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(54) **AUTONOMOUS VARIABLE BUOYANCY DEVICE**

AUTONOME VORRICHTUNG MIT VERÄNDERLICHEM AUFTRIEB

DISPOSITIF DE FLOTTABILITÉ VARIABLE AUTONOME

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(73) Proprietors:
• **Scuola Superiore di Studi Universitari
e di Perfezionamento Sant'Anna
56127 Pisa (IT)**
• **Fondazione Istituto Italiano Di Tecnologia
16163 Genova (IT)**

(72) Inventors:
• **FORNAI, Francesco
I-56030 Terricciola (Pisa) (IT)**

- **FERRI, Gabriele
I-57025 Piombino (Livorno) (IT)**
- **SAVIOZZI, Giacomo
I-56127 Pisa (IT)**
- **MAZZOLAI, Barbara
I-57012 Castiglioncello (Livorno) (IT)**
- **LASCHI, Cecilia
I-57100 Livorno (IT)**
- **DARIO, Paolo
I-57100 Livorno (IT)**

(74) Representative: **Brazzini, Silvia et al
Società Italiana Brevetti S.p.A.
Corso dei Tintori, 25
50122 Firenze (IT)**

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Description

Field of the invention

[0001] The present invention refers to a device, independent or to be associated with another structure, for the passive and the cyclical variation of the buoyancy configuration, that can be used in particular, but not exclusively, in the field of equipment for monitoring the environment.

Background of the invention

[0002] It is known that increasingly more effort has been going into research concentrating on the development of buoys and underwater devices amongst which so called "gliders" (submarine or under water gliders, belonging to the category of autonomous underwater vehicles - AUV), which, being provided with, or associated with, suitable equipment, are capable of autonomously carrying out tasks of detecting and monitoring the environment.

[0003] In such a field, the attention has been particularly focused on the development of systems that are capable of varying the buoyancy configuration of such devices, with the main purpose of allowing sampling and detections to be carried out at different depths.

[0004] Some examples of devices that are capable of modifying the buoyancy configuration according to the prior art foresee varying the volume of a chamber due to thermal exchange with sea levels at different temperatures. Devices of this kind are described in Russ E. Davis, et al.: Autonomous Buoyancy-driven Underwater Gliders; The Technology and Applications of Autonomous Underwater Vehicles; 2002 and in Douglas C. Webb et al.: SLOCUM: An Underwater Glider Propelled by Environmental Energy IEEE journal of oceanic engineering, vol. 26, no. 4, October 2001. In some cases the volume of the chamber is modified by an electric motor that is powered by batteries [Charles C. Eriksen et al: Seaglider: A Long-Range Autonomous Underwater Vehicle for Oceanographic Research; IEEE journal of oceanic engineering, vol. 26, no. 4, October 2001, and Sekhar Tangirala et al.: A Variable Buoyancy Control System for a Large AUV; IEEE journal of oceanic engineering, vol. 32, no. 4, October 2007]. Similar systems are also disclosed, in which the checking of the volume of a bladder is controlled by a hydraulic system driven by an electric pump [see for example Wen-de Zhao et al.: A Variable Buoyancy System for Long Cruising Range AUV; International Conference on Computer, Mechatronics, Control and Electronic Engineering (CMCE) 2010].

[0005] Other systems referring in various ways to the aforementioned principles are shown in patent applications RU2081782 (variation of the buoyancy exploiting the properties of a gas that is pre-compressed in a compartment), RU2153439 and RU2130401 (modification of the buoyancy with a hydraulic-gas accumulator control-

led by valves), RU2124457 (bladder containing a fluid which changes state, and therefore volume, due to the difference of temperature at the different sea levels), and US2011091284 (flexible component which allows the variation of volume of a chamber containing a gas).

[0006] US 2011091284 is considered as being the prior art closest to the subject-matter of claim 1 and discloses all the features of its preamble.

[0007] All known devices are however limited in terms of operation or application, and/or are affected by constructive complexity, poor flexibility of use (since they are focused on specific applications), lack of or no autonomy, difficulties in the control or the prediction of their motion.

Summary of the invention

[0008] The object of the present invention is to provide a device for the passive variation of the buoyancy configuration, of the very same device or of a body or structure to which the device is associated, which is both structurally simple and cost-effective, completely autonomous, can be used without particular application limits, and having a predictable control.

[0009] Such objects are achieved with the device according to the present invention, the essential characteristics of which are defined in the first of the attached claims.

[0010] Further important characteristics are contained in the dependent claims.

Brief description of the drawings

[0011] The characteristics and the advantages of the device for varying the buoyancy configuration according to the present invention shall become clearer from the following description of embodiments thereof given as an example and not for limiting purposes with reference to the attached drawings, in which:

- figure 1 is a split schematic view of a device according to a first embodiment of the invention;
- figure 2 is a schematic axial section view of the upper part, i.e. of a body for capturing solar radiation, of the device of figure 1;
- figures 3a and 3b represent schematic sections of the lower part, i.e. of a pneumatic chamber with a variable volume, of an analogous device as that in figure 1, in a positive buoyancy configuration phase (positive hydrostatic thrust) and in a negative buoyancy configuration phase (negative or neutral hydrostatic thrust), respectively; and
- figures 4a and 4b are schematic sections analogous to the sections in figures 3a and 3b, but referred to a second embodiment of the invention.

[0012] With reference to figures from 1 to 3b, a device according to the invention comprises a main body 1 in which, at the base, an immersion portion 2 is intended

to remain below the water line in every condition of passive navigation on open water, typically sea, river, lake water. The immersion portion 2 has a deformable configuration, i.e. such as to define an outer variable volume. This result can be achieved with different solutions, like for example but not with limiting purposes the bladder configuration of the illustrated embodiment, comprising a cup shaped base 21 and a tubular sleeve 22 which is partially housed in a central position inside the cup shaped base 21 and fixedly attached to it through connection means that have not been represented in figures 2, 3a and 3b and that are indicated with 27 in figure 1.

[0013] Between the cup shaped base 21 and the tubular sleeve 22, closed by a shutter 23, a housing 24 is delimited. The housing 24 is closed, outside the sleeve 22, by a ring-like cap 25, sealingly slidable between the outside of the sleeve and the inside of the cup. The housing 24, pneumatically sealed by means of suitable gaskets, is filled with a substance in a gaseous state, typically ambient air. A perforated diaphragm 26 is coaxially arranged in the housing 24. The diaphragm is integrally movable with the cap 25, so as to obtain a reciprocating piston arrangement.

[0014] From the diaphragm 26 a stem 3 extends centrally in an integral manner, perforating the shutter 23 of the sleeve 22 and penetrating into a cylinder 4, which defines an upper part of the body 1, like in the example of figure 1. The cylinder 4 can also be accommodated in an upper shaped portion 11 of the body, like in the variant of figures 3a and 3b in which it is the cylinder itself that forms the tubular sleeve 22.

[0015] Inside the cylinder 4 the stem 3 supports a sliding plate 41 at the opposite end with respect to the end connected to the diaphragm 26. Due to the plate 41, inside the cylinder 4 there is formed a chamber 42 with variable volume occupied by an expansible fluid, typically following a transition from the liquid state to the gaseous state (saturated vapour), for example methanol. The plate 41 and congruently a bottom wall of the chamber 42 can be shaped in various ways, for example with matching concavity/convexity like in figure 1, so as to optimise the fluid dynamic efficiency of the compression/expansion of fluid. Between the plate 41 and the shutter 23, and i.e. on the opposite side with respect to the chamber 42, the cylinder 4 houses a coil spring 5, which is thus compressed, coaxially with respect to the stem 3 and outside it, between the aforementioned plate and shutter. The spring elastically hinders the movement of the plate towards the shutter, that is the movement that corresponds to the increase in volume of the chamber 42.

[0016] From the cylinder 4, again with axial development and thus aligned with the stem 3, a rod 6 projects coming out from the top of the body 1 so as to rise outside and above the surface of the water in which the device is navigating, at least in a condition of positive hydrostatic thrust, as shall be soon made clearer. The rod 6 ends at the upper (free) end with a member 7 for capturing solar

radiation, specifically with a spheroidal shape, preferably surrounded by a shell 8 made from transparent material so as to generate, between the same shell and the sphere member 7, a gap that advantageously is filled with vacuum with the aim of minimising thermal dispersion.

[0017] The cylinder 4, the rod 6, and the sphere 7 are made from a highly thermal conductive material, for example an aluminium alloy. The sphere 7 is moreover advantageously coloured in black, so as to maximise the absorption of solar radiation. Both the rod 6, and the upper part of the cylinder 4 in the area of the chamber 42 are coated with a layer 9 of thermally insulating material.

[0018] The device according to the invention thus has an operative behaviour that can be described as follows.

[0019] In an initial condition the fluid substance inside the chamber 42 of the cylinder 4 is in a non-expanded condition. The spring 5, or equivalent elastic means, keeps the assembly of plate 41, stem 3 and diaphragm 26 in a raised position, i.e. displaced towards the upper part of the device. In such a position the ring-like cap 25 is lifted, and therefore the immersion portion 2 has a maximum volume. Such a condition, represented in figure 3a, generates a maximum hydrostatic thrust, which is in any case positive, such as to lead the device to float on the water surface. This configuration can be referred to as a positive buoyancy configuration.

[0020] As the solar radiation hits the captation member 7, heating it, through conduction along the rod 6 there is a heating of the fluid substance contained in the chamber 42. The substance, increasing its temperature, undergoes an expansion, typically through transition from the liquid state to the gas state. Consequently the plate 41 is urged downwards, overcoming the mechanical resistance of the spring 5. Consequently, the diaphragm 26 and the cap 25 are mechanically pushed down, and this causes a contraction of the immersion portion 2, and therefore the reduction of the hydrostatic thrust. The air contained in the bladder housing 24 is correspondingly compressed, contributing, in parallel with the spring, to elastically store a certain amount of mechanical energy. This is the situation of figure 3b, that schematically shows a maximum contraction, and therefore a minimum, below neutral, hydrostatic thrust, which makes the device sink. The configuration can in this case be referred to as a negative buoyancy configuration.

[0021] The immersion will on the other hand ensure that the chamber 42 is in turn below the water surface, with a consequent increase in the thermal exchange with the outside (heat is yielded towards the outside water). The fluid substance will thus tend to cool down, contracting its volume, and allowing the mechanical energy stored with the contraction of the spring 5 (but also partially with the compression of air in the housing 24, which will now expand) to be liberated, making the device return to the initial configuration. The immersion portion 2 expands, making the hydrostatic thrust increase and inducing the surfacing of the device until the positive buoyancy configuration is reestablished. At this stage with a new

heating there will be cyclical reoccurrence of immersion/emersion operations as described above.

[0022] With reference now also to figures 4a and 4b a second embodiment of the device is shown. Parts equal or corresponding to those of the first embodiment bear the same reference numerals, and will not be described again. The main aspect of this embodiment consists in restraining means 127 that prevent the downwards movement of the assembly of cap 125, diaphragm 126, stem 103 and plate 141, until a certain restraining force is overcome (as a result of the expansion force of the fluid in the chamber 142). The restraining means can e. g. include mutually attractive magnets 127a, 127b fixed respectively to the outer (top) face of the cap 125 and the side surface of the tubular sleeve 122.

[0023] The arrangement is such that in the positive buoyancy configuration (figure 4a), the magnets 127a, 127b are mutually in contact and magnetically coupled. Due to the magnetic force thus exerted, when change in status of the fluid in the chamber 142 starts to occur (as mentioned, following heating through the captation member 107), the corresponding expansion force is not successful in making the plate 141 slide down. As the expansion force progressively increase, the magnetic force is overcome, and this causes an abrupt and impulsive lowering of the above mentioned assembly. The bladder housing 124 in turn quickly reduces its volume to the negative buoyancy configuration (figure 4b), and this impulsive change can be more effective than the progressive change of the first embodiment in that the device can reach deeper below the water surface. The return to the positive buoyancy configuration will follow the same dynamics described for the first embodiment.

[0024] Of course the design choices, amongst which in particular the dimensional proportions between the various components, the calibration of the spring, of the magnets in the second embodiment, the characteristics of the fluids, will determine the functional characteristics of the device in terms of depth of immersion and frequency of the cycle, according to what can of course be implemented according to the specific requirements.

[0025] The proposed solution thus makes it possible to carry out monitoring and sampling campaigns in sea environments with a device that is capable of moving through different sea depths in a completely passive manner, with the propulsion of only solar radiation energy. Any control from outside of any active mechanical or electronic component, or battery means are not required. The proposed device is simple and cost-effective, operationally predictable, and can be applied without particular limitations to a wide array of operation requirements. For such a purpose, it should be noted that the device can be made so as to constitute the detection/sampling apparatus itself, with the suitable equipment mounted on the body 1 of the illustrated example configurations, or be mechanically associated with an outer structure/apparatus for which it will act as propulsion means, or even be incorporated in a complex structure, again with the

same function.

[0026] The thermal exchange between solar radiation capturing means and the expansible fluid can occur in different ways from that of the illustrated embodiment. For example, in a variant embodiment the transmission of heat is not obtained through conduction along the rod 6, but through an actual direct communication between the chamber 42 and the captation member 7, in this case necessarily hollow, through a rod having a tubular structure. In practice, the expansion chamber will be in this case a single cavity which extends to the captation member 7 and the fluid will be directly heated mainly inside the same element 7. Such a solution covers any other constructive variant in which it is the chamber itself, through an upwards extension, that defines or integrates the captation means.

[0027] The present invention has been described with reference to preferred embodiments thereof. It should be understood that there can be other embodiments which all belong to the same inventive core, all within the scope of the following claims.

Claims

1. A variable buoyancy device comprising:

an immersion portion (2) having a variable outer volume, adapted to be under the water level in any condition when the device passively floats in sea, river or lake water;

a variable volume chamber (42) housing a fluid, said chamber (42) being in a mechanical relationship with said immersion portion (2), such that, to an increase in volume of said chamber (42), as a result of an expansion of said fluid, there responds a reduction in the outer volume of said immersion portion (2), and vice versa, with a consequent variation of buoyancy of the device, said variation being adapted to, when the outer volume of the immersion portion (2) decreases, to bring also said chamber (42) at least partially under the water line of the device; and **characterized in that** the device comprises elastic means (5) arranged between said chamber (42) and said immersion portion (2), adapted to elastically hinder the volume increase of said chamber (42);

solar radiation capturing means (7) arranged above said immersion portion, associated or integrated with said chamber (42) and in a relationship of thermal exchange with said fluid so as to heat it and induce said expansion.

2. The device according to claim 1, wherein said solar radiation capturing means comprise at least one captation member (7) and a rod (6) mechanically connecting said member (7) to said chamber (42), said

member (7), said rod (6) and at least part of the walls defining said chamber (42) being made of a thermally conductive material.

3. The device according to claim 1, wherein said solar radiation capturing means comprise at least one hollow captation member, communicated with said chamber (42) and occupied by said fluid. 5
4. The device according to claim 3, wherein said captation member and said chamber (42) are connected by a tubular rod. 10
5. The device according to claim 2 or 4, wherein said rod (6) and said chamber (42) are provided with an external lining (9) in a thermally insulating material. 15
6. The device according to any of the claims from 2 to 5, wherein said captation member (7) has a dark colored surface and is enclosed by a shell (8) made of a material transparent to the solar radiation, said shell (8) and said member (7) being distanced so as to define a gap in which a depression is formed. 20
7. The device according to any of the claims from 2 to 6, wherein said captation member (7) has a spheroidal shape. 25
8. The device according to any of the previous claims, wherein said chamber (42) and said immersion portion are operatively connected by a sliding piston arrangement (41, 3, 26) comprising a plate (41) sealingly sliding within a hollow cylinder (4), said chamber (42) being defined by said cylinder (4) and said plate (41). 30
9. The device according to claim 8, wherein said immersion portion (2) comprises a cup shaped base (21), said cylinder (4, 22) being at least partially housed inside said base (21) in a central position and integrally therewith, a housing (24) being formed between said base (21) and said cylinder (4, 22), said cylinder (4, 22) being closed by a fixed shutter (23) externally to said chamber (42); said housing (24) being closed by an annular sliding cap (25) movable integrally with a perforated diaphragm (26) of said piston arrangement, said perforated diaphragm (26) being movable within said cup shaped base (21), the piston arrangement further comprising a stem (3) passing through said shutter (23) and connecting said plate (41) and said diaphragm (26). 35
10. The device according to claim 9, wherein said elastic means comprise a spring (5) arranged between said plate (41) and said shutter (23) around said stem (3). 40
11. The device according to any of the previous claims, comprising restraining means (127) adapted to oppose 45

pose the expansion of said chamber (141) until a predetermined restraining force is overcome.

12. The device according to claim 11, wherein said restraining means (127) comprise mutually attractive magnetic means (127a, 127b) 5
13. The device according to claim 9, comprising magnetic restraining means (127) adapted oppose the expansion of said chamber (141) until a predetermined restraining force is overcome, said magnetic restraining means (127) comprising mutually attractive magnets (127a, 127b) fixed respectively to an outer face of said cap (125) and to an outer side surface of said cylinder (104, 122). 10

Patentansprüche

1. Vorrichtung mit variablem Auftrieb, enthaltend:

ein Eintauchteil (2), das ein variables Außenvolumen hat, ausgelegt, um unter jeder Bedingung unter dem Wasserspiegel zu sein, wenn die Vorrichtung passiv in Meer-, Fluss- oder Seewasser schwimmt;

eine Kammer (42) mit variablem Volumen, in der ein Fluid untergebracht ist, wobei die Kammer (42) in einer mechanischen Beziehung mit dem Eintauchteil (2) ist, so dass auf eine Zunahme des Volumens der Kammer (42) als Ergebnis einer Ausdehnung des Fluids eine Verringerung im Außenvolumen des Eintauchteils (2) folgt und umgekehrt, mit einer konsequenten Variation des Auftriebs der Vorrichtung, wobei die Variation ausgelegt ist, um, wenn das Außenvolumen des Eintauchteils (2) abnimmt, auch die Kammer (42) zumindest teilweise unter den Wasserspiegel der Vorrichtung zu bringen, und **dadurch gekennzeichnet, dass** die Vorrichtung enthält Elastikeinrichtungen (5), die zwischen der Kammer (42) und dem Eintauchteil (2) angeordnet sind, ausgelegt, um die Volumenzunahme der Kammer (42) elastisch zu behindern;

Sonnenstrahlung-Einfangeinrichtungen (7), die über dem Eintauchteil angeordnet sind, zugeordnet zu der oder integriert in die Kammer (42) und in einer Wärmeaustauschbeziehung mit dem Fluid, um es zu erwärmen und die Ausdehnung zu induzieren.

2. Vorrichtung nach Anspruch 1, wobei die Sonnenstrahlung-Einfangeinrichtungen wenigstens ein Einfangelement (7) und einen Stab (6) enthalten, der das Element (7) mechanisch mit der Kammer (42) verbindet, wobei das Element (7), der Stab (6) und wenigstens ein Teil der Wände, die die Kammer (42) 55

definieren, aus wärmeleitfähigem Material bestehen.

3. Vorrichtung nach Anspruch 1, wobei die Sonnenstrahlung-Einfangeeinrichtungen wenigstens ein hohles Einfangelement enthalten, das mit der Kammer (42) kommuniziert und von dem Fluid eingenommen ist. 5
4. Vorrichtung nach Anspruch 3, wobei das Einfangelement und die Kammer (42) durch einen rohrartigen Stab verbunden sind. 10
5. Vorrichtung nach Anspruch 2 oder 4, wobei der Stab (6) und die Kammer (42) mit einer Außenverkleidung (9) in einem wärmeisolierenden Material versehen sind. 15
6. Vorrichtung nach einem der Ansprüche 2 bis 5, wobei das Einfangelement (7) eine dunkelfarbige Oberfläche hat und von einer Hülle (8) umgeben ist, die aus einem für die Sonnenstrahlung transparenten Material besteht, wobei die Hülle (8) und das Element (7) beabstandet sind, um eine Lücke zu definieren, in der eine Vertiefung ausgebildet ist. 20 25
7. Vorrichtung nach einem der Ansprüche 2 bis 6, wobei das Einfangelement (7) eine kugelförmige Form hat. 30
8. Vorrichtung nach einem der vorangehenden Ansprüche, wobei die Kammer (42) und das Eintauchteil wirksam durch eine Schiebekolbenanordnung (41, 3, 26) verbunden sind, die eine Platte (41) enthält, die sich abdichtend innerhalb eines hohlen Zylinders (4) verschiebt, wobei die Kammer (42) durch den Zylinder (4) und die Platte (41) definiert ist. 35 40
9. Vorrichtung nach Anspruch 8, wobei das Eintauchteil (2) eine tassenförmige Basis (21) enthält, der Zylinder (4, 22) wenigstens teilweise innerhalb der Basis (21) in einer zentralen Position untergebracht ist und integral damit ist, ein Gehäuse (24) zwischen der Basis (21) und dem Zylinder (4, 22) ausgebildet ist, der Zylinder (4, 22) durch einen bezüglich der Kammer (42) externen festen Verschluss (23) abgeschlossen ist; wobei das Gehäuse (24) durch eine ringartige Schiebekappe (25) abgeschlossen ist, die integral mit einem perforierten Diaphragma (26) der Kolbenanordnung beweglich ist, wobei das perforierte Diaphragma (26) innerhalb der tassenförmigen Basis (21) beweglich ist, wobei die Kolbenanordnung ferner einen Schaft (3) enthält, der durch den Verschluss (23) hindurch geht und die Platte (41) und das Diaphragma (26) verbindet. 45 50 55
10. Vorrichtung nach Anspruch 9, wobei die Elastikeinrichtungen eine Feder (5) enthalten, die zwischen

der Platte (41) und dem Verschluss (23) um den Schaft (3) herum angeordnet ist.

11. Vorrichtung nach einem der vorangehenden Ansprüche, wobei Rückhalteeinrichtungen (127) enthalten sind, die ausgelegt sind, um der Ausdehnung der Kammer (141) entgegenzuwirken, bis eine vorgegebene Rückhaltekraft überwunden ist.
12. Vorrichtung nach Anspruch 11, wobei die Rückhalteeinrichtungen (127) sich gegenseitig anziehende Magneteinrichtungen (127a, 127b) enthalten.
13. Vorrichtung nach Anspruch 9, enthaltend magnetische Rückhalteeinrichtungen (127), die ausgelegt sind, der Ausdehnung der Kammer (141) entgegenzuwirken, bis eine vorgegebene Rückhaltekraft überwunden ist, wobei die magnetischen Rückhalteeinrichtungen (127) sich gegenseitig anziehende Magnete (127a, 127b) enthalten, die entsprechend an einer Außenseite der Kappe (125) und an einer Außenseitenoberfläche des Zylinders (104, 122) befestigt sind.

Revendications

1. Un dispositif de flottabilité variable comprenant :

une partie immergeable (2) ayant un volume extérieur variable, adapté pour être sous le niveau de l'eau dans toutes conditions lorsque le dispositif flotte passivement dans l'eau de mer, rivière ou lac ;

une chambre à volume variable (42) logeant un fluide, ladite chambre (42) étant en relation mécanique avec ladite partie immergeable (2), de façon que, pour une augmentation du volume de ladite chambre (42), à la suite d'une expansion du dit fluide, il y a, en réponse, une réduction du volume extérieur de ladite partie immergeable (2), et vice versa, avec en conséquence une variation de la flottabilité du dispositif, ladite variation étant adaptée pour que, lorsque le volume extérieur de la partie immergeable (2) diminue, ladite chambre (42) soit amenée au moins en partie sous la ligne de flottaison du dispositif;

et caractérisé en ce que le dispositif comprend :

des moyens élastiques (5) disposés entre ladite chambre (42) et ladite partie immergeable (2), aptes à empêcher élastiquement l'augmentation de volume de ladite chambre (42); et des moyens pour capter le rayonnement solaire (7) disposés au-dessus de ladite partie immergeable, associés ou intégrés à ladite chambre (42) et dans une relation d'échange thermique

avec ledit fluide de manière à le chauffer et provoquer ladite expansion.

2. Dispositif selon la revendication 1, dans lequel lesdits moyens pour capter le rayonnement solaire comprennent au moins un élément capteur (7) et une barre (6) reliant mécaniquement ledit élément (7) à ladite chambre (42), ledit élément (7), ladite barre (6) et au moins une partie des parois définissant ladite chambre (42) étant réalisés en un matériau thermiquement conducteur. 5
3. Dispositif selon la revendication 1, dans lequel lesdits moyens pour capter le rayonnement solaire comprennent au moins un élément capteur creux, communiquant avec ladite chambre (42) et occupé par ledit fluide. 10
4. Dispositif selon la revendication 3, dans lequel ledit élément capteur et ladite chambre (42) sont reliés par une barre tubulaire. 20
5. Dispositif selon l'une des revendications 2 ou 4, dans lequel ladite barre (6) et ladite chambre (42) sont pourvues d'un revêtement extérieur (9) en un matériau thermiquement isolant. 25
6. Dispositif selon l'une quelconque des revendications 2 à 5, dans lequel ledit élément capteur (7) présente une surface de couleur sombre et est entouré d'une enveloppe (8) constituée d'un matériau transparent au rayonnement solaire, ladite enveloppe (8) et ledit élément (7) étant éloignés l'un de l'autre de façon à définir un espace dans lequel est formée une dépression. 30 35
7. Dispositif selon l'une quelconque des revendications 2 à 6, dans lequel ledit élément capteur (7) a une forme sphérique. 40
8. Dispositif selon l'une quelconque des revendications précédentes, dans lequel ladite chambre (42) et ladite partie immergeable sont fonctionnellement en liaison avec un dispositif à piston coulissant (41, 3, 26) comprenant une plaque (41) coulissant de manière étanche dans un cylindre creux (4), ladite chambre (42) étant définie par ledit cylindre (4) et ladite plaque (41). 45
9. Dispositif selon la revendication 8, dans lequel ladite partie immergeable (2) comprend une base (21) en forme de coupelle, ledit cylindre (4, 22) étant au moins partiellement logé à l'intérieur de ladite base (21) en position centrale et d'un seul tenant avec celle-ci, un logement (24) étant formé entre ladite base (21) et ledit cylindre (4, 22), ledit cylindre (4, 22) étant fermé à l'extérieur de ladite chambre (42) par un obturateur fixe (23) ; ledit logement (24) étant 50 55

fermé par un capot annulaire coulissant (25) pouvant se déplacer d'un seul tenant avec un diaphragme perforé (26) du dit dispositif à piston, ledit diaphragme perforé (26) étant mobile à l'intérieur de ladite base (21) en forme de coupelle, l'agencement de piston comprenant en outre une tige (3) passant à travers ledit obturateur (23) et reliant ladite plaque (41) et ledit diaphragme (26).

10. Dispositif selon la revendication 9, dans lequel lesdits moyens élastiques comprennent un ressort (5) disposé autour de ladite tige (3) entre ladite plaque (41) et ledit obturateur (23).
11. Dispositif selon l'une quelconque des revendications précédentes, comprenant des moyens de retenue (127) adaptés pour s'opposer à l'expansion de ladite chambre (141) jusqu'à ce qu'une force de retenue prédéterminée soit dépassée.
12. Dispositif selon la revendication 11, dans lequel lesdits moyens de retenue (127) comprennent des moyens d'attraction magnétique mutuelle (127a, 127b).
13. Dispositif selon la revendication 9, comprenant des moyens de retenue magnétiques (127) adaptés pour s'opposer à l'expansion de ladite chambre (141) jusqu'à ce qu'une force de retenue prédéterminée soit dépassée, lesdits moyens de retenue magnétiques (127) comportant des aimants d'attraction mutuelle (127a, 127b) fixés respectivement sur une face extérieure du dit capot (125) et sur une surface latérale extérieure du dit cylindre (104, 122).

Fig.1

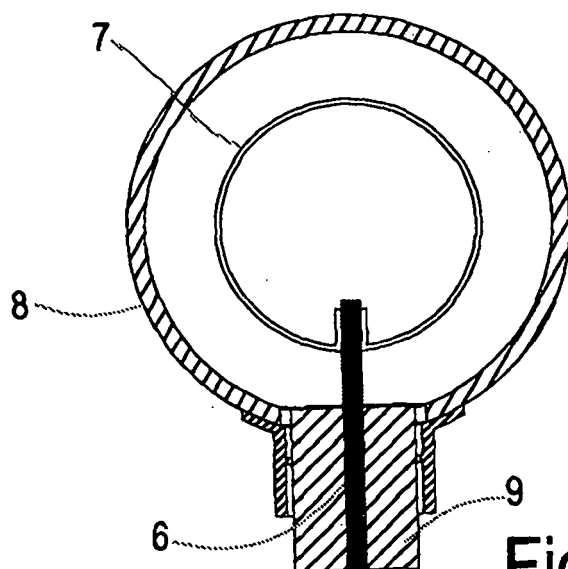
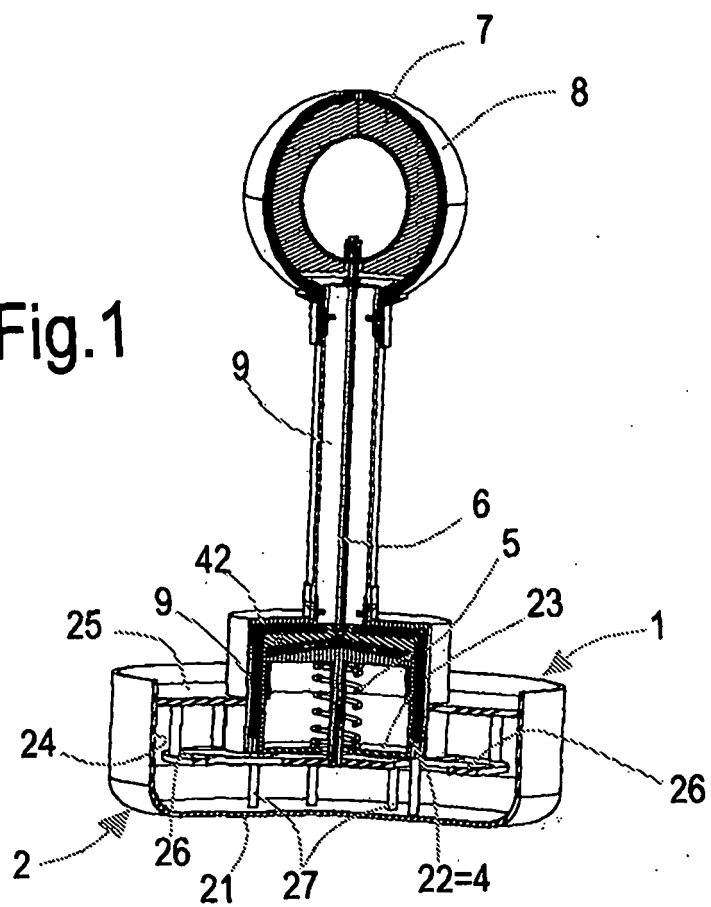


Fig.2

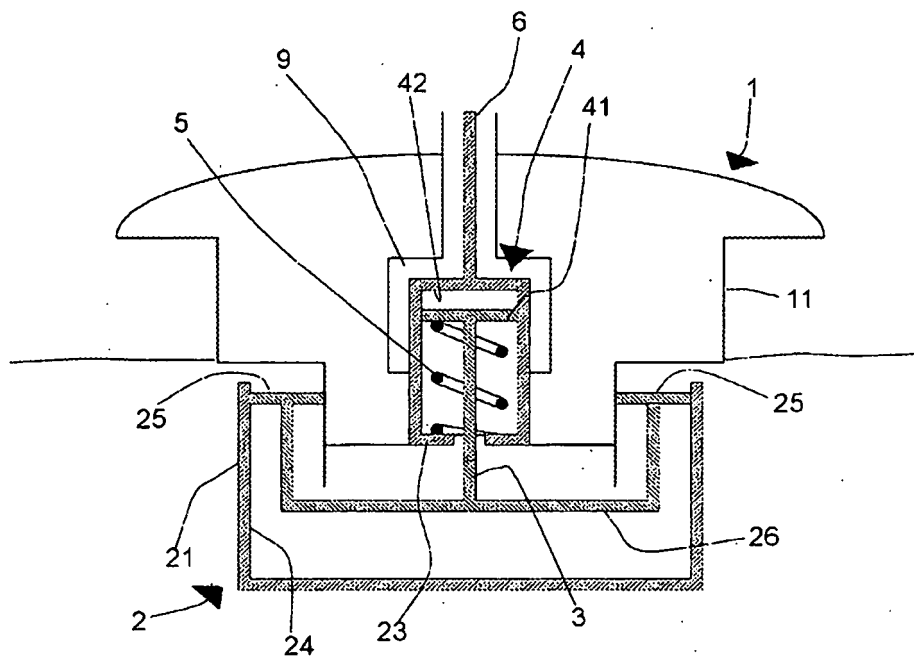


Fig.3a

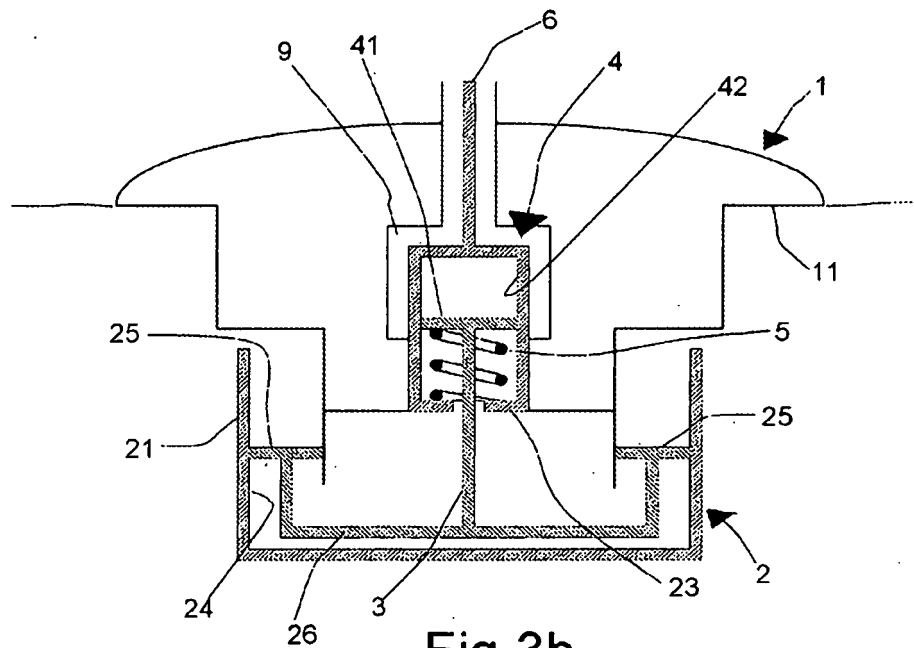
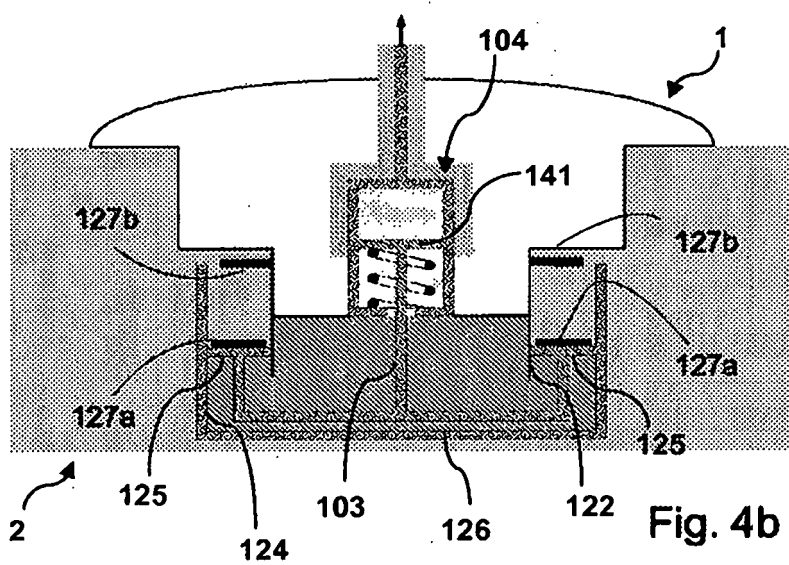
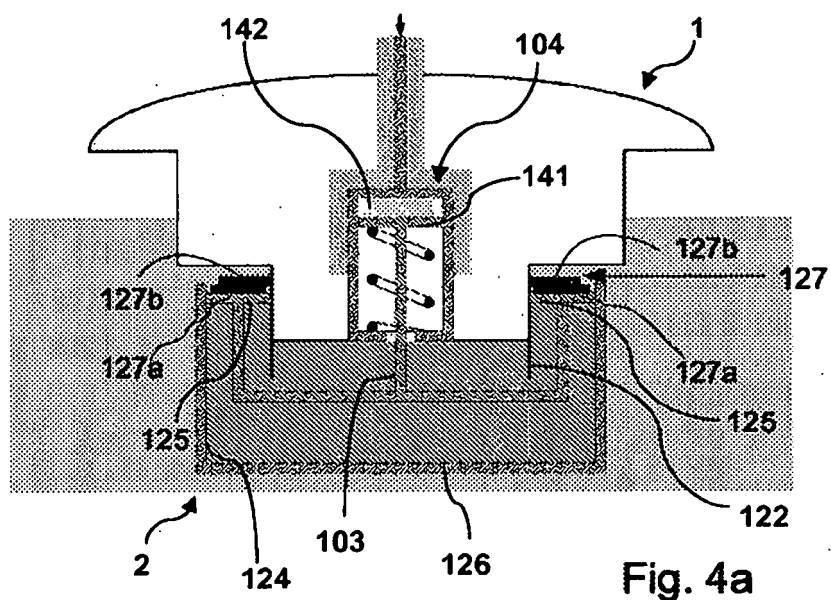


Fig.3b



REFERENCES CITED IN THE DESCRIPTION

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