 88 of the frame 84 may be formed with a plurality of grooves extending in a direction in which the side wall 55 is compressed. Alternatively, a plurality of projections may be provided around the hole 85 to keep the side wall 55 a predetermined distance away from the hole 85, thereby ensuring the path for the ink 89 to flow into the hole 85.

[0093] While the present invention has been described with reference to an ink container for use in ink jet printers, the invention may be applicable to any liquid containers which hold a liquid therein and supplies the liquid in accordance with the suction operation from outside.

[0094] The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art intended to be included within the scope of the following claims.

Claims

1. An ink container having an ink-holding space (3, 89a) which holds ink (89) therein and is held at a negative pressure with respect to an atmospheric pressure and, the container comprising:

a flexible wall (3, 55) defining a part of the ink-holding space (89a), said flexible wall (55) being displaceable inwardly of the ink-holding space (3, 89a) as the ink is supplied to an external device; and

an urging member (5, 59, 76) incorporated in the ink-holding space, said urging member being in contact with said flexible member (3, 55) and urging said flexible member outwardly of the ink-holding space, said urging member (5, 59, 76) being substantially in a plastic deformation region thereof.

2. An ink container the container comprising:

an ink bag (3) which holds ink (9) therein and is held at a negative pressure with respect to an atmospheric pressure, said ink bag (3) deforming inwardly as the ink therein is supplied from said ink bag (3) to an external device; and an urging member (5) which is incorporated in said ink bag (3) and urges said ink bag (3) outwardly, said urging member being substantially in a plastic deformation region thereof.

3. The ink container according to Claim 2, wherein said urging member is a spring (5) formed by folding a sheet material, and the ink bag (3) deforms inwardly as the ink is supplied to an external device, the spring (5) being yieldably deformed at a folded portion.

4. An ink container comprising:

a frame (52, 84) defining an ink-holding space (89a) which holds ink (89) therein and is held at a negative pressure with respect to an atmospheric pressure;

a flexible wall (55) having a periphery (56) securely assembled to close the space, said flexible wall being displaceable inwardly of the ink-holding space (89a) as the ink is supplied to an external device; and

an urging member (59, 77) which is incorporated in the ink-holding space (89a) and urges said flexible wall outwardly of the ink-holding space, said urging member being substantially in a plastic deformation region thereof.

5. The ink container according to Claim 4, wherein said urging member (59, 77) is a spring formed by folding a sheet material, the spring being yieldably deformed at a folded part thereof as the flexible wall deforms inwardly.

6. The ink container according to Claim 4, wherein said frame is a substantially hollow cylinder having a closed first end and a second end opposing the

first end, the second end having an opening and being closed by said flexible wall, the opening having rounded corners with a first radius,

wherein said flexible wall having a middle portion which is displaceable with respect to said frame into the ink-holding space, the middle portion having corners with a second radius not smaller than the first radius.

7. The ink container according to Claim 4, wherein said urging member has a flat part (77) in contact with an inner surface of said flexible wall (55), the flat part (77) having an edge (79) rolled away from said flexible wall (55).

8. The ink container according to Claim 4, wherein said frame has a hole (53) formed therein through which the ink is supplied to an external ink path (74), and said frame having at least one rib (86) formed on an inner surface thereof near the hole (53) and extends in a direction in which said flexible wall is displaced.

FIG.1

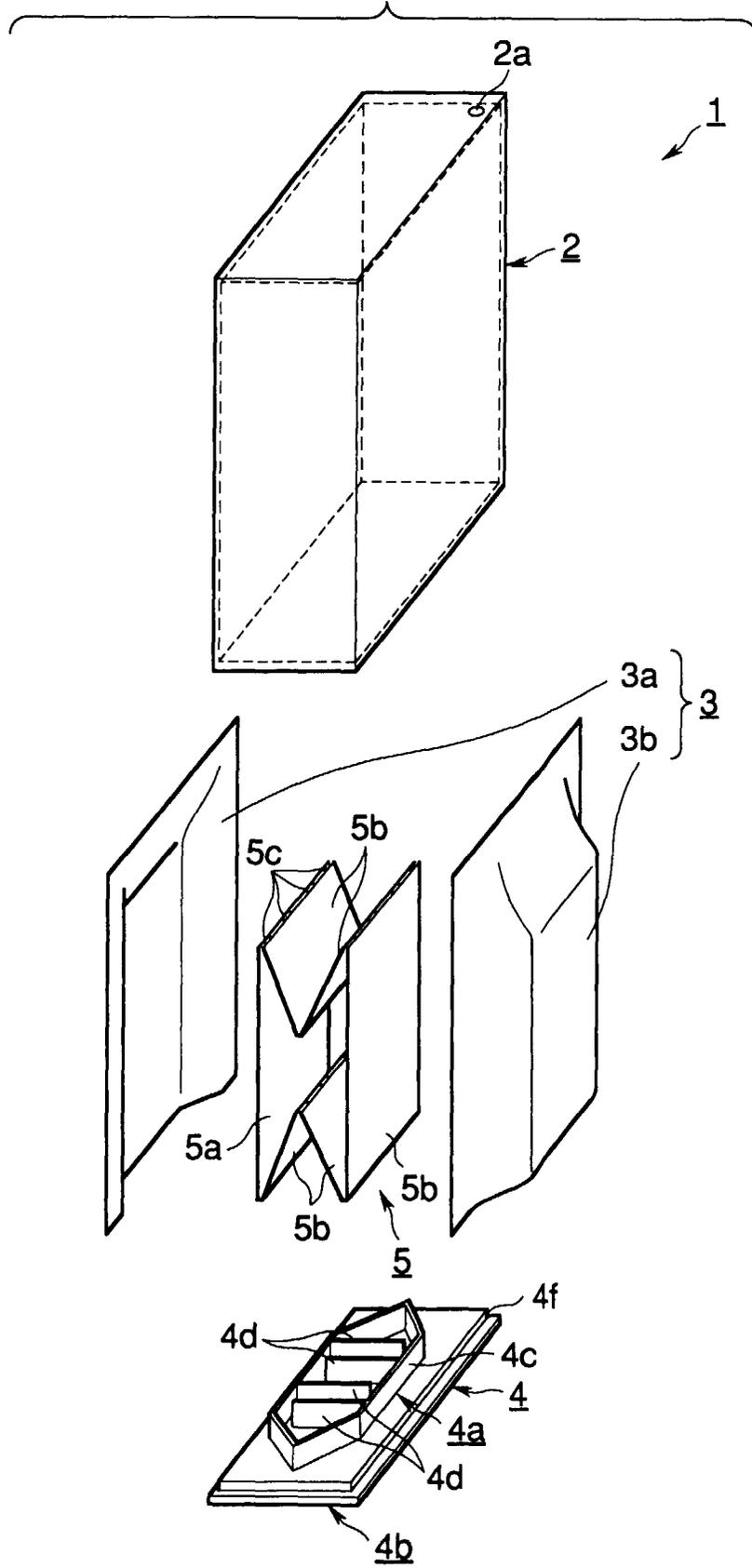


FIG.2

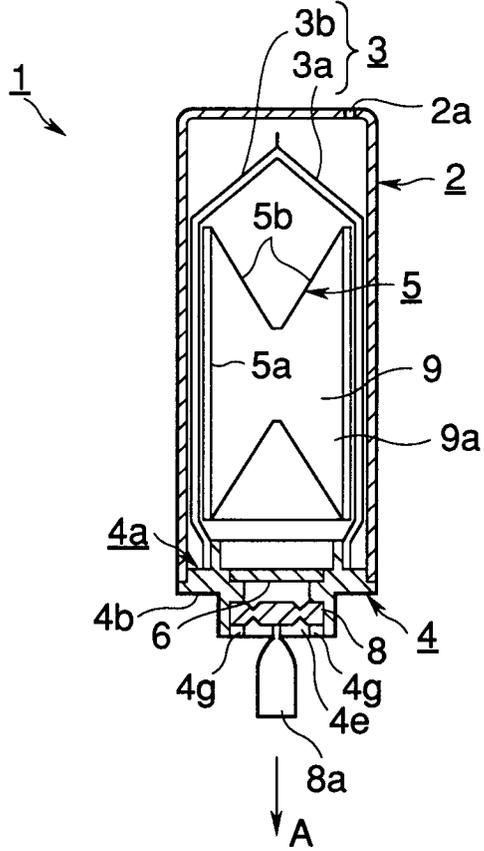


FIG.3

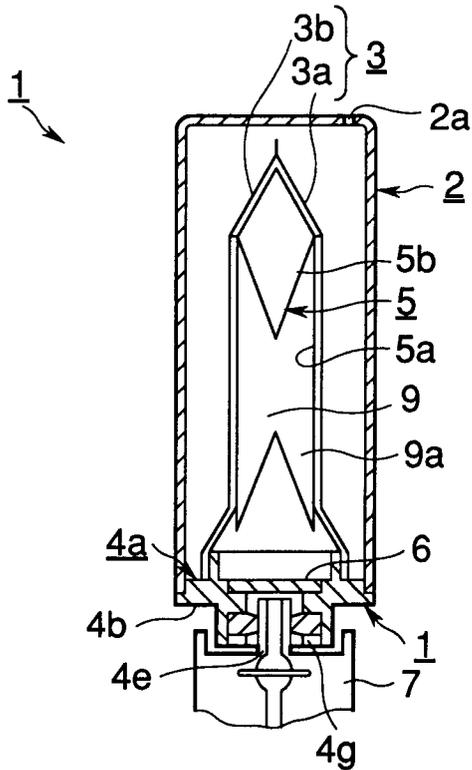


FIG.4

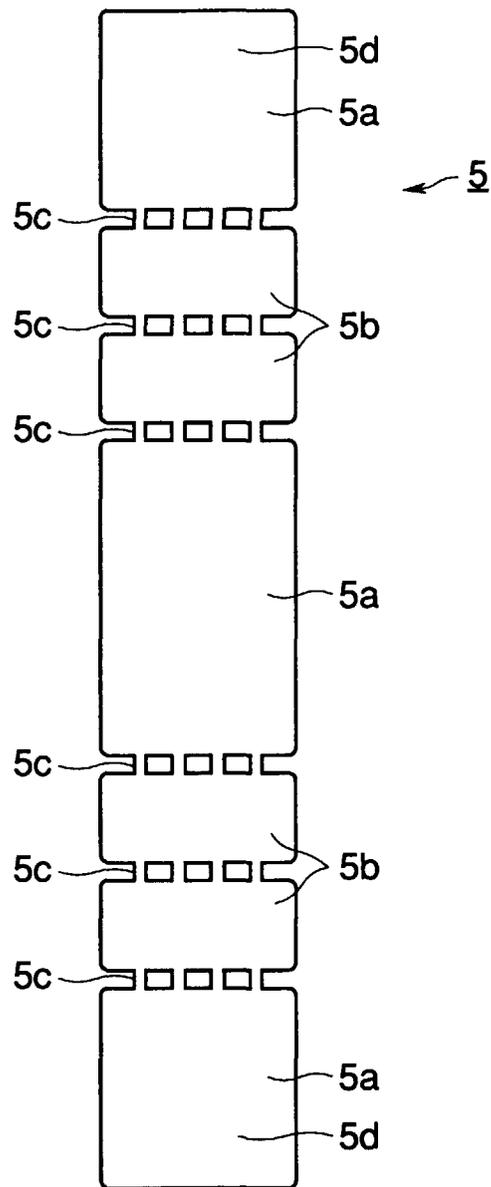


FIG.5

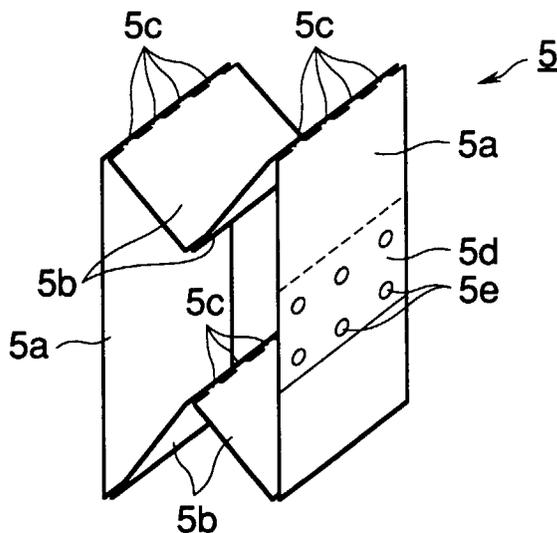


FIG.6

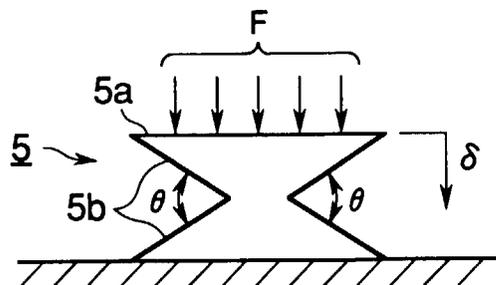


FIG.7

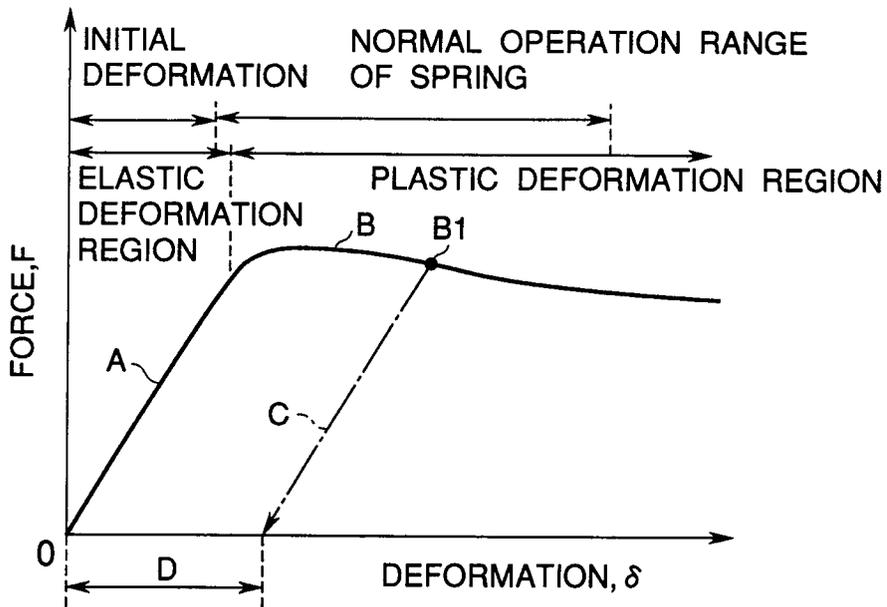


FIG.8

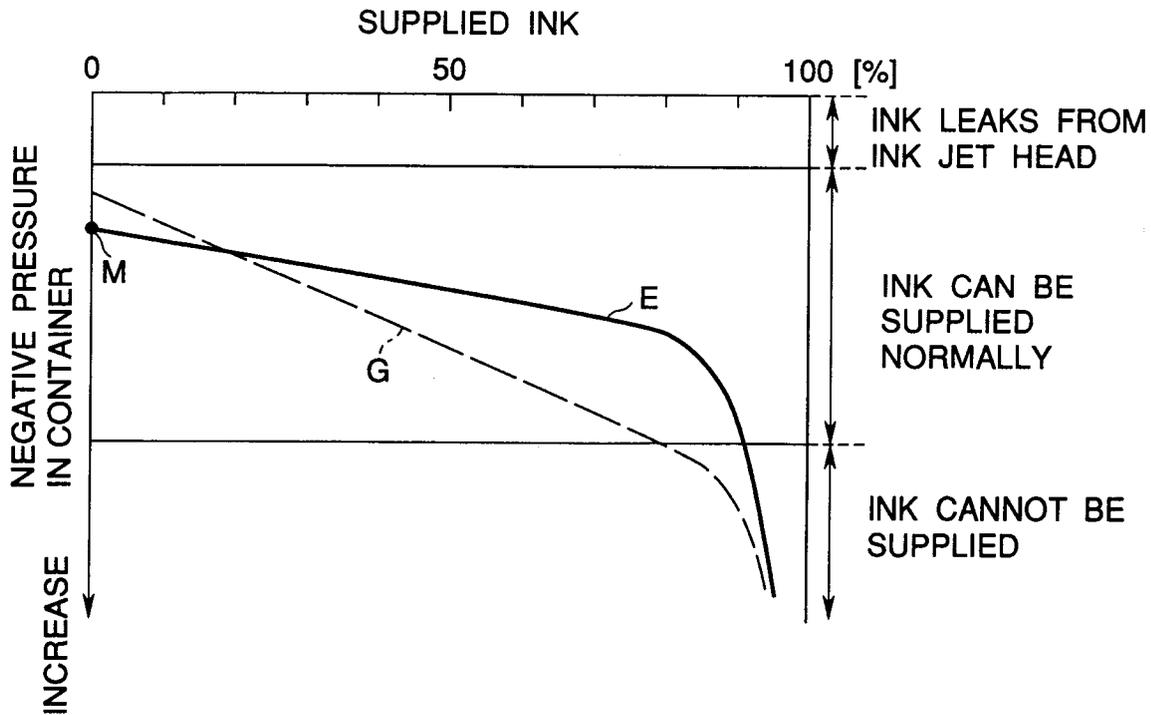


FIG.10

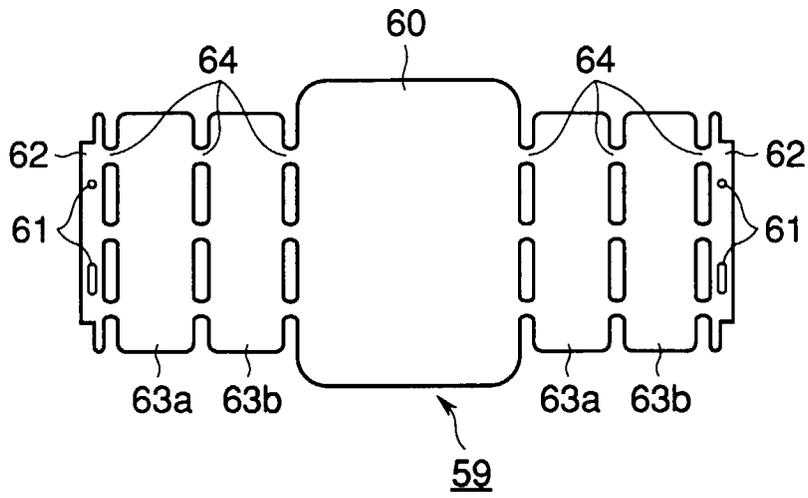


FIG.11A

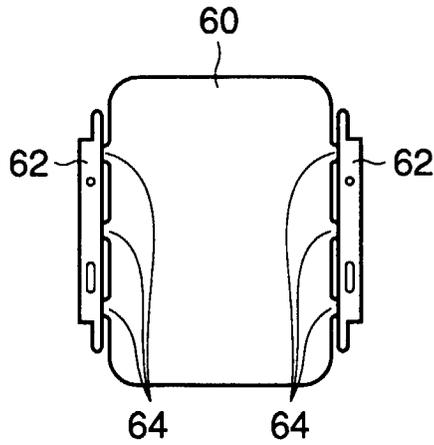


FIG.11B

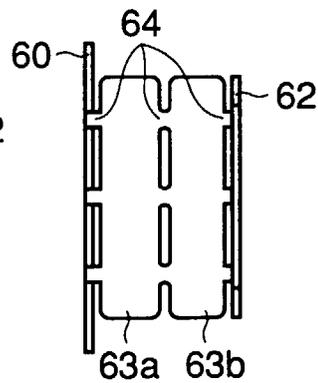


FIG.11C

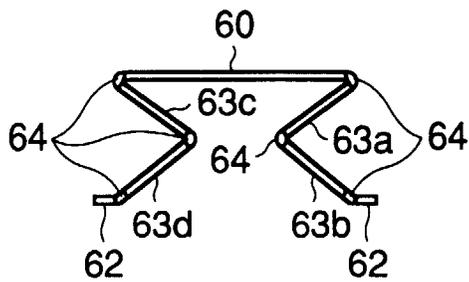


FIG.12

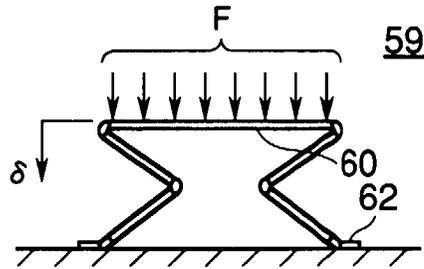


FIG.13

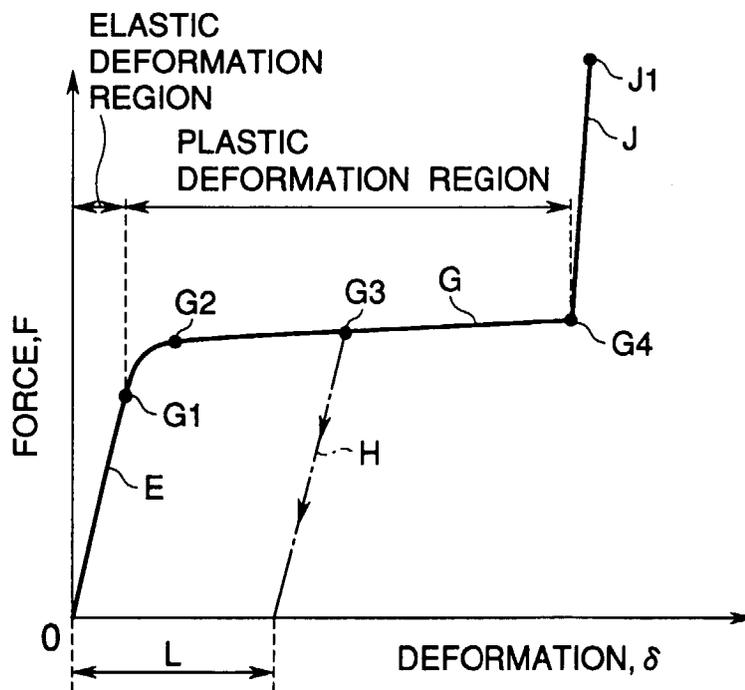


FIG.14

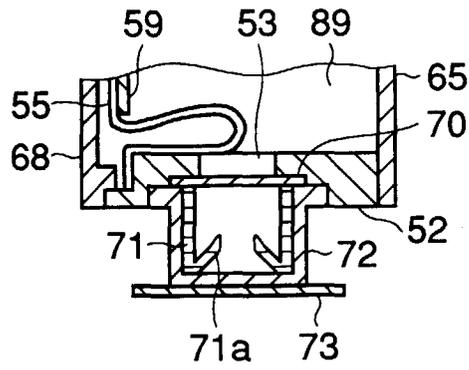


FIG.15

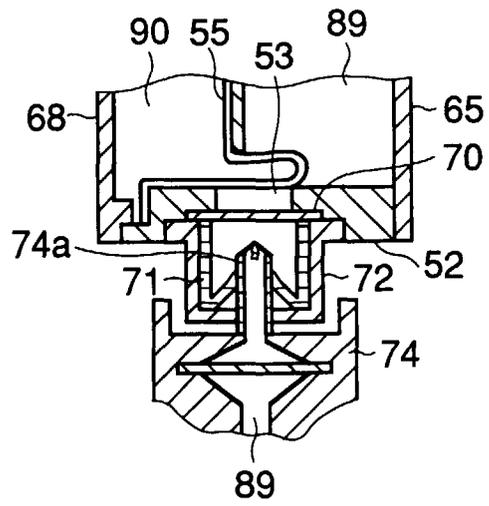


FIG.16

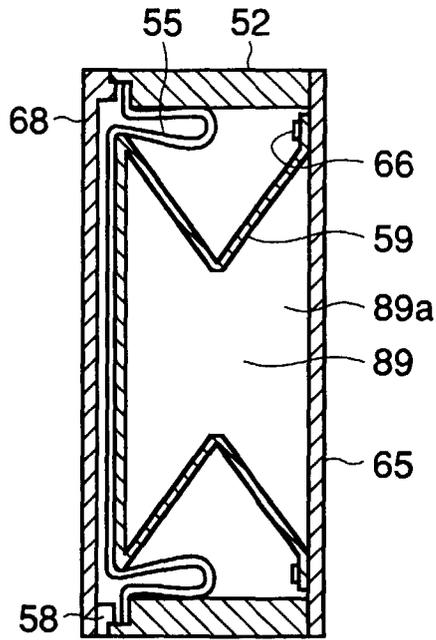


FIG.17

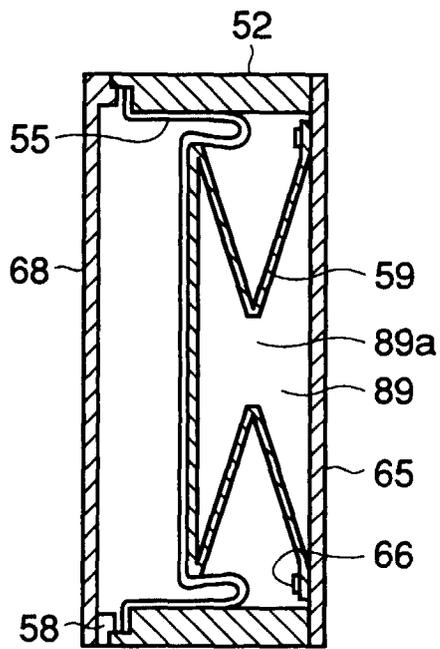


FIG.18

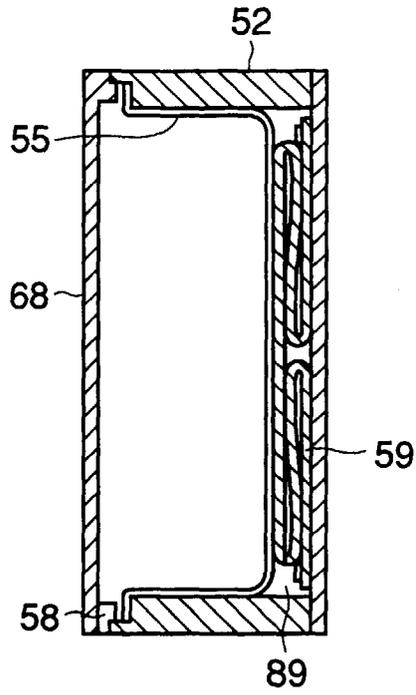


FIG.19

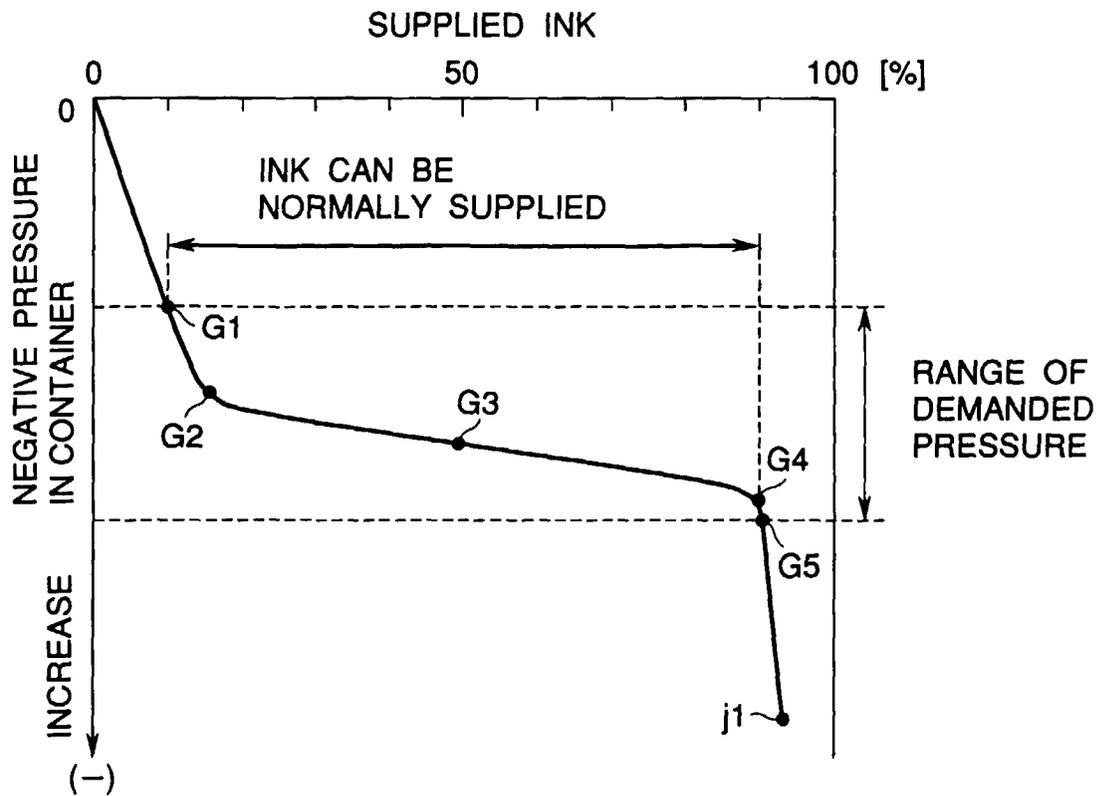


FIG.20

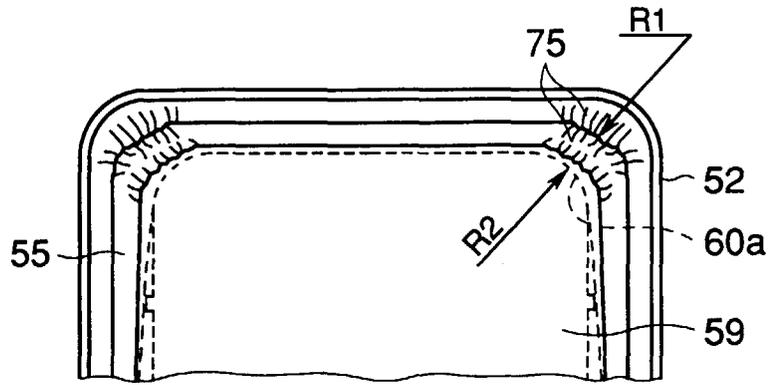


FIG.21

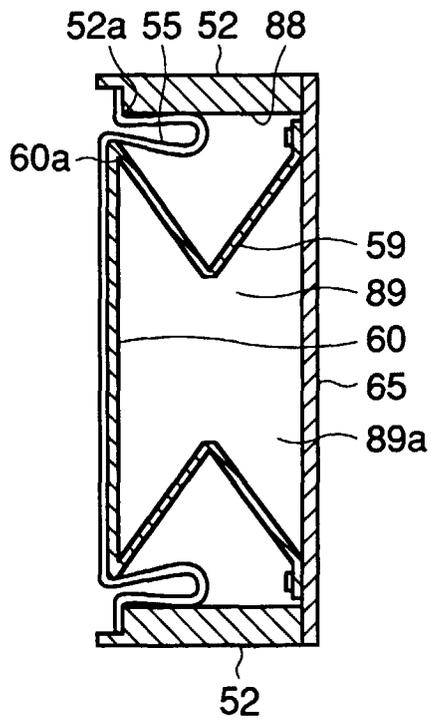


FIG.22

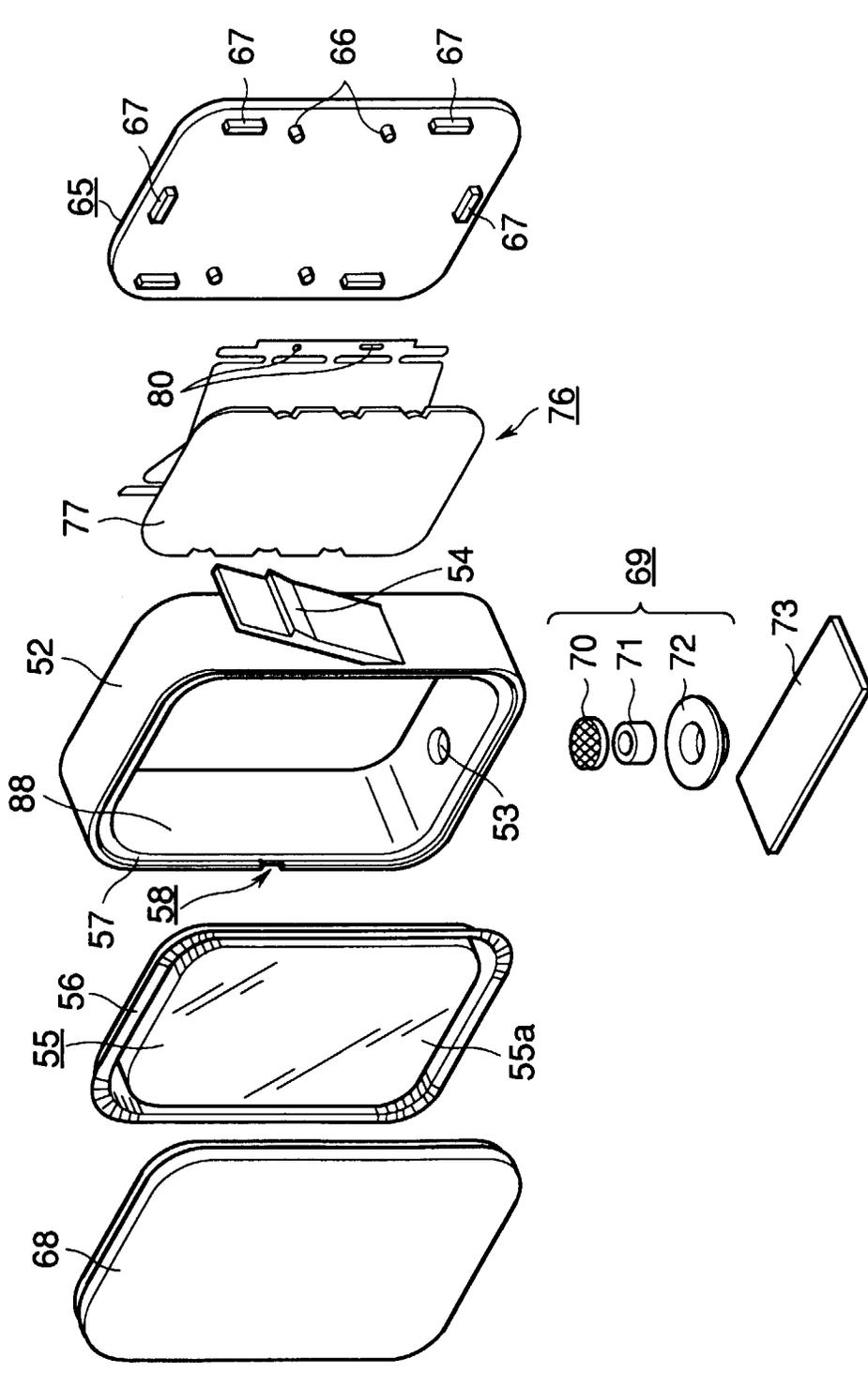


FIG.23A

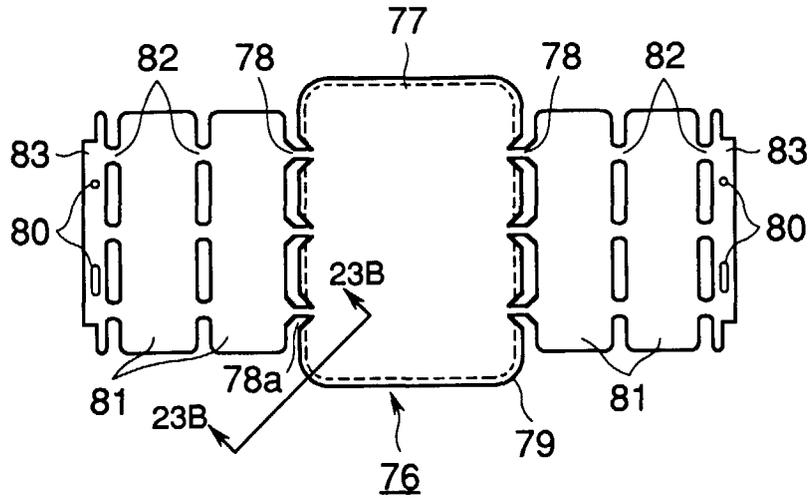


FIG.23B



FIG.24A

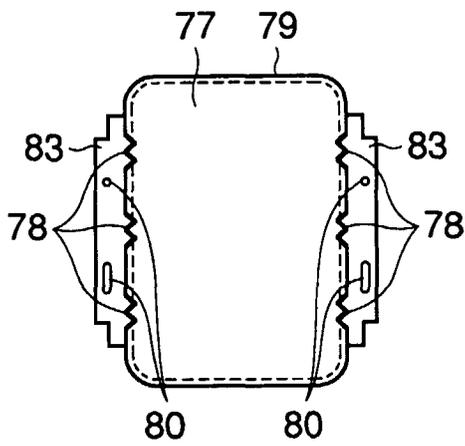


FIG.24B

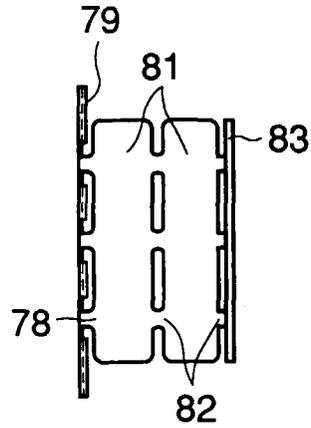


FIG.24C

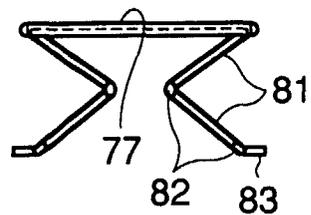


FIG.25

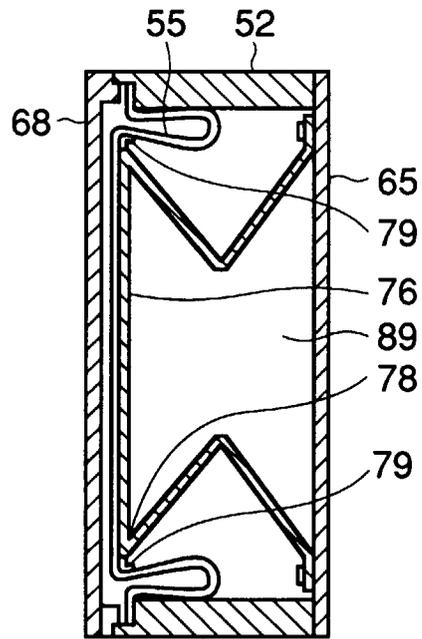


FIG.26

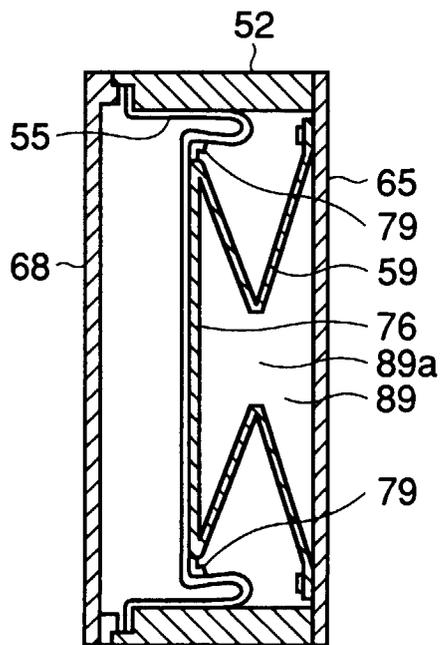


FIG.27

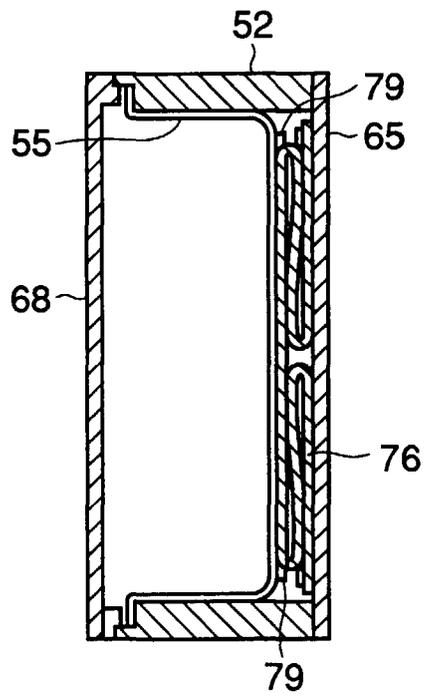


FIG.28

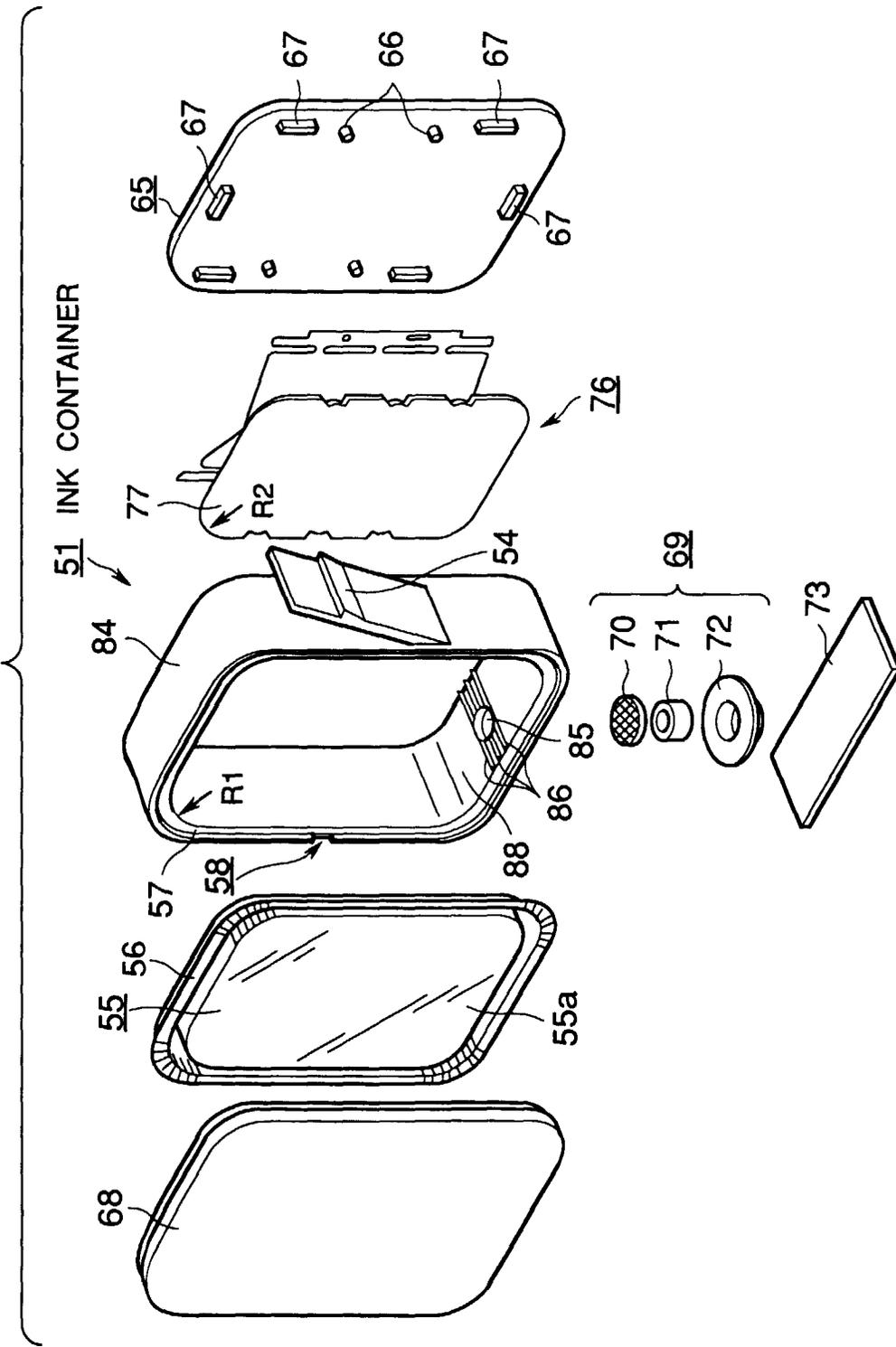


FIG.29

