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(54) **INDEPENDENT TANK SYSTEM FOR STORING LIQUID GAS**

UNABHÄNGIGES TANKSYSTEM ZUM SPEICHERN VON FLÜSSIGGAS

SYSTÈME DE RÉSERVOIR INDÉPENDANT POUR STOCKER UN GAZ LIQUIDE

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an independent tank system for storing liquid gas in a vessel.

BACKGROUND

[0002] The International Maritime Organisation IMO Code IGC (International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk) contains a definition of so-called Independent LNG tanks. Independent in this context means that the tank is self supporting and independent of the hull of the vessel. These independent tanks may be classified in three types A, B and C, whereas the type-A requires a full secondary barrier, the type-B requires a partly secondary barrier and the type-C has no requirements for a secondary barrier. The different safety philosophies applied for the three different tanks systems necessitates different design requirements for each system.

[0003] Following the principles of the independent tank system type A and B named above, there are two known tank systems for storing LNG (Liquefied Natural Gas) that are presently in use. The first is the Moss spherical tank, and the second is the IHI self supporting prismatic LNG tank.

[0004] There are several technical challenges involved with tank systems for storing liquid gas. The gas may be cryogenic, for LNG that means a temperature of -163°, which means that the tank has to be insulated to minimize the boil off and to prevent the ship hull from being exposed to harmful temperatures. The low temperature will also shrink the LNG tanks which mean that all support, i.e. connection to the ship, must have a flexible nature in order not to overstress the tank nor its foundations. A leak protection system must further be employed to protect the ships hull from a possible leakage. The latter is secured by adapting to the IMO Code for independent LNG tanks of type A or B by employing advanced design calculations, high safety factors and by including a full or partly secondary barrier. The tank must further withstand the inertia forces from the liquid gas caused by the vessel motions due to rough sea, and especially due to sloshing (i.e. impacts on the inside of the tank from liquid gas in motion).

[0005] WO 2007/062770 describes a device for mounting a tank in a ship. DE 40 19 278 describes a container for storing or transporting liquefied gasses. It has an inner spherical container for receiving the gas and an outer container provided with an insulation. A vacuum is produced between both containers. The outer container is formed by a concrete shell provided with a gas-tight coating.

[0006] WO 2007/142400 Al describes an extended spherical LNG storage tank installed on an LNG tanker. The LNG storage tank comprises a lower semi-spherical part and an upper semi-spherical part connected to each other via a cylindrical middle part. The LNG storage tank is fixed to the tanker via its central part. The object of the invention is to provide an independent tank system for storing liquid gas in a vessel, where the centre tank member is cylindrical for the purpose of improving the total storage capacity while keeping the total height of the tank relatively low. Moreover, all technical requirements mentioned above must be fulfilled.

SUMMARY OF THE INVENTION

[0007] The present invention relates to an independent vessel tank system for storing liquid gas, comprising: a first tank member; a second, cylindrical tank member connected to the first tank member; a third tank member connected to the second tank member; where the first, second and third tank members provide a tank device for the liquid gas; a first supporting device provided between the third tank member and a hull of the vessel, for supporting the weight of the tank device; a second supporting device at least partially provided along the periphery of the tank device, for supporting the tank device to the hull of the vessel, where the second supporting device is flexible in a first direction parallel to the centre axis of the tank device; flexible in a second direction perpendicular to the periphery of the tank device; rigid in a third direction tangentially to the periphery of the tank device; and where the second supporting device comprises a plate device having a first end fixed to the first and/or second tank member and a second end connected to the hull.

[0008] In one aspect of the invention, the plate device has at least one curved or angled bend.

[0009] In one aspect of the invention, the second supporting device comprises a corrugated plate device.

[0010] In one aspect of the invention, the tank device is made of 9 % nickel steel.

[0011] In one aspect of the invention, the second supporting device is fixed to the tank device at or adjacent to the connection interface between the first tank member and the second tank member.

[0012] In one aspect of the invention, the third tank member is toriconical.

[0013] In one aspect of the invention, the first supporting device is provided at least partially under the third tank member.

[0014] In one aspect of the invention, the first supporting device comprises supporting blocks.

[0015] In one aspect of the invention, the first tank member is hemispherical, torispherical or toriconical.

[0016] In one aspect of the invention, the system comprises stopping means to prevent or restrict sideways movement of the tank device in relation to the vessel.

DETAILED DESCRIPTION

[0017] Embodiments of the invention will now be de-

scribed in detail with reference to the enclosed drawings, where:

Fig. 1 illustrates a perspective cross sectional view of a tank system according to the invention;

Fig. 2 illustrates an embodiment of the second supporting device;

Fig. 3 illustrates the tank system from above being influenced by a force;

Fig. 4 illustrates a typical stiffening arrangement for the bottom tank member;

Fig. 5a illustrate a cross sectional view of the second supporting device of fig. 2;

Figs 5b - 5h illustrate alternative embodiments of the second supporting device.

[0018] It is now referred to fig. 1, where an independent tank system for storing liquid gas in a vessel is shown. In the following embodiment, the liquid gas is liquefied natural gas or LNG. The vessel is not shown in the drawings. The vessel may be a ship type carrier, a floating production and storing and offloading unit (FPSO), a floating, storage and re-gasification unit (FRSU) or a gravity based terminal.

[0019] The system comprises a tank device mainly comprising three tank members, a first tank member 1, a second tank member 2 and a third tank member 3.

[0020] The first tank member 1 is the upper or top tank member of the tank device. The first tank member is substantially hemispherical with radius R1 as indicated in fig. 1. Alternatively, the first tank member may be shaped as a spherical cap. In yet an alternative embodiment, the first tank member 1 may be torispherical or toriconical. In these alternative embodiments, the radius R1' indicates the radius of the circular lower edge of the first tank member (in case the first tank member 1 is a hemisphere, R1 = R1').

[0021] The second tank member 2 is cylindrical, with a radius R2 corresponding to the radius R1 or R1' of the circular lower edge of the first tank member 1. The upper circular edge of the second tank member 2 is connected to the lover circular edge of the first tank member 1, thereby defining a circular first joint 12.

[0022] The third tank member 3 is the lower or bottom tank member of the tank device, having a radius R3 corresponding to the radius R2 of the second tank member 2. An upper circular edge of the third tank member 3 is connected to a lower circular edge of the second tank member 2, thereby defining a circular second joint 23. In the present embodiment, the third tank member 3 is toriconical, i.e. having a conical bottom surface faced towards a hull of the vessel. An angle α between the conical bottom surface and the horizontal plane is indicated in fig. 1. Preferably, the angle $\alpha \geq 5°$. However, a too large angle α is a disadvantage since this will reduce the storage capacity of the tank device. The first, second and third tank members are in the present embodiment made of a 9% welded nickel steel construction. Alternatively, the material of the tank members could be other types of nickel steel, stainless steel etc. Moreover, the material of the tank members could be aluminium.

[0023] The first tank member is an un-stiffened structure. This simplifies the construction of the tank and reduces the amount of welds. This means lesser fatigue prone details in the containment system and a cheaper solution compared to a ordinary stiffened construction. The second tank member may be a stiffened structure. The stiffeners are however applied only to prevent buckling i.e. the stiffeners are not provided for carrying lateral loads. The third tank member is stiffened due to its flat nature and due to the local forces caused by the bottom support system. An example of a stiffening arrangement is illustrated in fig. 4. For example, the third tank member may be stiffened with ring- and radial- stiffeners and with radial girders. The ring stiffeners can for example be of welded T-type slotted through and attached to the radial girders. The radial stiffeners are of flat bar type and shall in general be attached as intercostals between the flanged ring stiffeners.

[0024] The tank device has a centre axis I-I as shown in fig. 1. In fig. 1, the centre axis I-I corresponds to a vertical axis being perpendicular to a horizontal plane. It should be noted that this vertical axis of course will move according to vessel movements due to influence from weather and sea conditions.

[0025] The vessel tank system comprises a traditional cargo handling system, control systems etc. A pipe tower (not shown) may be provided in the tank device for protection of cargo pipes and access to the bottom of the tank. The tower penetrates the top of the tank forming a dome where all connections to the tanks are arranged. The tower shall also support the spray system.

[0026] The tank system shall also be fitted with uplift stopper devices in the case that the vessel's cargo hold is flooded with sea- or ballast water. This is in accordance with IMO's and the Classification Societies' rules.

[0027] A first supporting device 5 is provided between the third tank member 3 and a hull of the vessel, for supporting the weight of the tank device. The first supporting device 5 is provided at least partially under the third tank member 3. In fig. 1 it is shown that the first supporting device 5 comprises supporting blocks, located between the conical bottom surface of the third tank member and the hull of the vessel.

[0028] The supporting blocks have an upper inclining surface adapted to the conical bottom surface. Alternatively, the bottom of the hull is inclining corresponding to the tank device, and rectangular supporting blocks may be used.

[0029] The supporting blocks may be made of compressed, laminated wood or other materials with similar

properties with respect to temperature and robustness.

[0030] The purpose of the conical geometry, for instance compared to a torispherical geometry, is that when the tank shrinks during cool down, the tank bottom will always stay in contact with the supports.

[0031] During ship motions, the tank system is exposed to transverse and longitudinal loads which will tend to force the tank system off its initial position at the supporting blocks. In such cases, friction forces between the supporting blocks and the conical bottom surface will be the main counteracting stopper for the tank to stay in position. Consequently, the conical shape of the third tank member has an additional task of locking the tank by introduction of forces normal to the tank shell and thereby counteracting the motion loads.

[0032] However, if the tank device is relatively empty, there is a risk that the sideways motion forces will exceed the supporting horizontal friction force. Consequently, the tank system may comprise stopping means (not shown), to prevent or restrict such sideways movement. Such stopping means may be provided as a part of the first supporting device.

[0033] It should be noted that if the angle α is large enough, these stopping means may be omitted, since the horizontal component of the friction forces between the conical bottom surface and the first supporting device will be large enough to counteract any transverse or longitudinal loads.

[0034] The conical shape of the third tank member shall finally drain the liquid gas to the pumps positioned at the centre of the tank.

[0035] A second supporting device 4 is at least partially provided along the periphery of the tank device, for supporting the tank device to the hull of the vessel. The second supporting device 4 is mainly supporting the tank device in a plane perpendicular to the centre axis I-I, for inertia loads and sloshing loads.

[0036] The second supporting device 4 is flexible in a first direction parallel to the centre axis I-I of the tank device. Moreover, the second supporting device 4 is flexible in a second direction perpendicular to the periphery of the tank device. This second direction is also perpendicular to the first direction for any position along the periphery. Moreover, the second supporting device 4 is rigid in a third direction tangentially to the periphery of the tank device.

[0037] The purpose of the geometry is to minimize local stresses in the tank shell due to deformations of the ships hull, typically perpendicular to the tank shell, and due to shrinkage of the tank, both while keeping the tank in position during ship motions. This is secured by employing the flexible nature together with rigid nature of the support 360 degrees around the periphery.

[0038] The second supporting device 4 may be continuous along the periphery of the tank device, or may be discontinuous, i.e. comprising several supporting devices provided with intervals along the periphery of the tank device.

[0039] It is now referred to fig. 2, illustrating an embodiment of the second supporting device 4. In this embodiment, the second supporting device 4 comprises a corrugated plate device 30 having a first end 31 connected to the tank device, and a second end 32 connected to the hull of the vessel. The ends may e.g. be connected to the hull and the tank by welding.

[0040] As illustrated in fig. 2, the corrugated plate device is flexible in a first direction Y parallel to the centre axis I-I of the tank device, it is flexible in a second direction Z perpendicular to the periphery of the tank device and it is rigid in a third direction X tangentially to the periphery of the tank device. In fig. 2 it is shown that all three directions X, Y and Z are perpendicular to each other at any point along the periphery.

[0041] The corrugated plate device 30 comprises at least one corrugation. The corrugated plate device 30 may be made of several plates welded together, or may be made of a one plate that is bent two or several times to form the corrugation.

[0042] In fig. 2, the corrugation is substantially right-angled. In fig. 2 and fig. 5a, it is shown a plate device 30 having four right-angled bends 33a, 33b, 33c, 33d. However, the corrugation may also be substantially U-shaped, or a similar shape giving the same stiffness characteristics as described above.

[0043] In the present embodiment, the second supporting device 4 is fixed to the tank device close to the connection interface or joint 12 between the first tank member 1 and the second tank member 2. Hence, the second supporting device 4 has an additional purpose of supporting the joint 12 where local plate bending will occur due to the changing geometry.

[0044] In a situation where an empty tank is filled with cryogenic liquid gas, the tank will contract due to the temperature change. Hence, the conical bottom surface of the third tank member will slide along the upper inclining surface of the supporting blocks. Consequently, the tank device will move a distance downwards in the direction of the centre axis I-I. This movement is allowed due to the flexibility of the second connection device 4 in the direction Y. The opposite movement when the tank device is heated is also allowed.

[0045] In fig. 3, a situation where the tank system is influenced by a inertia force F is illustrated. As shown, the flexibility of the second supporting device dampens the impact at the periphery of the tank in some areas indicated by the areas denoted A. However, the tank device is held in position in relation to the hull of the vessel due in other areas denoted B due to the rigidity of the second supporting device. It should be noted that fig. 3 is very simplified.

Alternative embodiments

[0046] The second supporting device 4 is also illustrated in fig. 5a, here the second supporting device 4 is fixed between the second tank member 2 and the hull 50 of

the vessel. As described above, the second supporting device 4 comprises a plate device 30 having a first end 31 connected to the tank device, and a second end 32 connected to the hull of the vessel. The plate device 30 here has four right-angled bends 33a, 33b, 33c, 33d..

[0047] It should be noted that there are several alternative embodiments of the second supporting device 4.

[0048] It is now referred to fig. 5b. Here, the second supporting device 4 comprises a plate device 30 having two right-angled bends 33a, 33b.

[0049] It is now referred to fig. 5c. Here, the second supporting device 4 comprises a plate device 30 having two curved bends 33a, 33b.

[0050] It is now referred to fig. 5d. Here, the plate device 30 have four curved bends 33a, 33b, 33c, 33d.

[0051] It is now referred to fig. 5e. Here, the plate device 30 has three curved bends 33a, 33b, 33d. As shown, there is a fluent transition from the embodiment shown in fig. 5d to the embodiment shown in fig. 5e.

[0052] It is now referred to fig. 5f. Here, it is shown that the plate device 30 may comprise one curved bend 33a. Alternatively, the plate device may comprise one angled bend (not shown).

[0053] It is now referred to fig. 5g. Here, the plate device 30 has six right-angled bends 33a, 33b, 33c, 33d, 33e, 33f.

[0054] It is now referred to fig. 5h. Here, the plate device 30 has five angled bends 33a, 33b, 33c, 33d, 33e, where the first bend 33a and the last bend 33e has a bend of ca 120° and the tree bends 33b, 33c and 33d have bends of ca 60°. Consequently, this embodiment shows a substantially triangular-shaped plate device.

[0055] It should be noted that several other embodiments are possible in view of the description above. For example it would be possible to combine angled bends with curved bends etc.

[0056] It should also be noted that the plate device 30 may comprise a connection device, such as a hinge connection. For example, the two bends 33b and 33d of fig. 5h could comprise hinge connections and yet provide the desired properties of the second supporting device 4.

Claims

1. Independent vessel tank system for storing liquid gas, comprising:

   - a first tank member (1);
   - a second, cylindrical tank member (2) connected to the first tank member (1);
   - a third tank member (3) connected to the second tank member (2);
   where the first, second and third tank members (1, 2, 3) provide a tank device for the liquid gas;
   - a first supporting device (5) provided between the third tank member (3) and a hull (50) of the vessel, for supporting the weight of the tank device;
   - a second supporting device (4) at least partially provided along the periphery of the tank device, for supporting the tank device to the hull (50) of the vessel, **characterized in that** the second supporting device (4) is
   - flexible in a first direction parallel to the centre axis of the tank device;
   - flexible in a second direction perpendicular to the periphery of the tank device;
   - rigid in a third direction tangentially to the periphery of the tank device; and where the second supporting device (4) comprises a plate device (30) having a first end (31) fixed to the first and/or second tank member (1, 2) and a second end (32) connected to the hull (50).

2. System according to claim 1, where the plate device (30) has at least one curved or angled bend (33a).

3. System according to claim 1, where the second supporting device (4) comprises a corrugated plate device.

4. System according to claim 1, where the tank device is made of 9 % nickel steel.

5. System according to claim 1, where the second supporting device (4) is fixed to the tank device at or adjacent to the connection interface between the first tank member (1) and the second tank member (2).

6. System according to claim 1, where the third tank member (3) is toriconical.

7. System according to claim 1, where the first supporting device (5) is provided at least partially under the third tank member (3).

8. System according to claim 7, where the first supporting device (5) comprises supporting blocks.

9. System according to claim 1, where the first tank member (1) is hemispherical, torispherical or toriconical.

10. System according to claim 1, where the system comprises stopping means to prevent or restrict sideways movement of the tank device in relation to the vessel.

Patentansprüche

1. Unabhängiges Tankbehältersystem zum Speichern von Flüssiggas, das folgendes aufweist:

   - ein erstes Tankelement (1);

- ein zweites zylindrisches Tankelement (2), das mit dem ersten Tankelement (1) verbunden ist;
- ein drittes Tankelement (3), das mit dem zweiten Tankelement (2) verbunden ist;
wobei das erste, das zweite und das dritte Tankelement (1, 2, 3) eine Tankeinrichtung für das Flüssiggas bilden;
- eine erste Stützeinrichtung (5), die zwischen dem dritten Tankelement (3) und einer Hülle (50) des Behälters vorgesehen ist, um das Gewicht der Tankeinrichtung abzustützen;
- eine zweite Stützeinrichtung (4), die zumindest teilweise längs des Umfanges der Tankeinrichtung vorgesehen ist, um die Tankeinrichtung gegenüber der Hülle (50) des Behälters abzustützen,
dadurch gekennzeichnet,
dass die zweite Stützeinrichtung (4)
- in einer ersten Richtung parallel zu der Mittelachse der Tankeinrichtung flexibel ist;
- in einer zweiten Richtung senkrecht zu dem Umfang der Tankeinrichtung flexibel ist; und
- in einer dritten Richtung tangential zu dem Umfang der Tankeinrichtung starr ist; und

wobei die zweite Stützeinrichtung (4) eine Platteneinrichtung (30) aufweist, die ein erstes Ende (31) besitzt, das an dem ersten Tankelement und/oder dem zweiten Tankelement (1, 2) befestigt ist,
und ein zweites Ende (32) besitzt, das mit der Hülle (50) verbunden ist.

2. System nach Anspruch 1,
wobei die Platteneinrichtung (30) mindestens ein gekrümmtes oder abgewinkeltes Biegeteil (33a) aufweist.

3. System nach Anspruch 1,
wobei die zweite Stützeinrichtung (4) eine wellenförmige Platteneinrichtung aufweist.

4. System nach Anspruch 1,
wobei die Tankeinrichtung aus 9% Nickelstahl besteht.

5. System nach Anspruch 1,
wobei die zweite Stützeinrichtung (4) an der Tankeinrichtung befestigt ist oder in der Nähe von dem Verbindungsübergang zwischen dem ersten Tankelement (1) und dem zweiten Tankelement (2) befestigt ist.

6. System nach Anspruch 1,
wobei das dritte Tankelement (3) torikonisch ist.

7. System nach Anspruch 1,
wobei die erste Stützeinrichtung (5) zumindest teilweise unter dem dritten Tankelement (3) vorgesehen ist.

8. System nach Anspruch 7,
wobei die erste Stützeinrichtung (5) Stützblöcke aufweist.

9. System nach Anspruch 1,
wobei das erste Tankelement (1) halbkugelförmig, torisphärisch oder torikonisch ist.

10. System nach Anspruch 1,
wobei das System Halteeinrichtungen aufweist, um seitliche Bewegungen der Tankeinrichtung relativ zu dem Behälter zu verhindern oder zu begrenzen.

Revendications

1. Système de réservoir indépendant pour bateau pour stocker du gaz liquide, comprenant :

un premier élément de réservoir (1) ;
un deuxième élément de réservoir cylindrique (2) raccordé au premier élément de réservoir (1) ;
un troisième élément de réservoir (3) raccordé au deuxième élément de réservoir (2) ;
dans lequel les premier, deuxième et troisième éléments de réservoir (1, 2, 3) fournissent un dispositif de réservoir pour le gaz liquide ;
un premier dispositif de support (5) prévu entre le troisième élément de réservoir (3) et une coque (50) du bateau, afin de supporter le poids du dispositif de réservoir ;
un second dispositif de support (4) au moins partiellement prévu le long de la périphérie du dispositif de réservoir, pour supporter le dispositif de réservoir sur la coque (50) du bateau, **caractérisé en ce que** le second dispositif de support (4) est :

flexible dans une première direction par rapport à l'axe central du dispositif de réservoir ;
flexible dans une deuxième direction perpendiculaire à la périphérie du dispositif de réservoir ;
rigide dans une troisième direction tangentielle à la périphérie du dispositif de réservoir ; et
dans lequel le second dispositif de support (4) comprend un dispositif formant plaque (30) ayant une première extrémité (31) fixée au premier et/ou deuxième élément de réservoir (1, 2) et une seconde extrémité (32) raccordée à la coque (50).

2. Système selon la revendication 1, dans lequel le dis-

positif formant plaque (30) a au moins un coude incurvé ou angulaire (33a).

3. Système selon la revendication 1, dans lequel le second dispositif de support (4) comprend un dispositif formant plaque ondulée.

4. Système selon la revendication 1, dans lequel le dispositif de réservoir est réalisé avec un acier à 9% de nickel.

5. Système selon la revendication 1, dans lequel le second dispositif de support (4) est fixé au dispositif de réservoir au niveau de ou de manière adjacente à l'interface de raccordement entre le premier élément de réservoir (1) et le deuxième élément de réservoir (2).

6. Système selon la revendication 1, dans lequel le troisième élément de réservoir (3) est toriconique.

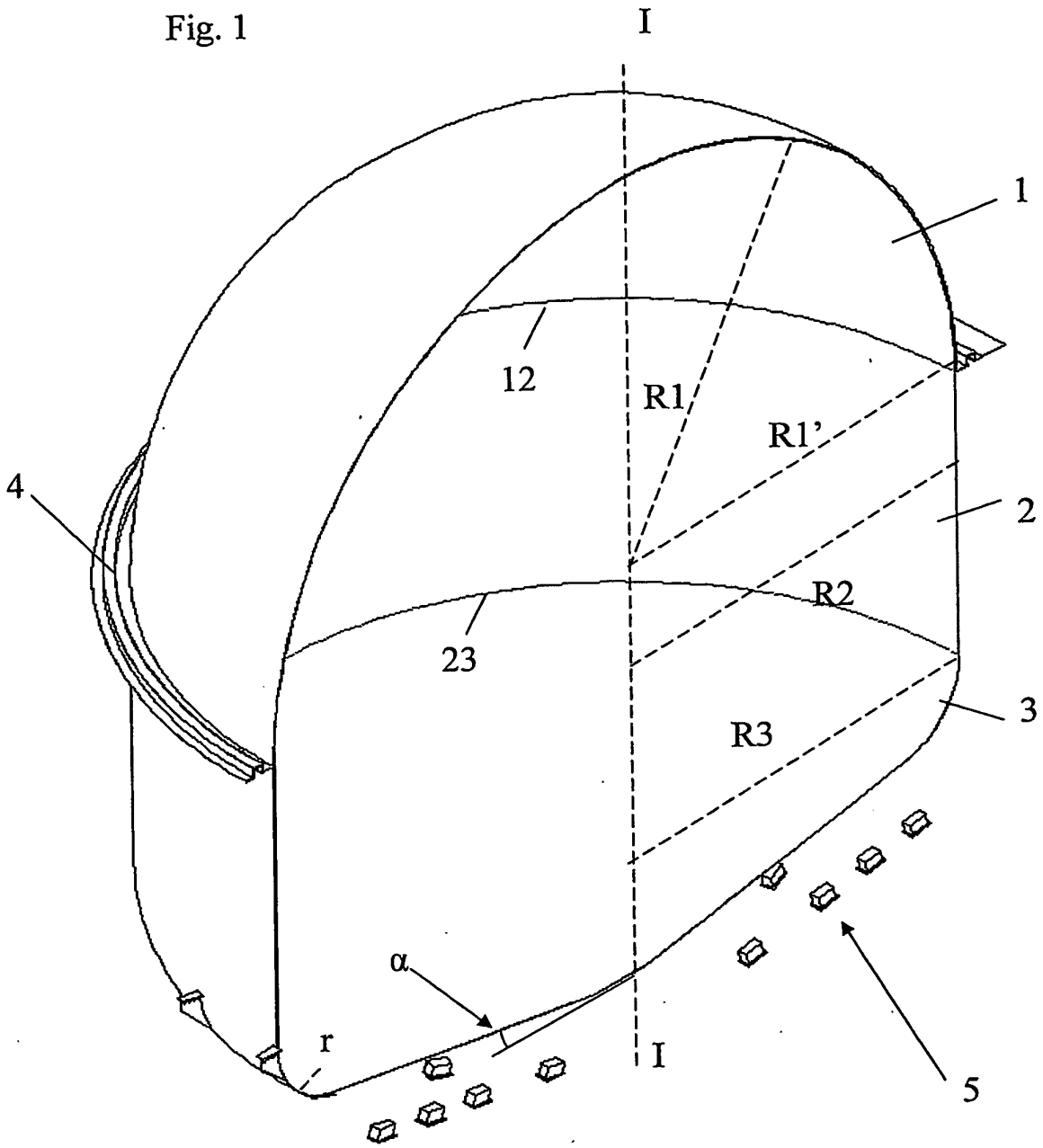
7. Système selon la revendication 1, dans lequel le premier élément de support (5) est prévu au moins partiellement sous le troisième élément de réservoir (3).

8. Système selon la revendication 7, dans lequel le premier dispositif de support (5) comprend des blocs de support.

9. Système selon la revendication 1, dans lequel le premier élément de réservoir (1) est hémisphérique, torisphérique ou toriconique.

10. Système selon la revendication 1, dans lequel le système comprend des moyens de butée pour empêcher ou limiter le mouvement latéral du dispositif de réservoir par rapport au bateau.

Fig. 1



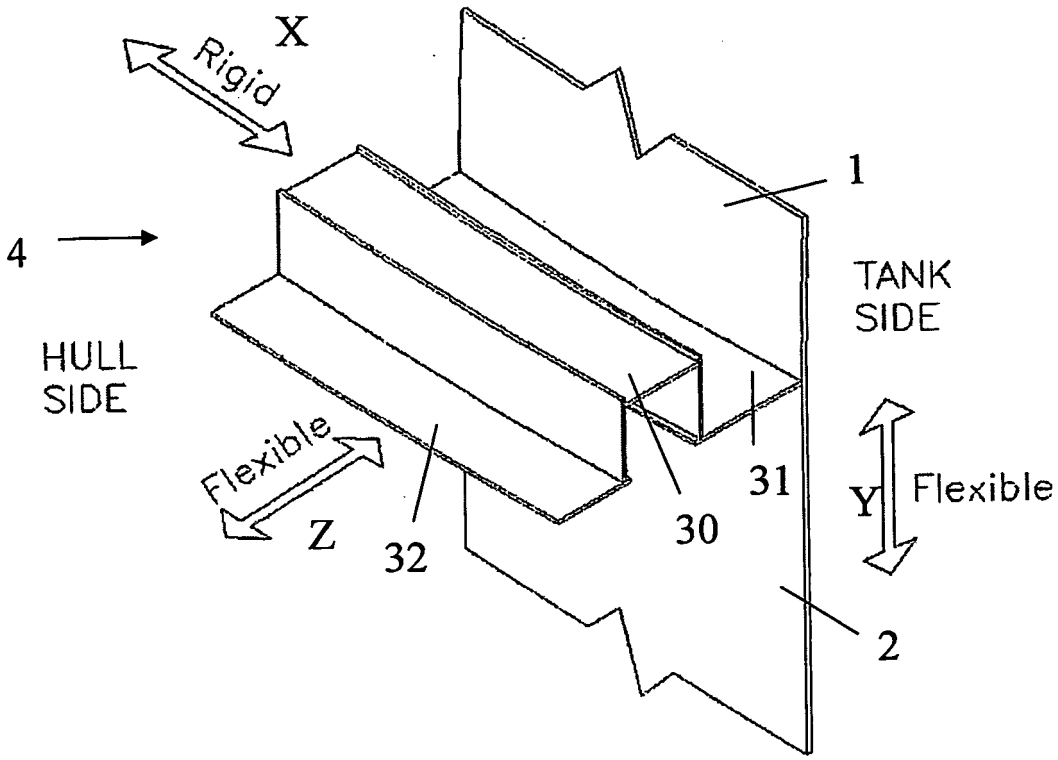


Fig. 2

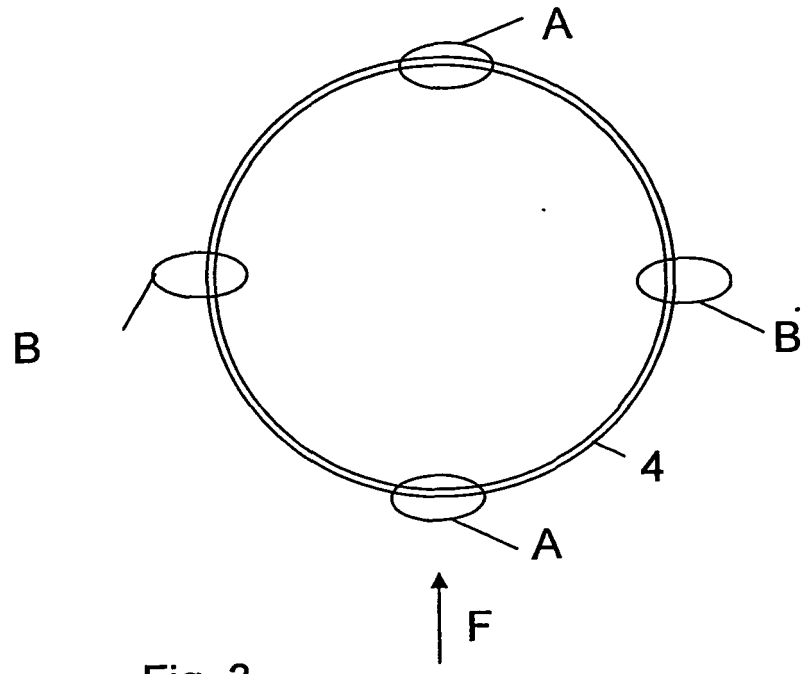


Fig. 3

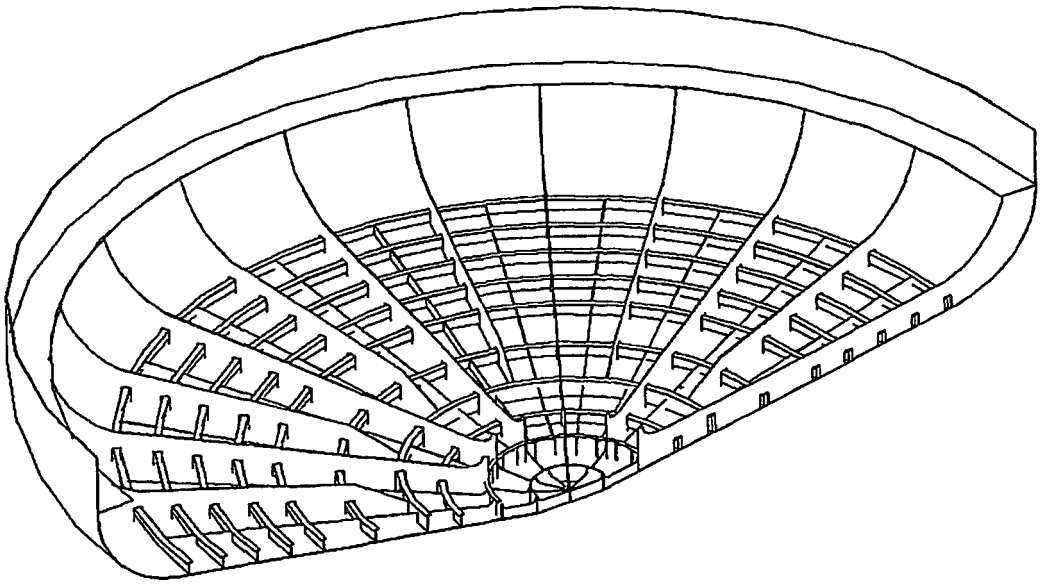


Fig. 4

Fig. 5a

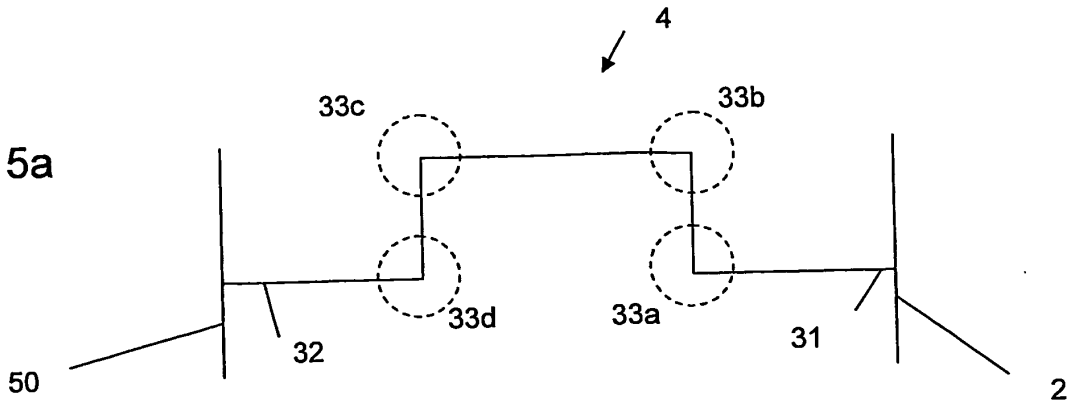


Fig. 5b

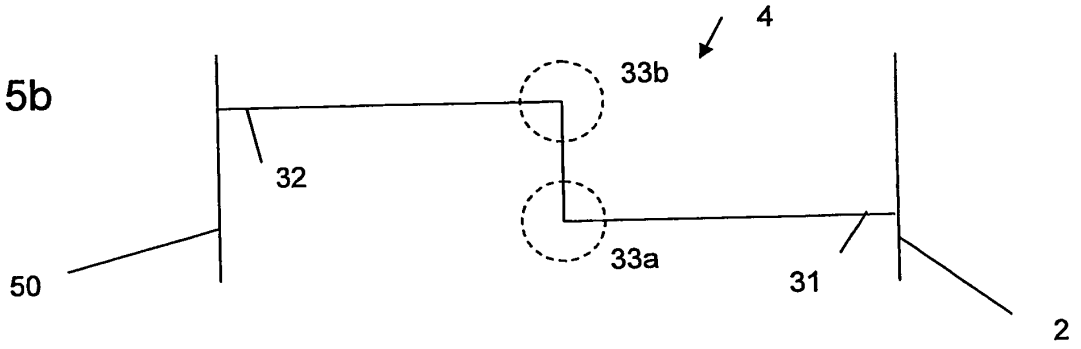


Fig. 5c

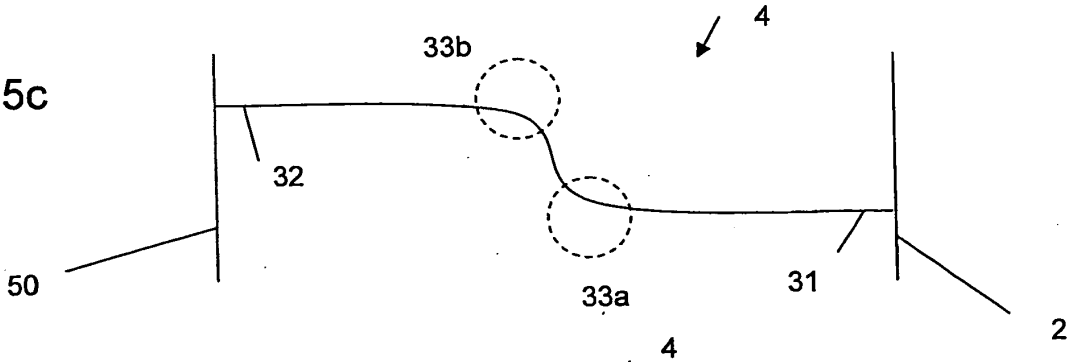


Fig. 5d

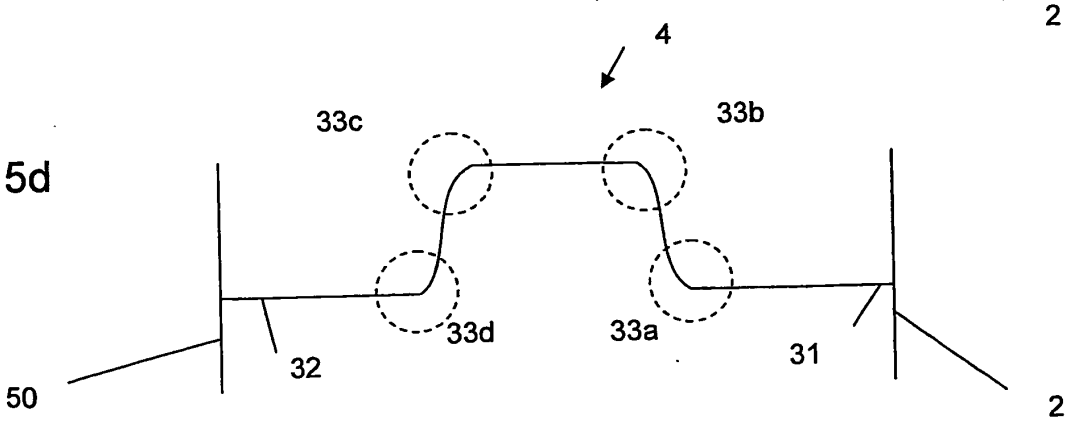


Fig. 5e

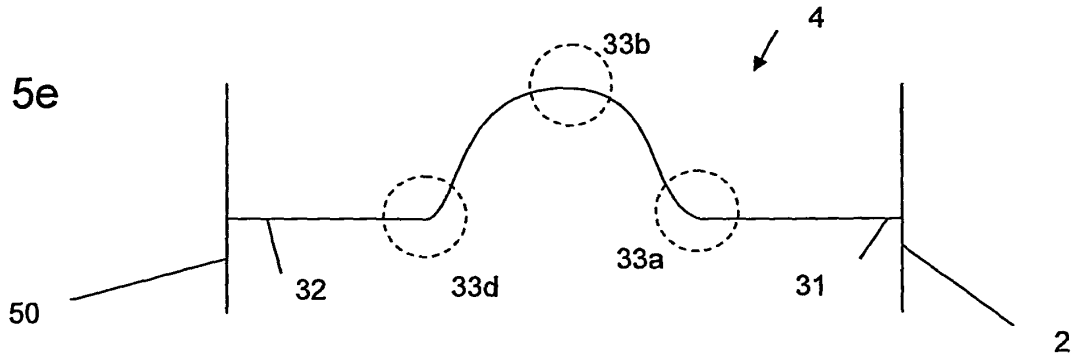


Fig. 5f

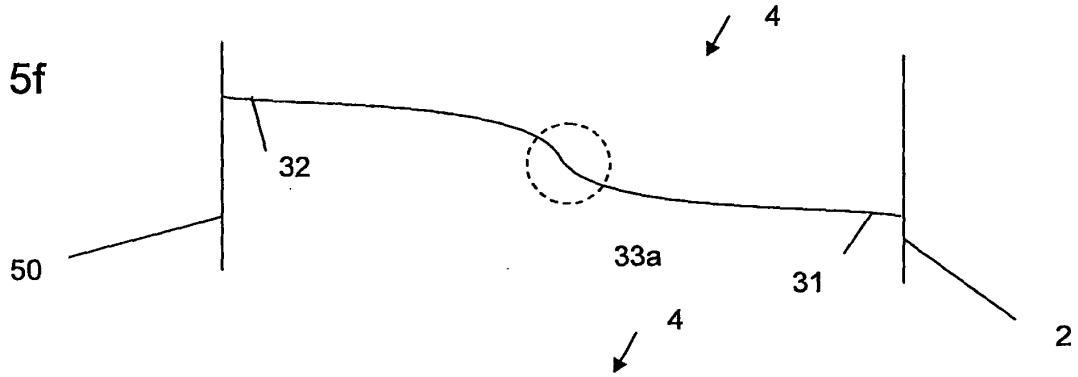


Fig. 5g

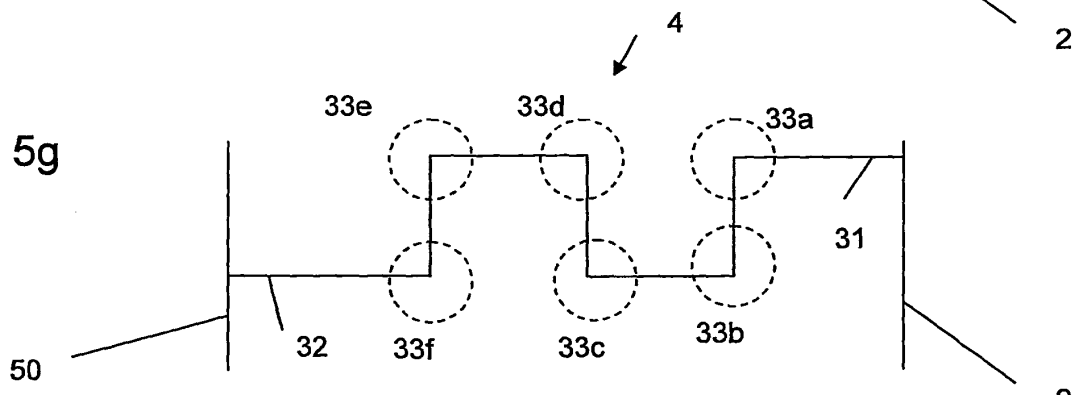
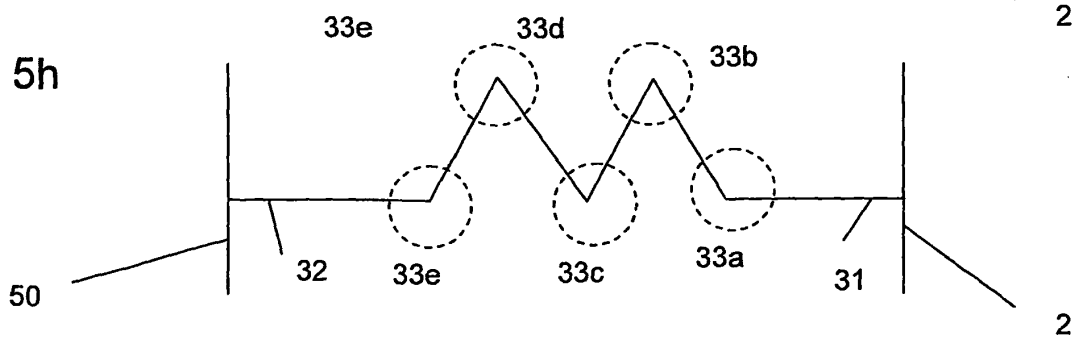


Fig. 5h



REFERENCES CITED IN THE DESCRIPTION

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