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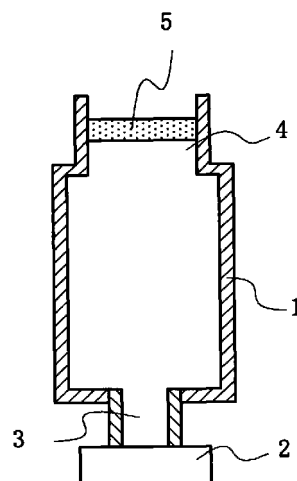
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(54) **A valve body and a liquid storage container for a liquid discharge device utilizing the valve body**

(57) A porous material such as polyurethane foam is compressed to form skeletal portions in a three-dimensional network and mutually communicated pores or passages. The passages are closed at the skeletal portions by contacting the skeletal portions with each other so that valve caps are formed for closing the passages. Thus formed valve body is applicable to pen tips for writing instruments and printer heads for ink jet printers.

FIG. 1



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DescriptionTECHNICAL FIELD OF THE INVENTION

5 **[0001]** The present invention relates to a valve structure or a valve body which serves to temporarily open cells (pores) or passages when a predetermined magnitude of force is added to the valve body and which also serves to close the bores when the force is released.

[0002] Further, the present invention relates to a liquid storage container or tank for a liquid discharging device which has the valve body, as an air exchange means, for regulating an inner pressure of the liquid discharge device for
10 the purpose of supplying a liquid in the container to the liquid discharge portion of the liquid discharge device.

BACKGROUND OF THE INVENTION

[0003] Heretofore, there have been many attempts in the field of ink reservoirs for writing instruments and ink cartridge for ink jet printers to provide improvements by taking an outer air into a reservoir according to an amount of ink that is consumed for writing or printing letters and/or images, so that no unfavorable influence is made on the consumption of ink by a change of pressure in the reservoir. For avoiding such an unfavorable influence as described, attempts have been made for taking the outer air into the reservoir by simply providing a hole, providing a gas-permeable and liquid-impermeable membrane, and providing a ventilation mechanism or air passage having a valve mechanism which
20 can be selectively opened.

[0004] Among the above attempts, mere provision of the hole has a serious problem of capability of an ink leakage from the thus formed hole. Further, in respect of both writing instruments and ink jet printers, a water head pressure (in other words, "pressure head" or "head" which will be explained presently) is added to ink discharging means such as pen tip for the writing instrument and a printer head for the ink jet printer due to a weight of ink. Accordingly, in the structure that a simple hole or a gas-permeable and liquid-impermeable membrane is merely provided as an opening for taking in the outer air into the interior, a pressure in the ink reservoir or an ink cartridge will be the same as an atmospheric pressure and, therefore, there is possibility that ink is splashed out of the reservoir or cartridge by the aforementioned water head pressure. Therefore, in order to restrict or minimize the possibility of the ink splashing, a special device or means will be necessary for holding or storing ink, such as a fiber bundle body for storing the ink therein.
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[0005] In the instant specification, the terminology "water head pressure" used frequently herein, which is used in the art also as "pressure head" or simply "head", intends to mean the pressure of water at a given point in a pipe arising from the pressure in it, and the pressure which is equal to a force effecting to a bottom surface of a liquid column arising to a liquid surface.
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[0006] The structure having the valve mechanism described above has an advantage that the aforementioned ink leakage can be restricted effectively because an air passage can be formed at a desired time or by necessity and has another advantage that the air passage can be closed with the interior pressure being a negative pressure relative to the atmospheric pressure by a water head pressure of the ink in the reservoir and, therefore, the disadvantage of the ink splashing can be prevented. An example of this mechanism is shown in Japanese Patent Publication (Unexamined) No. 7-076094 which shows a valve body having a slit-like passage, which is normally closed when no pressure is added to a resilient member.
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[0007] Further, in a structure that the valve mechanism is fixed in an air-tight condition is known in the art. For example, in Japanese Patent Publication (Unexamined) No. 7-076094 described above, an elastic member having a slit is held in the radial direction in a circumferential configuration to fix an outer end portion of the valve mechanism. In another example, Japanese Patent Publication (Unexamined) No. 8-300891 show a structure that a moisture permeable and water proof membrane is disposed between disc-shaped members so that an outer end portion of the membrane is held from opposed direction by the disc members.
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[0008] Japanese Patent Publication No. 6-69750 (Examined) shows a structure in which a valve member is disposed at a liquid discharge hole. In the structure, a slit or an aperture is provided to a valve member of an elastic material which can regulate permeation or passing of a liquid.

[0009] However, although the structure having a valve mechanism as an air passing means for the purpose of regulation of inner pressure as shown in Japanese Patent Publication (Unexamined) No. 7-076094 has an advantage that a pressure in the reservoir can be regulated by opening the air passage at a predetermined value of pressure, the passage can be opened at the predetermined pressure only and, therefore, it is difficult to comply with both a small change of pressure and a large change of pressure.
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[0010] In other words, regardless of the matter whether a pressure change is large or small, the valve mechanism is opened in a similar manner when it reaches a predetermined pressure, and in order to restrict a pressure reduction in the container by the use of the ink therein, it must be set so that small pressure-reduction state is recovered. With respect to a large change of pressure, it is required to have a substantial time for passing the necessary amount of air
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and, therefore, it takes a time for recovering the inner pressure. In the course of an regulating operation of an increased inner pressure from a high level to a low level, it will cause an excessive flow or "gobbing" of ink due to over-supply and, on the other hand, in the course of regulation of a reduced inner pressure from a low level to a high level, there is a problem of blurring or thinning of ink due to shortage of supply of ink. Further, a reliable recovery of the valve is not always assured when the valve is opened once and closed again and, if there is a time-lag or difference of timing in a closing action, the valve will not be suitably opened at a predetermined, desired pressure. This results in thinning or blurring of writing and, on the other hand, even when the pressure does not reach a predetermined value of pressure, the valve will be unexpectedly opened to possibly result in generation of over-flowing or splashing of ink.

[0011] In the structure that an outer end of the valve body is held or fixed, the valve body is influenced by a distortion of the volume of the valve body caused by the deformation by a holding force, and peripheral portions of the valve body is deformed so that accurate regulation of the inner pressure by incoming and discharging of air is not assured. Particularly, when an inner pressure is raised by temperature elevation or the like, the valve is reacted to open to communicate with the exterior even when the valve is closed at the time of non-use and, therefore, the liquid or ink is evaporated and reduced in its volume. When the container is positioned with the valve being located lower than the position of ink, there is a serious problem of ink leakage.

[0012] Further, in a structure that a valve body of an elastic material having a slit or an aperture is provided for regulating the passage of liquid to the liquid discharge hole, the deformation of the valve body results in dimensional difference of the slit or aperture when such slit or aperture is produced, so that discharging amount of the ink is not regulated. Further, since the slit or aperture is made open by deformation of the valve body when a pressing force is added thereto, a member for providing the pressing force is contacted with the peripheral portion of the opened slit of aperture and, therefore, movement of ink is substantially restricted. Therefore, it is necessary to add a relatively large pressing force which is an undesirable "load" to the valve member and its peripheral portions.

[0013] Further, since the resilient material with a hole formed therein is used, there is a problem in reliability of a liquid-tight or water proof property at a closed state. Namely, in the structure of aforementioned Japanese Patent Publication No. 6-69750 (Examined) which has a slit, when an inner pressure of the ink container is raised, its pressure serves as a pressing force to substantially open the slit and, therefore, this structure has a serious problem of ink leakage at the time of non-use of the device. Particularly, along with recent popularization of mobile network personal computers, small sized handy printers have been required in the market but if the printers are of portable or handy type, it must be considered that an ink cartridge alone is carried by users apart from a printer, that the ink cartridge is repeatedly fitted to and taken from the printer for carrying purposes, that it is positioned without determining the direction, and that it must meet with an abrupt or rapid change in pressure (environmental pressure) at the time of boarding an airplane. Thus, it is strongly required that there is no leakage of ink.

DISCLOSURE OF THE INVENTION

[0014] The present invention has been made in view of the above problems. The subject matter of the present invention resides in a valve body having a plurality of interconnecting pores or passages and a plurality of valve caps made of a resilient material for closing the interconnecting pores.

[0015] Further, there is provided a liquid storage container for a liquid discharging device, comprising:

a liquid passage connected with the liquid discharging device containing therein a predetermined liquid, an air passage for permitting air to pass through between an interior of the container and exterior of the container, and
a valve means, adapted to the air passage, for temporarily opening the air passage in accordance with a change of pressure between the exterior and interior of the container to thereby permit the air through the air passage, wherein the valve body has:
a plurality of passages connected with each other, and a plurality of valve cap made of an elastic material and adaptable to the passages.

[0016] Further, there is provided a liquid storage container for a liquid discharge device such as an ink jet printer, wherein the liquid storage container comprises:

a discharge valve member of an elastic material, the discharge valve member being pressed against a circumferential end portion of an ink discharge hole for supplying ink to a printing head for the printer so that the discharge valve member can close a circumferential end portion of the ink discharge hole, whereby when a force is added to the discharge valve member, the discharge valve member is deformed to produce a gap relative to an inner wall of the circumferential end portion of the ink discharge hole.

[0017] With respect to the valve body, by a selective operation of each of the valve caps which are made of the elastic material, a volume of air passing through the passages can be regulated so that an inner pressure of the container is balanced with a water head pressure of the contained liquid. Further, it is preferred that the air volume is regulated by a balance between the deformation easiness of the resilient material for the valve cap and the difficulty of deformation of the material as the structural body and, a favorable operation of the valve cap is obtained by selecting Young's modulus to be between 1MPa and 5000MPa (that is, from 1MPa to 5000MPa, both inclusive) under the consideration that the valve body serves as a cantilever of an elastic material, wherein Young's modulus represents an amount of deformation of a material relative to a load applied thereto.

[0018] In order to obtain the valve having a cap as described, it is desired that, in view of deforming properties (easiness of deformation) of the valve cap structure, an apparent density which represents a substantial volume of a material relative to an apparent volume is set to be more than 0.03g/cm³ inclusive and less than 1.5 g/cm³ inclusive. In order to obtain such a valve cap as described above, it will be desired to use synthetic resins having the above-mentioned Young's modulus and having mutually connected pores (to form an interconnecting foam body) which are formed by foaming or stripping method, or granular aggregates of synthetic fibers, synthetic resins, rubbers, etc. or partly integral body of these aggregates by heating or by using solvents, and these porous bodies, fiber bundles and granular aggregates can be compressed to form a body having the above-stated apparent density.

[0019] At this moment, it is desired that the number of pores per unit length before compression is determined between 4 pores/cm to 1000 pores/cm, so that regulation of the inner pressure can be made easily. Further, it will be desired that compression is applied from one direction while applying heating or high frequency heat release to form into a desired shape because it will be advantageous in handling as a part which constitutes the container and can be produced at a lower cost. The thus formed member preferably has a hardness (measured by Asker hardness meter of Type C, JIS s 6050-1994) of more than 20, inclusive, and less than 100 when it has a thickness of 8 mm and is disc shaped. In this case, it is desired that compressibility is determined to be between 5% and 40% (that is, more than 5% inclusive and less than 40% inclusive) of a thickness of the material prior to compression, so that the air passages can be completely and reliably closed when the inner pressure is of normal condition, without obstructing the inner pressure regulation.

[0020] The elastic material having Young's modulus of from 1MPa to 5000MPa is selected from the mutually communicated porous materials (that is, open cell foam or interconnecting foam), fiber bundles and granular aggregates, as described above.

[0021] When it is selected from the interconnecting foam materials, an example is that rubber and/or plastic material is mixed with an inert gas, decomposable foaming agent and volatile organic liquid to provide foams or bubbles to form the structure of intercommunicated pores, and another example is that rubber or plastic material is mixed with an inorganic particles such as calcium carbonate, etc. and then formed into a planar shape and then the inorganic particles are dissolved to thereby form a intercommunicated porous material. As the rubber or plastic material, examples of the resilient material are natural rubber, styrene-butadiene rubber, acrylonitrile-butadiene rubber, chloroprene rubber, neoprene rubber, polyvinyl chloride, polyethylene, polypropylene, acrylonitrile-butadiene-styrene, polystyrene, polyamide, polyurethane, silicone resin, epoxy resin, phenolic resin, urea resin, fluorine plastics, etc. In view of characteristics such as durability to liquid, forming capability of the interconnecting foam or open cell foam material and productivity, it was found that ether type polyurethane resins are especially desirable.

[0022] With respect to the fiber bundles, desired materials are selected from polyester, acrylonitrile, nylon, rayon, acetate, polyvinyl chloride, vinylidene, polyethylene, polypropylene, polyurethane, etc. short and long fibers of these synthetic fibers are mechanically entangled with each other by needle punching, or otherwise formed into a felt-like body and heated to be fused, or bonded by using resins as a solvent or a binder or any other chemically entangled construction. Especially, a thermoplastic material such as polyester, when heat fused, is desirable because it can prevent a skeletal portions except the valve cap from being displaced, so that it is desirable for shape maintenance and reliable operation.

[0023] With respect to the granular aggregates, elastically deformable rubbers, synthetic resin elastomers, etc. can be used. Examples of the rubbers are natural rubber, isoprene rubber, 1,2-polybutadiene, styrene-butadiene rubber, chloroprene rubber, nitrile rubber, butyl rubber, ethylene-propylene rubber, ethylene-propylene-diene rubber, ethylene-vinyl acetate rubber, acrylic rubber, ethylene-acrylic rubber, chlorosulfonated polyethylene, chlorinated polyethylene, polysulfide rubber, epichlorohydrin rubber, silicone rubber, urethane rubber, fluororubber, and other vulcanized synthetic rubber. As the synthetic resin elastomers, examples are selected from polystyrene elastomers, polyolefin elastomers, polyurethane elastomers, polyester elastomers, polyamide elastomers, 1,2-polybutadiene elastomers, ethylene-vinyl acetate elastomers, polyvinyl chloride elastomers, and other thermoplastic elastomers. As the granular aggregates, they may be molded form of particulates (i.e., particulate products) which are synthesized by polymerization, and molded form of particulates formed by ejection or extrusion molding. These particulates have various kinds of spherical shapes such as a complete sphere, spherical segment, elliptical body, paraboloidal body of revolution, or rod shapes such as cylinders, polygonal prisms, truncated cones, or other shapes such as a star-shape which is formed by

forming projections to a spherical body, or a rod shape having a star shape in transversal cross section, or mixture of these shapes. With respect to the granular aggregates, it is desired that an average particle size is 50 to 3000 microns (μm) in diameter. If desired, particles of a plurality of different particle sizes can be used. Further, if the granular aggregates are made by bonding or heat fusing the grains or particles together by applying heat or solvent to form a unitary structure, it is desirable for producing a valve body having an excellent property of shape recovery.

[0024] Further, if a skeletal portion which constitutes and serves as the valve cap has a substantially triangular shape in cross section, it will be advantageous because when the skeletal portions are contacted with each other, the surfaces are contacted with each other to provide a desired sealing effect and, in addition, the cells between each of the skeletal portions for forming air passages can have a maximum volume and, therefore, a desired ventilation or air passage can be obtained.

[0025] When the inner pressure of the container becomes lower than a predetermined pressure level as a result of, for example, using the ink in the container, it is desired that the valve is opened at least one time when the contained liquid is used in the amount of 0.00001 cm^3 to 0.0001 cm^3 . In other words, even when a pressure difference between inside and outside of the container is large by a large amount of consumption of ink at one time, repeated and rapid ventilation or air flowing at the stage of less pressure difference for very minute regulation of the inner pressure will prevent the pressure difference from becoming large and restrict a large pressure from being added within the container.

[0026] When the valve body of a disc shape is fixed, an air space is provided to a surface of the valve for holding and an outer end portion of the surface to be held so that any deformation by the holding force of the valve body can be absorbed. By the air space, the deformation does not effect on an air exchange portion of the valve body so that a suitable air flowing is achieved to provide a suitable regulation of the pressure in the container.

[0027] Ink as an example of the contained liquid used for writing instruments or printers has preferably a surface tension of between $25\text{ m} \cdot \text{N/m}$ and $55\text{ m} \cdot \text{N/m}$, and its example of the compounds are as set forth below.

Water-color ink 1:

[0028]

Duasyn Black HEF SF liquid (C.I. Direct Black 168 produced by Clariant Japan Co., Ltd.)	30.0 part
Ethylene glycol	6.0 part
Glycerine	3.0 part
Isopropanol	3.0 part
NIKKOL BO-10TX (POE oleyl ether: produced by Nikko Chemicals Co., Ltd.)	0.02 part
PROXCEL GXL (1,2-Benzisothiazolin-3-one, produced by Zeneca Ltd.	0.2 part
Deionized water	57.78 part

[0029] The above described components were mixed and agitated for two hours by a propeller agitator to obtain black recording liquid which had a surface tension of $40\text{ m} \cdot \text{N/m}$.

Water-color ink 2:

[0030]

Duasyn Red 3B-SF VP346 (C.I. Reactive Red 23, produced by Clariant Japan Co., Ltd.)	3.0 part
Diethylene glycol	7.0 part
Glycerine	3.0 part
Isopropanol	2.0 part
Urea	5.0 part

(continued)

NIKKOL BT-12	0.5 part
PROXCEL GXL	0.2 part
Deionized water	79.3 part

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[0031] The above components were mixed and agitated for two hours by a propeller agitator and obtained Magenta (fuchsine) recording liquid which had a surface tension of 36 m • N/m.

10 **[0032]** Examples of liquid discharging device using the liquid storage container or chamber are: writing instruments such as pen tips for fountain pens which have ink passages for holding therein ink by capillary action of slits which are formed to planar metal plates; pen tips for ball point pens which hold metal balls at the extended end of the instruments; fiber pen tips using a fiber bundle such as acrylic fiber or polyester fiber; and pen tips of synthetic resin rods which have ink passages having inner projections. Other examples are ink jet printers having printer heads of thermal ink jet type
15 and piezo (pressure) -ink jet type, etc.

[0033] A rubber-like elastic material for the discharge valve member which serves to supply ink to the liquid discharge portion such as a pen tip and a printer head is selected from the materials which will deform by receiving a pressure and recover to its original shape and state after the pressure added thereto is released. Such suitable materials are styrene-butadiene rubber, chloroprene rubber, butyl rubber, chlorinated butyl rubber, brominated butyl rubber, buta-
20 dien rubber, isoprene rubber, nitrile rubber, silicone rubber, ethylene-propylene rubber, urethane rubber, chlorinated polyethylene, polysulfide rubber, epichlorohydrin rubber, fluorine rubber, ethylene-propylene terpolymer, polyethylene elastomer, polyolefin elastomer, polyurethane elastomer, polyester elastomer, polyamide elastomer, 1,2-polybutadiene elastomer, polyvinyl chloride elastomer, etc. Considering the contact with the ink, it is required to be considered that any added chemical materials are not eluted into the ink and do not react with the ink.

25 **[0034]** Further, since the initial production quality must be maintained after repeated operations for fitting and removing the ink cartridge to and from the printer and reliable recovery of the shape is required, it is desired that a compression set is less than 70% and an impact resilience is more than 20%. Incidentally, the impact resistance used herein represents the values disclosed in Japan Industrial Standard JIS K 6301-1995.

[0035] According to the present invention, there is provided a valve body which permits repeated operation of ventilation (air flowing) and very stable operation of ink discharge in compliance with a strength of the pressure. Namely, the valve body is temporarily opened by a small pressure of the predetermined level and, therefore, ventilation or air passing is carried out repeatedly and little by little. In order to obtain discharging stability at all times, it is necessary that the inner pressure of the container is designed to be correspondent with the water head pressure (that is, "pressure head" or "head") which changes along with the consumption or use of the contained liquid such as ink. Although a necessary volume of the air-flowing is changed in response to the change of the water head pressure, the plurality of air passages, which intersect in a three-dimensional network configuration and are communicated with each other to provide interconnection, are provided with valve caps, so that air can pass through air passages which have less flow-resistance. Similarly, in the structure that numbers of resilient granular particles are filled in a compressed state so that air passages are formed by small air spaces or gaps between the adjacent granular particles, numbers of covers or
40 caps are formed along the way of the passages so that the air passages are separated into various divergences. Thus, air can pass through air passage portions which have less flow-resistance in a similar manner as described above. Therefore, an air flow of a desired amount can be realized in response to the changing water head pressure so that a reliable supply of the ink or other contained liquid can be accomplished. At the same time, when a pressure change is so large that a great amount of air must be ventilated, the ventilation holes which are opened in accordance with the
45 necessary amount of the ventilated air can be regulated automatically and, therefore, a short time recovery of the inner pressure can be established so that the change of the inner pressure, large or small, hardly provides unfavorable effect on the quality and nature of the liquid to be discharged. Further, opening /closing operation is conducted by the cover portion and, therefore, even through some of the cover portions do not work well for recovering their original positions, the other cover portions can make up for these less-working cover portions and a desired operational pressure can be maintained. Thus, thinning or blurring of the ink as well as over-flowing or splashing of ink can be strictly prevented.

50 **[0036]** Further, in case that the valve body is made of the interconnecting foam material, it is desired to use the material having a hardness (measured by Asker hardness meter of Type C, JIS S 6050-1994) of from 20 to 100. This permit deformation when the inner pressure of the container is elevated to about 27 to 266 Pa from a level of no pressure difference between the interior and the exterior so that the air passages are communicated with each other. Since
55 the material itself is a resilient material, the opened state of the air passages can be returned to a closed state. In accordance with the pressure difference between the interior and exterior of the container, the opening and closing operations of the air passages are proceeded repeatedly, so that it can comply with various pressure differences. Here, the fact that the valve body is made of the interconnecting foam material means that an elastic material of the structure

in which skeletal portions of the three dimensional structure are all communicated in a unitary structure is used in the invention. When the pressure difference is again returned to a level lower than the predetermined value after opening of the air passages, it is assured that the material is reliably returned to the original condition. Since the material is of unitary structure at the time when it is adapted to the liquid storage container, it can be easily fitted with the air passages being not communicated with each other. Thus, it is assured that ink leakage as well as unintentional air flowing can be completely prevented at the time of assembly.

[0037] When the valve body of the resilient material as described is fixed by holding method to a predetermined position, a volume distortion caused by holding is hardly transmitted to the air exchange portion of the valve body because of the air space which absorbs the deformation due to the holding pressure. Thus, reliable regulation of the inner pressure can be accomplished without difficulty of ink discharge and occurrence of ink leakage.

[0038] Further, in another embodiment of the present invention, a sealed cover body is closely contacted with the cartridge body. This will shield the interior of the ink container or tank from the environment (or exterior) to provide an air-tight condition and, therefore, ink evaporation and ink leakage from the valve body can be prevented when the valve is opened at the time of elevation of the inner pressure.

[0039] In a further embodiment of the invention, ink supply for the printer head is made by the structure which has an injection molded container, discharge valve member of a rubber-like elastic material and an ink passage which serves as a valve mechanism can be closed. This will permit cost reduction and a reliable ink supply. Further, a pressure which serves to provide deformation of the material can be selected as desired and the material for providing the pressure is made of an elastic material, so that a desired liquid-tight condition can be assured and ink leakage can be prevented at the time of abrupt change of inner pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040]

Fig. 1 is schematic diagram of an example of a liquid discharging apparatus to which a valve body of the present invention is to be applied.

Fig. 2 is an electronic microscopic photograph (100 x magnification) showing a surface of the valve body according to a first embodiment (Embodiment 1) of the invention.

Fig. 3 is an electronic microscopic photograph (100 x magnification) showing a sectional shape of the valve body according to the first embodiment of the invention.

Fig. 4 is an electronic microscopic photograph (500 x magnification) showing the sectional shape of the valve body according to the first embodiment of the invention.

Fig. 5 is a sectional view of a writing instrument to which the valve body of the present invention is applied.

Fig. 6 is an enlarged sectional view of a portion identified as "I" in Fig. 5.

Fig. 7 is a sectional view of a writing instrument of another type to which the valve body of the invention is applied.

Fig. 8 is an enlarged sectional view of a portion identified as "II" in Fig. 7.

Fig. 9 is a sectional view of an ink cartridge for an ink jet printer, to which the valve body of the invention is applied.

Fig. 10 is an enlarged sectional view of a portion identified as "III" in Fig. 9.

Fig. 11 is an enlarged sectional view of a portion identified as "IV" in Fig. 9.

Fig. 12 is a partly sectional view of the ink cartridge which is adapted to an ink cartridge holder having an ink head.

Fig. 13 is a perspective view of an ink jet printer showing a printing procedure.

Fig. 14 is a sectional view of a discharge valve member.

Fig. 15 is a sectional view showing a modification of the discharge valve member of Fig. 14.

Fig. 16 is an enlarged sectional view of a portion identified as "V" in Fig. 15.

Fig. 17 is an enlarged sectional view of a portion of the ink cartridge which is adapted to an ink cartridge holder having an ink head.

Fig. 18 is, similar with Fig. 16, an enlarged sectional view of a portion of the modified structure.

Fig. 19 is a sectional view showing the conventional prior art structure.

Fig. 20 is a sectional view showing a comparative valve body of the conventional prior art.

Fig. 21 is a schematic diagram of an inner pressure regulation test apparatus.

Fig. 22 is a schematic diagram of an ink leakage test apparatus.

PREFERRED EMBODIMENTS OF THE INVENTION

[0041] The valve body of the present invention provides the most advantageous effect when it is adapted to a liquid storage container which has discharging device portion for discharging the liquid for writing or printing, a supply device portion for supplying the liquid to the discharging device portion and a ventilation device portion for maintaining the

inner pressure of the container within a predetermined range of pressure. A liquid discharge device incorporating the container as described above will be shown in Fig. 1.

[0042] As shown in Fig. 1, the container 1 is provided with a discharging device portion 2 such as a pen tip for a writing instrument (such as a ball point pen, a fountain pen) and an ink discharging head or nozzle for an ink jet printer, an ink supply passage 3 for supplying the ink to the discharge device portion, a plurality of air passages 4 which communicate the interior with the exterior of the container for adjusting or regulating the inner pressure, and a valve body 5 which has a plurality of valve caps positioned at each of the air passages.

[0043] When writing operation or printing operation is not being carried out at which the pressure in the container 1 is within a lower range by the water head pressure of ink relative to an atmospheric pressure, the valve body 5 serves to close the air passages 4 to shut off the interior from the exterior of the container 1. The air passages 4 are connected with each other and divided into number of branch passages, and formed in such a manner that the air passages to be ventilated, relative to a pressure at the time of opening the air passage, are selected according to and depending upon distance and direction of the branch air passages, size and shape of the valve caps, etc. In other words, when the inner pressure is lowered to an extent that the difference between the inner pressure of the container and an atmospheric pressure is much lower than the water head pressure, and when the inner pressure is elevated or raised above the atmospheric pressure, the valve caps are actuated to either introduce the external air into the container or otherwise discharge the internal air out of the container, so that the pressure in the container is regulated to a lower range by the water head pressure of the ink in the container relative to the atmospheric pressure. However, under the condition that the inner pressure is low due to the ink discharge, a smaller amount of air than the amount of the discharged ink (that is, an amount of supply from the container to the discharge device portion) is taken or introduced into the container, so that a pressure reduction condition is produced in compliance with the water head pressure (or, "pressure head", or simply "head") of a remaining ink in the container. When a pressure difference between interior and exterior of the container is small, only the valve caps which can be actuated by the smallest or minimum force for providing communication for ventilation are opened, and when a large pressure difference is abruptly added, the other valve caps are also opened immediately to comply with the abrupt and large difference of pressure. Thus, in order to cancel a small pressure difference, the valve caps are not excessively opened more than the necessity. Therefore, the inner pressure of the container is restricted from being raised above and beyond the lower range by the water head pressure of the ink to an extent of the level of atmospheric pressure. Further, with respect to a large difference of pressure, it is restricted that the inner pressure of the container does not reach the lower range by the water head pressure of ink due to a shortage of the air for ventilation. Thus, a large difference of pressure can be canceled immediately.

[0044] As the valve body having air passages each of which is communicated with each other and provided with valve caps for closing the air passages as described above, an elastic material is basically used to provide the communicated apertures in which the apertures or air passages are apparently closed by compression. Roughly distinguishing, they are the interconnecting porous materials, the fiber bundles and the aggregations of elastic granules. In the examples of the valve body of the present invention, compressed members of the interconnecting porous material, the fiber bundles and the elastic granular aggregations, respectively, are prepared. Table 1 to Table 3 show a basic structure, material, Young's modulus, apparent density, hardness measured by Asker hardness meter of Type C, JIS S 6050-1994 of Kobunshi Keiki Co., Ltd., porosity (number of pores), compressibility and a sectional shape of a skeletal portion, of each of the prepared compressed members for the valve body. In each example, the materials were subject to a dipping treatment by Frescera-D treatment liquid which is a fluorocarbon coating liquid produced by Matsushita Denko K.K. and dried at 200 °C for five minutes and followed by a repellent treatment.

[0045] In the examples described in Tables 1 to 3, the examples in which ether type polyurethane foam materials are used and treated by a heat compression technique are shown in Figs. 2 to 4. In Fig. 2 which is a picture of 100x magnification of a surface of the valve body 5, it is recognized that there are apertures 5b between the skeletal portions 5a. Fig. 3 is a picture of 100x magnification of the longitudinal sectional view of a surface of the valve body 5 and Fig. 4 is a picture of 500x magnification of longitudinal sectional view of a surface of the valve body 5. As is seen from the pictures of the drawings, the valve body 5 has a substantially triangular sectional shape at the skeletal portion 5a and the skeletal portions 5a are superposed or positioned in an overlapping relation.

[0046] The photographs of Figs. 2 to 4 were taken by cutting samples into a cubic body having an edge of approximately 1.0 cm in a liquid nitrogen and the samples were observed and photographed by using a scanning electron microscope (JSM 5310LV produced by Nippon Denshi K.K., a.k.a. JEOL, Ltd. a Japanese corporation).

[0047] Examples of use of the liquid storage container having the valve body of the present invention will be described by adapting the same to a writing instrument and an ink cartridge for ink jet printer.

[0048] Fig. 5 shows an example of a ball point pen having a ball point tip and a barrel or tubular shaft 11 which has an ink storage portion containing water-color ink indicated by reference numeral 6. The tubular shaft 11 is coupled at its one end with a ball point pen tip 12 through a tip holder 11b so that the ink 6 can flow through the ball point pen tip 12 through a communicating passage 13. The tubular shaft 11 is of tubular shape having an inner diameter of 10mm for an ink storage portion and made of a gas-impermeable and transparent synthetic resin, such as polypropylene so

that remaining amount of ink in the writing instrument can be visually inspected.

[0049] Further, the tip 12 for a ball point pen has a ball which is rotatably held and partly projected from an end of the ball holder so that ink is discharged from a gap between the ball and the ball holder. In a non-writing posture of the ball point pen in which the ball is not contacted with a writing paper surface, the ball is closely contacted with an inner wall of the ball holder when the pen tip is positioned and directed downwardly and, therefore, ink can be fed to the ball point pen tip in a desired manner with no excessive flow of ink, without using an ink feeding core member such as the fiber bundle member. In a writing posture in which the ball is contacted with a writing paper and raised or lifted above into the ball holder, the gap between the ball and the ball holder is formed so that the ink is fed through the gap. In order to assure the close contact between the ball and the ball holder at the time of non-use or non-writing posture of the ball point pen, a resilient member or spring can be provided in the ball holder to forcibly press the ball toward the ball holder.

[0050] The tubular shaft 11 has at its rear end an opening to which an end plug 11a is fitted. The end plug 11a has a hole portion 14 as an air passage. As shown in Fig. 6 which is an enlarged view of Fig. 5, an inner portion of a cover fitting portion 11c of the end plug 11a serves as a valve positioning portion 11d, at which a valve body which is composed of compressed foam body of interconnecting foam material such as ether-polyurethane foam material. The valve positioning portion 11d is an inner diameter larger than an outer diameter of the valve body 15. At the cover fitting portion 11c, a cover 11e which is an injection molded product of polypropylene resin is press-fitted such that the valve body 15 is held relative to the end plug 11a. The cover 11e has a central hole 14a which can be connected with the hole portion 14 of the end plug 11a through the valve body.

[0051] The valve body 15 is pressed, from both the upper and lower portions, by the cover 11e and the end plug 11a to form an air tight portion at the press-contacted portion. However, since the inner diameter is larger than the outer diameter of the valve body 15, an air space is formed by the difference of diameters at the circumferential portion of the valve body 15. This air space serves to absorb deformation by a pressure which is received by the valve body 15 when the valve is held. In other words, when the valve body 15 is compressed or deformed by a pressure, an expanded portion due to deformation (compression) of the valve body 15 is absorbed by the air space. Thus, deformation in the radially inward direction (that is, toward a center portion which forms an air passage) of the valve body 15 is restricted as much as possible and, therefore, a reliable regulation of the inner pressure in the container or tank can be obtained.

[0052] Modification is shown in Figs. 7 and 8 in which the writing instrument has a pen tip of a fiber bundle. Basic structure of the fiber bundle tip is as same as the structure shown in Fig. 5 with an exception of a portion to which the valve body 15 is fitted. The fiber-made pen tip 12' is composed of a pen tip portion projecting from the tip holder and an ink discharge control portion 13a which is positioned at a communicating hole 13.

[0053] As shown in Fig. 8 which is an enlarged view of a part of Fig. 7, an inner diameter is made substantially same as an outer diameter of the valve body 15 so that accurate positioning of the valve body 15 is not required when the valve body is to be assembled but the valve body 15 can be positioned at the same position all the time.

[0054] Further, at an outer end portion of the valve fitting portion 11d is provided a recess to form an air space 7 so that deformation in a radial direction by the holding pressure of the valve 15 is absorbed and, therefore, deformation toward a central portion which serves as an air passage can be restricted, so that a reliable regulation of the inner pressure in the container can be effectively prevented. Further, as a result that the deformation of the valve body 15 is absorbed by the air space 7, the valve body 15 is deformed into a shape having a projection around an edge of the circumferential portion so that it is caught by the valve fitting portion 11d and, therefore, the valve body 15 is firmly and reliably held in the radial direction to prevent the valve body from moving due to dropping of the writing instrument.

[0055] Figs. 9 to 13 show an example of an ink jet printer to which the valve body of the present invention is adapted, wherein Fig. 9 shows an ink cartridge, Fig. 10 shows a peripheral portion of the discharge hole, Fig. 11 shows a periphery of the valve body, Fig. 12 shows an ink cartridge holder having a printer head, and Fig. 13 shows a printer.

[0056] The ink cartridge shown in Fig. 9 is basically composed with a cartridge body 21 having a box-shaped configuration with a bottom and a cover 21a.

[0057] The cartridge body 21 is an injection molded product of polypropylene having transparency so that a remaining volume of the contained liquid can be visually recognized. At the upper opening of the cartridge body 21, there is provided, in an air tight and liquid tight manner by an ultrasonic welding technique, a cover 21a which is also an injection molded product of polypropylene resin. The cover 21a has a hole portion 24 which serves as an air passage and a projecting tubular portion 21c surrounding the hole portion 24. The bottom 21b of the cartridge body 21 has a discharge hole 23 for supplying ink to the printer head (not shown) and the discharge hole 23 is provided with a discharge valve member 22 which serves to provide a non-discharge state of ink when it is not connected with the printer head.

[0058] The discharge valve member 22 is made of a rubber-like resilient material and is composed of a columnar cover portion 22a, and a flange-like deformed portion 22b projecting from a side wall of the cover portion 22a. The flange-like deformed portion 22b is held between a fixed tubular portion 21d formed on the cover 21a and a fitting tubular portion 21e formed on the bottom 21b of the cartridge body 21. Each of the fixed tubular portion 21d and the fitting tubular portion 21e is provided with side holes 21f, 21g for feeding ink, so that ink 6 can be located in an entire interior of the container, and an inclined wall 21h which is located lower as it comes nearer to the discharge hole 23 is formed

on the bottom 21b, so that remaining ink can be used up completely.

[0059] Further, as shown in Fig. 10 which is an enlarged view of a portion III of Fig. 9, a circumferential inner wall of the discharge hole 23 serves as a valve seat 23a, to which an outer surface of the cover portion 22a of the discharge valve member 22 is closely contacted in a liquid tight manner. In other words, in the condition of Figs. 9 and 10 in which no pressure is added to the discharge valve member 22 from outside of the cartridge, the cover portion 22a and the valve seat 23a are contacted with each other at their circumferential portions in a liquid-tight manner to thereby restrict the ink from flowing out. When the valve is pressed upward by an outer (lower in the drawing) pressure, the deformed portion 22b of the discharge valve member 22 is easily deformed to shift upward the cover portion, and a gap is formed relative to the valve seat 23a. Thus, ink which passes through the side hole 21g of the fitting tubular portion 21e and so forth can be discharged.

[0060] As shown in Fig. 11 which is an enlarged view of a portion IV of Fig. 9, the cover 21a has a projecting tubular portion 21c which has a hole portion 24 serving as an air passage. The projecting tubular portion 21c serves as a fitting portion for an air-tight cap 8 which closes the hole portion 24 in an air-tight and liquid-tight manner.

[0061] The cap 8 which can provide air-tight condition is an injection molded product of polypropylene resin having a bottom, and has on its inner wall a circumferential contact portion 8a relative to an outer wall of the projecting tubular portion 21c and a plurality of inner projections 8b which are provided on a circumference. The circumferential contact portion 8a serves as an air-tight contact portion for closing the hole portion 24 in an air-tight manner. If the outer wall of the projecting tubular portion 21c is moved in a sliding manner while the air-tight contact is being maintained, the air-tight cap 8 which is of bottomed tubular shape will push the inner air into the container and, accordingly, it is preferred that the air-tight contact is provided nearer to the opening portion of the projecting tubular portion 21c. The inner projection 8b serves to releasably fix the air-tight cap 8 to the projecting tubular portion 21c and also to provide a fixture to a circumferential recess on the outer wall of the projecting tubular portion 21c. Thus, in the air-tight cap 8, the circumferential contact portion 8a is positioned nearer the bottom (that is, upper portion in the drawing) than the inner projection 8b. By the structure that the circumferential contact portion 8a is contacted with the cartridge body in an air-tight manner, the interior of the ink tank or container can be sealed from the atmosphere to thereby obtain an air-tight state and, therefore, an unexpected leakage or evaporation of ink can be prevented when the instrument is not used.

[0062] On the inside of the projecting tubular portion 21c of the cover 21a is provided a valve fitting portion 21i for positioning the valve 25 which is made of an interconnecting foam material such as ether-polyurethane resin, the interconnecting foam being compressed to close pores or passages. Further, on the projecting tubular portion 21c, a closure member 21j which is an injection-molded product of polypropylene resin is fixed by an ultrasonic welding technique in such a manner that the valve body 25 is held relative to the valve fitting portion 21i. The valve body 25 is pressed from above and below by the cover 21a and the closure member 21j to form an air-tight state and is fixed. An inner diameter of the valve fitting portion 21i is determined to be substantially equal to an outer diameter of the valve body so that a special positioning is not required for setting the valve body 25 and so that the valve body can be positioned at the same position all the time.

[0063] A recess is formed on the outer end portion of the valve fitting portion 21i to provide an air space 7 which absorbs deformation of the valve body in a radially outward direction so that deformation toward a center of the valve body is restricted, wherein the an air passage is formed at the center of the valve body. Thus, a reliable regulation of the inner pressure of the container can be established.

[0064] Further, in the embodiment of the invention described above, a contact surface between a bottom surface of the valve fitting portion 21i for holding the valve body 25 and the valve body 25 at the bottom surface of the closure member 21j is design to have an inclined surface which increases the holding length (or distance) toward a central portion, and an outer circumferential portion of the valve body 25 is pressed to form an air-tight portion at this pressed portion. With respect to a pressing length of the portion of the valve body 25, the holding length becomes larger toward a center thereof and a ratio of a pressing length at a center portion and a pressing length at an outer circumference is substantially 1:3. Since a contact length at the center portion of the valve body 25 is relatively small, deformation generated at the center portion is also small, so that deformation at the center portion of the valve body 25 can be restricted. Therefore, in the embodiment of the invention described above, deformation at the central portion of the valve body 25 can be effectively restricted and, therefore, this can prevent a closing state of the interconnecting passages in the valve body 25 from becoming stronger than necessity. Further, this can prevent unintentional release of the closed state of the interconnecting passages. Thus, reliable regulation of the inner pressure of the container or tank can be obtained.

[0065] A projecting portion 21k is provided in the container so that it has a slit-like opening 21l on the side wall of the projecting portion 21k. This serves as an air passage and also serves to prevent the ink 6 from splashing toward the valve body 25 when a shock is added.

[0066] With reference to Fig. 12 which shows an example in which the ink cartridge is connected with the cartridge holder having a printer head, a cartridge holder 27 has an ink supply tube 27a for supplying ink to a printer head at the position of a discharging port 23 at a lower portion of the ink cartridge, and is press-contacted with the discharge valve

member 22. A rubber packing or gasket 27b is disposed around the ink supply tube 27a to have a close contact with the circumference of the ink cartridge to thereby prevent the ink from leaking out of the device.

[0067] In Fig. 13 which shows an ink jet type printer incorporating the valve body of the present invention, the cartridge holder 27 is fitted to a driving arm K so that the cartridge holder 27 is moved along a longitudinal direction of the driving arm K for printing operation while paper P is being fed to a predetermined position.

[0068] Further embodiments of the invention will be explained with reference to Figs. 14 to 17, which will be almost similar with previous embodiments described above except the shape of the discharge valve member 22 and the closing method of the air-tight cap 8 which provides a sealed or air-tight posture of the hole portion 24 for providing a sealed state of the hole portion 24. In Fig. 14 showing the discharge valve member 22, it is substantially cup-shaped configuration having a bottom. The discharge valve member 22 has a cover portion 22a for providing a liquid-tight state by contact with the valve seat 23a, a fixed tubular portion 21d formed on the cover 21a, a flange portion 22c which is held relative to a fitting tubular portion 21e formed on the bottom portion 21b of the cartridge body 21, and a deformed portion 22b which connects the cover portion 22a and the flange portion 22c. The deformed portion 22b is a portion which is positively changed in its shape when the cover portion 22a receives a pressure or force and it has a recess 22d which defines, in a certain degree, the direction of deformation (that is, folding posture). Thus, when the cover portion 22a receives a pressure, the recess 22d is curved or bent inwardly. Further, the recess 22d is provided with an ink hole 22e so that the ink contained in the cup-like container can be used for printing purposes. The inner wall surface of the cover portion 22a has an inclined wall 22f which is raised at its central portion so that the ink in the container can be effectively discharged out of the discharge valve member 22.

[0069] In Fig. 15 which shows the cartridge body to which the valve body of the invention is adapted, a tapered and inclined surface 22g is formed on the outer side of the cover portion 22a so that it can be easily adapted to the discharge hole 23, and the portion adjacent to the inclined surface 22g contacts the valve seat 23a to thereby form a liquid-tight state. At the time when the discharge valve member 22 is assembled, the discharge valve member 22 is press-fitted to the discharge hole 23 from inside of the cartridge body 21 to which the cover 21a is not yet installed, and then the cover 21a is mounted on the cartridge body 21 to hold and fix the cover 21a the discharge valve body 22. The cover 21a may be fitted in position with the ink contained therein, or otherwise it may be possible that the ink is filled from the hole portion 24 for adapting the valve body 25. Alternatively, a hole with a plug can be formed on a separate member for filling the ink. In case that the ink-filling hole with a plug is provided, it is convenient for refilling of the ink when the ink is used up.

[0070] As shown in Fig. 16, a sheet 8c of ethylene-propylene-diene rubber is disposed on a bottom of the sealed type cap 8, and the sheet 8c and an opened rear end of the projecting tubular portion 21c is contacted in a circumferential configuration to form an air-tight condition. By the structure as described above, no sliding movement of the cap 8 is required in the air-tight state when the cap is fitted and removed and, therefore, possibility of introducing the air in the sealed cap 8 into the container, which is seen in the embodiment of Fig. 11, can be minimized. The sheet 8c is an elastomer member having a Shore hardness 30 in A-scale and slightly deformed at the time of contact. By establishing an air-tight condition by utilizing an elastomer member having excellent elasticity, a dimensional allowance of the products is widened, so that a desired air-tight condition can be obtained reliably. In this embodiment of the invention, as the elastomer member, ethylene-propylene-diene terpolymer which has Shore hardness of 30 in A-scale but it should be noted that the Shore hardness in A-scale can be set as desired and not limited to the above. Further, the material can be selected, in view of a liquid-tight property as well as an air-tight property, from acrylonitrile-butadiene rubber, styrene-butadiene rubber, urethane rubber, butyl rubber, chloroprene rubber, Hypalon (product of du Pont), fluororubber, etc.

[0071] In Fig. 17 which shows a cartridge holder 27 for a printer to which the valve body of the present invention is adapted, an ink supply tube 27a is a bypass for feeding the ink to the printer head. In this embodiment of Fig. 17, the ink supply tube 27a is formed by tubular member having an opening and a net 27c at the opening. When the net 27c is pressed against a bottom of the discharge valve member 22, the aforementioned deformed portion 22b is deformed or changes its shape so that the cover portion 22a is shifted upward. At this moment, a gap is formed between the cover portion 22a and the valve seat 23a so that the ink is discharged through the gap. On the outer side bottom surface which contacts the net 27c of the discharge valve member 22, a plurality of radial grooves for feeding the ink are provided to intersect with each other at a center. The ink which is discharged along the outer side of the discharge valve member 22 is delivered along the radial grooves 22h to the ink supply tube 27a. If necessary, a gasket or packing member 27b such as an O-ring may be provided to the ink supply tube 27a for prevention of ink leakage, and a special container (not shown) can be provided which can encase the entire structure of the cartridge.

[0072] Fig. 18 shows another modification, in which an ink cartridge which is similar with that of the embodiment of Fig. 16 has a structure that the cap 8 is unitarily formed with the cover 21a. A connecting belt portion 8d is bent to be removably fitted to the projecting tubular portion 21c in a liquid-tight manner.

[0073] Returning back to Fig. 9 which shows a cartridge, samples of the discharge valve members were produced by changing the shape, material, dimensions, etc. and Embodiments 101 to 107 and Comparative Example 101 were

made by using the valve body of Embodiment 1 of the invention. Further, Comparative Example 101 was made by producing a cartridge by using the discharge valve member 221 which has a slit-like ink passage 221a to the disc shaped member (of silicone rubber) as illustrated in Fig. 19. The Embodiments 101 to 107 and the Comparative Example 101 are shown in Table 4.

[0074] In the embodiments 1 through 21 of the invention described above, tests were made with respect to the following items, the test results of which are described in Table 5 and Table 6. In a comparative example shown in the Table, a comparative valve body D of nitrile rubber as shown in Fig. 20 was made and a test was conducted in a similar manner as those of the tests of the embodiments of the present invention. The comparative valve body D has a circumferential flange 25b and a dome-like projection 25c at the center of the flange 25b. The projection 25c has at its top a slit 25a which serves as an air passage. The slit 25a is generally closed when no force is added to it. When a convex or projected side of the projection 25c is lowered or depressed beyond a predetermined value relative to a concave or recessed side of the projection 25c, the slit 25a is opened to permit the air to pass therethrough. The comparative valve body D has a thickness of 1.0 mm and the slit 25a which will serve as the air passage has a length of 3.0 mm. In order to fit the comparative valve body D to the writing instrument or the ink cartridge for the ink jet printer, the flange 25b is held by the adjacent portions of the device in a liquid-tight manner in a similar manner as Figs. 9 to 11.

1. Inner Pressure Regulation Test:

(1) Test Apparatus

[0075] A test apparatus for the inner pressure regulation test is schematically shown in Fig. 21. The valve bodies of the embodiments 1 through 21 of the present invention and the valve body of the comparative example are installed in a similar manner as the case of the writing instrument of Fig. 7, and the fiber pen tip is removed, and the writing instrument is connected through a silicone tube 33 with a vacuum pump 32 (Type: PCX 135 produced by Yamato Kagaku K.K.) which is capable of regulating a pressure reduction value by a needle valve 31. Further, a hole is formed on the tubular shaft of the writing instrument and a tube 34 is connected at one end thereto, and the tube 34 is connected at its other end with a gauge pressure device 35 (Type: GPM 104N, produced by Okano Seisakusho, a Japanese corporation) through another silicone tube 33. The gauge pressure device 35 is connected with a recorder 37 for observing a relationship relative to the time.

(2) Test

[0076] A vacuum pump 32 was used to regulate the pressure reduction of the interior or the tubular shaft relative to the atmospheric pressure by reducing the predetermined values (6.5hPa, 13.0hPa, 19.5hPa), and relationship between the pressure change in the tubular shaft and the time was recorded on a graph of the recorder 37. By suction force of the vacuum pump 32, an inner pressure of the tubular shaft is lowered when the valve body is closed, and the inner pressure of the tubular shaft became minimum immediately before the valve body is opened. When the valve body is opened, the air is introduced into the tubular shaft and, therefore, the inner pressure of the tubular shaft is raised, and the inner pressure becomes maximum immediately before the valve body is closed again. The time length from the minimum value to the maximum value of the inner pressure of the tubular shaft was measured. Further, in a continuous manner, also the time length from the aforementioned maximum value to the following minimum value of the next time was measured.

(3) Test Results

[0077] The time length which is required from the maximum value of the pressure in the tubular shaft to the minimum value represents that a shorter time facilitates and enhances an easier opening of the valve body. Further, the time length from the minimum value to the maximum value represents that a shorter time facilitates and enhances an easier closing of the valve body.

[0078] In the embodiments, the time length from the maximum value to the minimum value is extremely short and the time length from the minimum value to the maximum value is a very short moment. This is based upon the fact that although the valve used in the embodiments can be very readily opened, the valve body can be immediately returned to the original position after the regulation of the inner pressure. In addition, the embodiments show that there is less changes in the maximum values and in the minimum values and that a stable regulation of the inner pressure is obtained even after repeated operations of opening and closing of the valve body.

2. Writing/Printing Test by Difference of Discharging Amount:

(1) Test Method

5 **[0079]** Test samples for writing instrument were prepared by adapting the valve bodies to an end plug portion of a marker pen (Model S520, produced by Pentel K.K. a corporation of Japan and the assignee of the present invention), with an air passage of the tip end being closed, in a similar manner as the writing instrument of Fig. 7. A width of the writing mark (that is, width or thickness of written mark) was determined to be 0.7mm. Further, test samples for ink cartridge for the ink jet printer were prepared by adapting the valve bodies to an end plug portion of an ink cartridge 'Type

10 BCI-21 Black, produced by Canon Co., Ltd., a Japanese corporation) in a similar manner as the ink cartridge shown in Fig. 9.

[0080] With respect to the samples of the writing instrument, a writing test machine (Model TS-4C-10, produced by Seiki Kogyo K.K., a corporation of Japan) was used to carry out the tests under the conditions of: a writing load of 0.98N, writing angle of 70°, and writing speed of 70 mm/sec., and ink discharge amount was measured in case of 50-meter long writing at the time when an ink filling height is 100mm.

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[0081] With respect to the samples of the ink cartridge, an ink jet printer (Model: BJC465J, produced by Canon Co., Ltd.) was used to print a black-out (or, paint out) line having a width of 0.2mm on a paper of A-4 size at a printing speed of 70mm/second, and ink discharge amount in case of a printing of 50 meters long (that is, black-out line of 0.2 mm width) was measured when an ink filling height was 50mm.

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[0082] Next, in order that the discharging volume of ink is increased, the pen tip of the sample was exchanged to a pen tip having a writing width of 2.1mm rather than 0.7mm in the previous case. With respect to the ink jet cartridge, setting of the printer is changes so that a printing width is 0.6mm. Thereafter, similar tests for writing and printing were conducted to measure an ink discharge amount.

[0083] In the tests described above, the ink discharge amount was exchanged into a volume (cm³) from a change of mass (g) of samples before and after the writing or printing by a specific gravity of ink (that is, 1.06). Further, the tests were carried out to recognize by visual examination the results of the writing and printing.

25

(2) Test Results

30 **[0084]** In the embodiments described above, the writing and printing results were good when the writing/printing width was changed to be larger (that is, even when a discharge amount of the ink was increased). By contrast, in the comparative example, it was found that the writing was blurred or thinned and/or incapability of writing/printing with no supply (discharge) of ink.

35 3. Writing/Printing Test by Difference of Temperature:

(1) Test Method

[0085] As similar as the above-described tests by difference of discharging amount, test samples were obtained.

40 The samples were subjected to the test of ink discharge amount by 50-meter long writing/printing by the above-described test machine for writing instrument and ink jet printer, in a thermostatic chamber at temperature of 50°C. Then, the samples were moved to a thermostatic chamber at temperature of 10°C and then subjected to the similar tests as described above to proceed 50-meter long writing/printing to obtain the discharged amount of ink. Further, writing/printing results were examined by visual examination at each environmental temperature.

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(2) Test Results

[0086] In the embodiments of the invention, even when the environmental temperature was abruptly dropped to a low temperature, a stable discharge of the ink was accomplished and good writing/printing was obtained. By contrast,

50 the sample of the comparative example showed an excessive flow and splashing of ink.

[0087] Tests were conducted with respect to embodiments 101 to 107 and comparative example 101 and tests results are shown in Table 7.

4. Production Scattering Test:

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(1) Test Method

[0088] Ten (10) samples were prepared and the ink cartridge of aforementioned Type BCI-21 Black of Canon Co.,

5 Ltd. was used. The samples were adapted to the ink jet printer (BJC465 J of Canon Co., Ltd.) and printing was made on A4-size paper at 70mm/sec. to obtain printing width of 0.2 mm to measure an ink discharge amount of a 50-meter long printing at the time of 50mm in ink filling height. In the tests described above, the ink discharge amount was exchanged into a volume (cm³) from a change of mass (g) of samples before and after the writing or printing by a specific gravity of ink (that is, 1.06). Further, the tests were carried out to recognize by visual examination the results of the writing and printing.

(2) Test Results:

10 **[0089]** In the embodiments of the invention, every sample shows similar values of the discharge amount and, on the other hand, the comparative example showed deviation or scattering of discharge amount and failed to provide stable products.

5. Ink Leakage Test:

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(1) Test Method

20 **[0090]** In the embodiments of the invention (Embodiments 101 to 107) and the comparative example 101, an ink filling height was set to be 24mm. The samples were positioned and stood still in a thermostatic chamber at environmental temperature of 50 °C, with the ink discharging holes being positioned downwardly, for one (1) hour and then visual examination was made to find ink leakage from the discharge valve member.

(2) Test Results

25 **[0091]** No ink leakage was found in the samples of the embodiments of the invention and a reliable sealing effect (air-tight condition) of the discharge valve member was perfect.

6. Ink Reduction Test:

30 (1) Test Method

[0092] In the embodiments of the invention (Embodiments 101 to 107) and the comparative example 101, an ink filling height was set to be 24mm. The samples were positioned and stood still in a thermostatic chamber at environmental temperature of 50 °C, with the ink discharging holes being positioned downwardly, for one (1) month and then visual examination was made to find ink leakage from the discharge valve member. An amount of the ink reduction was measured from the change of mass (g) of the samples before and after the test.

(2) Test Results

40 **[0093]** In the samples of the embodiments of the invention, ink reduction is small regardless of the direction in which an air-tight portion of the discharge valve member is positioned.

7. Repeated Mounting/Removing Test:

45 (1) Test Method

[0094] In each of the embodiments of the invention (Embodiments 101 to 107) and the comparative example 101, ink filling height is set to be 24mm. The samples were repeatedly mounted to and removed from the cartridge holder (Type BC-10, made by Canon Co., Ltd.) having an ink jet printer head by 1000 times and, thereafter, placed and stood still for one (1) hour in a thermostatic chamber at environmental temperature of 50°C with the ink discharge hole positioned downwardly. Then an ink leakage from the discharge valve member was examined by visual examination.

(2) Test Results

55 **[0095]** There was no ink leakage in the samples of the embodiments of the invention. Generally, the number of mounting/removing of the ink cartridge in a normal use would be less than 1000 times until the contained ink is used up completely even if the cartridge is removed every time printing is carried out. The test results show that durability or maintenance of the air-tight condition of the discharge valve member is very high when repeated mounting (or attach-

ing)/ removing (or detaching) is made.

[0096] Composition of the ink used in the tests are as set forth below.

(1) Ink Sample for Writing Instrument:

[0097]

FISCO BLACK 883 (dye, product of Orient Chemical Co., Ltd., a corporation of Japan)	40 part
Ethylene glycol	10 part
Deionized water	50 part

(2) Ink Sample for Ink Jet Cartridge:

[0098]

DUASYN-D. BLACK HEF-SSLIQ 10% Aqueous Solution (dye, a product of Clariant Japan Co., Ltd.)	30 part
Ethylene glycol	5.0 part
Glyceline	10.0 part
Isopropanol	3.0 part
BO-10TX (surface active agent, product of Nikko Chemicals Co., Ltd.)	0.02 part
Deionized water	50.98 part

[0099] According to the present invention, the valve body is capable of meeting with a range from a very small change of pressure to a large change of pressure and, therefore, it is beneficially applicable to ink storage containers for writing instruments and ink jet printers. Thus, a shortage of ink supply to an ink discharging device can be minimized. Further, when there is a relatively large difference of pressure, the inner pressure of the container can be immediately and suitably recovered to a suitable pressure condition and, therefore, an excessive flow or "gobbing" and splashing of a liquid due to an excessive supply of the liquid can be suitably restricted as well as the aforementioned restriction of blurred (or thinned) condition due to shortage of the supply. Further, scattering of the ink discharge amount can be minimized.

[0100] Although the present invention has been described with reference to the preferred embodiments thereof, many modifications and alterations can be made within the spirit of the invention.

Table 1

	Embodiment 1	Embodiment 2	Embodiment 3	Embodiment 4	Embodiment 5	Embodiment 6	Embodiment 7
Structure	interconnecting foam	interconnecting foam	interconnecting foam	interconnecting foam	interconnecting foam	granular aggregate nitrile rubber	granular aggregate nitrile rubber
Materials	ether polyurethane foam (heat compression)	ether polyurethane foam (heat compression)	ether polyurethane foam (heat compression)	ether polyurethane foam (heat compression)	glass balloon filled in ether polyurethane resin (30 μ m diameter, 1 μ m thickness)	spherical particle of (spherical particle of 1.0 mm diameter) heat welding	spherical particle of (spherical particle of 1.0 mm diameter) heat welding
Young's modulus (MPa)	900	900	3000	3000	5000	1	2500
Apparent density (g/cm ³)	0.03	0.73	1.50	1.50	1.50	0.71	0.71
Hardness	30	45	60	70	85	30	70
Number of pores (pores/cm)	16	16	16	16	16	10	10
Compressibility (%)	20	20	20	20	20	33	33
Sectional shape of skeletal portion	triangular	triangular	triangular	triangular	triangular	circular	circular

(Hardness: measured by Asker hardness meter of Type C, JIS S 6050-1994)

Table 2

	Embodiment 8	Embodiment 9	Embodiment 10	Embodiment 11	Embodiment 12	Embodiment 13	Embodiment 14
Structure	granular aggregate nitrile rubber (spherical particle of 1.0 mm diameter) heat welding	granular aggregate nitrile rubber (spherical particle of 1.0 mm diameter) heat welding	granular aggregate nitrile rubber (spherical particle of 1.2 mm diameter) heat welding	fiber bundle 4 denier polyethylene terephthalate fiber felt	interconnecting foam	interconnecting foam	interconnecting foam
Materials					ether polyurethane foam (heat compression)	ether polyurethane foam (heat compression)	ether polyurethane foam (heat compression)
Young's modulus (MPa)	5000	3500	3500	3500	900	900	900
Apparent density (g/cm ³)	0.71	0.71	0.71	0.71	0.13	0.13	0.13
Hardness	90	20	35	85	30	50	70
Number of pores (pores/cm)	10	4	83	833	197	197	197
Compressibility (%)	33	33	33	33	5	27	40
Sectional shape of skeletal portion	circular	circular	circular	circular	triangular	triangular	triangular

(Hardness: measured by Asker hardness meter of Type C, JIS S 6050-1994)

Table 3

	Embodiment 15	Embodiment 16	Embodiment 17	Embodiment 18	Embodiment 19	Embodiment 20	Embodiment 21
Structure	interconnecting foam	interconnecting foam	interconnecting foam	interconnecting foam	interconnecting foam	interconnecting foam	interconnecting foam
Materials	ether polyurethane foam (heat compression)	polyvinyl chloride foam	polyvinyl formal foam	ether polyurethane foam (heat compression)	ether polyurethane foam (heat compression)	ether polyurethane foam (heat compression)	ether polyurethane foam (heat compression)
Young's modulus (MPa)	900	3000	3000	3000	3	3500	3500
Apparent density (g/cm ³)	0.08	0.50	0.50	0.50	0.06	0.83	0.83
Hardness	35	50	50	50	20	95	95
Number of pores (pores/cm)	16	167	167	167	16	16	16
Compressibility (%)	10	20	20	20	40	40	40
Sectional shape of skeletal portion	triangular	triangular	circular	triangular	triangular	triangular	triangular

(Hardness: measured by Asker hardness meter of Type C, JIS S 6050-1994)

Table 4

Embodiment	Shape	Material	Compression set (%)	Impact resilience	Thickness of deformed portion (mm)	Diameter of cover portion (mm)	Ratio of thickness of deformed portion/ diameter of cover portion	Length of deformed portion (mm)	Ratio of thickness of deformed portion/ length of deformed portion
Embodiment 101	disc shape	chlorinated butyl rubber	20	50	11.3	11.3	100.0%	2.0	565.0%
Embodiment 102	cup shape	chlorinated butyl rubber	20	50	1.0	11.3	8.8%	7.0	14.3%
Embodiment 103	cup shape	acrylic rubber	70	20	2.0	11.3	17.7%	7.0	28.6%
Embodiment 104	cup shape	silicone rubber	10	80	0.5	11.3	4.4%	7.0	7.1%
Embodiment 105	cup shape	chlorosulfonated polyethylene	80	40	1.0	11.3	8.8%	7.0	14.3%
Embodiment 106	cup shape	nitrile rubber	50	10	1.0	11.3	8.8%	7.0	14.3%
Embodiment 107	cup shape	low-density polyethylene	98	5	1.0	11.3	8.8%	7.0	14.3%
Comparative example 101	slit valve	silicone rubber	10	80	---	---	---	---	---

Table 5

Inner pressure regulation test	6.5hPa	Max. to min. time (sec.)	Embodi-ment 1	Embodi-ment 2	Embodi-ment 3	Embodi-ment 4	Embodi-ment 5	Embodi-ment 6	Embodi-ment 7	Embodi-ment 8	Embodi-ment 9	Embodi-ment 10	Embodi-ment 11
			6.50	4.50	3.50	2.20	2.10	8.40	6.10	4.30	2.10	3.50	4.80
Writing/ printing test by difference of discharge amount	writing test	Min. to max. time (sec.)	0.30	0.50	0.30	0.30	0.30	0.50	0.20	0.12	0.40	0.30	0.40
		Max. to min. time (sec.)	5.00	3.00	1.90	2.00	2.00	6.70	4.80	3.20	1.90	1.90	3.50
		Min. to max. time (sec.)	0.20	0.30	0.30	0.20	0.20	0.30	0.20	0.08	0.20	0.30	0.20
		Max. to min. time (sec.)	4.20	2.20	1.00	1.70	1.70	5.70	4.10	2.10	1.70	1.00	2.30
Writing/ printing test by difference of temperature	printing test	Min. to max. time (sec.)	0.05	0.10	0.10	0.17	0.17	0.10	0.13	0.04	0.15	0.10	0.05
		Ink discharge volume (cc)	0.196	0.197	0.184	0.178	0.167	0.192	0.178	0.166	0.216	0.212	0.170
		writing width 0.7mm	good	good	good	good	good	good	good	good	good	good	good
		writing width 2.1mm	0.609	0.566	0.498	0.508	0.466	0.577	0.493	0.468	0.619	0.623	0.478
Writing/ printing test by difference of temperature	printing test	writing width 0.2mm	good	good	good	good	good	good	good	good	good	good	good
		printing width 0.6mm	0.223	0.196	0.187	0.183	0.178	0.193	0.188	0.176	0.236	0.242	0.188
		Ink discharge volume (cc)	0.619	0.498	0.566	0.528	0.498	0.581	0.514	0.506	0.619	0.623	0.530
		printing volume (cc)	0.207	0.232	0.204	0.183	0.170	0.222	0.187	0.177	0.208	0.208	0.232
Writing/ printing test by difference of temperature	writing test	50 °C	good	good	good	good	good	good	good	good	good	good	good
		10 °C	0.168	0.161	0.156	0.168	0.156	0.161	0.159	0.162	0.176	0.178	0.168
		Ink discharge volume (cc)	good	good	good	good	good	good	good	good	good	good	good
		writing width 0.7mm	0.217	0.194	0.190	0.185	0.177	0.194	0.183	0.176	0.227	0.232	0.181
Writing/ printing test by difference of temperature	printing test	50 °C	good	good	good	good	good	good	good	good	good	good	good
		10 °C	0.183	0.174	0.165	0.170	0.153	0.185	0.163	0.164	0.186	0.196	0.164
		Ink discharge volume (cc)	good	good	good	good	good	good	good	good	good	good	good
		printing width 0.6mm	good	good	good	good	good	good	good	good	good	good	good

Table 6

[illegible]

Table 7

	Production scattering test													Ink leakage test	Ink reduction test	Repeated mounting/removing test	
	ink discharge amount										max. value	min. value	difference between max. and min. values				light & shade between max. and min. values
	sample 1	sample 2	sample 3	sample 4	sample 5	sample 6	sample 7	sample 8	sample 9	sample 10							
Embodiment 101	0.195g	0.191g	0.201g	0.208g	0.193g	0.198g	0.210g	0.203g	0.195g	0.199g	0.210g	0.191g	0.019g	No	No	No	
Embodiment 102	0.199g	0.203g	0.205g	0.206g	0.198g	0.195g	0.197g	0.201g	0.203g	0.194g	0.206g	0.194g	0.012g	No	No	No	
Embodiment 103	0.196g	0.189g	0.195g	0.201g	0.202g	0.193g	0.198g	0.193g	0.194g	0.203g	0.203g	0.189g	0.014g	No	No	No	
Embodiment 104	0.205g	0.199g	0.193g	0.192g	0.207g	0.203g	0.211g	0.202g	0.194g	0.198g	0.211g	0.192g	0.019g	No	No	No	
Embodiment 105	0.201g	0.190g	0.197g	0.198g	0.192g	0.208g	0.203g	0.195g	0.191g	0.209g	0.209g	0.190g	0.019g	No	No	No	
Embodiment 106	0.197g	0.211g	0.212g	0.196g	0.193g	0.198g	0.201g	0.207g	0.206g	0.197g	0.212g	0.193g	0.019g	No	No	No	
Embodiment 107	0.206g	0.193g	0.205g	0.211g	0.201g	0.196g	0.195g	0.199g	0.202g	0.208g	0.211g	0.193g	0.018g	No	No	No	
Comparative example 101	0.212g	0.203g	0.199g	0.088g	0.194g	0.199g	0.213g	0.194g	0.113g	0.195g	0.213g	0.088g	0.125g	Yes	Yes	Yes	

Claims

1. A valve body comprising:

5 a plurality of passages connected with each other, and
a plurality of valve cap made of an elastic material and adaptable to the passages.

2. A valve body according to claim 1, wherein said valve cap adaptable for closing the air passage is made of a resilient material having Young's modulus in the range of from 1 MPa, inclusive, to 5000 MPa, inclusive.

10 3. A valve body according to claim 2, wherein said valve cap is composed of an elastic material having skeletal portions in the form of a continuous three-dimensional network and a plurality of interconnecting foams formed at a gap of the skeletal portions,

15 wherein the elastic material is compressed to form a member having an apparent density of from 0.03g/cm³ to 1.5g/cm³, and

the skeletal portions are connected with each other to thereby close the interconnecting foams to thereby form the valve cap.

20 4. A valve body according to claim 3, wherein compression of the elastic material is made thermally so that the compressed state of the elastic material can be maintained by itself.

25 5. A valve body according to claim 4, wherein said elastic material of interconnecting foam material in a three-dimensional network skeleton after the thermal compression has a hardness (measured by Asker hardness meter of Type C, JIS s 6050-1994) of more than 20 inclusive and less than 100, when the interconnecting foam material has a thickness of 8mm.

30 6. A valve body according to claim 5, wherein the thermal compression is made in one direction, and a thickness of the compression direction of the resilient material after compression molding is from 5% to 40% of the thickness of the resilient material prior to the compression molding.

7. A valve body according to claim 3, wherein the number of pores per unit length on a surface of said elastic material prior to compression is more than 4 pores/cm, inclusive and less than 1000 pores/cm, inclusive.

35 8. A valve body according to claim 3, wherein said skeletal portion of the continued three-dimensional network has a substantially triangular sectional shape.

9. A valve body according to claim 2, wherein the elastic material is made of ether-polyurethane resin.

40 10. A liquid storage container for a liquid discharging device comprising:

a liquid passage connected with the liquid discharging device containing therein a predetermined liquid, an air passage for permitting air to pass through between an interior of the container and exterior of the container, and

45 a valve means, adapted to the air passage, for temporarily opening the air passage in accordance with a change of pressure between the exterior and interior of the container to thereby permit the air through the air passage,

wherein the valve body has:

a plurality of passages connected with each other, and

50 a plurality of valve cap made of an elastic material and adaptable to the passages.

11. A liquid storage container according to claim 10, the valve body is held at its surface and an air space is formed at an outer end portion of the holding surface of the valve body

55 12. A liquid storage container according to claim 11, wherein the valve body is held by a holding member, and the holding member has an inclined surface which is increasing in its holding width toward a center so that a compression deformation is increased as it goes from a central portion of the valve to an outer portion thereof.

13. A liquid storage container according to claim 10, wherein the air passage is opened at least one time to permit the air can pass through between the interior and exterior of the container when a liquid in the amount of 0.00001 cm^3 to 0.0001 cm^3 is supplied to the liquid discharging device.
- 5 14. A liquid storage container according to claim 10, wherein the liquid discharge device is selected from a pen tip for a fountain pen, a pen tip for a ball point pen, and a pen tip for synthetic resin pen having an ink feeding aperture.
15. A liquid storage container according to claim 10, wherein the liquid discharge device is a printer head for an ink jet printer.
- 10 16. A liquid storage container according to claim 15, a releasable air-tight cover member is positioned for externally closing the air passages wherein the air passages have the valve bodies.
- 15 17. A liquid storage container according to claim 16, wherein the air-tight cover member is made of a polypropylene resin.
18. A liquid storage container according to claim 16, wherein the air-tight cover member is of box shape having a bottom and has:
20 a fixed portion releasably adapted to the cartridge body, and
 an air-tight circumferential contact portion relative to the cartridge body, and
 wherein the fixed portion is fitted to the cartridge body so that the air-tight contact portion is contacted with the cartridge body in an air-tight manner.
- 25 19. A liquid storage container according to claim 18, wherein the air-tight contact portion is made of a sheet-like elastomer fitted in the air-tight cover member.
20. A liquid storage container according to claim 16, wherein the air-tight cover member is connected with the container body.
- 30 21. A liquid storage container according to claim 15, wherein the liquid discharge device is an ink jet printer, and
 wherein a discharge valve member made of a rubber-like elastic material is compressed against the circumferential portion of the ink discharge hole for supplying the ink to the printer head, and the discharge valve member is held in the compressed state, and
35 wherein when a pressing force is added to the discharge valve member, the discharge valve member is deformed so that a space is formed relative to an inner circumferential wall of the ink discharge hole to thereby permitting a flow of the ink.
22. A liquid storage container according to claim 21, wherein the rubber-like elastic material for forming the discharge valve member has a compression set of 70% or less.
- 40 23. A liquid storage container according to claim 21, wherein an impact resilience of the rubber-like elastic material is 20% or more.
- 45 24. A liquid storage container according to claim 21, wherein the discharge valve member has a cover portion for forming a liquid-tight state by contacting with the circumferential inner wall of the ink discharge hole, a flange portion held and fixed to the container, and a deformed portion for connecting the cover portion with the flange portion, wherein the deformed portion extends in the same direction as the direction of said pressing force.
- 50 25. A liquid storage container according to claim 24, wherein a thickness of the deformed portion of the discharge valve member is set to be 4% or more and 18% or less of a diameter of the cover portion.
26. A liquid storage container according to claim 24, wherein a thickness of the deformed portion of the discharge valve member is set to be 7% or more and 30% or less of a length of the deformed portion.
- 55 27. A liquid storage container according to claim 21, wherein the pressing force for deforming the discharge valve member is given by contacting an ink connecting means of a capillary action to an outer surface of the discharge valve member, and wherein a plurality of radially intersecting ink passages are formed on an outer surface of the

discharge valve member.

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FIG.1

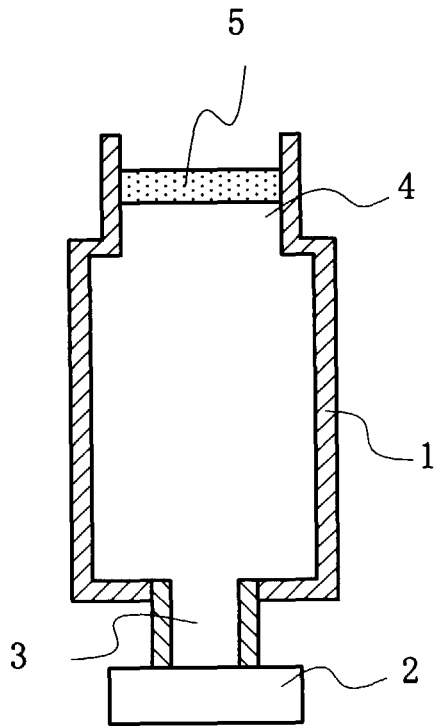


FIG.5

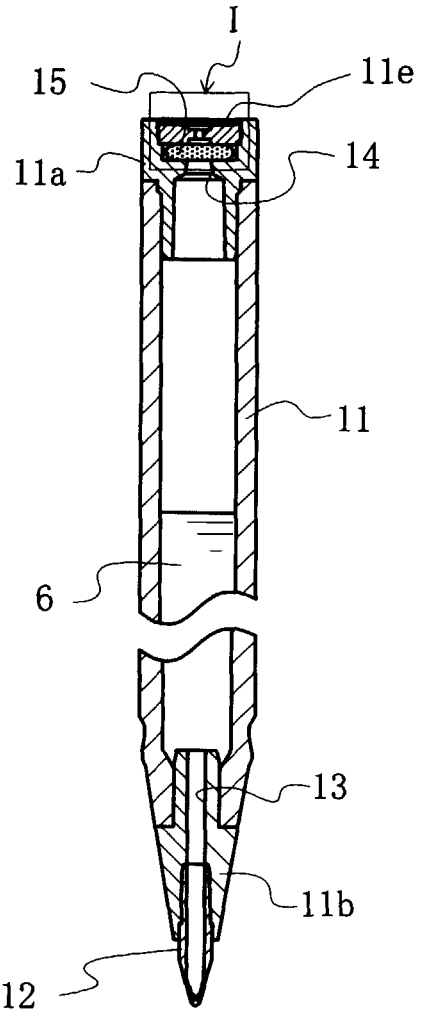
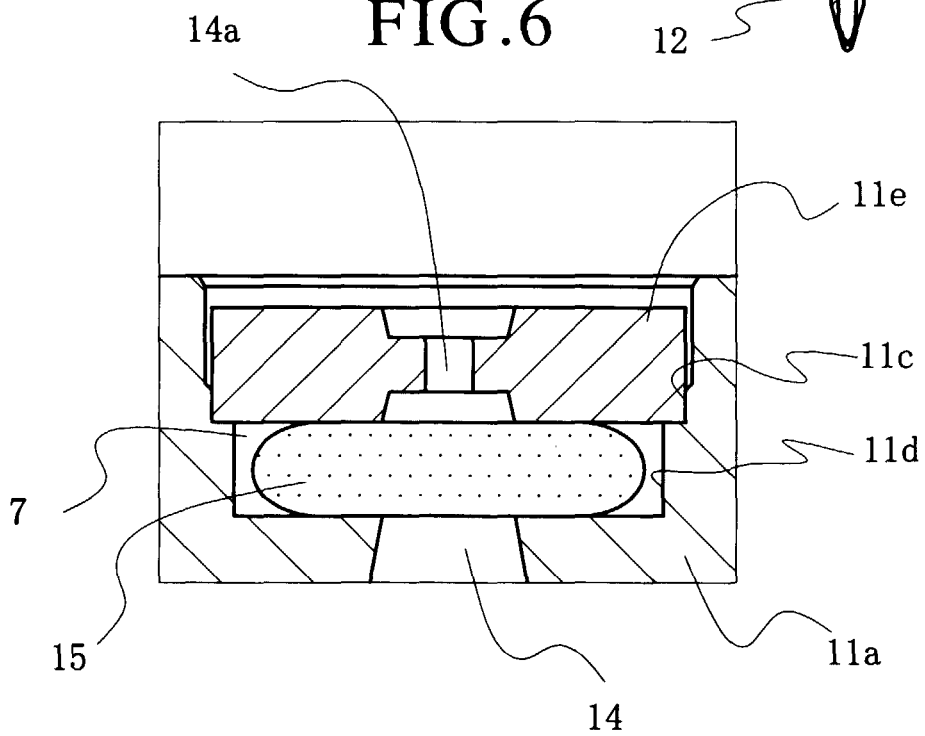
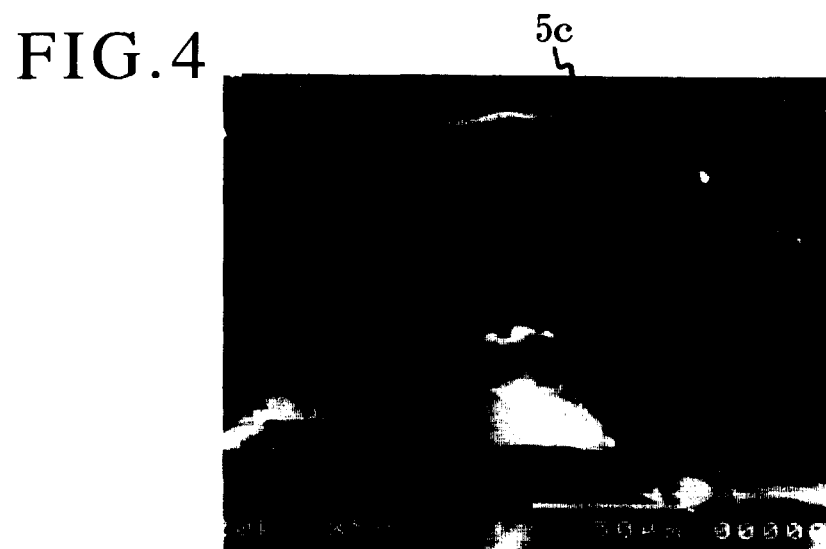
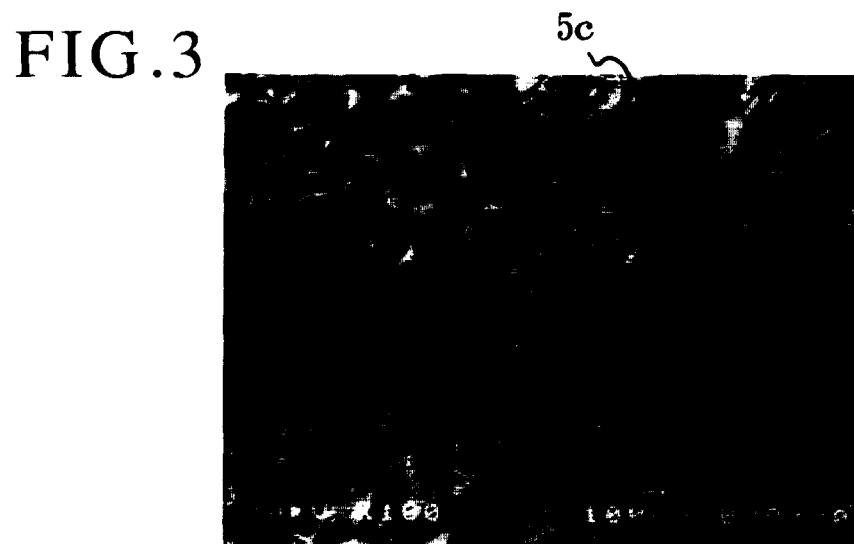
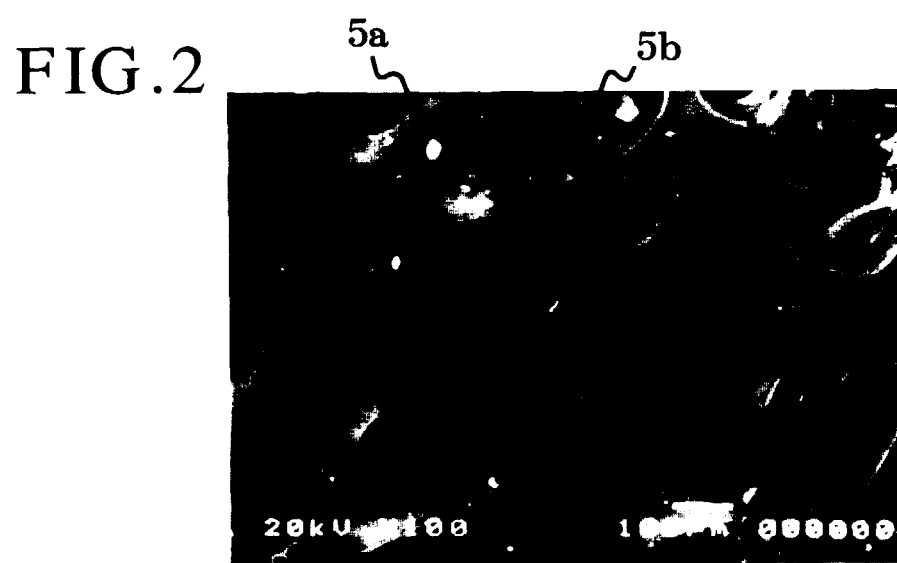


FIG.6





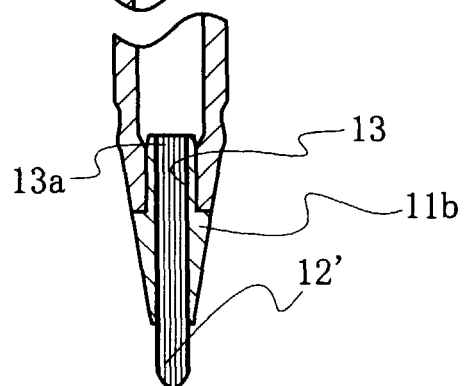
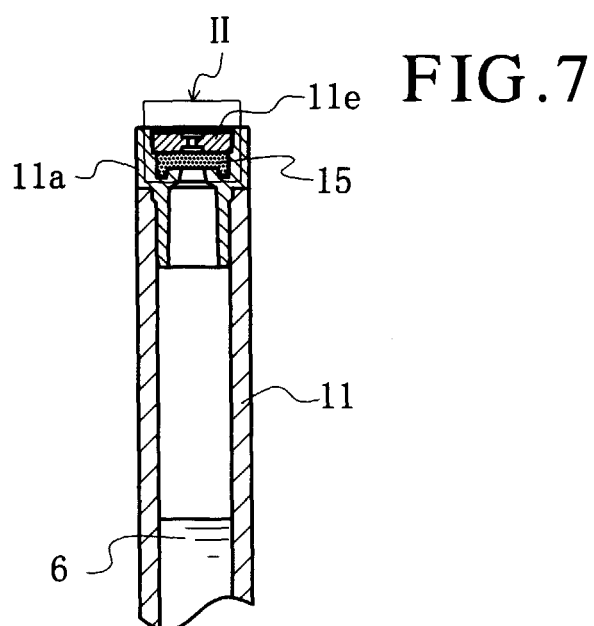
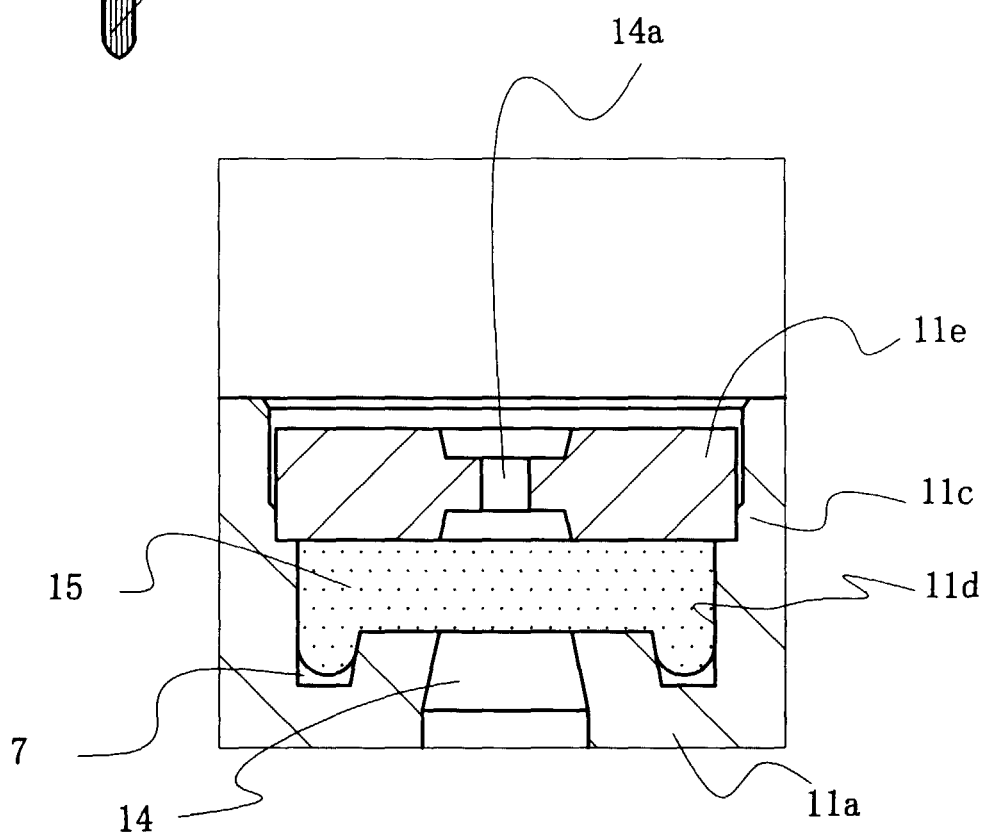


FIG. 8



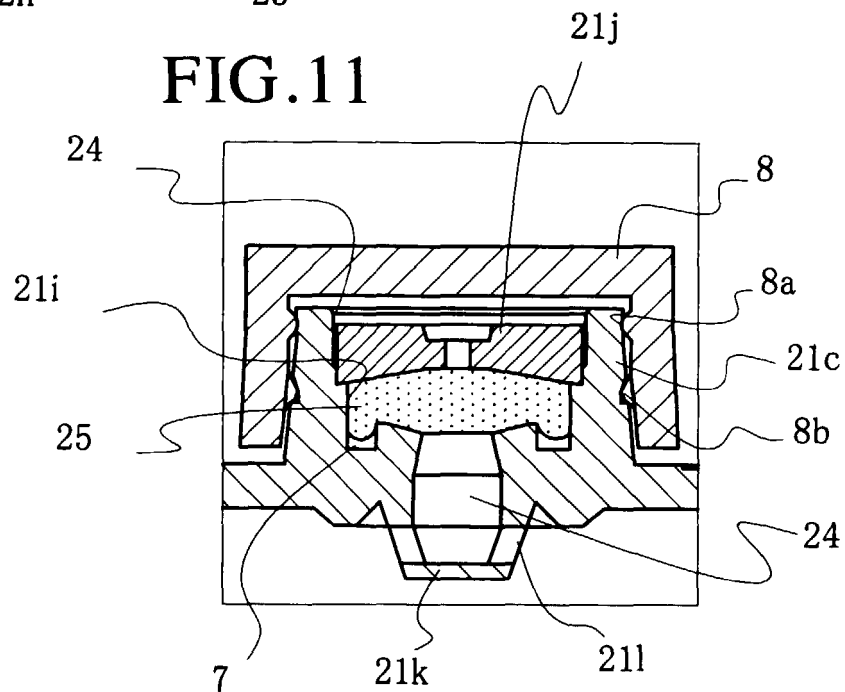
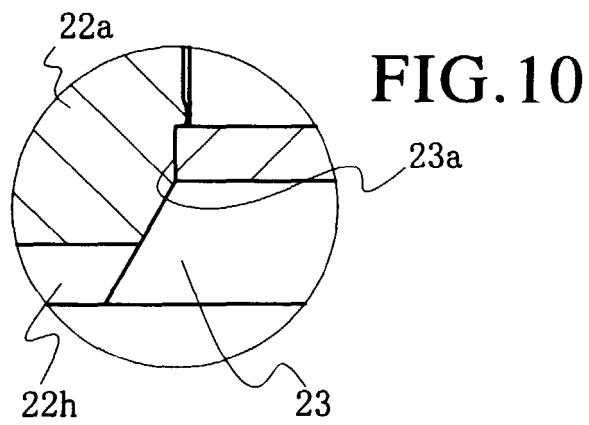
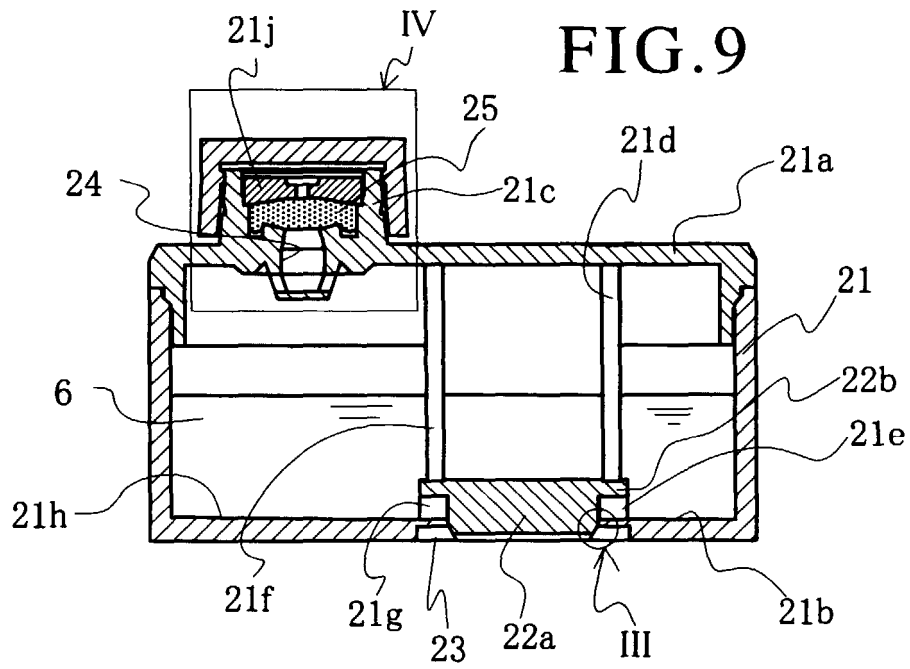


FIG.12

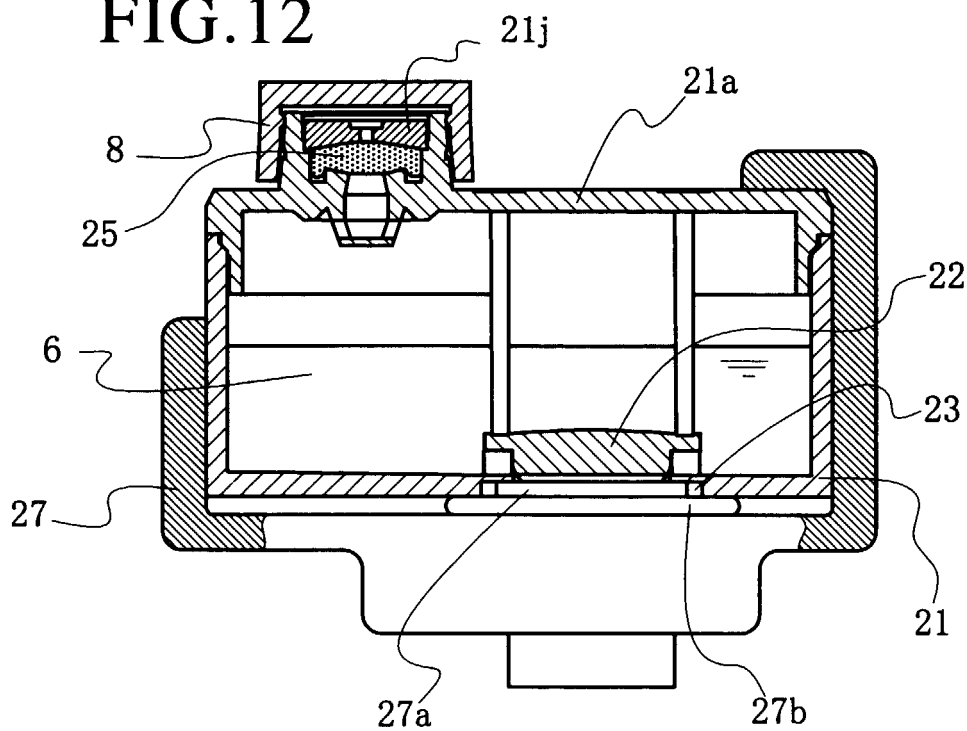


FIG.13

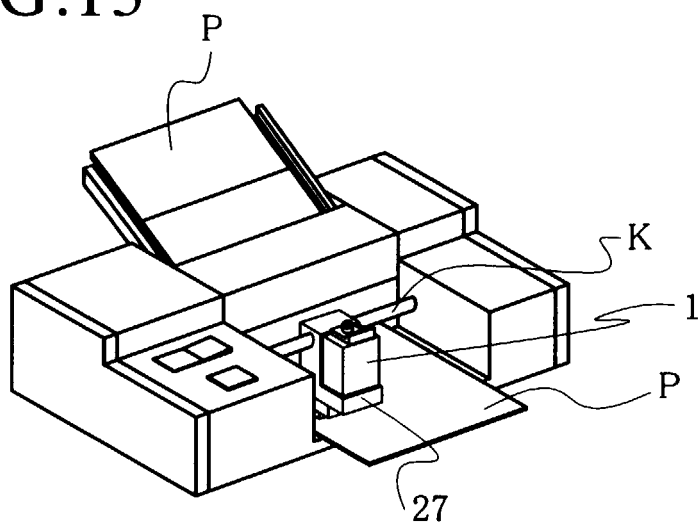


FIG.14

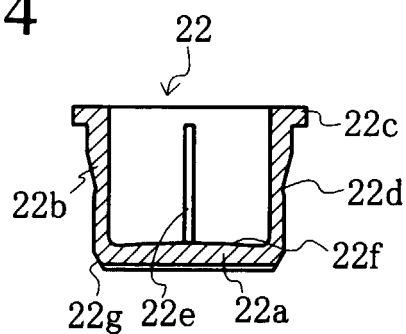


FIG.15

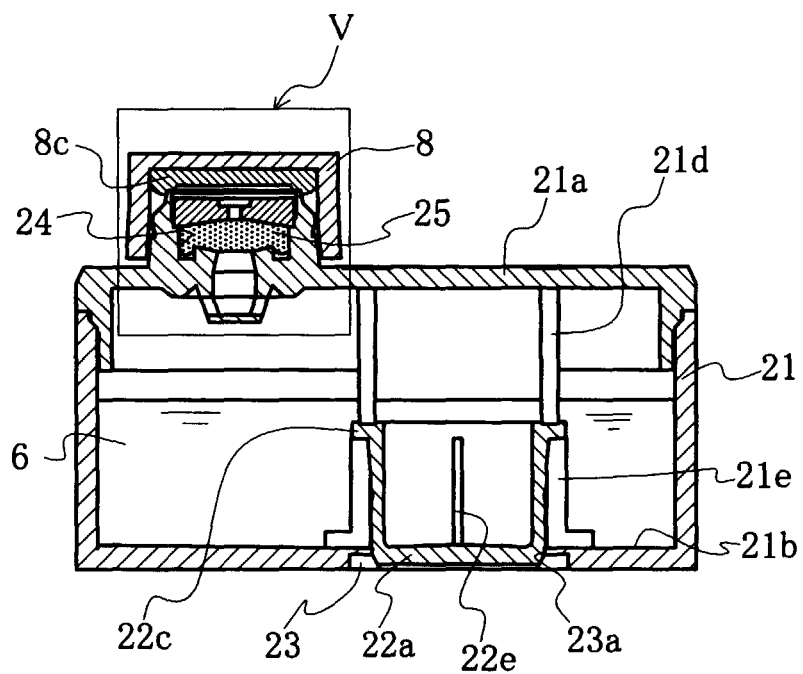


FIG.16

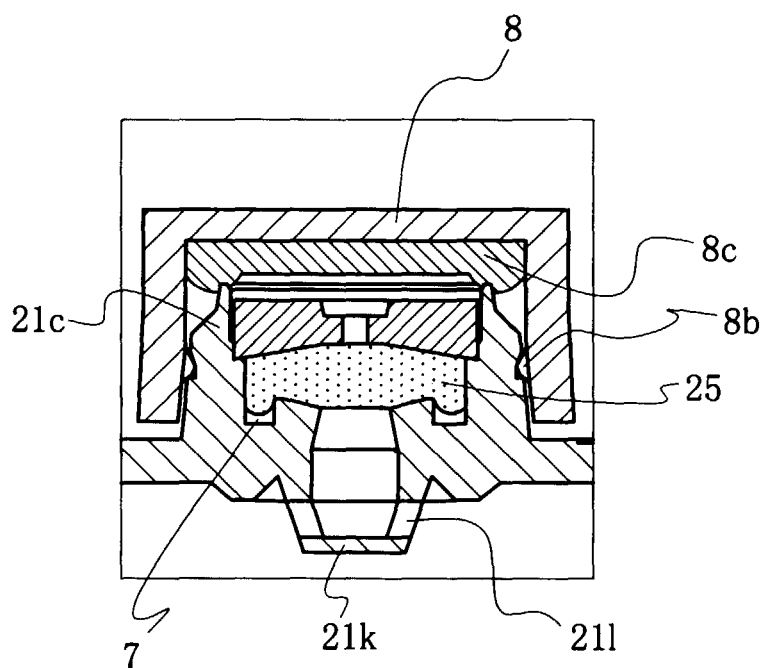


FIG.17

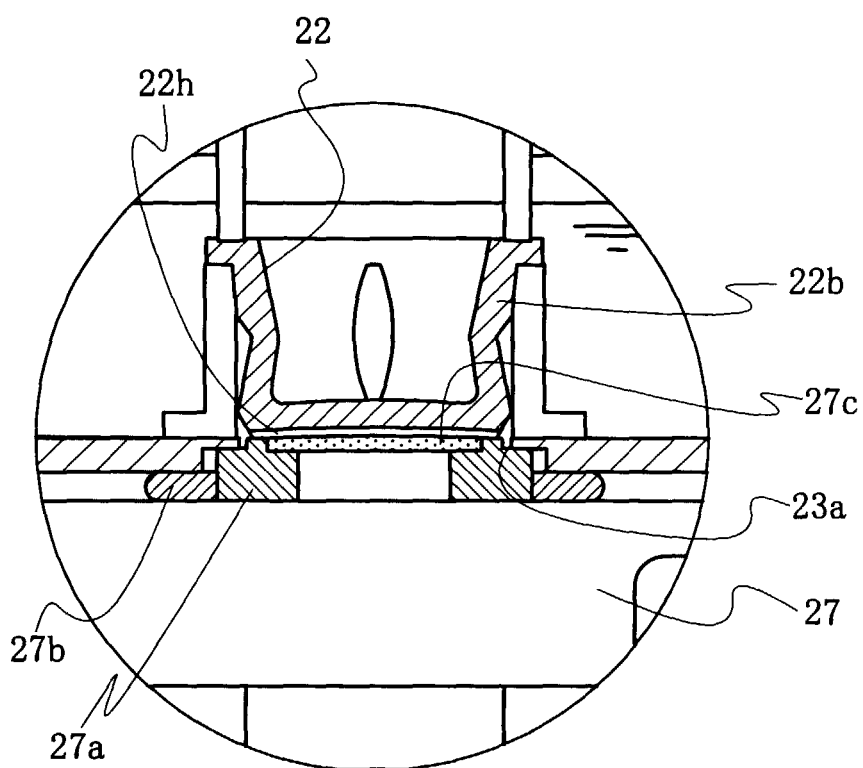


FIG.18

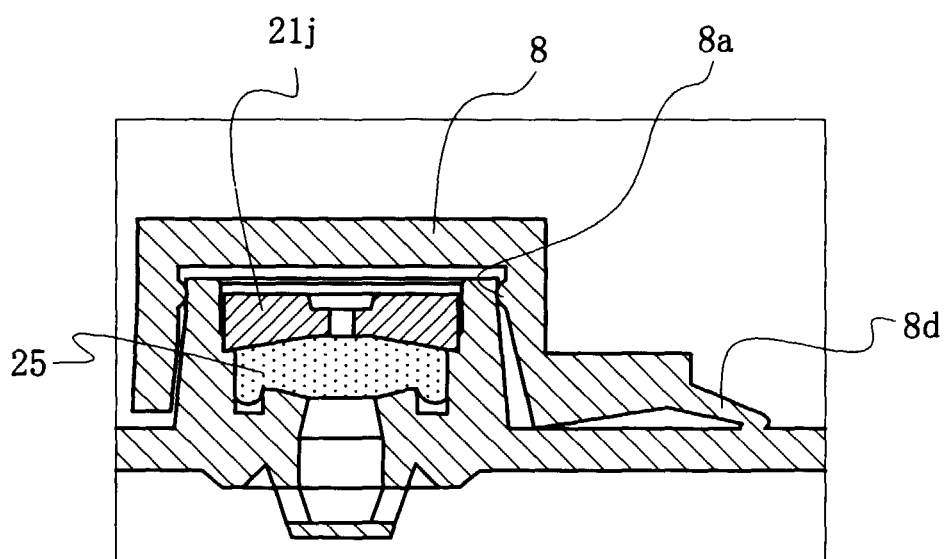


FIG.19

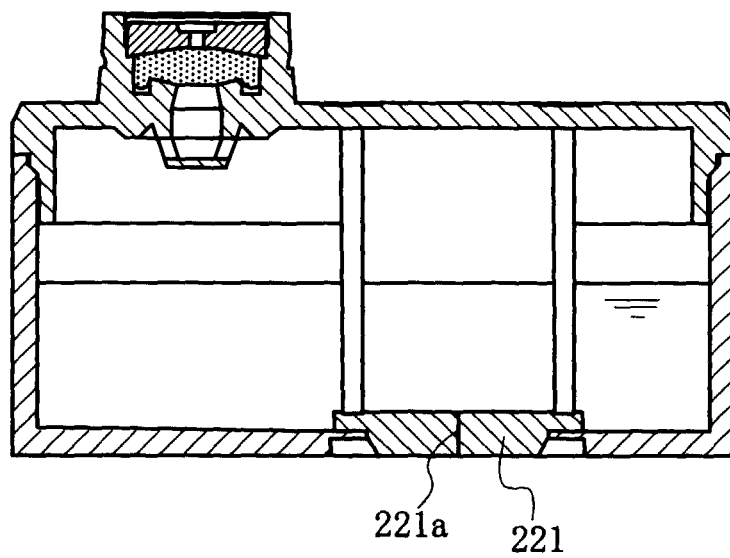


FIG.20

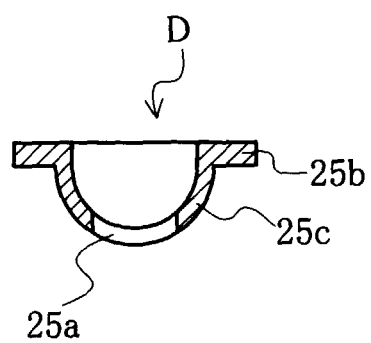


FIG.21

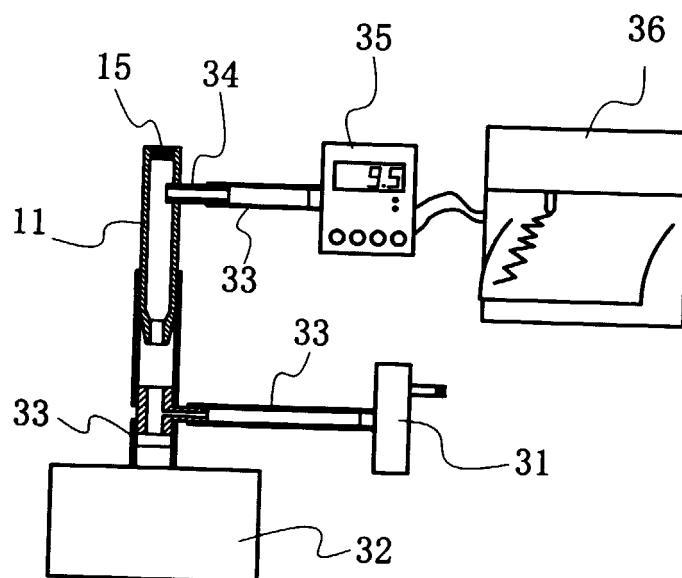


FIG.22

