United States Patent [19]

Tabata

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[45] **Oct. 23, 1973**

[54] **APPARATUS FOR MOUNTING LOW TEMPERATURE LIQUID STORAGE TANKS**

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May 22, 1970 Japan 45/44408

[52] **U.S. Cl.** .... **248/146,** 114/74 A
[51] **Int. Cl.** **G63b 25/08**
[58] **Field of Search** .... 114/74 A; 220/15; 188/311; 248/DIG. 1, 146

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[57] **ABSTRACT**

Apparatus for mounting a low temperature liquid storage tanks is operable to substantially prevent shifting movement of the whole tank while permitting the thermal expansion and contraction of the tank. The apparatus includes cylinder units installed between the tank supporting structure and the tank and connected in pairs by hydraulic circuits which are so arranged that quick shifting movement of the tank is prevented by hydraulic pressures in the circuits while the slow thermal expanding and contracting movements of the tank are permitted by the flow of liquid in the circuits.

5 Claims, 10 Drawing Figures

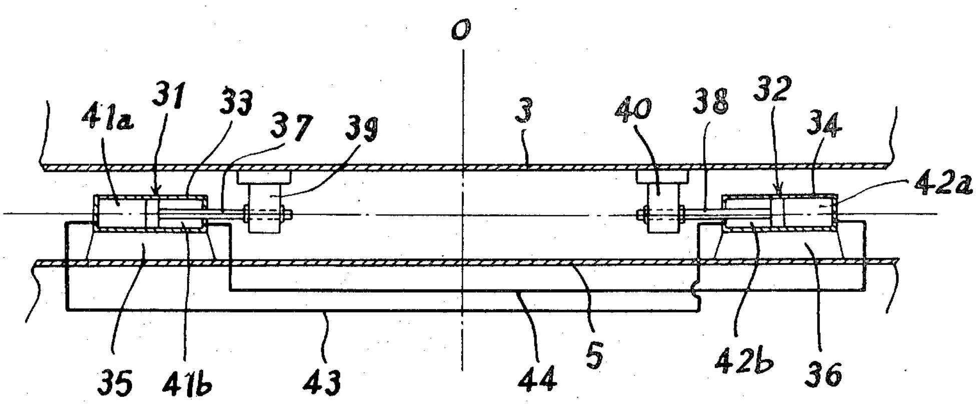

FIG. 1

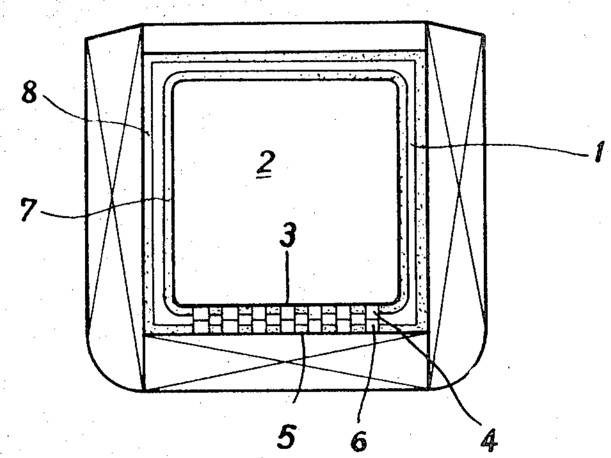

FIG. 2

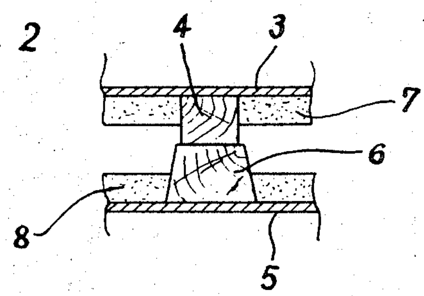

FIG. 3

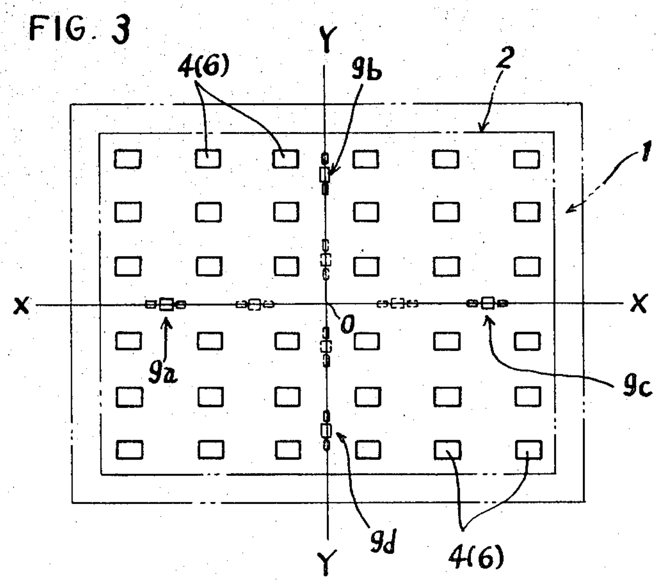

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FIG. 4

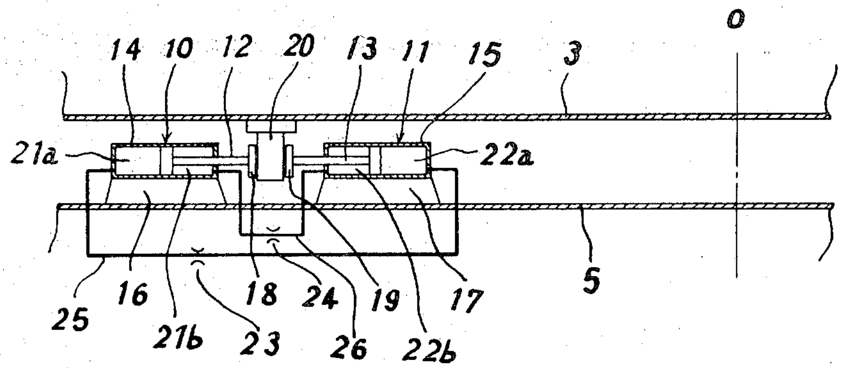


FIG. 5

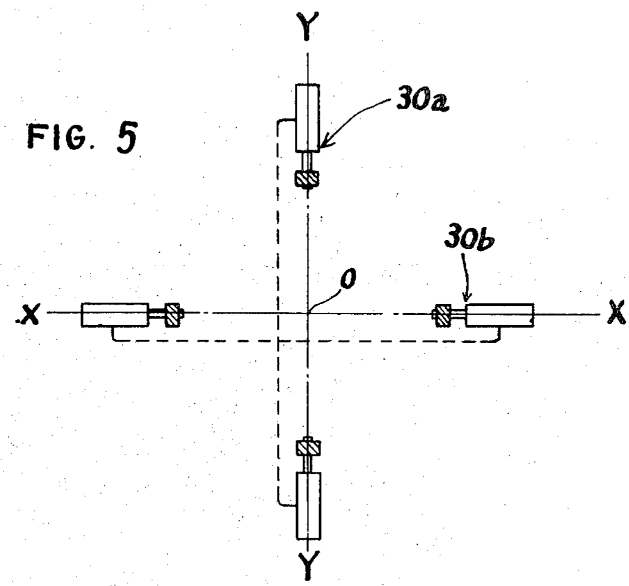
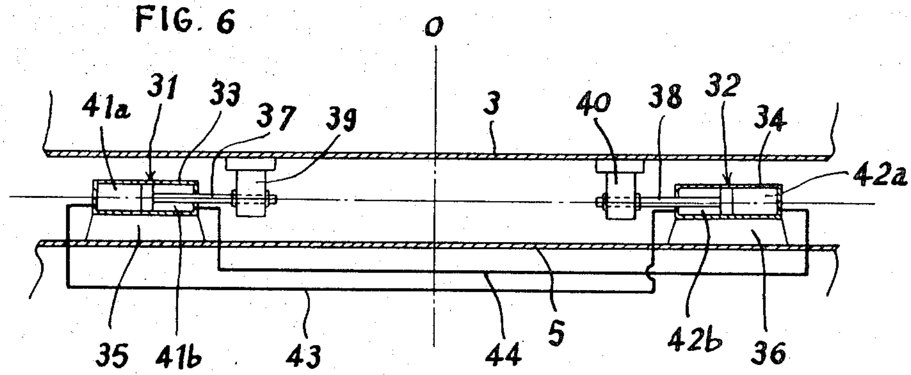


FIG. 6



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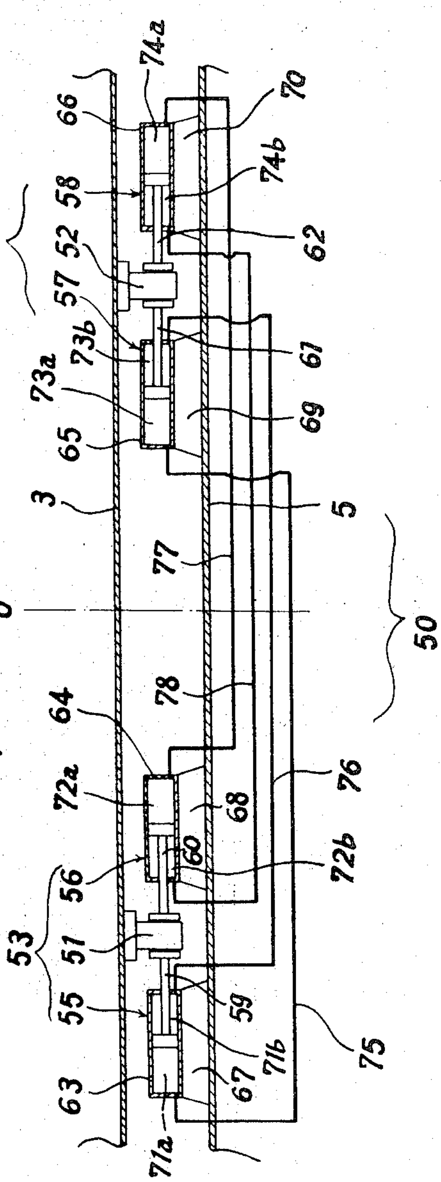

FIG. 7

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FIG. 8

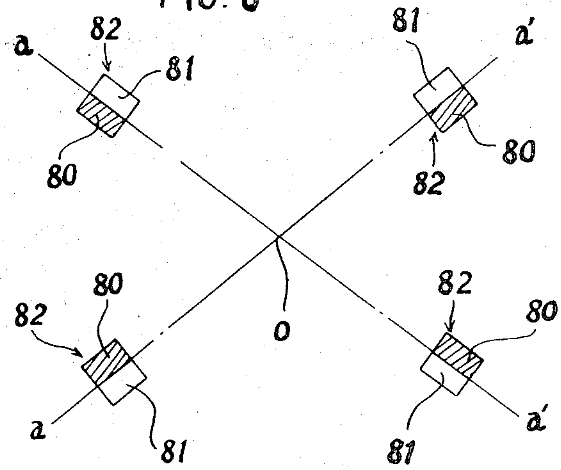


FIG. 9

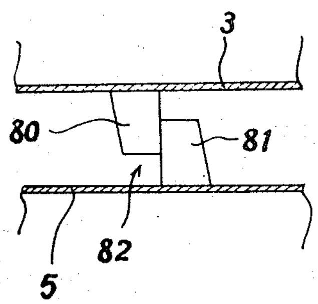
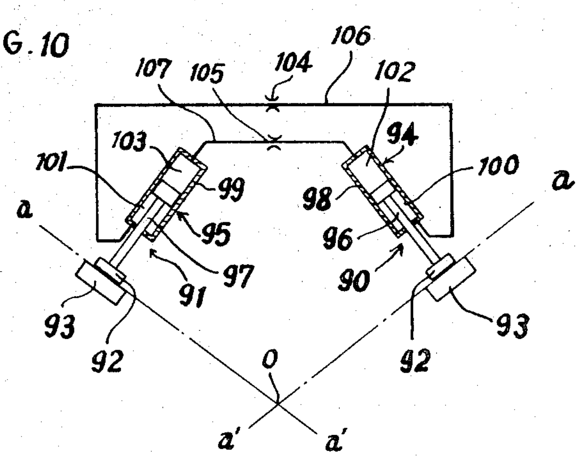


FIG. 10



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APPARATUS FOR MOUNTING LOW TEMPERATURE LIQUID STORAGE TANKS

BACKGROUND OF THE INVENTION

A low temperature liquefied gas storage tank is subjected to relatively large thermal expansion and contraction due to the great difference in temperature of the tank when it contains a liquefied gas therein and when it is empty. As a result, when such a tank is placed in the hold of a ship, for example, it is impossible to provide a rigid connection between the tank and hull. If however, said tank is supported in such a manner that it is free to move, this would be undesirable from the standpoint of safety in that the tank would be improperly and impulsively moved to and fro by the pitching and rolling oscillations of the hull.

Therefore, it will be understood that said tank must be supported by a suitable means which effectively prevents the movement of the tank due to the oscillations of the hull while permitting the expanding and contracting movements caused by temperature differences of the tank.

SUMMARY OF THE INVENTION

The present invention relates principally to the mounting of low temperature liquefied gas storage tanks placed in the hold of a ship and provides apparatus which permits the expansion and contraction of such tank due to changes in the temperature thereof but does not permit relative shifting movement between the tank and the hull due to the oscillations thereof.

A study of the behavior of this type of tank, supported for movement in the hold of a ship, has shown that under the influence of pitching and rolling the movement of the tank is prevented by a frictional force between the tank and the tank supporting structure until the hull is tilted beyond a certain angle. Once the hull is tilted beyond such angle, the tank quickly slides downwardly as a result of its inertia force overcoming said frictional force. In reality, however, as soon as the tank begins to slide in this manner, the direction of inclination of the hull is reversed so that the direction of the force on the tank is also reversed.

Therefore, if it is possible to prevent the tank from quickly moving against the supporting frictional force, then the substantial movement of the whole tank can be completely prevented since there is no continuing force to cause the tank to move in the same direction; and at the same time, the relatively slow thermal expansion and contraction of the tank can be permitted.

This is the basic concept on which the present invention is based. This concept, however, does not exclude the idea of positively and completely preventing the movement of the whole tank. Thus, if at least the sudden shifting movement of the whole tank can be prevented, the intended object of providing an apparatus for mounting tanks installed in the hold of a ship can be achieved, but it would be most ideal if any movement of the whole tank, whether sudden or relatively slow, could be completely prevented (it being noted that thermal expansion and contraction do not come under the category of the movement of the whole tank).

Apparatus for mounting a low temperature liquid storage tank according to the invention comprises a plurality of cylinder assemblies each including at least one cylinder unit having a cylinder member and a piston rod member; means mounting the cylinder assemblies between the tank and the tank supporting structure with one of the cylinder and piston rod members of each cylinder unit operatively associated with the tank, with the other of said members operatively associated with the tank supporting structure and with the piston rod member disposed on a reference line intersecting the center axis of the tank; and, said cylinder assemblies being provided with hydraulic circuit means so arranged that the thermal expanding and contracting movements of the tank are permitted by fluid flow in said circuit means but a shifting movement of the tank is opposed by hydraulic pressure in the circuit means of at least one of said cylinder assemblies.

Therefore, even in the case of a tank being installed in the hold of a ship where there are violent pitching and rolling oscillations, the utilization of the present invention makes it possible to positively prevent the tank from being suddenly shifted as the ship oscillates while satisfactorily permitting thermal expansion and contraction incidental to temperature changes.

Preferably the apparatus of the present invention comprises cylinder assemblies each having two cylinder units arranged symmetrically with respect to the center of a tank, wherein the hydraulic circuit means establishes communication between the cylinder chamber of one cylinder unit, which will be pressurized due to the thermal expansion or contraction of the tank starting with the center of the tank as the origin, and the cylinder chamber of the other cylinder unit, which at that time will be depressurized, whereby the movement of the whole tank is completely prevented by the hydraulic pressures.

With this arrangement it is possible to completely prevent the movement of the whole tank while permitting expanding and contracting movements to take place smoothly. Therefore, the use of the invention as an apparatus for mounting tanks in the hold of a ship makes it possible to completely prevent the tanks from being moved even if the periods of pitching and rolling are relatively long or the hull remains tilted.

Other features of the invention will be fully understood from the following description of the embodiments thereof disclosed in and with reference to the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic section showing a tank installed in the hull of a ship;

FIG. 2 is an enlarged sectional elevation showing vertical load supporting means for the tank of FIG. 1;

FIG. 3 is a schematic plan view of the tank of FIG. 1 showing the layout of cylinder assemblies in a first embodiment of the invention;

FIG. 4 is an enlarged elevation in longitudinal section of one of the cylinder assemblies of FIG. 3;

FIG. 5 is a schematic plan view showing the layout of cylinder assemblies in a second embodiment of the invention;

FIG. 6 is an enlarged elevation in longitudinal section of one of the cylinder assemblies of FIG. 5;

FIG. 7 is an elevation in longitudinal section of a modification of the cylinder assembly of FIG. 6;

FIG. 8 is a schematic plan view showing a layout of rotation-preventive means;

FIG. 9 is an enlarged sectional elevation of a pair of members in the rotation preventive means of FIG. 8; and,

FIG. 10 is a sectional plan view of a modified form of rotation preventive means.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIGS. 1 and 2, a low temperature liquefied gas storage tank 2, installed in the hold 1 of a ship, has a large number of blocks 4 secured to the bottom plate 3 of the tank and engaging corresponding support blocks 6 secured to the floor plate 5 of the hold in such a manner so that the tank is free to move horizontally.

In these Figures, the numeral 7 designates a heat insulator covering the tank 2 and the numeral 8 denotes a heat insulator covering the interior of the hold.

FIRST EMBODIMENT - FIGS. 3 AND 4

Four cylinder assemblies **9***a*, **9***b*, **9***c* and **9***d* are disposed between the bottom plate **3** of the tank **2**, supported in the manner described above, and the hold floor plate **5**, each cylinder assembly **9***a*–**9***d* including a pair of cylinder units **10** and **11**. These pairs of cylinder units **10** and **11** are disposed at positions symmetrical with respect to the center O of the tank and on two horizontal straight reference lines X—X and Y—Y orthogonally intersecting at said center O. The cylinder units **10** and **11** of each pair are opposed to each other with their piston rod members **12** and **13** longitudinally parallel to one of the lines X—X or Y—Y; with their cylinder members **14** and **15** fixed to the floor plate **5** by means of pedestals **16** and **17**; and, with the opposed free ends **18** and **19** of their rod members bearing against the opposite lateral surfaces of a chock **20** fixed to the tank bottom plate **3**.

The cylinder units **10** and **11** in each pair have head end and rod end cylinder chambers **21***a*, **21***b* and **22***a*, **22***b*, respectively. The head, or oppositely facing end chambers **21***a* and **22***a* are interconnected by a flow passageway **25** having a throttle or orifice valve **23**, and form a hydraulic circuit. Similarly, the rod end chambers **21***b* and **22***b* are interconnected by a flow passageway **26** having an orifice **24**. Instead of interposing the orifices **23** and **24**, the flow passageways **25** and **26** may be constituted in whole by pipes of very small diameter.

With this arrangement, when the bottom plate **3** of the tank **2** expansively deforms outwardly from its center O, each chock **20** slowly pushes each piston rod **12** of the cylinder units **10** which are more remote from the center O. Therefore, the oil in the chamber **21***a* of the cylinder unit **10** is pressurized to flow through the passageway **25** and orifice **23** into the chamber **22***a* of the other cylinder unit **11** and push the piston rod **13** to cause its free end **19** to follow the chock **20**. Flow of oil also takes place between the chambers **21***b* and **22***b* through the passageway **26** and orifice **24**. When the tank bottom plate **3** contractively deforms toward the center O, the direction of movement of each piston rod **12** and **13** will be opposite to what has been described above.

Consideration will now be given to a case where the whole tank **2** tends to move quickly, e.g., in the direction of the line X—X when an inertia force exerted on the tank as a result of the pitching and rolling of the hull is great enough to overcome the frictional force between the blocks **4** and support blocks **6**. In this example, the chocks **20** and piston rod ends **18** and **19** of the cylinder assemblies **9***b* and **9***d* lying on the line Y—Y will tend to relatively slip sideways along their contacting surfaces, while the cylinder assemblies **9***a* and **9***c* lying on the line X—X will be pressurized. Since the oil in the chamber **21***a* or **22***a* pressurized by the piston rod **12** or **13**, urged by the chock **20** can flow out only through the orifice **23** or **24**, it is impossible for said oil to flow out quickly in response to the pressing force on the piston stem **12** or **13**. Therefore, sudden movement of the piston stem **12** or **13** is prevented by the oil pressure in the chamber **21***a* or **22***a* which is pressurized at that time. The net result is that sudden shifting movement of the whole tank **2** in the direction of the line X—X is prevented. By the time the tank **2** is actually about to move as permitted by the gradual outflow of oil from the pressurized chamber **21***a* or **22***a*, the direction of inclination of the hull will be reversed and hence the direction of the force on the tank will also be reversed. Therefore, the tank **2** will not move substantially. Further, even if there is a movement of part of the oil, the position of the chock **20** and hence the tank **2** will not vary to the extent that there is any substantial effect, since such oil will be returned when the chamber **21***a* or **22***a* is switched over to a chamber being pressurized.

When the tank **2** tends to move in the direction of the line Y—Y, the cylinder assemblies **9***b* and **9***d* will then act to prevent such movement in the same manner as described above.

When the tank tends to move in a direction at angles with the lines X—X and Y—Y, all the cylinder assemblies operate with respect to the X—X and Y—Y components of the force so that the movement of the tank is prevented.

The flow passageways **26** may be omitted.

Further, the chocks **20** may be fixed to the floor plate **5**, and the cylinder members **14** and **15** may be fixed to the tank bottom plate **3**.

Further, such cylinder assemblies may be installed between the tank ceiling and the hold structure opposed thereto. The number of cylinder assemblies may be increased as indicated by the phantom lines in FIG. 3.

If the chocks **20** were fixedly secured to the piston rods **12** and **13**, the movement of the whole tank **2** could be completely prevented by shearing stresses at the joints between the piston rods **12**, **13** and chocks **20**. In this case, however, it would be necessary to correspondingly increase the strength of the piston rods and also the joint strength. It would also be necessary to increase the number of cylinder assemblies. The following embodiment is capable of completely preventing the movement of the whole tank without involving such drawbacks.

SECOND EMBODIMENT - FIGS. 5 AND 6

Two cylinder assemblies **30***a* and **30***b* are used in this embodiment with each having two cylinder units **31** and **32** disposed on one of the reference lines X—X and Y—Y, respectively, and arranged symmetrically with respect to the center O. Said units have cylinder members **33** and **34** fixed to a floor plate **5** through pedestals **35** and **36** and have piston rod members **37** and **38** secured to separate chocks **39** and **40**. In each cylinder assembly **30***a*, **30***b*, the opposed chambers **41***a*, **41***b* and **42***a*, **42***b* of the cylinder units **31** and **32** communicate with each other through flow passageways **43** and **44** in such a manner that one chamber of one cylinder unit and one chamber of the other cylinder unit, which are in inner-outer reversed positional relation with respect to the center O, are paired.

According to the above-mentioned arrangement, at the time of expansive or contractive deformation of the tank bottom plate **3** relative to the center O as the origin, the respective chocks **39** and **40** move the piston rods **37** and **38** secured thereto away from (at the time of expansion) or toward (at the time of contraction) the center O. Therefore, in each cylinder assembly **30***a*, **30***b*, the outer chambers **41***a* and **42***a* or the inner chambers **41***b* and **42***b* of the opposed cylinder units **32** and **33** are pressurized while the other chambers are depressurized, but since such pressurized and depressurized chambers communicate with each other through the flow passageways **43** and **44**, the movement of the chocks **39** and **40** with the expansive and contractive deformations of the tank bottom plate **3** takes place without any interference.

When the whole tank **2** tends to move, the chocks **39** and **40** tend to move in the same direction, which means that the two chambers **41***a* and **42***b* or **41***b* and **42***a* communicating with each other through the flow passageway **43** or **44** are pressurized, so that such movement of the two chocks is positively prevented by the oil pressures. That is, according to this embodiment, the movement of the whole tank can be positively prevented while permitting the expansion and contraction of the tank **2** to take place smoothly with the center O as the origin. Therefore, even though the piston stems **37** and **38** are rigidly connected to the chocks **39** and **40**, it is possible to avoid a situation in which serious bending stresses are produced in the piston stems **37** and **38**.

FIG. **7** shows a modification of the cylinder assembly shown in FIG. **6**. Cylinder assemblies **50** are disposed on lines X—X and Y—Y, as shown in FIG. **5**, the feature of this modification residing in the fact that rigid connections between the chocks and piston rods can be dispensed with.

The cylinder assembly **50** has two chocks **51** and **52** and two pairs of cylinder units **53** and **54** disposed on the line X—X (or Y—Y) symmetrically and oppositely with respect to the tank center O, said pairs of cylinder units consisting of the cylinder units **55, 56** and **57, 58**, respectively symmetrically disposed with one of the chocks **51** and **52** positioned between each pair. The chocks **51** and **52** are fixed to the tank bottom plate **3** and the free ends of piston rods **59, 60** and **61, 62** engage the chocks **51** and **52.** Cylinder members **63, 64** and **65, 66** are secured to the floor plate **5** through pedestals **67, 68** and **69, 70.** The cylinder chambers **71***a*, **73***a; ***71***b*, **73***b; ***72***a*, **74***a;* and **72***b*, **74***b*, which are in remote-near reversed positional relation with respect to the tank center O communicate with each other through flow passageways **75, 76, 77** and **78,** respectively.

In the case of the tank bottom plate **3** being expansively deformed with the center O as the origin, the movement of the chocks **51** and **52** away from the center O urges the piston rods **59** and **62** of the cylinder units **55** and **58** to pressurize the cylinder chambers **71***a* and **74***a* and cause the oil therein to flow through the flow passageways **75** and **77** into the cylinder chambers **73***a* and **72***a* of the other cylinder units **57** and **56,** thereby pushing out the piston rods **60** and **61** to follow the movement of the chocks **51** and **52.** Concurrently therewith, oil flows from the cylinder chambers **73***b* to **71***b* and **74***b* to **72***b* through the flow passageways **76** and **78.** As a result of such action, the movement of the chocks **51** and **52** with the expansive deformation of the tank bottom plate **3** takes place without any difficulty.

On the other hand, when the whole tank tends to move or shift, the chocks **51** and **52** tend to move in the same direction so that the two chambers **71***a* and **73***a* or **72***a* and **74***a* communicating with each other through the flow passageway **75** or **77**, are pressurized. Therefore, such movement of the chocks **51** and **52** is strongly prevented by the oil pressures and hence no movement of the whole tank occurs.

When the movement of the whole tank tends to take place in a direction parallel to the line X—X or line Y—Y, in the junctions between the chocks **51, 52** and piston rods **59–62** of the cylinder assembly located on a line perpendicular to the direction of such movement, there will be a force acting in a direction in which lateral slip occurs, but no build-up of oil pressure will be created.

In the construction shown in FIGS. **6** and **7**, the chocks and cylinder bodies may have their mounting reversed, the number of cylinder assemblies may be increased and/or the cylinder assemblies may be interposed between the tank ceiling and the hold structure adjacent thereto. Further, in the construction shown in FIG. **7**, the hydraulic circuits which include the flow-passageways **76** and **78**, for example, may be omitted.

THIRD EMBODIMENT - FIGS. 8 AND 9

In practice it is desirable to position a chock between a pair of piston rods, without rigid connections therebetween as in the construction shown in FIGS. **4** and **7.** Not only is the installation of tanks easy and efficient but also no excessive forces are produced acting on the junctions between the piston rods and chock. However, it is then impossible to prevent the tank **2** from turning around the center O.

In order to solve this problem, a plurality of rotation-preventive means **82** are disposed so as to prevent both clockwise and counter-clockwise turning around the center O, each of said rotation-preventive means comprising a pair of members **80** and **81** which are relatively movable along a straight reference line *a–a'* extending through the tank center O and which bear against each other so that each prevents the turning of the other around the center O, one member **81** being fixed to the tank bottom plate **3** and the other member **81** being fixed to the bottom plate **5** of the hold. This arrangement permits the tank to expansively and contractively deform with the center O as the origin while positively preventing the tank from turning around said center O. Therefore, it is preferable to incorporate this third embodiment when the constructions shown in FIGS. **4** and **7** are employed.

The rotation-preventive means described above may also be provided on the tank ceiling side.

A modification of the rotation-preventive means will now be described with reference to FIG. **10.**

In FIG. **10,** a set of rotation-preventive means **90** and **91** includes pairs of contacting members **92** and **93,** the members **92** being fixed to the ends of the piston rods **96** and **97** of a set of cylinder units **94** and **95** mounted on the tank supporting structures. The inner chambers **100** and **101** of the cylinders communicate with each other through a flow passageway **106** and the outer chambers **102** and **103** communicate with each other through a flow passageway **107.**

When the members **93** fixed to the tank, turning of the tank results in one piston rod **96** or **97** of either of the cylinder units **94** and **95** being pushed by its associated member **93** to pressurize the outer chamber **102** or **103,** but quick outflow of the fluid in the chamber **102** or **103** is prevented by the presence of a throttle valve **105.** Therefore, quick movement of the tank is prevented. Optionally, the hydraulic circuit which includes the flow passageway **106** may be omitted.

Functionally, this modification may be considered to be an adaptation of the means shown in FIG. **4** to prevent rotational shifting of the tank, but it is also possible to provide a construction in which one member **93** is positioned between the ends of the piston rods of the two cylinder units **94** and **95.** Further in order to completely prevent rotation of the tank, the means shown in FIG. **7** may be adapted to prevent rotational shifting.

I claim:

1. Apparatus for mounting a low temperature liquid storage tank for thermal expanding and contracting movements relative to structure supporting the tank and for restraining the tank from shifting movement relative to such supporting structure, comprising:

pairs of cylinder units, each unit having a cylinder member and a piston rod member:

means mounting the pairs of cylinder units between the tank and the tank supporting structure with one of the cylinder and piston rod members of each cylinder unit operatively associated with the tank, with the other of said members operatively associated with the tank supporting structure, and with the cylinder units of a pair spaced apart in a direction transversely of the tank and located on a common reference line at opposite sides of a line passing through the tank center; and,

each pair of cylinder units being connected by hydraulic circuit means so arranged that the thermal expanding and contracting movements of the tank are permitted by fluid flow in said circuit means but a shifting movement of the tank is opposed by hydraulic pressure in the cylinder members of at least one pair of cylinder units, the hydraulic circuit means including a pair of connections between each pair of cylinder units, each connection extending between that portion of the cylinder member of one of the cylinder units which is pressurized in response to a thermally induced movement of the tank and that portion of the cylinder member of the other cylinder units which is unpressurized in response to such movement of the tank, each of said pair of connections enabling the portions of the cylinder members connected thereby to be simultaneously pressurized in response to a shifting movement of the tank in one of the directions of said common reference line on which a pair of cylinder units are located.

2. Apparatus as set forth in claim **1** wherein the cylinder members are each fixed to the tank supporting structure and the piston rod members are each fixed to the tank.

3. Apparatus as set forth in claim **1** wherein the piston rod members of the pairs of cylinder units are disposed on at least two reference lines which intersect each other at the tank center.

4. Apparatus as set forth in claim **1** wherein at least some of the pairs of cylinder units are mounted so that the longitudinal axis of the piston rod member of any cylinder unit thereof is disposed on a reference line intersecting the center axis of the tank.

5. Apparatus as set forth in claim **1** further comprising means restraining the tank from rotational shifting movement about the center axis thereof.

* * * * *