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Description

Technical field

The invention relates to the field of sealed and thermally insulating tanks integrated into a support structure to contain a cold fluid, in particular to membrane tanks for containing liquefied gases, and in particular to the mechanical anchor devices usable in such a tank.

Sealed and thermally insulating tanks may be used in various industries to store cold products. For example, in the energy field liquefied natural gas (LNG) is a liquid with a high methane content that can be stored at atmospheric pressure at approximately -163°C in terrestrial storage tanks or in tanks onboard a floating structure. Liquefied petroleum gas (LPG) can be stored at a temperature between -50°C and 0°C inclusive.

In the case of a floating structure, the tank may be intended for transporting the liquefied gas or for receiving liquefied gas serving as fuel for the propulsion of the floating structure.

Prior art

There is known, for example from the documents WO-A-2014096600 and WO-A-2019110894, a sealed and thermally insulating tank for storing liquefied natural gas arranged in a support structure and the walls of which have a multilayer structure, namely, from the exterior toward the interior of the tank, a secondary thermally insulating barrier anchored against the support structure, a secondary sealing membrane that is supported by the secondary thermally insulating barrier, a primary thermally insulating barrier that is supported by the secondary sealing membrane, and a primary sealing membrane that is supported by the primary thermally insulating barrier and is intended to be in contact with the liquefied natural gas stored in the tank.

Each of the primary and secondary thermally insulating barriers includes an assembly of modular primary and secondary insulating blocks of parallelepipedal general shape that are juxtaposed and therefore form a support structure for a respective sealing membrane. The insulating blocks are anchored to the support structure by means of anchor devices that are fixed to the support structure and are positioned at the level of the corners of the primary and secondary insulating blocks. Each anchor device thus cooperates with the corners of four adjacent secondary insulating blocks and with the corners of four adjacent primary insulating blocks in order to retain them against the support structure. WO-A-2019110894 thus discloses an anchor device according to the preamble of Claim 1.

Summary of the invention

Some aspects of the invention are based on the observation that the tank walls may suffer high and localized compression stresses because of phenomena of sloshing of the liquids contained in the tank. Now the anchor devices are produced with components that are generally stiffer than the insulating blocks to be able to anchor the thermally insulating barriers reliably whilst being of limited overall size. These stiffness differences lead to a risk of creating flatness defects in a thermally insulating barrier in response to compression stresses, in particular when the thermally insulating barrier is essentially made of polymer foam. These flatness defects can cause stress concentrations in line with the anchor devices that would compromise the integrity of the sealing membrane supported by the thermally insulating barrier.

An idea on which the invention is based consists in introducing a flexibility of the anchor devices in the direction of a compression force coming from the interior of the tank, with a view to homogenizing the response of a thermally insulating barrier to the compression stresses. Another idea on which the invention is based consists in allowing the upper surface of an anchor device approximately to follow the movements of the upper surface of the insulating blocks during use of a sealed and thermally insulating membrane tank.

To this end the invention proposes an anchor device intended to retain insulating blocks against a supporting wall, including:
a clamping assembly including a lower plate, an upper plate parallel to the lower plate, a connecting member connecting the lower plate to the upper plate and a spacing member arranged between the lower plate and the upper plate, the spacing member including an abutment part defining a minimum spacing between the lower plate and the upper plate in an abutment position of the lower and upper plates against the abutment part, the abutment part comprising a rigid part and
an anchor rod projecting from the clamping assembly perpendicularly to the lower plate, the anchor rod including a lower end intended to be attached to a supporting wall and an upper end opposite the lower end and coupled to the lower plate to be able to exert traction on the lower plate in the direction of the lower end,
in which the spacing member further includes an elastically compressible member tending to maintain the lower plate and the upper plate in an apart position, the connecting member defining a maximum spacing between the lower plate and the upper plate in the apart position, said maximum spacing being greater than said minimum spacing, the elastically compressible member being configured to be compressed elastically as far as said abutment position of the lower and upper plates against the abutment part in response to a force tending to move the upper plate toward the lower plate.

Thanks to the above features, the anchor device can have a lower stiffness than in the aforementioned prior art in response to a compression force and therefore have a capacity for elastic deformation by crushing between the apart position and the abutment position.

In accordance with other advantageous embodiments, an anchor device of the above kind may have one or more of the following features.

The spacing member that defines the maximum spacing between the lower plate and the upper plate may be produced in various ways.

In accordance with one embodiment, the connecting member includes at least one connecting rod perpendicular to the lower plate and to the upper plate and extending through a bore formed in the abutment part, the lower plate and/or the upper plate being mounted to slide relative to said connecting rod to be able to slide to the abutment position.

In accordance with one embodiment, the connecting member further includes a first abutment element coupled to a first end of the connecting rod to immobilize the upper plate longitudinally relative to the connecting rod in the apart position.

In accordance with one embodiment, the connecting member further includes a rotation immobilizing element coupled to the first abutment element, a portion of the rotation immobilizing element being received in a notch in the upper plate so as to immobilize the connecting rod in rotation.

In accordance with one embodiment, the rotation immobilizing element is accommodated in a housing of the upper plate receiving the first abutment element, the notch opening into the housing.

In accordance with one embodiment, the connecting member further includes a second abutment element coupled to a second end of the connecting rod to immobilize the lower plate longitudinally relative to the connecting rod in the apart position.

In accordance with one embodiment, the first abutment element includes a nut screwed onto and welded to the first end of the connecting rod and the second abutment element is rigidly attached to the lower plate.

In accordance with one embodiment, the second abutment element is received in a groove in the lower plate, the groove including two facing faces with which cooperate two distinct faces of the second abutment element so as to immobilize the connecting rod in rotation and the first abutment element is rigidly attached to the upper plate.

In accordance with one embodiment, the anchor device further further includes a spacing part disposed under the lower plate and including a central housing through which the anchor rod passes, the spacing part including an upper surface configured to bear against the lower plate of the clamping assembly and a lower surface intended to bear on an insulating block and the second abutment element is received in a groove in the spacing part, the groove including two facing faces with which cooperate two opposite faces of the second abutment element so as to immobilize the connecting rod in rotation and the first abutment element is rigidly attached to the upper plate.

The elastically compressible member may be arranged in various ways between the lower plate and the upper plate. The elastically compressible member may be mounted in series or in parallel with the abutment part defining the minimum spacing.

In accordance with one embodiment, the elastically compressible member is engaged on the connecting rod.

In accordance with embodiments, the elastically compressible member bears against the abutment part and/or against the lower and/or upper plate(s).

In accordance with one embodiment, the bore formed in the abutment part includes a stage in which the elastically compressible member is arranged. Thanks to these features the elastically compressible member may have a small overall size.

The elastically compressible member may be produced in various ways, in particular in the form of one or more springs. In accordance with one embodiment, the elastically compressible member includes a stack of spring washers. For example between 2 and 10 Belleville washers may be used to generate an elastic movement of between 1 and 8 mm inclusive. In accordance with another embodiment, the elastically compressible member includes a coil spring.

The elastic movement between the apart position and the abutment position of the upper and lower plates preferably corresponds relative precisely to the movement of a cover plate of the insulating block between a rest state corresponding to an empty tank and to ambient temperature and a service state corresponding to tank operating conditions. This movement is caused by the thermal contraction and the contraction of the insulating block under the pressure load exerted by the cargo. There should preferably be considered a differential movement between the upper surface of the insulating block and the upper surface of the anchor device less the contraction of the other parts of the anchor device under the same conditions. In accordance with one embodiment, the elastic movement is between 1 and 8 mm inclusive, preferably between 4 and 7 mm inclusive, preferably equal to 5 mm. In accordance with another embodiment, the elastic movement is between 1 and 6 mm inclusive, preferably 3 mm.

In accordance with one embodiment, the connecting member is configured to exert a static load on the elastically compressible member in the apart position. A static load (or preload) of this type in particular allows reliable supporting of the underlying sealed membrane during operations of constructing the tank that are liable to generate localized pressures on the tank wall (for example a localized drilling operation of the sealed membrane or movement of a worker or of a tool over the tank wall under construction). The static load is for example of the order of 1 kN.

In accordance with one embodiment, the lower plate includes a central bore through which the upper end of the anchor rod passes and the anchor device includes a nut that cooperates with a threaded portion of the upper end of the anchor rod and one or more spring washers threaded onto the upper end of the anchor rod between the nut and the lower plate in such a manner as to be able to exert an elastic force on the lower plate in the direction of the lower end of the anchor rod.

In this case, the clamping assembly preferably includes at least two connecting rods disposed symmetrically relative to said central bore. Thanks to these features, the forces may be distributed in a balanced manner in the clamping assembly.

In accordance with one embodiment, the or each connecting rod is immobilized in rotation by a spot weld on one or both plates or by a split locknut. The split locknut is for example placed above, below or partly in the lower plate.

In accordance with one embodiment, the abutment part is fixed, for example screwed and/or riveted and/or glued, to one of the lower plate or the upper plate. The abutment part is preferably fixed to the lower plate.

In accordance with one embodiment, the abutment part consists of the rigid part.

In accordance with one embodiment, the abutment part further includes a polymer foam layer disposed on a surface of the rigid part facing the other of the lower plate or the upper plate, the polymer foam layer being compressed in said abutment position of the lower and upper plates against the abutment part. The polymer foam layer may be glued to the rigid part.

The polymer foam layer advantageously has a thickness between 2 and 8 mm inclusive in order to preserve in the abutment position a thickness between 1 and 6 mm.

In accordance with one embodiment, the other of the lower plate or the upper plate includes a polymer foam layer disposed on a surface of said plate facing the rigid part, the polymer foam layer being compressed in said abutment position of the lower and upper plates against the abutment part. The polymer foam layer may be glued to said plate.

In accordance with one embodiment, the anchor device further includes a spacing part disposed under the lower plate and including a central housing through which the anchor rod passes, the spacing part including an upper surface configured to bear against the lower plate of the clamping assembly and a lower surface intended to bear on an insulating block. The spacing part is for example made of plywood to limit thermal bridging. The spacing part preferably has a section identical to the lower plate, of rectangular shape in the embodiments represented. It may be formed of a small number of elongate parts having simple shapes, rigidly assembled, for example stapled, screwed and/or glued to one another. The central housing is preferably filled by thermal insulation around the anchor rod, for example glass wool, wadding, expanded polystyrene or polyurethane foam.

In accordance with one embodiment, the spacing part is formed of four identically profiled elongate parts an inclined flat on which forms a respective wall of the central housing.

In accordance with one embodiment, the spacing part is formed of two facing plates and two cleats disposed between said two facing plates, each of the two cleats and each of the two plates forming a respective wall of the central housing.

In accordance with one embodiment, the thermal insulation includes a block of glass wool around the anchor rod.

In accordance with one embodiment, the block of glass wool includes within its thickness a notch intended to receive the anchor rod.

In accordance with one embodiment, the block of glass wool includes at least one sheet of glassfibre matting, Kraft paper or polymer, said sheet being disposed between the block of glass wool and a facing wall of the central housing.

In accordance with one embodiment, the thermal insulation includes a block of polymer foam including a through-hole intended to receive the anchor rod.

In accordance with one embodiment, the through-hole has a section that widens from one of the upper and lower ends of the anchor rod to the other of the upper and lower ends of the anchor rod. In particular, in accordance with one embodiment, the through-hole has a section that widens from the upper end of the anchor rod to the lower end of the anchor rod.

In accordance with one embodiment, the spacing part includes a blind hole extending in line with the connecting rod and adapted to receive a part of the connecting rod.

In accordance with one embodiment, the clamping assembly forms a secondary clamping member intended to cooperate with a secondary insulating barrier, the upper plate including a central bore into which is screwed a stud projecting from the clamping assembly on the side opposite the anchor rod, said stud carrying a primary clamping member intended to cooperate with a primary insulating barrier.

In accordance with one embodiment, the anchor device further includes a bush engaged on the lower end of the anchor rod and intended to be fixed to the supporting wall, the bush including a housing receiving the lower end of the anchor rod in such a manner as to form a ball-and-socket joint connection.

In accordance with one embodiment, the clamping assembly has a parallelepipedal overall shape, the lower plate and the upper plate having a rectangular contour.

In accordance with one embodiment, the anchor rod, the lower plate and the upper plate are made of metal, the abutment part being made of plywood or other rigid material providing better thermal insulation than metal, for example polyurethane foam with a density greater than 200 kg/m^3.

In accordance with one embodiment, the invention also provides an anchor device intended to retain insulating blocks against a supporting wall, including:
a clamping assembly including a lower plate, an upper plate parallel to the lower plate, a connecting member connecting the lower plate to the upper plate, and a spacing member arranged between the lower plate and the upper plate, the spacing member including a rigid abutment part defining a minimum spacing between the lower plate and the upper plate in an abutment position of the lower and upper plates against the abutment part,
an anchor rod projecting from the clamping assembly perpendicular to the lower plate, the anchor rod including a lower end intended to be attached to a supporting wall and an upper end opposite the lower end coupled to the lower plate to be able to exert traction on the lower plate in the direction of the lower end, and
a spacing part disposed under the lower plate and including a central housing through which the anchor rod passes, the spacing part including an upper surface configured to bear against the lower plate of the clamping assembly and a lower surface intended to bear on an insulating block.

The spacing part may have one or more of the features already explained hereinabove.

In accordance with one embodiment, the invention also provides a sealed and thermally insulating tank for storing a fluid, including a supporting wall, anchor devices fixed to the supporting wall and a tank wall anchored to the supporting wall with the aid of the anchor devices, the tank wall including successively in a thickness direction, from the exterior to the interior of the tank, a thermally insulating barrier and a

sealing membrane that rests against the thermally insulating barrier,
in which the thermally insulating barrier comprises insulating blocks of parallelepipedal shape that are juxtaposed on the supporting wall, said insulating blocks including a cover plate defining a support surface for the sealing membrane;
in which at least one of said anchor devices mentioned above is used, the lower end of the anchor rod being fixed to the supporting wall between a plurality of insulating blocks, the lower plate of the anchor device cooperating with the plurality of the insulating blocks in order to clamp the plurality of insulating blocks in the direction of the supporting wall.

In accordance with other advantageous embodiments, a tank of the above kind may have one or more of the following features.

In accordance with one embodiment, the elastically compressible member is configured to retain the lower plate and the upper plate in the apart position in an empty state of the tank, the upper plate of the anchor device in the apart position being aligned with the cover plates of the plurality of insulating blocks to support the sealing membrane.

The insulating blocks may have various structures. In accordance with one embodiment, said insulating blocks include a bottom plate parallel to and spaced from the cover plate, a fibre-reinforced polymer foam block arranged between the cover plate and a bottom plate, and the lower plate of the anchor device cooperates directly or indirectly with said bottom plate without exerting any clamping effect on the polymer foam block. For example the lower plate of the anchor device may cooperate with the bottom plate via a rigid element such as a spacing part, a pillar and/or a cleat, for example made of plywood.

In accordance with one embodiment, said insulating blocks include a bottom plate and successively an intermediate plate and a cover plate both parallel to the bottom plate and spaced from each other, and two fibre-reinforced polymer foam blocks respectively arranged between the cover plate and the intermediate plate and between the intermediate plate and the bottom plate. The lower plate of the anchor device cooperates directly with said intermediate plate at the level of a corner zone.

The stiffness of the elastically compressible member is preferably lower than a stiffness in the thickness direction of the insulating barrier adjacent to the anchor device. In accordance with one embodiment, a ratio between the stiffness of the elastically compressible member and a stiffness in the thickness direction of the tank wall equivalent to a spring consisting of the fibre-reinforced polymer foam having a section equal to that of the upper plate is between 0.3 and 1 inclusive.

In accordance with one embodiment, the thermally insulating barrier is a secondary thermally insulating barrier, the insulating blocks are secondary insulating blocks and the sealing membrane is a secondary sealing membrane , the tank wall further including a primary thermally insulating barrier resting against the secondary sealing membrane and a primary sealing membrane that rests against the primary thermally insulating barrier and is intended to be in contact with the fluid contained in the tank, the primary thermally insulating barrier including primary insulating blocks each of which is stacked on one of the secondary insulating blocks,
in which said stud passes in a sealed manner through the secondary sealing membrane and the primary clamping member bears in the direction of the supporting wall against a plurality of primary insulating blocks stacked on said plurality of secondary insulating blocks in such a manner as to retain the plurality of primary insulating blocks in the direction toward the supporting wall.

In accordance with one embodiment, the fluid is a liquefied gas, such as liquefied natural gas, liquefied petroleum gas, liquefied ethylene.

A tank of the above kind may form part of a terrestrial storage installation, a storage installation placed on a seabed, for example to store LNG, or installed in a floating structure, in coastal or deep water, in particular a methane tanker ship, a floating storage and regassification unit (FSRU), a floating production storage and offloading (FPSO) unit, etc.

In accordance with one embodiment, a ship for transporting a fluid includes a double hull and an aforementioned tank disposed in the double hull. In accordance with one embodiment, the double hull includes an internal hull forming the supporting wall of the tank.

In accordance with one embodiment, the invention also provides a transfer system for a fluid, the system including the aforementioned ship, insulated pipes arranged in such a manner as to connect the tank installed in the hull of the ship to a floating or terrestrial storage installation, and a pump for driving a fluid through the insulated pipes from or to the floating or terrestrial storage installation to or from the tank of the ship.

In accordance with one embodiment, the invention also provides a method of loading or offloading a ship of the above kind in which a fluid is routed through insulated pipes from or to a floating or terrestrial storage installation to or from the tank of the ship.

Brief description of the figures

The invention will be better understood and other aims, details, features and advantages thereof will become more clearly apparent in the course of the following description of particular embodiments of the invention given by way of nonlimiting illustration only with reference to the appended drawings.

[Fig.1] Figure 1 is a cutaway perspective view of a tank wall.

[Fig.2] Figure 2 is a side view of the tank wall in the direction of the arrow II in Figure 1, showing the anchor device in a rest state on the left and in a compressed state on the right.

[Fig.3] Figure 3 is a side view of an anchor device used in the tank wall from Figure 2 in the rest state.

[Fig.4] Figure 4 is a half-view analogous to Figure 2 showing another embodiment of the anchor device.

[Fig. 5A] Figure 5A is a view in section analogous to Figure 3 showing a further embodiment of the anchor device.

[Fig. 5B] Figure 5B is a view in section analogous to Figure 3 showing a further embodiment of the anchor device.

[Fig. 6A] Figure 6A is a perspective view from above showing a further embodiment of the anchor device.

[Fig. 6B] Figure 6B is a sectional perspective view of the anchor device represented in Figure 6A.

[Fig. 7A] Figure 7A is a perspective view from above analogous to Figure 6A showing a further embodiment of the anchor device.

[Fig. 7B] Figure 7B is a perspective view from above showing a variant rotation immobilizing element that is usable in the embodiment represented in Figure 7A.

[Fig. 7C] Figure 7C is a perspective view from above showing another variant rotation immobilizing element that is usable in the embodiment represented in Figure 7A.

[Fig. 8] Figure 8 is a sectional view analogous to Figure 3 showing a further embodiment of the anchor device.

[Fig. 9] Figure 9 is a sectional view analogous to Figure 3 showing a further embodiment of the anchor device.

[Fig. 10A] Figure 10A is a sectional view analogous to Figure 3 showing a further embodiment of the anchor device.

[Fig. 10B] Figure 10B is a sectional view analogous to Figure 3 showing a variant of the embodiment from Figure 10A.

[Fig. 11] Figure 11 is a sectional view analogous to Figure 3 showing a further embodiment of the anchor device.

[Fig. 12] Figure 12 is a perspective view from below of the anchor device represented in Figure 11.

[Fig.13] Figure 13 is a perspective view of spacing parts in accordance with three embodiments.

[Fig. 14] Figure 14 is a perspective view of a spacing part in accordance with a further embodiment.

[Fig. 15] Figure 15 is a perspective view of a thermal insulation block that can be received in the central housing through the spacing parts represented in Figures 13 and 14.

[Fig. 16] Figure 16 is a view from above of the thermal insulation block represented in Figure 15.

[Fig. 17] Figure 17 is a sectional view taken along the line A-A in Figure 16 of the thermal insulation block represented in Figures 15 and 16.

[Fig. 18] Figure 18 is a perspective view of a different thermal insulation that can be received in the central housing through the spacing parts represented in Figures 13 and 14.

[Fig. 19] Figure 19 is a sectional view analogous to Figure 3 showing a further embodiment of the anchor device.

[Fig. 20] Figure 20 is a partial perspective view from above of the spacing part of the anchor device represented in Figure 19.

[Fig.21] Figure 21 is a schematic view from above of the tank wall from Figure 2 showing the position of the anchor device.

[Fig.22] Figure 22 is a perspective view of another insulating block that can be used in the tank wall from Fig. 1.

[Fig.23] Figure 23 is a schematic cutaway representation of a methane tanker ship tank and of a terminal for loading/offloading that tank.

Description of embodiments

By convention, the terms "lower" and "upper" are used to define the relative position of one element with respect to another, respectively in the direction of the exterior or the interior of the tank as in the horizontal wall that is represented in Figure 1. Nevertheless, the following description is applicable to any wall independently of its orientation in the gravity field.

In Figure 1 there has been represented the multilayer structure of a sealed and thermally insulating tank wall 1 for storing a liquefied fluid, such as liquefied natural gas (LNG). The tank wall 1 includes successively in the thickness direction, from the exterior to the interior of the tank, a secondary thermally insulating barrier 3 retained on a supporting wall 2, a secondary sealing membrane 4 resting against the secondary thermally insulating barrier 3, a primary thermally insulating barrier 5 resting against the secondary sealing membrane 4, and a primary sealing membrane 6 intended to be in contact with the liquefied natural gas contained in the tank.

The supporting wall 2 may in particular be formed by the hull or the double hull of a ship. The supporting wall 2 typically forms part of a support structure including a plurality of walls defining the general shape of the tank, usually a polyhedral shape.

The secondary thermally insulating barrier 3 includes a plurality of secondary insulating blocks 7 that are anchored to the supporting wall 2 by means of anchor devices 20 that will be described in detail hereinafter. The secondary insulating blocks 7 have a parallelepipedal general shape and are disposed in parallel rows.

The secondary sealing membrane 4 includes a continuous layer of metal strakes 8 with raised edges. The metal strakes 8 are welded by their raised edges to parallel weld supports that are fixed in grooves 9 formed in cover plates of the secondary insulating blocks 7. The metal strakes 8 are for example made of Invar ®: that is to say an alloy of iron and nickel the coefficient of expansion of which is typically between 1.2×10^{-6} and 2×10^{-6} K^{-1}.

The primary thermally insulating barrier 5 includes a plurality of primary insulating blocks 11 having a parallelepipedal general shape and length and width dimensions identical to those of the secondary insulating blocks 7. Each of the primary insulating blocks 11 is positioned in line with one of the secondary insulating blocks 7, aligned with the latter in the thickness direction of the tank wall 1.

The primary sealing membrane 6 may be produced in various ways. Here it includes a continuous layer of metal strakes 8 with raised edges. As in the secondary sealing membrane 4, the metal strakes 8 are welded by their raised edges to parallel weld supports that are fixed in grooves formed on cover plates of the primary insulating blocks 11.

In Figure 1 a secondary insulating block 7 has been omitted to show thickness shims 12 and beads 13 of mastic intended to compensate flatness defects of the supporting wall 2.

Positioning shims that are not represented may also be provided as described in the publication WO-A-2018069585.

The anchor devices 20 are preferably positioned at the level of the four corners of the secondary insulating blocks 7 and the primary insulating blocks 11. Each stack comprising a secondary insulating block 7 and a primary insulating block 11 is anchored to the supporting wall 2 by means of four anchor devices 20. Moreover, each anchor device 20 cooperates with the corners of four adjacent secondary insulating blocks 7 and with the corners of four adjacent primary insulating blocks 11.

Referring to Figure 2, there is seen in more detail the structure of a secondary insulating block 7 in accordance with one embodiment. The secondary insulating block 7 here includes an insulating polymer foam layer 16 sandwiched between a bottom plate 14 and a cover plate 15. The bottom plate 14 and the cover plate 15 are for example made of plywood. The insulating polymer foam layer 16 is glued to the bottom plate 14 and the cover plate 15. The insulating polymer foam may in particular be a foam based on polyurethane, optionally reinforced by fibres.

Figure 21 shows more precisely the positioning of an anchor device 20 between the corners of four adjacent secondary insulating blocks 7 in accordance with one embodiment, seen from above. The anchor device 20 is represented by the contour of the clamping assembly 30. It is seen that the bottom plate 14 of each secondary insulating block 7 includes a cut-out 52 at the level of its corner zone to free up a clearance 55 in the form of a rectangular chimney that receives the anchor device 20.

The cover plate 15 and the insulating polymer foam layer 16 of the secondary insulating block 7 include a rectangular chimney shaped recess 53 that exposes a corner portion 54 of the bottom plate 14. The corner portion 54 is intended to have the anchor device 20 bear on it directly or indirectly, for example via a spacing part 50 that will be described below or a rigid element rigidly attached to the bottom plate 14, such as a corner pillar.

The structure of an anchor device 20 in accordance with one embodiment is described next with reference to Figures 2 and 3.

The anchor device 20 essentially includes a clamping assembly 30 and an anchor rod 22. The lower end of the anchor rod 22 is received in a bush 23 the base of which is welded to the supporting wall 2 in a central position of the clearance 55 between the corner zones of four adjacent secondary insulating blocks 7. The bush 23 forms a ball-and-socket joint for the anchor rod 22. For example, it accommodates a nut 18 into which the lower end of the anchor rod 22 is screwed. The anchor rod 22 extends in the thickness direction of the tank wall 1 and passes between the adjacent primary insulating blocks 22.

The clamping assembly 30 includes successively in the thickness direction a lower plate 31, a spacing block 33 and an upper plate 32. The lower plate 31 and the upper plate 32 have a rectangular parallelepipedal general shape comprising two opposite larger faces that are parallel to the supporting wall 2. The contour of the spacing block 33 is also rectangular and has the same dimensions. Alternatively, the shape of the contour of the clamping assembly 30 could be different, for example hexagonal or circular.

The lower plate 31 is retained by the anchor rod 22 so that it bears in the direction of the supporting wall 2 against the corner portion 54 of each of the four adjacent secondary insulating blocks 7. In the embodiment represented the spacer part 50 is disposed between the lower plate 31 and the corner portion 54 of each of the secondary insulating blocks 7 and thus transmits a clamping force to the bottom plate 14.

The upper end 44 of the anchor rod 22 is engaged through a central bore 41 of the lower plate 31 and in a housing 45 formed in the spacing block 33. A nut 42 cooperates with a thread formed at the level of the upper end 44 of the anchor rod 22 in such a manner as to retain the lower plate 31 in the direction of the supporting wall 2.

In the embodiment represented, the anchor device 20 further includes one or more Belleville type spring washers 43. The spring washers 43 are threaded onto the anchor rod 22 between the nut 42 and the lower plate 31, which allows elastic anchoring of the secondary insulating block 7 to the supporting wall 2. Furthermore, a locking member is advantageously welded locally to the upper end of the anchor rod 22 in such a manner as to prevent the nut 42 from being unscrewed.

The spacing block 33 further includes two bores through it in the thickness direction of the tank wall in which are engaged two fixing bolts 34 that connect the lower plate 31 and the upper plate 32 to two opposite faces of the spacing block 33. To be more precise, the lower end 35 of each fixing bolt 34 is threaded and screwed into a threaded hole 38 in the lower plate 31. A split locknut 37 is also screwed onto the lower end 35 against the upper surface of the lower plate 31 to lock the fixing bolts 34 in position in the lower plate 31. In a manner that is not represented the split locknut 37 may also be placed against the lower surface of the lower plate 31.

At the opposite end each fixing bolt includes a head 36, for example a conical head, slidingly accommodated in a bore 46 in the upper plate 32. An abutment position of the head 36 against a bottom of the bore 46, represented in Figure 3 and on the left in Figure 2, defines a position of maximum spacing of the plates 32 and 31. The dimension of this maximum spacing is defined by the usable length of the fixing bolts 34 between the lower plate 31 and the upper plate 32. This length may be finely adjusted during manufacture, by adjusting the length engaged by screwing in the threaded holes 38.

The spacing block 33 includes a lower face and an upper face 48 both parallel to the plates 32 and 31. The thickness of the spacing block 33 between the lower face and the upper face 48 defines a minimum spacing between the lower plate 31 and the upper plate 32. This minimum spacing is reached in an abutment position represented on the right in Figure 2 in which the lower plate 31 and the upper plate 32 abut against the lower face and the upper face 48 of the spacing block 33.

The dimensional difference between the minimum spacing and the maximum spacing is represented by the arrow 40 and corresponds to a sliding clearance of the head 36 in the bore 46. Its dimension is determined as a function of the structure of the tank wall and of the tank operating conditions so that the upper plate 32 is able overall to follow the depression of the cover plate 15 of the secondary insulating blocks 7 during use of the tank, in particular because of the effect of the thermal contraction and the static and dynamic pressures to which the tank wall 1 is subjected in operation. These pressures may in particular lead to creep of the insulating polymer foam layer 16. This dimension is typically a few millimetres.

Spring elements 39, for example Belleville washers or any other compression springs, are engaged on the two fixing bolts 34 between the spacing block 33 and the upper plate 32 and in a rest state hold the plates 32 and 31 in the apart position represented in Figure 3. To be more precise the spring elements 39 create a clearance equal to the dimensional difference 40 between the spacing block 33 and the upper plate 32. In response to a pressure force exerted on the upper plate 32, the spring elements 39 are compressed and progressively eliminate this clearance, as far as the position of the lower face 49 of the upper part 32 abutted against the upper face 48 of the spacing block 33.

To be more precise, here the spring elements 39 are housed in a large diameter stage 19 of the bores receiving the fixing bolts 34 and bear against a shoulder at the bottom of the stage 19. In the abutment position the spring elements 39 are entirely contained inside the stage 19.

In accordance with one embodiment, each fixing bolt 34 carries a stack of Belleville washers successively disposed in mutually inverted positions, preferably an odd number thereof, for example five of them, so that the two ends of the stack consist of the largest diameters of the Belleville washers.

The fixing bolts 34 are preferably configured to generate a compression preload on the spring elements 39 in the rest position in such a manner that the upper plate 32 is able to receive moderate loads without being pressed down. For example a preload of approximately 1000 N is applied, which makes it possible to support the weight of an adult man who might walk in line with the anchor device 20 during the construction of the tank.

The stiffness of the spring elements 39 is determined as a function of the structure of the tank wall and of the operating conditions of the tank so that the upper plate 32 is globally able to follow the depression of the cover plate 15 of the secondary insulating blocks 7 during operation of the tank, in particular because of the effect of the thermal contraction and the static and dynamic pressures to which the tank wall is subjected in operation. Those pressures can in particular lead to creep of the insulating polymer foam layer 16.

It will be noted that the spring elements 39 may be positioned differently to fulfil the same functions. For example the fixing bolts 34 may be inverted with the bolt head 36 on the same side as the lower plate 31 and the spring elements 39 are then positioned between the lower plate 31 and the spacing block 33. In another variant, not represented, the spacing block 33 is divided into two parts in the thickness direction and the spring elements 39 are disposed between the two parts.

In another variant illustrated in half-view in Fig. 4 the bolt head 36 is positioned in the upper plate 32 and the spring elements 39 are positioned between the lower plate 31 and the spacing block 33. In this case the upper plate 32 and the spacing block 33 slide together relative to the fixing bolts 34. Moreover, the immobilization in rotation of the fixing bolts 34 relative to the lower plate 31 may be achieved by a spot weld or a locknut, not represented. In Fig. 4 the plates 32 and 31 are represented in the abutment position.

In a further variant illustrated in section in Figure 5A the fixing bolts 34 are inverted with a bolt head 36A on the same side as the lower plate 31, the spring elements 39 for their part being still positioned between the upper plate 32 and the spacing block 33. Here the immobilization in rotation of the fixing bolts 34 relative to the lower plate 31 is achieved by rigidly fixing the bolt heads 36A to the lower plate 31, for example by welding, in particular by spot welding. The threaded end 35 of the fixing bolts 34 is received in a hole 38A, possibly a threaded hole, in the upper plate 32. A locknut 37A that is preferably not split is screwed onto this threaded end 35. The locknut 37A is moreover welded, in particular spot welded, to the threaded end 35. This prevents the locknut 37A from being unscrewed from the threaded end 35.

In a further variant illustrated in section in Figure 5B, the bolt head 36 is replaced by a nut 36B that is threaded onto a threaded end 35A. In other words, the fixing bolts are replaced by fixing rods 34 that are threaded at both their ends 35 and 35A. The threaded end 35A is screwed into a threaded hole 38A in the upper plate 32. The threaded end 35 for its part is screwed into the hole 38, possibly a threaded hole, in the lower plate 31. Immobilization in rotation of the fixing rods 34 relative to the upper plate 32 is moreover achieved by rigidly connecting the nuts 36B to the upper plate 32, for example by welding, in particular by spot welding. Immobilization in rotation of the fixing rods 34 relative to the lower plate 31 may further be achieved by rigidly connecting the threaded end 35 to the lower plate 31, for example by welding, in particular by spot welding.

Figure 6A represents a perspective view from above of a further variant that is seen in section and in perspective in Figure 6B. In this variant the immobilization in rotation of the fixing bolts 34 is achieved by an elongate bar 90 coupled to the bolt head 36. The bar 90 is received in two opposite notches 91A and 91B opening into the bore 46. The cooperation between the bar 90 and those notches 91A and 91B immobilizes the corresponding fixing bolt 34 in rotation relative to the upper plate 32. The bar 90 may for example be made of metal. The fixing of the bar 90 to the bolt head 36 may be achieving by clipping, by spot welds, or by forcibly driving the bar 90 into a housing (not represented) on the bolt head 36. The threaded lower end 35 of the fixing bolts 34 may simply be screwed into the threaded hole 38 in the lower plate 31 with no locknut or spot weld.

Figure 7A represents in perspective view from above a further variant that is similar to those from Figures 6A and 6B except that the bar 90 cooperates with only one notch 91 opening into the bore 46. The notch 91 may open onto a lateral face of the upper plate 32 as represented in Figure 7A but the notch 91 could alternatively not open onto that lateral face.

There has been represented in Figure 7B a rotation immobilizing element 90C that can be used in place of the bar 90. This element 90C is of the key type, that is to say it comprises a central washer 90C2 from which extends a tongue 90C1. The tongue 90C1 is received in the notch 91 and thus immobilizes the corresponding fixing bolt 34 in rotation relative to the upper plate 32. The central washer 90C2 is accommodated in the bore 46. The central washer 90C2 may be fixed to the bolt head 36 by clipping, by spot welds, or again by forcibly driving the element 90C into a housing (not represented) on the bolt head 36. In a variant that is not represented the element 90C may have two opposite tongues respectively received in the notches 91A and 91B.

There has been represented in Figure 7C another rotation immobilizing element 90D that can be used in place of the bar

90. Like element 90C, element 90D is of the key type, that is to say it comprises a central cup 90D2 from which extends a tongue 90D1. The tongue 90D1 is received in the notch 91 and thus immobilizes the corresponding fixing bolt 34 in rotation relative to the upper plate 32. The central cup 90D2 is accommodated in the bore 46. As represented in Figure 7C, the central cup 90D2 has a flared shape that is complementary to the shape of the bolt head 36. The bolt head 36 is received in the central cup 90D2, the central cup 90D2 then being disposed between the bolt head 36 and the bottom of the bore 46. The bolt head 36 may be fixed to the central cup 90D2 by clipping, by spot welds, or again by forcibly driving the bolt head 36 into the flared shape of the central cup 90D2.

Figure 7C also shows that the central cup 90D2 may optionally have a cut-out 90D3 such that the central cup 90D2 has an overall “C” shape when viewed from above. The cut-out 90D3 may for example be diametrically opposite the tongue 90D1 with respect to the centre of the central cup 90D2. In a manner not represented in the drawings, the central washer 90C2 may also have a cut-out similar to the cut-out 90D3, for example diametrically opposite the tongue 90C1.

A further variant is represented in section in Figure 8. In this variant compression springs 69, for example coil springs, are engaged on the two fixing bolts 34 between the spacing block 33 and the upper plate 32 and in a rest state hold the plates 32 and 31 in the apart position represented in Figure 8. To be more precise, acting as spring elements, the compression springs 69 create a clearance equal to the dimensional difference 40 between the spacing block 33 and the upper plate 32. In response to a pressure force exerted on the upper plate 32, the springs 69 are compressed and progressively eliminate this clearance, as far as the position with the lower face 49 of the upper plate 32 abutted against the upper face 48 of the spacing block 33.

Here the compression springs 69 are accommodated in a large diameter stage 19 of the bores receiving the fixing bolts 34 and bear against a shoulder at the bottom of the stage 19. This shoulder may be provided with a spring seat 69A for the compression spring 69 to bear on. In the abutment position the compression springs 69 are entirely contained inside the stage 19.

Also in this variant the immobilization in rotation of the fixing bolts 34 is achieved by an elongate bar 90 that cooperates with a single notch 91 opening into the bore 46, that notch opening onto a lateral face of the upper plate 32 as represented in Figure 8. Alternatively, the notch 91 need not open onto that lateral face.

Also in this embodiment the threaded lower end 35 of the fixing bolt 34 may simply be screwed into the threaded hole 38 in the lower plate 31 with no locknut or spot weld.

The fixing bolts 34 are configured to generate a compression preload on the compression springs 69 in the rest position in such a manner that the upper plate 32 is able to receive moderate loads without being depressed. For example a preload of approximately 1000 N is applied which makes it possible to support the load of an adult man who might walk in line with the anchor device 20 during the construction of the tank.

The stiffness of the compression springs 69 is determined as a function of the structure of the tank wall and of the operating conditions of the tank so that the upper plate 32 is globally able to follow the depression of the cover plate 15 of the secondary insulating blocks 7 during operation of the tank, in particular because of the effect of the thermal contraction and the static and dynamic pressures to which the tank wall 1 is subjected in operation. Those pressures may in particular lead to creep of the insulating polymer foam layer 16.

It will be noted that the compression springs 69 may be positioned differently to fulfil the same functions. For example the fixing bolts 34 may be inverted, with the bolt head 36 on the same side as the lower plate 31 and the compression springs 69 are then positioned between the lower plate 31 and the spacing block 33. In another variant that is not represented, with the fixing bolts 34 inverted the compression springs 69 are positioned between the upper plate 32 and the spacing block 33.

A further variant has been represented in section in Figure 9. This variant differs from that from Figure 8 in that the spacing block 33 has no such stage, with the result that the compression springs 69 bear directly on the lower plate 31. The lower plate 31 may possibly be provided with spring seats (not represented in Figure 9) for the coil springs 69 to bear on. The bores receiving the fixing bolts 34 and the compression springs 69 here have a uniform diameter across the thickness of the spacing block 33. The Figure 9 variant is otherwise identical to that from Figure 8 and is not described in detail again.

A further variant has been represented in section in Figure 11 and in perspective view from below in Figure 12. In that variant a locknut 37B that is preferably not split is screwed onto the threaded lower end 35 of the fixing bolt 34. The locknut 37B is received in a groove 92 in the lower plate 31 into which the possibly threaded hole 38 opens. The groove 92 opens onto the lower face of the lower plate 31. The groove 92 has two facing faces with which two distinct faces of the locknut 37B cooperate. This cooperation immobilizes the fastening bolt 34 in rotation relative to the lower plate 31. In the example represented in the figures the locknut 37B is a square locknut. However, the locknut 37B may also be another shape provided that it has two distinct faces able to cooperate with two facing faces of the groove 92. In particular, the locknut 37B may be of hexagonal shape, two adjacent faces of the hexagon then cooperating with the two facing faces of the groove 92. Immobilization in rotation of the fixing bolts 34 relative to the upper plate 32 is furthermore achieved by rigidly connecting the bolt heads 36 to the upper plate 32, for example by welding, in particular by spot welding. The groove 92 may open onto a lateral face of the lower plate 31 as represented in Figures 11 and 12 but alternatively the groove 92 need not open onto that lateral face.

It is also seen in Figure 11 that the spacing part 350 includes a blind hole 60 extending in line with each fixing bolt 34 as will be described later.

It is to be noted that in all the variants that have been described above the spacing block 33 may be fixed to the lower plate 31 in order to prevent any relative movement between the spacing block 33 and the lower plate 31, in particular in the direction in which the fixing bolts 34 extend. This fixing of the spacing block 33 to the lower plate 31 may be effected by screwing and/or by riveting and/or by gluing. Alternatively, the spacing block 33 may be fixed to the upper plate 32, for example by bolts and/or by rivets and/or by glue, in particular when the spring elements 39 or 69 are positioned between the lower plate 31 and the spacing block 33.

It is further to be noted that in all the variants that have been described above a polymer foam layer may be disposed on the spacing block 33 facing the upper plate 32 or on the upper plate 32 facing the spacing block 33.

Purely by way of example, Figure 10A represents the anchor device in accordance with the Figure 8 variant including this kind of polymer foam layer. In that Figure 10A the polymer foam layer 68 is fixed to the upper face 48 of the spacing block 33 on either side of the upper end 44 of the anchor rod 22.

The thickness of the uncompressed polymer foam layer 68 is made equal to the required dimensional difference 40. Thus when the polymer foam layer 68 is not compressed it extends between the face 48 of the spacing block 33 and the lower face 49 of the plate 32 and thus defines the dimensional difference 40 between the plates 32 and 31 in their maximum spacing position. The polymer foam layer 68 therefore materializes the required dimensional difference 40, which facilitates assembly of the clamping assembly 30.

When a pressure force is exerted on the upper plate 32, not only are the compression springs 69 compressed and progressively eliminate the difference 40, as far as the abutment position described hereinabove, but the lower face 49 of the plate 32 also compresses the polymer foam layer 68.

The stiffness of the uncompressed polymer foam layer 68 is preferably very low compared to the stiffness of the compression springs 69 with the result that the compression of the polymer foam layer 68 does not significantly interfere with the compression of the compression springs 69.

By way of example, the thickness of the uncompressed polymer foam layer 68 is between 2 and 8 mm inclusive with the result that in the abutment position the polymer foam layer 68 has a thickness between 1 and 6 mm inclusive.

The polymer foam layer 68 may be made from a polyurethane, polyethyl or polypropylene foam or a melamine foam, in particular a melamine foam from the family of foams marketed by the company BASF SE under the name Basotect ®. The polymer foam layer 68 may be glued to the upper face 48 of the spacing block 33 or include an adhesive tape, for example.

The geometry of the polymer foam layer 68 represented in Figure 10A is only one example. In another example represented in Figure 10B the polymer foam layer 68 also extends to the lateral edges of the spacing block 33 around the bores in the spacing block 33 receiving the compression springs 69 so as not to risk coming into contact with the turns of the compression springs 69. The polymer foam layer 68 may equally be disposed only around said bores.

The tank wall 1 could be limited to the secondary insulating barrier 3 and the secondary sealed membrane 4 to produce a single membrane tank. In the situation where the primary insulating barrier 5 and the primary sealed membrane 6 are present, the anchor device 20 also includes a primary stage. To that end the upper plate 32 has a threaded bore 47 at its centre in which is mounted a threaded base of a stud 27 intended for anchoring the primary insulating blocks 11. The stud 27 passes through a bore formed through a metal strake 8 of the secondary sealed membrane 4. The stud 27 includes a flange that is welded at its periphery, around the bore, to provide the seal of the secondary sealed membrane 4.

The primary stage of the anchor device 20 also includes a primary bearing plate 28 that bears in the direction of the supporting wall 2 on a bearing zone formed in each of the four adjacent primary insulating blocks 11 in such a manner as to retain them against the secondary sealed membrane 4. In the embodiment represented each bearing zone 29 is formed by a projecting part of a bottom plate of the primary insulating block 11.

A nut 29 cooperates with a thread formed at the level of the upper end of the stud 27 in such a manner as to fix the primary bearing plate 28 to the stud 27. In the embodiment represented the anchor device 20 further includes a Belleville type spring washer threaded onto the stud 27 between the nut 28 and the primary bearing plate 28, which allows elastic anchoring of the primary insulating blocks 11 to the secondary sealed membrane 4.

Figure 13 illustrates a number of embodiments of a spacing part 50, 150 or 250 of the anchor device 20, each of which includes a central through-housing 51 to allow the anchor rod 22 to pass through it, an upper end surface 56 for receive the lower plate 31 bearing on it and a lower end surface 57 to bear on the secondary insulating block. The spacing part 50, 150 or 250 is for example made of plywood to limit thermal bridging. The spacing part 50, 150 or 250 preferably has a section identical to that of the lower plate 3, of rectangular shape in the embodiments represented. It may be formed of a small number of elongate parts having simple shapes, rigidly assembled together, for example by staples, bolts and/or glue.

In a manner that is not represented the central through-housing 51 is filled with thermal insulation around the anchor rod 22, for example glass wool, wadding, expanded polystyrene or polyurethane foam.

The spacing part 50 or 250 is formed of two plane rectangular plates 58 forming the principal faces of the spacing part and two cleats 59 disposed between the two plane rectangular plates along the edges of the latter. Each of the four parts thus forms a wall of the central through-housing 51, which has a square or rectangular section.

The spacing part 150 is formed of four identically profiled elongate parts having a right-angle trapezium shape section, one inclined edge of which forms a respective wall of the central through-housing 51, which has a lozenge shape section. To limit thermal bridging longitudinal cells are formed on either side of the central through-housing 51 and also filled with an insulating material.

Figure 14 illustrates a further embodiment of a spacing part 350. This spacing part 350 is identical to the spacing part 250 except that each cleat 59 includes a blind hole 60, each blind hole 60 being intended to align with the fixing bolt 34 in such a manner as to be able to receive a part of that fixing bolt 34. In another variant that is not represented the spacing part 50 may also include blind holes 60 of this kind. In the spacing part 150 the longitudinal cells formed on either side of the central through-housing 51 may be only partially filled with the insulating material, so that the insulating material and the longitudinal cells together form blind holes analogous to the blind holes 60.

Figures 15 to 17 together illustrate one embodiment of a thermal insulation block 451 that can be received in the central through-housing 51. The thermal insulator block 451 has an exterior shape complementary to that of the central through-housing 51, here a parallelepipedal exterior shape. Here the thermal insulator block 451 is made from a thermally insulating polymer foam. The polymer foam may be of low density, that is to say have a density between 10 kg/m^3 and 60 kg/m^3 inclusive, more particularly between 10 kg/m^3 and 30 kg/m^3 inclusive. The polymer foam may be a polyurethane foam or a melamine foam, in particular a melamine foam from the family of foams marketed by the company BASF SE under the name Basotect ®. The polymer foam may optionally be reinforced by fibres, for example glass fibres.

It is further seen in Figures 15 to 17 that the thermal insulation block 451 includes a through-hole 452. The through-hole 452 is intended to receive the anchor rod 22 when the spacing part is disposed under the clamping assembly 30 as described above. As can be seen in Figure 14, the through-hole 452 has a section that widens from the upper end of the anchor rod 22 to the lower end of the anchor rod 22. In particular, this may be achieved by imparting to the through-hole 452 a frustoconical section as represented in Figure 14. This widening of the section in the direction toward the lower end of the anchor rod 22 allows installation of the spacing part around the anchor rod 22 to be facilitated, noting that this installation is carried out when the anchor rod 22 has already been fixed to the supporting wall 2 by the bush 23 and the nut 18. Moreover, this widening allows some clearance to be offered in which the anchor rod 22 is free to move because of the ball-and-socket joint connection formed by the bush 23. According to a variant which has not been represented, the though-hole 452 may also have a section that widens from the lower end of the anchor rod 22 to the upper end of the anchor rod 22. In particular, this may be achieved by imparting to the through-hole a frustoconical section.

Figure 18 illustrates another embodiment of a thermal insulation block 551 that can be received in the central through-housing 51. The thermal insulation block 551 has an exterior shape complementary to that of the central through-housing 51, here a parallelepipedal exterior shape. The thermal insulation block 551 is here made of glass wool. It may consist of two back-to-back sub-blocks 552 of glass wool. The thermal insulation block 551 surrounds the anchor rod 22 (not represented in Figure 15) when the spacing part is disposed under the clamping assembly 30 as described above. To this end the thermal insulation block 551 may include within its thickness a notch 554 that extends parallel to the anchor rod 22. The notch 554 allows the anchor rod 22 to pass through the thermal insulation block 551 whilst allowing elastic return of the glass wool to grip the anchor rod 22 once the latter has passed through the thermal insulation block 551. The thermal insulation block 551 may also be made in the same manner with cellulose or polyester wadding.

It is further seen in Figure 18 that films 555 may be disposed on the opposite two faces of the thermal insulation block 551, more particularly the two larger faces of the thermal insulation block 551 that face the two larger faces of the central through-housing 51. The films 555 may be made of glassfibre matting, Kraft paper or a polymer such as PVC. The films 555 allow the sliding of the thermal insulation block 551 on the faces of the central through-housing 51 to be facilitated when the thermal insulation block 551 is inserted in the central through-housing 51. Alternatively, only one of the films 555 may be present and/or supplementary films that are not represented may be added on the faces of the thermal insulation block 551 that are not covered by the films 555.

A further variant of a spacing part together with the clamping assembly 30 has been represented in Figures 19 and 20, Figure 19 being a sectional view and Figure 20 being a partial perspective view from above of the spacing part. In this variant, as in the variant from Figures 11 and 12, a locknut 37B that is preferably not split is screwed onto the threaded lower end 35 of the fixing bolt 34. The locknut 37B is received in a groove 660 in the spacing part 650. Here the spacing part 650 is formed, like the spacing part 250, by two plane rectangular plates 58 forming the principal faces of the spacing part 650 and two cleats 59 disposed between the two plane rectangular plates 58 along the edges of the latter. A groove 660 is formed in each of the two cleats 59. The groove 660 includes two facing faces with which two distinct faces of the locknut 37B cooperate. This cooperation immobilizes the fixing bolt 34 in rotation relative to the lower plate 31. In the example represented in the figures the locknut 37B is a square nut. However, the locknut 37B may also be another shape provided that it has two distinct faces able to cooperate with two facing faces of the groove 660. In particular, the locknut 37B may be of hexagonal shape, two opposite faces of the hexagon then cooperating with the two facing faces of the groove 660. The fixing bolts 34 are stopped from rotating relative to the upper plate 32 by rigidly connecting, for example welding, in particular spot welding, the bolt heads 36 to the upper plate 32

<u>Example of dimensions</u>

Because of the stiffness of the spring elements 39 or 69 the clamping assembly 30 is in the apart position corresponding to the maximum spacing when the tank is empty and at ambient temperature, that is to say under the conditions applying in its initial construction. In that state the position of the upper plate 32 is adjusted to be aligned with the cover plate 15 in such a manner as to offer a uniform support surface for the secondary sealed membrane 4.

During operation of the tank, following filling of the tank with the liquefied gas, phenomena of thermal contraction and of contraction and of creep under hydrostatic load are going to occur in the secondary insulating barrier 3.

The thermal contractions are not identical in all materials and the insulating polymer foam layers 16 tend to contract more than the plywood constituting the spacing part 50 and the spacing block 33. Moreover the pressure loads are different according to the position of the tank wall at the bottom, at the ceiling or at the sides. All the walls receive at least the service pressure of the vapour phase, which is for example 2 kPa or 5 kPa (20 or 50 mbar).

The stiffness of the spring elements 39 or 69 may be determined in such a manner that, after cooling and at the service pressure of the vapour phase, the elastic compression of the spring elements 39 or 69 enables supplementary lowering of the upper plate 32 that is greater than or equal to the additional contraction and creep of the secondary insulating blocks 7 relative to the thermal contraction of the anchor device 20. This additional contraction and creep of the secondary insulating blocks 7 is for example about 1 mm under the service pressure of the vapour phase. Thus the upper plate 32 follows the level of the cover plates 15 and there is no risk of it generating a projecting zone liable to shear the secondary sealing membrane 6.

The stiffness of the spring elements 39 or 69 and the dimension of the difference 40 may also be determined in such a manner that the clamping assembly 30 reaches the abutment position, corresponding to the minimum spacing, under the following conditions:

- either under hydrostatic load, if the underlying primary insulation block receives a maximum cargo pressure;
- or under dynamic loading, if the underlying primary insulation block receives an impact pressure due to sloshing of the cargo exceeding a predetermined nominal threshold.

In all cases, the spring elements 39 or 69 increase the flexibility of the anchor device 20 and thus limit the risk of localized formation of a hard spot or a projecting zone that could accelerate the ageing of the secondary sealing membrane 6.

The total stiffness of the spring member acting between the two plates, namely the spring elements 39 or 69 here, is preferably less than the equivalent stiffness of the thermally insulating barrier at the service temperature in the immediate vicinity of the anchor device. In the embodiment illustrated it is the insulating polymer foam layer 16 that controls the stiffness of the thermally insulating barrier. In one embodiment the total stiffness of the spring elements 39 or 69 is approximately 1880 N/mm whereas the stiffness in the thickness direction of the tank wall equivalent to a spring consisting of the insulating polymer foam block 16 having a section equal to that of the upper plate is approximately 1920 N/mm, i.e. there is a thickness ratio equal to 0.98. This ratio could more generally be chosen between 0.3 and 1.

The structure of the secondary insulation block 7 is described hereinabove by way of example. Also, in another embodiment, the secondary insulating blocks 7 are liable to have another general structure, for example that described in the document WO-A-2012127141. The secondary insulating blocks 7 are then produced in the form of box sections including a bottom plate, a cover plate and support webs extending in the thickness direction of the tank wall 1 between the bottom plate and the cover plate and delimiting a plurality of compartments filled with an insulating lining such as perlite, glass wool or rockwool.

Another embodiment of the secondary insulating blocks 107 is illustrated in Figure 22. In Figure 22 elements analogous or identical to those from the previous figures bear the same reference number increased by 100 and are not described again. Here the insulation polymer foam layer is divided into lower and upper layers 16b and 16a separated by an intermediate plate 10, for example made of plywood, stuck to them. The length of the upper layer 16a is shorter than the length of the lower layer 16b and exposes a rim 10a at two longitudinal ends of the intermediate plate 10.

A rigid pillar 17 extends in the thickness direction of the lower layer 16b between the intermediate plate 10 and the bottom plate 114 in recesses formed at the four corners of the lower layer 16b. The rigid pillar 17 is partly in vertical alignment with the rims 10a to withstand the clamping force of the anchor device 20, the lower plate 31 of which may here be applied directly to the rim 10a. Other details of the secondary insulation block 107 can be found in the publication WO-A-2014096600.

The primary insulating block 11 may be produced in various ways, for example in the form of an insulating polymer foam layer sandwiched between a bottom plate and a cover plate like the secondary insulating block 7.

The bottom plate then includes grooves intended to receive the raised edges of the strakes 8 of the secondary sealing membrane 4. The cover plate also includes grooves to receive the weld supports.

The structure of the primary insulating panel 11 is described hereinabove by way of example. Also, in another embodiment, the primary insulating panels 22 are liable to have another general structure, for example that described in the document WO-A-2012127141.

The technique described hereinabove for producing a tank wall having a single sealed membrane or two sealed membranes may also be used in different types of reservoirs, for example to constitute a double membrane tank for liquefied natural gas (LNG) in a terrestrial installation or in a floating structure such as a methane tanker or other ship.

Referring to Figure 23, a cutaway of a methane tanker ship 70 shows a sealed and insulated tank 71 of prismatic general shape mounted in the double hull 72 of the ship. The wall of the tank 71 includes a primary sealed barrier intended to be in contact with the LNG contained in the tank, a secondary sealed barrier arranged between the primary sealed barrier and the double hull 72 of the ship, and two insulating barriers respectively arranged between the primary sealed barrier and the secondary sealed barrier and between the secondary sealed barrier and the double hull 72.

In a manner known in itself loading/offloading pipes 73 disposed on the top deck of the ship may be connected by means of appropriate connectors to a maritime or harbour terminal to transfer a cargo of LNG from or to the tank 71.

Figure 23 shows an example of a maritime terminal including a loading and offloading station 75, an underwater pipe 76 and a terrestrial installation 77. The loading and offloading station 75 is a fixed off-shore installation including a mobile arm 74 and a tower 78 that supports the mobile arm 74. The mobile arm 74 carries a bundle of insulated flexible tubes 79 that can be connected to the loading/offloading pipes 73. The orientable mobile arm 74 adapts to all methane tanker loading gauges. A connecting pipe that is not shown extends inside the tower 78. The loading and offloading station 75 enables loading and offloading of the methane tanker 70 from or to the terrestrial installation 77. The latter includes liquefied gas storage tanks 80 and connecting pipes 81 connected via the underwater pipe 76 to the loading or offloading station 75. The underwater pipe 76 enables transfer of the liquefied gas between the loading or offloading station 75 and the terrestrial installation 77 over a great distance, for example 5 km, which enables the methane tanker ship 70 to remain at a great distance from the coast during loading and offloading operations.

Pumps onboard the ship 70 and/or pumps equipping the terrestrial installation 77 and/or pumps equipping the loading and offloading station 75 are used to generate the pressure necessary to transfer the liquefied gas.

Although the invention has been described in connection with a plurality of particular embodiments, it is obvious that it is in no way limited to them and that it encompasses all technical equivalents and combinations of the means described if the latter fall within the scope of the invention which is defined by the claims.

The use of the verb "to include" or "to comprise" and conjugate forms thereof does not exclude the presence of elements or steps other than those stated in a claim.

In the claims, any reference sign between parentheses should not be interpreted as a limitation of the claim.

Patentkrav

1. Forankringsanordning (20), beregnet til at fastholde isoleringsblokke mod en bærende væg, idet forankringsanordningen (20) omfatter:

en fastspændingsenhed (30), der omfatter en nedre plade (31), en øvre plade (32), der er parallel med den nedre plade, et forbindelseselement (34), der forbinder den nedre plade med den øvre plade, og en afstandsholder, der er anbragt mellem den nedre plade og øvre plade, idet afstandsholderen omfatter en stopdel, der afgrænser en minimumsafstand mellem den nedre plade og den øvre plade i en stopposition, hvor den nedre og den øvre plade ligger an mod stopdelen, idet stopdelen omfatter en stiv del (33), og

en forankringsstang (22), der rager ud fra fastspændingsenheden vinkelret på den nedre plade (31), idet forankringsstangen omfatter en nedre ende, der er beregnet til at blive fastgjort til en bærende væg (2), og en øvre ende, der er modsat den nedre ende, og som er koblet til den nedre plade (31) for at kunne udøve en trækkraft på den nedre plade i retning af den nedre ende,

idet forankringsanordningen (20) er kendetegnet ved, at afstandsholderen i øvrigt omfatter et elastisk sammentrykkeligt element (39, 69), som tjener til at holde den nedre plade og den øvre plade (32) i en adskilt position, idet forbindelseselementet definerer en maksimal afstand mellem den nedre plade og den øvre plade i den adskilte position, hvor den maksimale afstand er større end minimumsafstanden, idet det elastisk sammentrykkelige element (39, 69) er konfigureret til at komprimeres elastisk hen til af den nedre og øvre plades (31, 32) stopposition mod stopdelen som reaktion på en kraft, som har en tendens til at bringe den øvre plade tættere på den nedre plade.

2. Forankringsanordning ifølge krav 1, hvor forbindelseselementet omfatter mindst én forbindelsesstang (34), der er vinkelret på den nedre plade og den øvre plade, og som strækker sig gennem en i stopdelen udført boring, idet den

nedre plade og/eller den øvre plade er forskydeligt monteret i forhold til forbindelsesstangen for at kunne glide hen til stoppositionen.

3. Forankringsanordning ifølge krav 2, hvor forbindelseselementet i øvrigt omfatter et første stopelement (36, 37A, 36B), der er koblet til en første ende af forbindelsesstangen for at stoppe den øvre plade (32) i længderetningen i forhold til forbindelsesstangen i den adskilte position.

4. Forankringsanordning ifølge krav 3, hvor det første stopelement omfatter en møtrik (36B), der er skruet på og svejset til den første ende af forbindelsesstangen (34), og hvor en anden ende af forbindelsesstangen (34) er fast forbundet til den nedre plade (31).

5. Forankringsanordning ifølge krav 3, hvor forbindelseselementet i øvrigt omfatter et rotationsblokeringselement (90, 90C), der er koblet til det første stopelement (36), idet en del af rotationsblokeringselementet (90, 90C) modtages i et indhak (91, 91A, 91B), der forefindes i den øvre plade (32), for at blokere forbindelsesstangen (34) i rotation.

6. Forankringsanordning ifølge krav 2 eller 3, hvor forbindelseselementet i øvrigt omfatter et andet stopelement (37, 38, 36A, 38A, 37B), der er koblet til en anden ende af forbindelsesstangen, for at stoppe den nedre plade (31) i længderetningen i forhold til forbindelsesstangen i den adskilte position.

7. Forankringsanordning ifølge krav 3 og 6, hvor det første stopelement omfatter en møtrik (37A), der er skruet på og svejset til den første ende af forbindelsesstangen (34), og hvor det andet stopelement (36A) er fast forbundet til den nedre plade (31).

8. Forankringsanordning ifølge krav 3 og 6, hvor det andet stopelement (37B) er optaget i en rille (92), der forefindes i den nedre plade (31), idet rillen (92) har to flader, der vender mod hinanden, sammen med hvilke to særskilte flader af det andet stopelement (37B) arbejder for at blokere forbindelsesstangen (34) i rotation, og hvor det første stopelement (36) er fast forbundet til den øvre plade (32).

9. Forankringsanordning ifølge krav 3 og 6, der i øvrigt omfatter et afstandsstykke (650), som er anbragt under den nedre plade, og som har et centralt hus (51), der gennemkrydses af forankringsstangen, idet afstandsstykket omfatter en øvre overflade (56), der er konfigureret til at hvile mod fastspændingsenhedens nedre plade, og en nedre overflade (57), der er beregnet til at hvile mod en isoleringsblok, og hvor det andet stopelement (37B) optages i en rille (660), der forefindes i afstandsstykket (650), idet rillen omfatter to flader, der vender mod hinanden, sammen med hvilke to modstående flader af det andet stopelement (37B) arbejder for at blokere forbindelsesstangen (34) i rotation, og hvor det første stopelement (36) er fast forbundet til den øvre plade (32).

10. Forankringsanordning ifølge et af kravene 2 til 9, hvor det elastisk sammentrykkelige element (39, 69) er i indgreb med forbindelsesstangen (34).

11. Forankringsanordning ifølge et af kravene 2 til 10, hvor det elastisk sammentrykkelige element (39, 69) hviler mod stopdelen.

12. Forankringsanordning ifølge krav 11, hvor den i stopdelen udførte boring har et trin (19), hvori det elastisk sammentrykkelige element (39, 69) er anbragt.

13. Forankringsanordning ifølge et af kravene 1 til 12, hvor det elastisk sammentrykkelige element (39) omfatter en stabel af elastiske skiver.

14. Forankringsanordning ifølge et af kravene 1 til 13, hvor det elastisk sammentrykkelige element (69) omfatter en skruefjeder.

15. Forankringsanordning ifølge et af kravene 1 til 14, hvor den elastiske bevægelse mellem den øvre og den nedre plades (31, 32) adskilte position og stopposition er på mellem 1 og 8 mm, fortrinsvis mellem 4 og 7 mm.

16. Forankringsanordning ifølge et af kravene 1 til 15, hvor den nedre plade (31) har en midterboring (41), gennem hvilken forankringsstangens (22) øvre ende passerer, hvor forankringsanordningen omfatter en møtrik (42), der arbejder sammen med en gevindskåren del af forankringsstangens øvre ende, og én eller flere spændeskiver (43), der er trukket på forankringsstangens øvre ende mellem møtrikken og den nedre plade, for at kunne udøve en elastisk kraft på den nedre plade i retning af forankringsstangens nedre ende.

17. Forankringsanordning ifølge krav 16 i sammenhæng med krav 2, hvor fastspændingsenheden (30) omfatter mindst to forbindelsesstænger (34), der er anbragt symmetrisk i forhold til midterboringen (41).

18. Forankringsanordning ifølge et af kravene 1 til 17, der omfatter et afstandsstykke (50, 150, 250, 350, 650), som er anbragt under den nedre plade, og som har et midterhus (51), der gennemkrydses af forankringsstangen, idet afstandsstykket omfatter en øvre overflade (56), der er konfigureret til at hvile mod fastspændingsenheden, og en nedre overflade (57), der er beregnet til at hvile på en isoleringsblok.

19. Forankringsanordning ifølge et af kravene 1 til 18, der i øvrigt omfatter en bøsning (23), som går i indgreb med forankringsstangens nedre ende, og som beregnet til at blive fastgjort på den bærende væg (2), idet bøsningen har et hus, der optager forankringsstangens (22) nedre ende for at danne et hængselsled.

20. Forankringsanordning ifølge et af kravene 1 til 19, hvor stopdelen er fastgjort til den nedre plade (31) eller den øvre plade (32).

21. Tæt og varmeisolerende tank til lagring af et fluidum, hvilken tank omfatter en bærende væg, forankringsanordninger (20), der er fastgjort til den bærende væg (2), og en tankvæg (1), der er forankret til den bærende væg ved hjælp af forankringsanordningerne, idet tankvæggen (1) successivt i en tykkelsesretning fra ydersiden mod indersiden af tanken omfatter en varmeisolerende barriere (3) og en tætningsmembran (4), som hviler mod den varmeisolerende barriere (3),
hvor den varmeisolerende barriere (3) omfatter isoleringsblokke (7) med en form som et parallelepipedum, som er anbragt side om side på den bærende væg (2), idet en isoleringsblok omfatter en dækplade, der afgrænser en støtteflade for tætningsmembranen (4);
hvori mindst én forankringsanordning er ifølge et af kravene 1 til 20, idet forankringsstangens (22) nedre ende er fastgjort til den bærende væg mellem en flerhed af isoleringsblokke (7), idet forankringsanordningens nedre plade (31) arbejder sammen med flerheden af isoleringsblokke (7, 107) for at spænde flerheden af isoleringsblokke i retning af støttevæggen (2).

22. Tank ifølge krav 21, hvor det elastisk sammentrykkelige element (39, 69) er konfigureret til at holde den nedre plade og den øvre plade i den adskilte position i en tom tilstand af tanken, idet forankringanordningens øvre plade (32) i den adskilte position er på linje med dækpladerne i flerheden af isoleringsblokke for at støtte tætningsmembranen (4).

23. Tank ifølge krav 21 eller 22, hvor isoleringsblokken omfatter en bundplade (14), der er parallel med og i afstand fra dækpladen (15), en blok af fiberforstærket polymerskum (16), der er anbragt mellem dækpladen og en bundplade, og hvor forankringsanordningens nedre plade arbejder direkte eller indirekte sammen med bundpladen (14) uden at udøve spænding på blokken af polymerskum (16).

24. Tank ifølge krav 21 eller 22, hvor isoleringsblokken (107) omfatter en bundplade (114) og successivt en mellemplade (10) og en dækplade (115), der er parallelle med bundpladen og med en indbyrdes afstand, samt to blokke af fiberforstærket polymerskum (16a, 16b), der henholdsvis er anbragt mellem dækpladen og mellempladen og mellem mellempladen og bundpladen, hvor forankringsanordningens nedre plade (31) arbejder direkte sammen med mellempladen (10) ved et hjørneområde.

25. Tank ifølge krav 21 eller 22, hvor et forhold mellem stivheden af det elastisk sammentrykkelige element og en stivhed i tankvæggens tykkelsesretning er på mellem 0,3 og 1, idet tankvæggen svarer til en fjeder, der udgøres af det fiberforstærkede polymerskum, og som har et tværsnit, der er lig med tværsnittet af den øvre plade.

26. Tank ifølge et hvilket som helst af kravene 21 til 25, hvor den varmeisolerende barriere er en sekundær varmeisolerende barriere (3), isoleringsblokkene er sekundære isoleringsblokke (7), og tætningsmembranen er en sekundær tætningsmembran (4), idet tankvæggen i øvrigt omfatter en primær varmeisolerende barriere (5), der hviler mod den sekundære tætningsmembran (4), og en primær tætningsmembran (6), der hviler mod den primære varmeisolerende barriere (5), og som er beregnet til at være i kontakt med det i tanken indeholdte fluidum, idet den primære varmeisolerende barriere (5) omfatter primære isoleringsblokke (11), som hver er stablet på en af de sekundære isoleringsblokke (7),
hvor fastspændingsenheden (30) danner et sekundært spændeelement, der er beregnet til at arbejde sammen med den sekundære isoleringsbarriere, idet den øvre plade (32) har en central boring (47), hvori en tap (27) er skruet ind, der rager ud fra fastspændingsenheden på siden modsat forankringsstangen, hvilken tap (27) bærer et primært spændeelement (28), der er beregnet til at arbejde sammen med den primære isoleringsbarriere (5), og hvor tappen (27) på en forseglet måde gennemkrydser den sekundære tætningsmembran (4), og det primære

spændeelement holdes hvilende i retning af den bærende væg (2) mod en flerhed af primære isoleringsblokke (11), der er stablet på flerheden af sekundære isoleringsblokke, for at fastholde flerheden af primære isoleringsblokke i retning af støttevæggen (2).

27. Skib (70) til transport af et fluidum, hvilket skib omfatter et dobbelt skrog (72) og en tank (71) ifølge et hvilket som helst af kravene 21 til 26, der er anbragt i det dobbelte skrog (72).

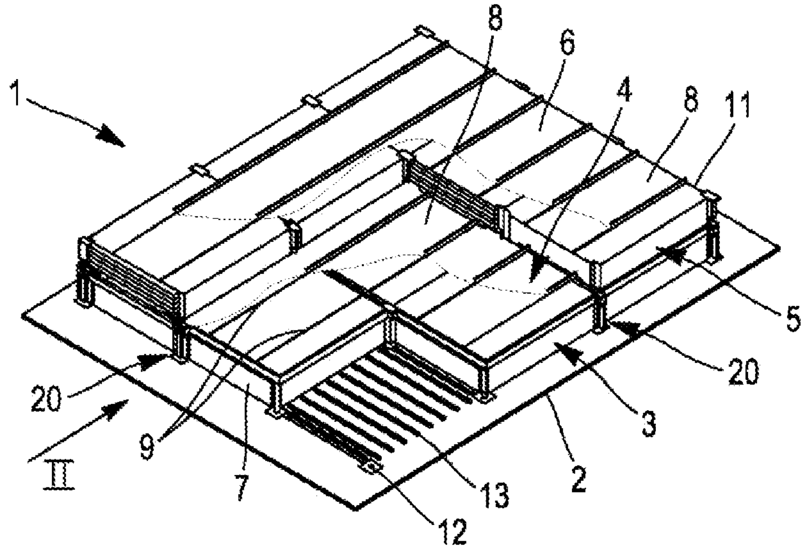

FIG. 1

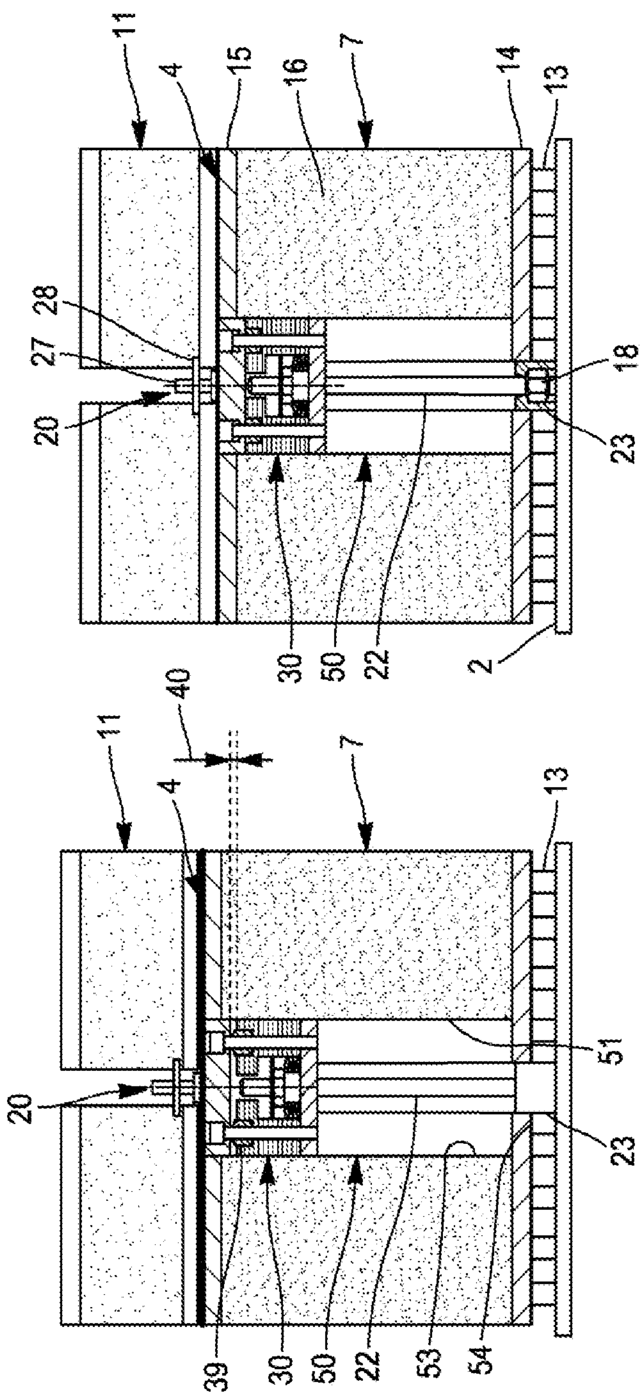
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FIG. 2

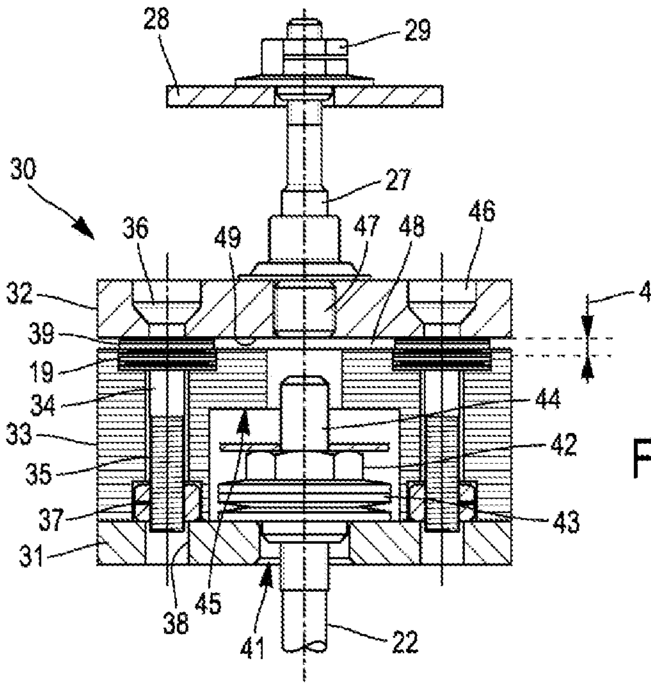
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FIG. 3

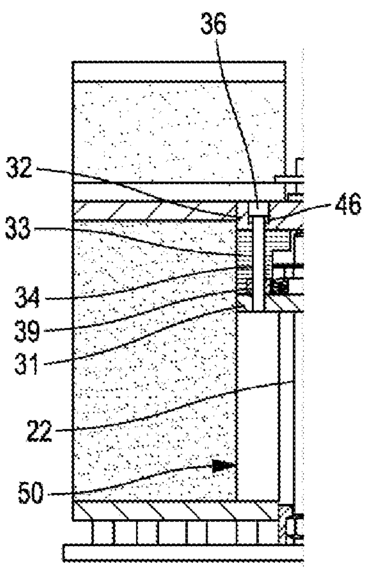
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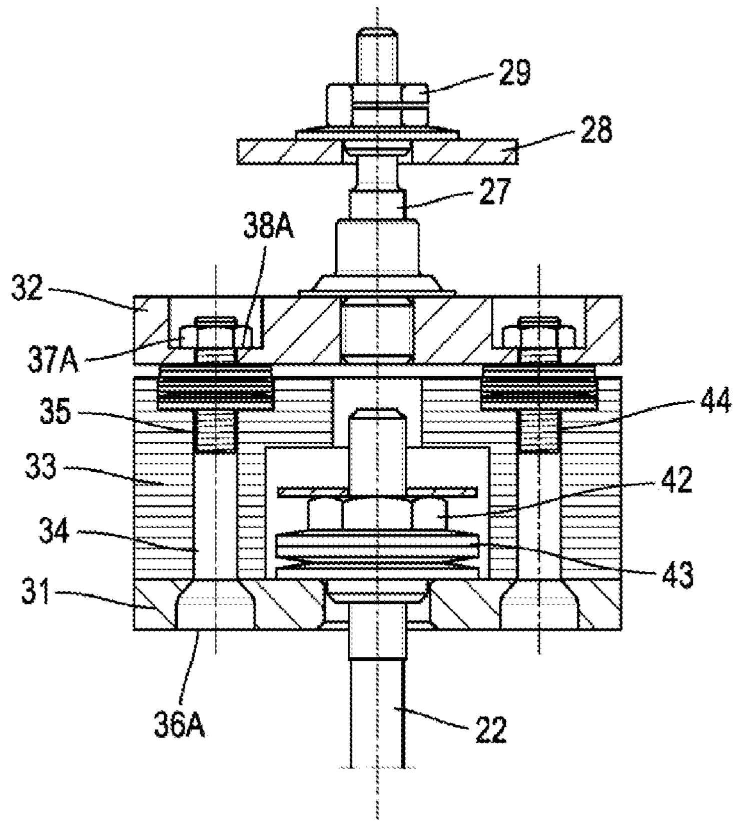
FIG. 4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36A
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FIG. 5A

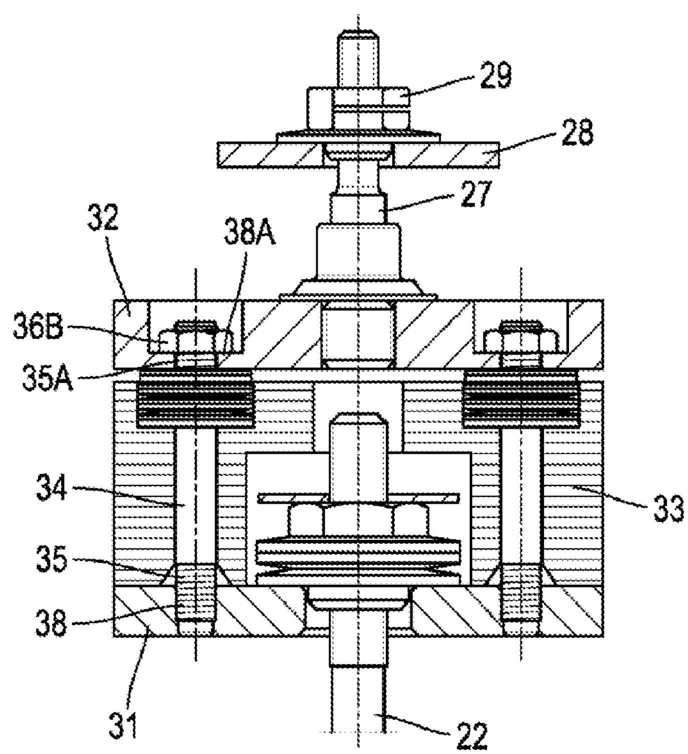
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FIG. 5B

FIG. 6A

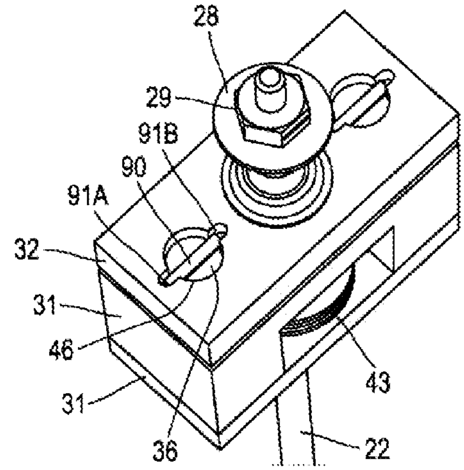
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FIG. 6B

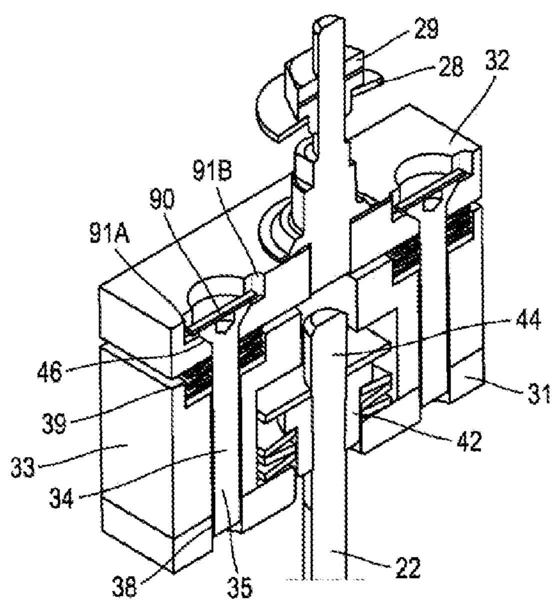
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FIG. 7A

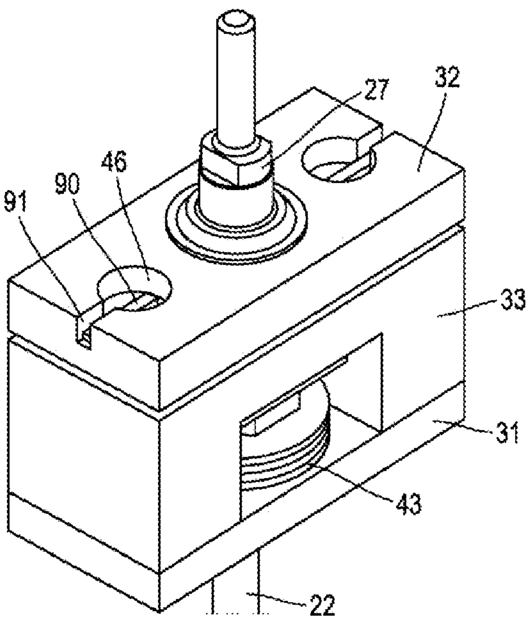

FIG. 7B

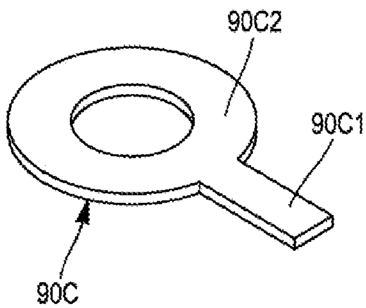

FIG. 7C

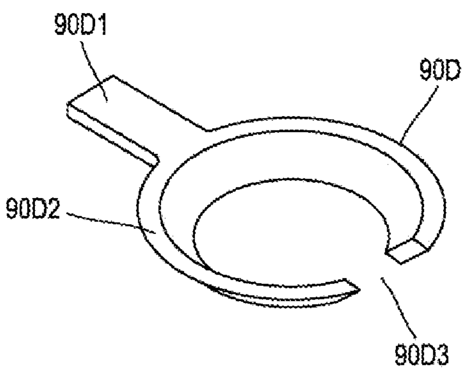

FIG. 8

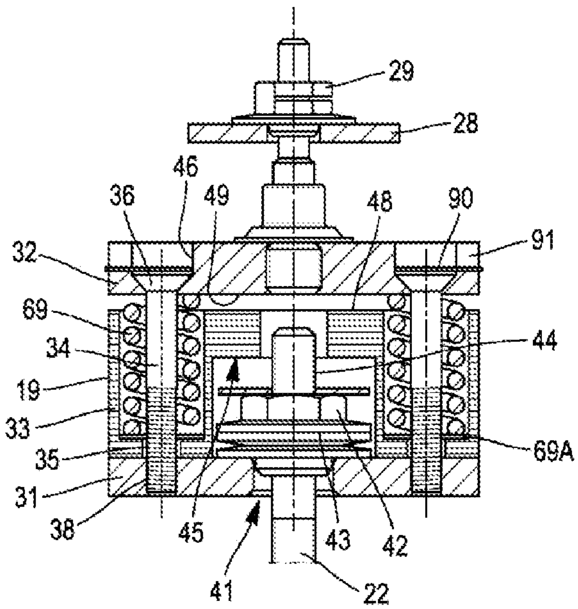
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FIG. 9

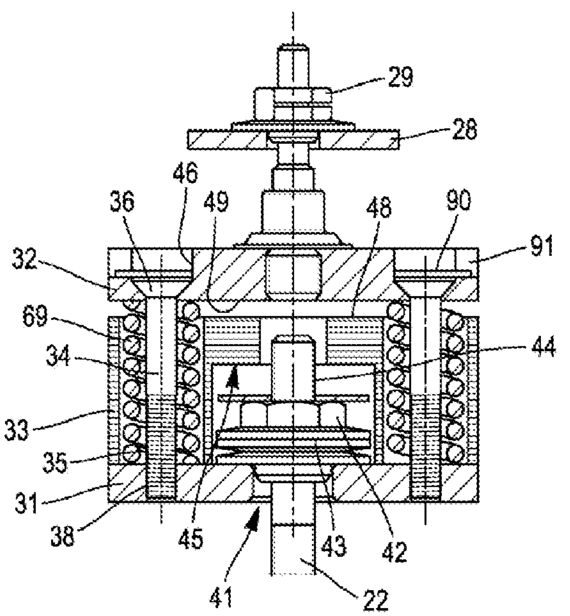
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FIG. 10A

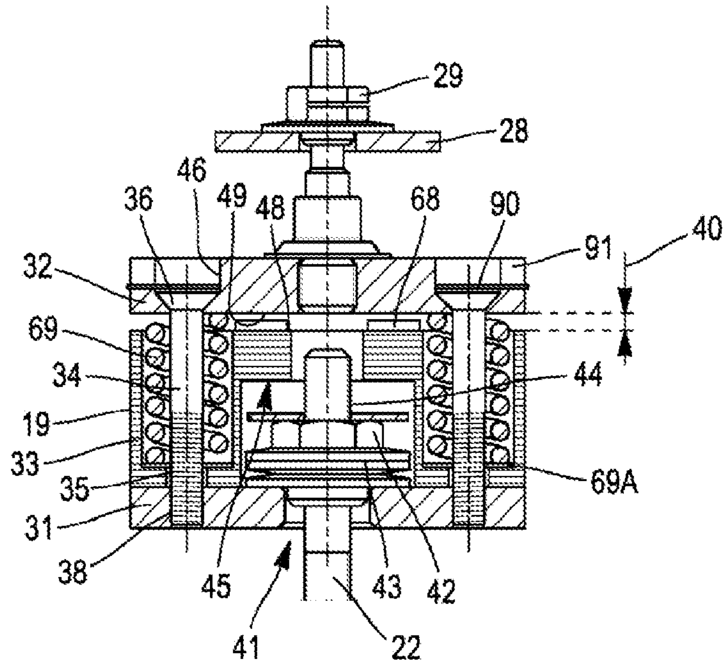


FIG. 10B

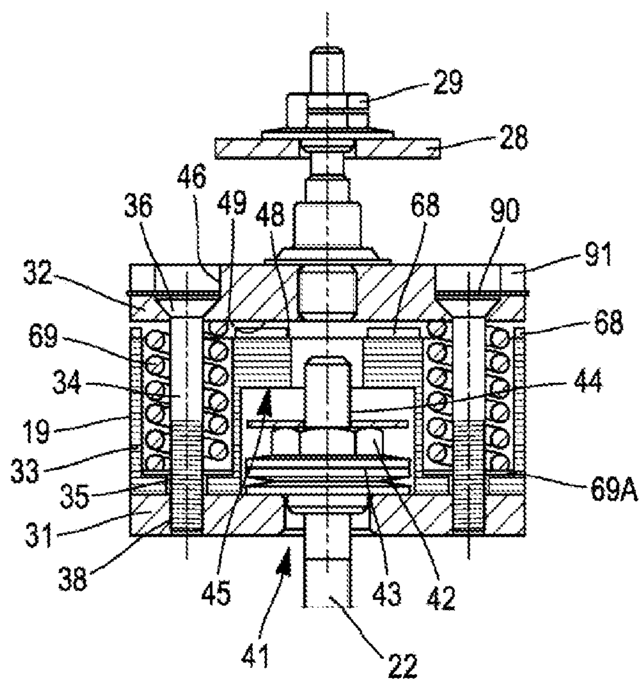


FIG. 11

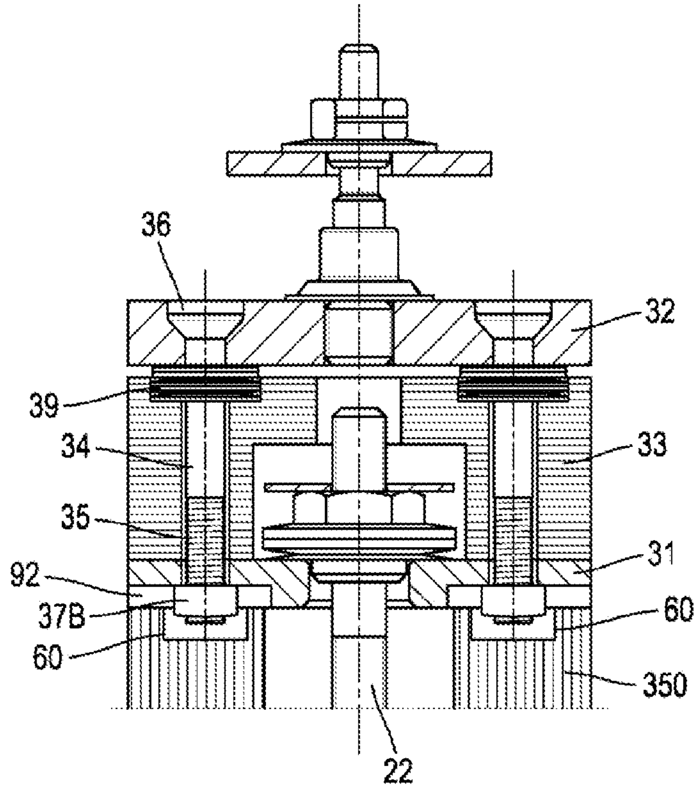
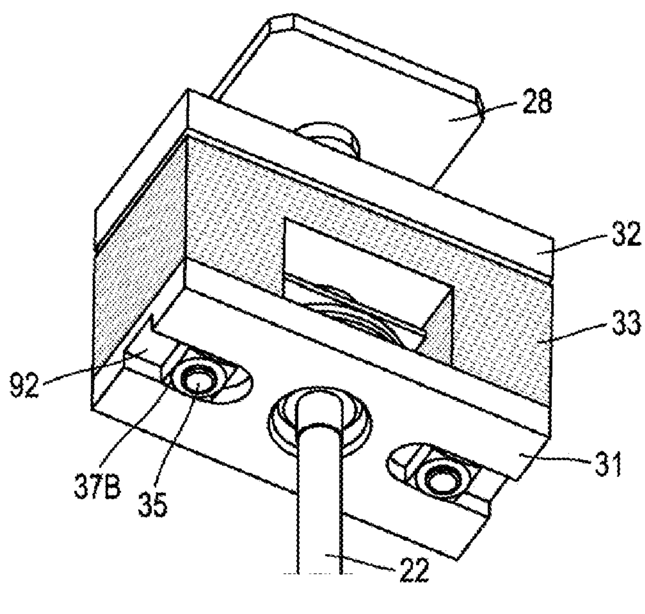


FIG. 12



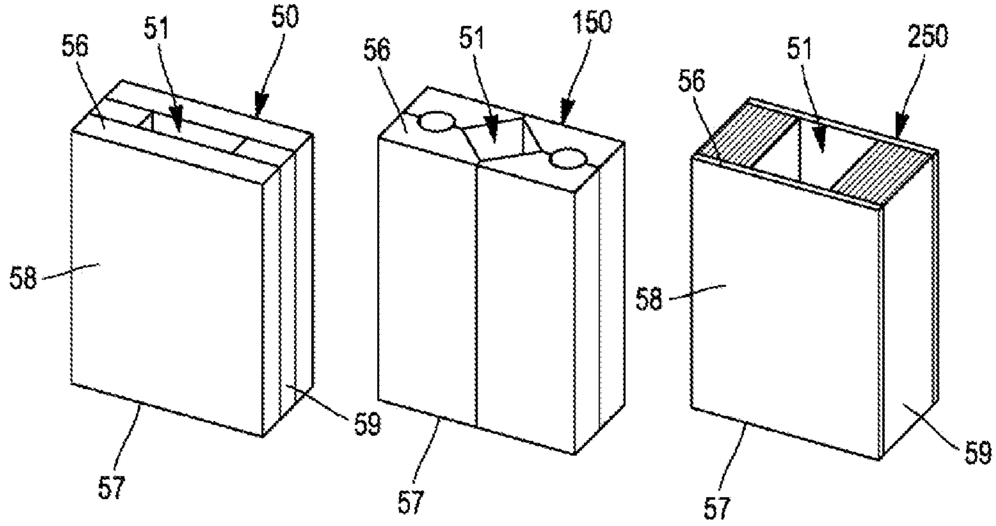

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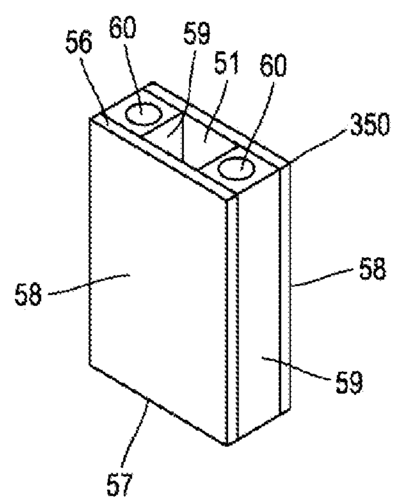
FIG. 13

FIG. 14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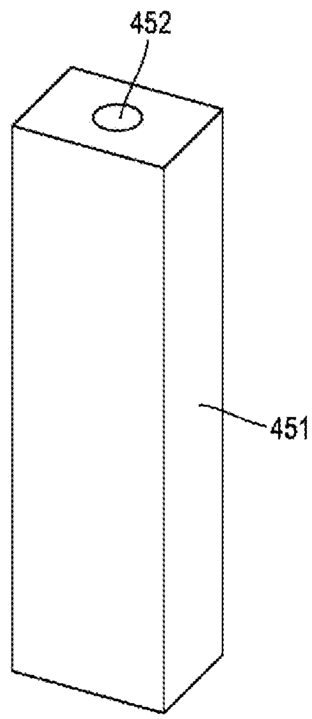


FIG. 15

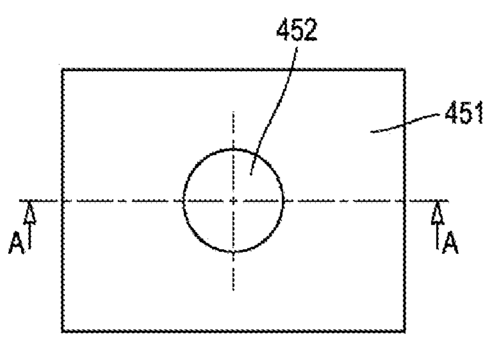


FIG. 16

FIG. 17

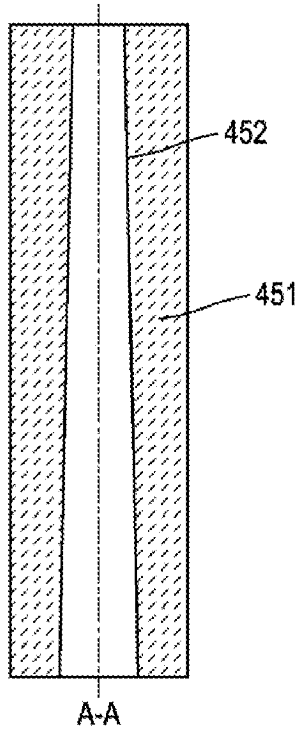


FIG. 18

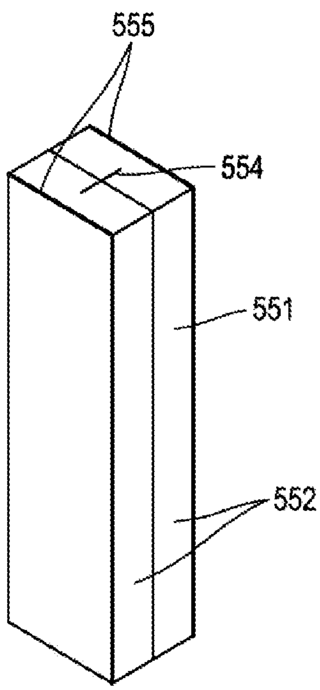
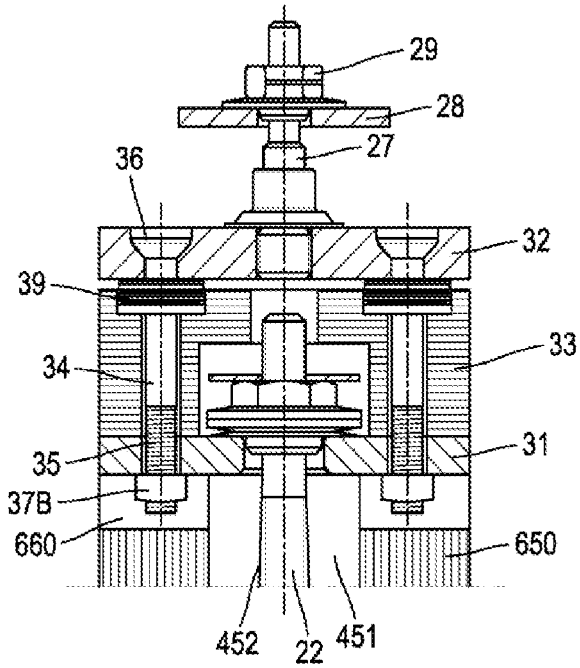


FIG. 19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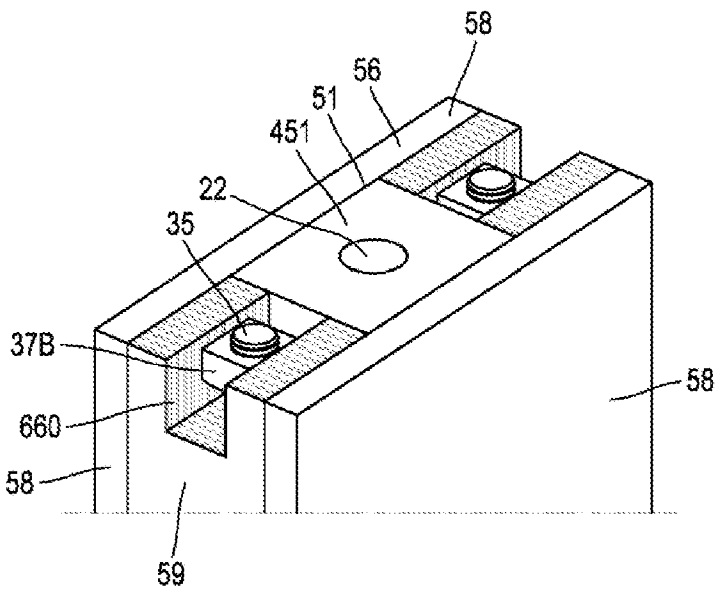
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FIG. 20

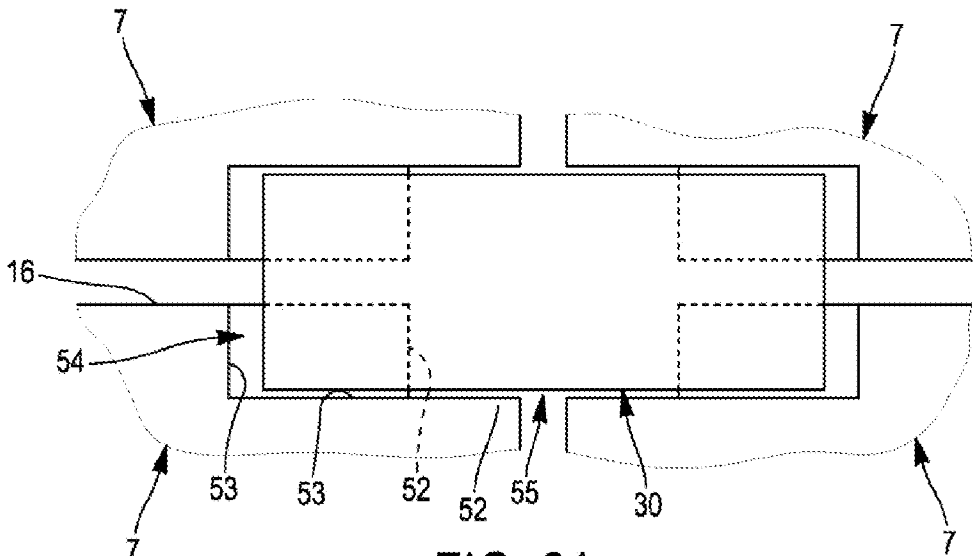
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FIG. 21

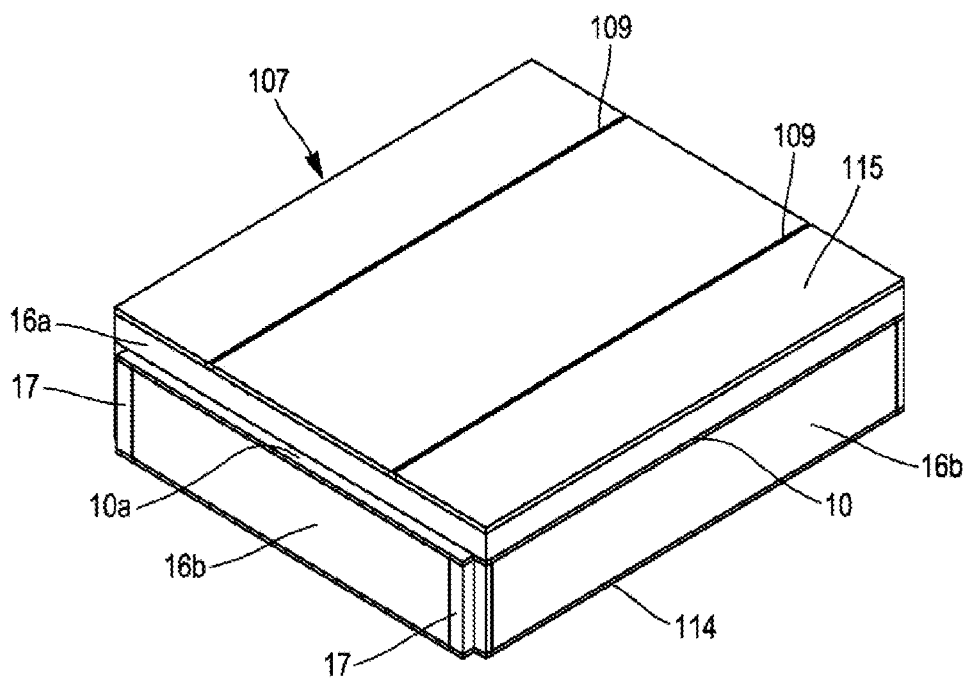
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FIG. 22

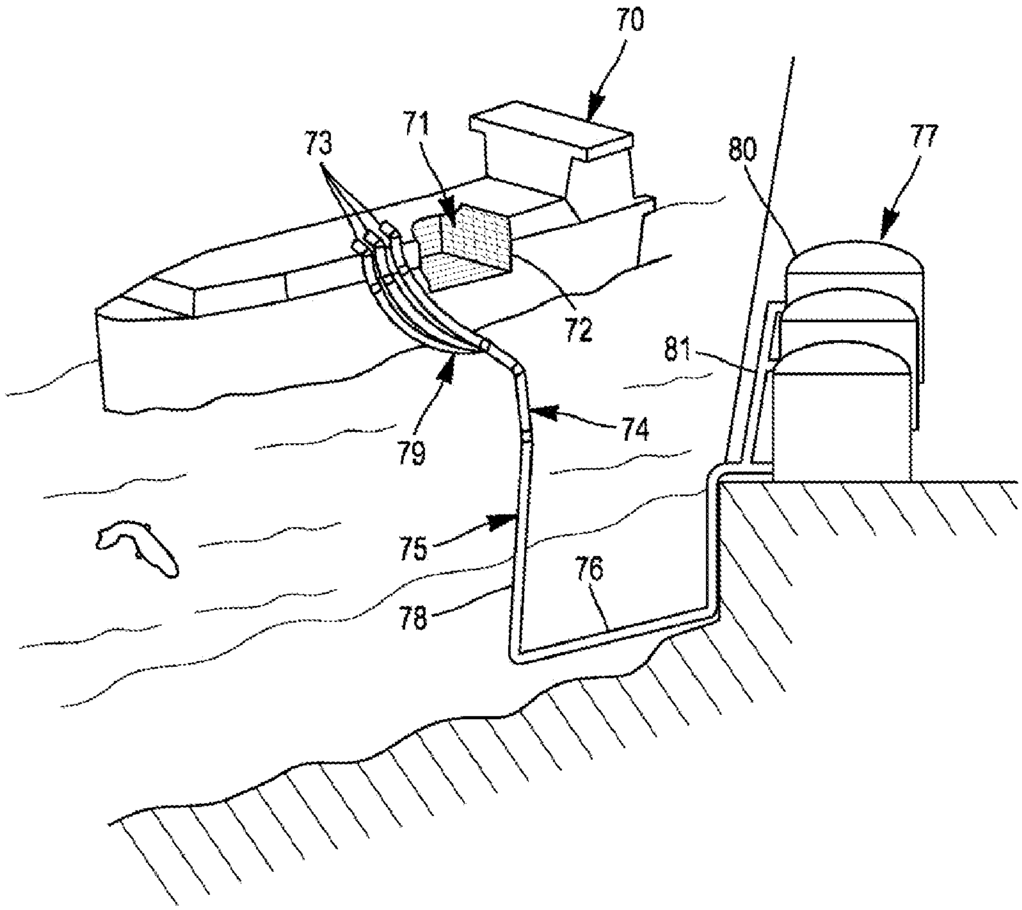

FIG. 23