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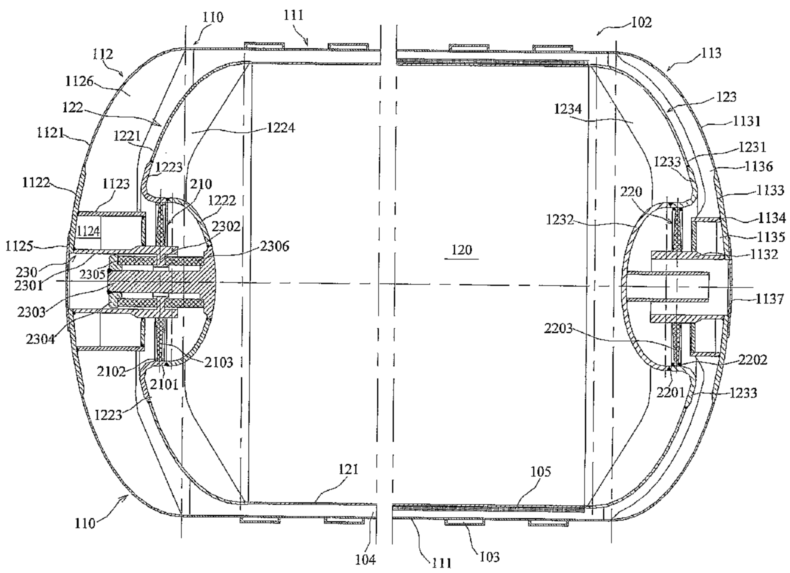

(57) Abstract: A super-vacuum insulation tank for cryogenic liquefied gas comprises a framework; and a tank body including an outer shell, an inner vessel, and a combined support structure connecting the outer shell and inner vessel. The combined support structure is only provided between the dome ends of the out shell and inner vessel at both ends of the tank, which can bear the force in both radial and longitudinal direction. The conduction heating surface between the inner vessel and the outer shell is small, but the support structure can bear heavy load, and the effective shipment volume of the inner vessel is large.

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SUPER-VACUUM INSULATION TANK FOR CRYOGENIC LIQUEFIED GAS

FIELD OF THE INVENTION

The present invention relates to a type of storage or transport equipment for cryogenic liquefied gas, and more particularly, to a super-vacuum insulation tank applied as a road tanker or a tank container for efficiently transporting cryogenic liquefied gas.

DESCRIPTION OF THE RELATING ART

The performance of the cryogenic tank was improved greatly by the vacuum-powder insulation technology born in 1909. By the end of last thirties, the vacuum-powder insulation technology had been widely used in the whole filed of cryogenic technology, with air separation and liquefaction technique as the typical examples. At the beginning of last fifties, the super-vacuum multi-layer insulation technology came forth, which was a very significant development in the history of cryogenic insulation technology. Specially, by the end of last fifties, the consumption of liquid hydrogen and liquid helium increased sharply with the development of space technology, which motivated the research and the application of super-vacuum multi-layer insulation technology, wherein the road tanker and the tank container for cryogenic liquefied gas were the main application products.

In the field of cryogenic technology, the cryogenic liquefied gas refers to the gas in liquid status with the temperature below-160°C, such as liquefied oxygen, liquefied nitrogen, liquefied argon, liquefied hydrogen, liquefied helium, liquefied methane and liquefied natural gas (LNG) etc.. Because the volume of the above gases in liquid status shrinks more than 600 times comparing to that in gaseous status, they are often transported in liquid. The equipments for transporting the cryogenic liquefied gas include the road tanker and the tank container etc. The tank is formed with a bilayer structure and a vacuum interlayer disposed between the inner vessel and the outer shell, which are connected by a support structure. Due to the requirement for regulations of transportation, all transport equipments (such as the road tanker and tank container etc.) should comply with the limit to the maximal overall size, and within the limit, the effective volume for cargo is determined by the thickness of the vacuum layer.

The vacuum-powder insulation road tanker and tank container are widely used as the cryogenic transport equipments currently. Fig. 1 illustrates the main structure of a transport equipment 10 according to the relating art, which comprises: an outer shell 1; an inner vessel 2; an insulation structure 3; several radial supports 4 and a front and a back longitudinal supports 15 and 16 between the outer shell 1 and the inner vessel 2; and a rigid assembly 6. A supper-vacuum layer 8 is formed between the inner vessel 2 and the outer shell 1, in which materials such as perlite can be added to realize the heat insulation. In order to achieve satisfied effect of heat insulation, the vacuum layer 8 is designed to be of big thickness, which is often in a range of 200 to 300 mm. However, the effective volume for cargo of such equipment has to be sacrificed, and the perlite will deposit gradually during transportation, which affects the performance of heat insulation. Therefore, the multiplayer insulation technology was developed, with its improvement in practice application, especially in the equipment carrying cryogenic liquefied gas.

According to the multiplayer insulation technology, in the above transport equipment 10, heat insulation materials are entwined outside the inner vessel 2, and the insulation layer is formed by pumping the vacuum interlayer which comprises multiple layers of heat insulation materials in to super-vacuum state. The thinner the vacuum interlayer is, the more cargo the tank can hold and transport. However, the difficulty lies on that the thinner the insulation layer is, the more difficult it is to set the support structure between the inner vessel and outer shell; and the thinner the insulation layer is, the lower the vacuum degree is, and then the more heat is transferred from the inner vessel to the outer shell.

Currently, in most multilayer insulation techniques, such as disclosed in Chinese Patent ZL 00249960.6 and ZL 01272605.2, in order to set the radial support in the vacuum layer, the thickness of the vacuum layer has to be about 100 mm.

In fact, the support structure between the inner vessel and the outer shell should not only bear the load from the liquid, the weight of the tank and the force caused by shock acceleration, but also reduce the heat leakage caused by itself as much as possible, therefore it is a key part to design the support structure of the cryogenic tank. In the above-mentioned transport equipment, the support structure comprises the radial support 4, the front longitudinal support 15 and the back longitudinal support 16. Taking the back longitudinal support 16 as an example, it comprises a reinforced plate 23 and a supporting steel tube 24 for the inner vessel, an insulation back-up ring 26 and a holding ring 25 thereof, a supporting steel tube 32 for the outer shell and a reinforced rib 33. The supporting steel tube 24 for the inner vessel is welded with the outer surface of the back dome end of the inner vessel 2 through the reinforced plate 23, and the supporting steel tube 32 for the outer shell is welded with the inner surface of the back dome end of the outer shell 1. The supporting steel tube 24 for the inner vessel is held by the supporting steel tube 32 for the outer shell through the insulation back-up ring 26 and the holding ring 25. The rigid assembly 6 comprises an insulation fill block 28, an inside nut 27 and a compression nut 29 for the insulation fill block 28, a supporting axle pin 30 and a supporting lid 31. The rigid assembly 6 is connected with the supporting steel tube 24 through the inside nut 27; the compression nut 29 is welded with the supporting lid 31; and the supporting lid 31 is welded with the supporting steel tube 32 for the outer shell. It is obvious that the structure of the above insulation fill block between the inner vessel and the outer shell can effectively solve neither the problem that the heat leakage by the support structure is very high due to the narrow gap between the multiple super-vacuum insulation layers, nor the problem that the multiple super-vacuum insulation layers will be damaged or interrupted by heat-expansion and cold-shrink of the inner vessel. Secondly, it is very difficult to produce the stainless steel sleeve tube between the dome ends of the inner vessel and the outer shell. Finally, the distance between the dome ends of the inner vessel and the outer shell is big and the endurance against impact is poor.

Another support structure of the cryogenic container is called the "suspender" structure; however, it can not effectively overcome the problem that the resistance against impact weakens due to heat-expansion and cold-shrink. If the supporting capacity of the stainless steel suspender is improved, the heat transferred will increase, and therefore the vaporization losses of the cryogenic container will increase and the storage efficiency of cryogenic liquid will decrease.

Chinese Patent ZL 00216678.X discloses a type of support structure 40 to resist intense impact for the cryogenic container, as shown in Fig. 2. The support structure 40 comprises a radial support provided at the inner surface of the outer shell of each end of the cryogenic container; and a longitudinal support provided at one end of the cryogenic container, while the other end being a free end. The radial support includes a radial supporting ring 41, a supporting tube 42 for the outer shell, and a reinforced rib 43. An end of supporting tube 51 of the inner vessel is welded at the center of the outer surface of each dome end of the inner vessel 50, and the other end is inserted into the radial supporting ring 41. The supporting tube 42, the reinforced rib

43 and the outer shell 44 are fixed integratedly. The longitudinal support includes a longitudinal stand bar 45; a longitudinal supporting plate 47 which is thread-connected with the supporting tube 51 and positioned by welding; a glass reinforced plastic support plate 46, which is mounted on each end of the longitudinal support plate 47; a pressure strip 48, which cooperates with the longitudinal support plate 47 to press the glass reinforced plastic support plate 46 firmly; and a transition joint 49, by which the longitudinal stand bar 45 is welded with the dome end of the outer shell 44. In the above support structure, a bigger distance between the dome ends must be left because each end of the cryogenic container is provided with both radial and longitudinal support structure, which makes the ability to resist shock weaken and the contacting gap increase during the transition from normal temperature to low temperature.

With the development of storage or transport tank for cryogenic liquefied gas, it becomes the objective to effectively increase the effective volume for cryogenic liquefied gas and the shock resistance ability within the limited overall size.

SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to a super-vacuum insulation tank for cryogenic liquefied gas provided with a reversed small dome end at the center of the dome end of the inner vessel, and disposing a combined support structure in the reversed small dome end and between the dome ends of the outer shell and the inner vessel to support radial and longitudinal force simultaneously, which substantially obviates one or more of the problems due to limitations and disadvantages of the related art.

An advantage of the present invention is to provide a tank that can maintain the excellent insulation performance and simultaneously make the insulation layer thinner in order to increase the effective volume of the tank.

Additional advantages and features of the invention will be set forth in the description which follows, and in part will be apparent to those skilled in the art upon examination of the following or may be learned from practice of the invention. These and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present invention, as embodied and broadly described herein, a super-vacuum insulation tank for cryogenic liquefied gas comprises a framework; and a tank body, including an outer shell, having a cylinder and two dome ends; an inner vessel, having a cylinder and two dome ends; a super-vacuum insulation layer between the outer shell and inner vessel; and a support structure connecting the outer shell and the inner vessel, wherein the support structure is a combined support structure only provided between the dome ends of the out shell and the inner vessel at both ends of the tank to bear the force in radial and longitudinal direction. Specially, the distance between the outer shell and the inner vessel is not more than 50 mm. And the center of the dome end of the inner vessel depresses into the inner vessel and forms a reversed small dome end, and the cambered surface of the reversed small dome end is opposite to the cambered surface of the dome end of the outer shell. A plurality of reinforced rings is provided outside of the outer shell.

According to the present invention, the combined support structure is only provided between the inner and outer dome ends at both ends of the tank and the radial support does not contact with the outer shell directly, which reduces the heat conduction area of the support between the inner vessel and outer shell, therefore obtaining better insulation performance. At the same time, due to the absence of the radial support in the straight portion, the super-vacuum insulation layer between the inner vessel and outer shell can decrease to 50 mm, which increases the effective volume of the inner vessel and efficiency of loading.

Moreover, the outer shell of the tank according to the present invention comprises two dome ends, a cylinder and a plurality of stiffening rings. Different from the relating art, the stiffening rings are provided outside the outer shell, which makes the outer shell consume less material, have smaller weight and cost less, while satisfying the precondition of having the same inside diameter of the outer shell and the same size of the stiffening rings. At the same time, the stiffening ring also works as a protector of the outer shell. The dome ends of the inner vessel and outer shell (hereinafter referring to as the inner and outer dome ends) are arranged in opposite direction and the inner vessel is entwined with multiple layers of heat insulation material. The inner vessel is connected with the outer shell by the combined support structure between the inner and outer dome ends at both ends, which simultaneously bears the force in radial and longitudinal directions. Because the dome ends of the inner vessel and outer shell are arranged in opposite direction, the combined support structure can be provided inside the inner dome end, which makes the distance between the inner and outer dome ends smaller. Therefore, with the same size of outer shell, the inner vessel obtains larger effective volume.

The present invention provides a super-vacuum inner support structure with multiple insulation layers that has very good capacity to resist shock and insulate heat. As a result, the endurance against shock on the storage or transport equipment for cryogenic liquefied gas and temperature fluctuation of cargo satisfy the requirement of the storage or transportation of cryogenic liquefied gas. Furthermore, the super-vacuum layer between the inner vessel and outer shells of the cryogenic tank is very thin, which finally achieves the largest efficiency of loading of the cryogenic liquefied gas.

It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiment of the invention and together with the description serve to explain the principles of the invention. In the drawings:

Fig. 1 is a schematic sectional view of a tank for cryogenic liquefied gas according to the relating art;

Fig. 2 is a schematic view of a shock-resistance support structure applied in a cryogenic container according to the relating art;

Fig. 3 is a perspective view of a super-vacuum multi-layer insulation for cryogenic liquefied gas according to the present invention;

Fig. 4 is a schematic vertical sectional view of the tank illustrated in Fig. 3;

Fig. 5 is a perspective sectional view of a first dome end of the tank illustrated in Fig. 3;

Fig. 6 is a perspective sectional view of a second dome end of the tank illustrated in Fig. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference will now be made in detail to the preferred embodiments, examples of which are illustrated in the accompanying drawings.

Fig. 3 is a perspective view of a super-vacuum multilayer insulation for cryogenic liquefied gas according to the present invention. As shown in Fig. 3, the tank 100 includes a framework 101 and a tank body 102, which are welded together in a specific way. As for a road tanker, the framework 101 refers to the structure that fixes the tank body 102 to the automobile chassis; as for a tank container, the framework refers to the structure that fixes the tank body 102 into the designated area of the container. Furthermore, a plurality of stiffening rings 103 is provided on the outer surface of the tank.

Fig. 4 is a schematic vertical sectional view of the tank shown in Fig. 3. Referring to Fig. 4, the tank body 102 includes: an outer shell 110 comprising a cylinder 111, a first dome end 112 and a second dome end 113 to seal the cylinder 111 at two ends respectively; an inner vessel 120 disposed inside the outer shell 110, comprising a cylinder 121, a first dome end 122 and a second dome end 123 to seal the cylinder 121 at two ends respectively. A super-vacuum insulation layer 104 is formed between the outer shell 110 and the inner vessel 120, in which multiple layers of insulation material 105 are entwined on the outer surface of the inner vessel 120.

Referring to Figs. 4 and 5, Fig. 5 is a perspective sectional view of a first dome end of the tank illustrated in Fig. 3. In particular, the first dome end 122 of the inner vessel 120 comprises: a first main body 1221; a first reversed small dome end 1222, which is formed depressedly from the center of the first main body 1221 into the inner vessel 120, i.e. the cambered surface of the first reversed end dome end 1222 is consequentially opposite to that of the corresponding dome end 112 of the outer shell 110; and a first extended neck 1223 welded between the first reversed small dome end 1222 and the first main body 1221, which forms a rounding off structure and reduces the inner stress of the inner vessel 120. In addition, a reinforced plate 1224 can be further provided on the inner side of the dome end 122 of the inner vessel 120 to improve the capability to resist shock. Similarly, referring to Figs. 4 and 6, the second dome end 123 of the inner vessel 120 comprises: a second main body 1231; a second reversed small dome end 1232, which is formed depressedly from the center of the second main body 1231 into the inner vessel 120, i.e. the cambered surface of the second reversed end dome end 1232 is consequentially opposite to that of the corresponding dome end 113 of the outer shell 110; and a second extended neck 1233 welded between the second reversed small dome end 1232 and the second main body 1231, which forms a rounding off structure and reduces the inner stress of the inner vessel 120. In addition, a reinforced plate 1234 can be further provided on the inner side of the dome end 123 of the inner vessel 120 to improve the capability to resist shock.

In order to guarantee intensity enough, the first dome end 112 of the outer shell 110 further comprises: a main body 1121; a stiffening plate 1122, formed at the center of the main body 1121; a reinforced tube 1123 connected with the stiffening plate 1122, with a reinforced plate 1124 provided thereon to strengthen the structure. Preferably, a reinforced plate 1126 is provided on the inner side of the first dome end 112, in order to strengthen the intensity of the first dome end 112. To meet the requirement of assembly, the second dome end 113 of the outer shell 110 includes: a main body 1131; a support tube 1132, mounted to the center of the main body 1131 from inside; a stiffening plate 1133, formed at the center of the main body 1131 and connected with the support tube 1132; a reinforced tube 1134, connected with the stiffening plate 1133 and surrounding the support tube 1132, on which a reinforced plate 1135 is provided to improve the strength of the structure; and a reinforced plate 1136 provided on the inner side of the second dome end 113. Thereby, the present invention can take full advantage of the distance between the dome end of the outer shell and the dome end of the inner vessel to arrange a combined support structure.

Referring to Fig. 4, the combined support structure comprises a radial support structure and a longitudinal support structure separately. The radial support structure includes a first radial support structure 210 cooperating with the first dome end 122 of the inner vessel 120 and a second radial support structure 220 cooperating with the second dome end 123 of the inner vessel 120. The first/second radial support structure 210/220 separately comprises: an inner fixed ring 2101/2201; an outer fixed ring 2102/2202; and a first/second radial supporting plate 2103/2203 correspondingly. The inner fixed ring 2101/2201 and the outer fixed ring 2102/2202 are in turn fixed on the predefined positions on the inner side of the extended neck 1223/1233 or the reversed small dome end 1222/1232; and the radial supporting plate 2103/2203 is fixed between the inner fixed ring 2101/2201 and the outer fixed ring 2102/2202 and cooperates closely with the transition tube 1223/1233 or the reversed dome end 1222/1232. Because the dome end of the inner vessel has a rounding off structure, it is obvious that the radian from the extended neck to the reversed small dome end decreases gradually, i.e. the contacting gap between the radial supporting plate and the dome end is self-adjustable. Therefore, when transforming from the normal temperature state to the cryogenic state, although there is heat-expansion and cold-shrink effect upon the inner vessel 120, the first and second radial supporting plates can still closely engage with the reversed small dome end or the extended neck, without a gap therebetween. More significantly, because the radial support is provided directly on the dome end of the inner vessel, the super-vacuum insulation layer between the inner vessel and outer shell can decrease to 50 mm, which further increases the effective volume of the inner vessel.

Moreover, the longitudinal support structure 230 is provided between the first dome end 112 of the outer shell and the first dome end 122 of the inner vessel, and passes through the first radial supporting plate 2103. The longitudinal support structure 230 comprises: a supporting tube 2301 mounted on the stiffening plate 1122 of the outer shell 110, on the inner side of which a blow-up 2302 for spacing is provided; a supporting axle 2303, mounted at the center of the reversed small dome end 1222 and extends to the supporting tube 2301; a locking element 2304, provided at the end of the supporting axle 2303; a first fill block 2305, locked between the locking element 2304 and the blow-up 2302; a second fill block 2306, locked between the reversed small dome end 2222 and the blow-up 2302 of the supporting tube. The reinforced tube 1123 and the reinforced plate 1124 thereof surround the supporting tube 2301, so as to strengthen the structure of the supporting tube 2301. As a result, during the movement of the tank 100, the leftward and rightward longitudinal force caused by the inner vessel 120 and the cargo will press the second fill block and the first fill block, and then is transferred to the outer shell through the supporting tube. Using finite element structure and thermal analysis software, the inner support structure, which satisfies the requirement of heat leakage and stress with maximal shipment capacity, is designed in control, and the gap of the first dome ends provided with longitudinal support should only satisfy the requirement for assembly, which in deed obtains the inner support structure well matching with the super-vacuum multilayer insulation structure. In the present invention, at the end provided with the longitudinal support structure, the distance between the dome ends of the inner vessel and the outer shell to transfer longitudinal force, is determined by the liquid sealing of the tube to deliver liquid or gas and the necessary gap for compensation for the heat-expansion and cold-shrink effect, for instance, the gap can be around 300 mm. In addition, in order to improve the strength of the supporting tube, the supporting tube can be provided with a reinforced structure.

The first radial support structure 210 together with the second radial support structure 220 bears the radial force caused by the inner vessel 120 and the shipped medium. The outer circles of the supporting plates 2103, 2203 contact with the dome ends 122, 123 at the portions extending into the inner vessel 120, which is advantageous for arranging the longitudinal support and reducing the heat leakage caused by the longitudinal support. The inner circles of the supporting plates 2103, 2203 engage with the supporting tubes 2301, 1132 which are mounted on the dome ends 112, 113 of the outer shell 110, thus making the radial force balanced and increasing the reliability of the support structure. At the same time, a good insulation performance is obtained; the longitudinal conduction heating surface between the inner vessel and the outer shell is only the stress surface of the inner support structure, and heat is transferred by radiation on other areas of the vessel, which successfully overcomes the problem of the heat leakage of the longitudinal support in the relating art. Furthermore, due to the small distance between the inner and outer end dome ends, the shipment ratio is increased at the same time. The supporting plate of the present invention is formed of proper glass-fiber plastic material. By the finite element analysis and experimental test, it is possible to make the gap at the inner ring and the outer ring self-adjust and change little when transforming from normal temperature state to cryogenic state, which improves the shock resistance ability of the structure in radial direction and is advantageous for assembly and gap control at normal temperature.

Furthermore, the present invention takes full advantage of the characteristics of the glass-fiber plastic material that the ratio of the compression strength to coefficient of heat conductivity is larger than the contact thermal resistance, which improves the ability of the support structure to bear radial force and reduce the heat leakage, thereby solving the tough problem in the relating art that the expansion of the gap in cold conditions is disadvantageous for shock resistance. The portion where the dome end of the inner vessel extends into the inner vessel lengthens the length of the glass-fiber plastic fill block in longitudinal direction, which reduces the heat leakage of the longitudinal support and solves the problem in the relating art that it is impossible to control the heat leakage by the support structure in longitudinal direction. At the same time the maximal volume is ensured to hold liquid in the limited overall size and solves the paradox between the inner stress and heat insulation.

The tank of the present invention is very convenient for assembly. Firstly, the second dome end 113 is welded with the cylinder 111 to form a combined portion. Secondly, the first dome end 122, the second dome end 123 and the cylinder 121 are welded together to form the inner vessel 120. Then, multiple layers of heat insulation material are entwined on the outer surface of the inner vessel 120. During assembly, firstly, the second radial supporting plate 2203 and the fixed ring 2201 on the inner side thereof are put into the inner vessel 120; then the outer fixed ring 2202 is put into and the inner circle of the outer fixed ring 2202 is pressed firmly by using a special tool; and then, the outer fixed ring 2202 is welded corner-joint with the second extended neck of the inner vessel 120, to conveniently install the combined portion of the outer shell to enclose the second radial supporting plate 2203 under the guide of the horizontal assembly process tube. Secondly, the first radial supporting plate 2103 and the fixed ring 2101 at the inner side thereof are put into the inner vessel 120; then the outer fixed ring 2102 is put in and the inner circle of the outer fixed ring is pressed firmly by a special frock, and the outer fixed ring 2102 is welded corner-joint with the first extended neck; then the second fill block 2306 is put onto the supporting axle 2303; finally, the first dome end 122 of the outer shell 110 is installed to enclose the first radial plate 2103, and the first dome end 112 is welded with the combined portion of the outer shell. In the following step, the first fill block 2305 is put into the supporting tube 2301 and locked onto the supporting axle 2303 by the locking element 2304 to press the first fill block 2305 and the second block 2306, and the locking element 2304 is welded corner-joint with the supporting axle 2303 to realize the assembly of the combined support structure. Lastly, the first sealing plate 1125 is welded corner-joint with the first stiffening plate 1122 and the second stiffening plate 1133 is welded corner-joint with the second sealing plate 1137, thereby forming the tank accordingly. Through super-vacuum pumping, a super-vacuum insulation layer 104 is formed between the outer shell 110 and the inner vessel 120. Then the stiffening rings 103 of the outer shell 110 are welded on the outer surface of the outer shell 110.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

WHAT IS CLAIMED IS:

1. A super-vacuum insulation tank for cryogenic liquefied gas, comprising

a framework; and

a tank body, including

an outer shell, including a cylinder and two dome ends;

an inner vessel, including a cylinder and two dome ends;

a super-vacuum insulation layer between the outer shell and inner vessel; and

a support structure connecting the outer shell and the inner vessel,

wherein

the support structure is a combined support structure only provided between the dome ends of the out shell and the inner vessel at both ends of the tank to bear the force in radial and longitudinal direction.

2. The tank according to claim 1, wherein the distance between the outer shell and the inner vessel is not more than 50 mm.

3. The tank according to claim 1 or 2, wherein the center of the dome end of the inner vessel depresses into the inner vessel and forms a reversed small dome end, and the cambered surface of the reversed small dome end is opposite to the cambered surface of the dome end of the outer shell.

4. The tank according to claim 3, wherein the support structure is provided with

a supporting plate, contacting with the reversed small dome end but keeping a self-adjustable contacting gap;

two fixed rings, disposed on both sides of the supporting plate to hold the supporting plate.

5. The tank according to claim 1, 2 or 4, wherein an extended neck is provided between the dome end of the inner vessel and the reversed small dome end, and the support structure is disposed at the position of the extended neck.

6. The tank according to claim 4, wherein the support structure further comprises a longitudinal support structure provided between the dome ends of the inner vessel and the outer shell, and passes through the center hole of the supporting plate, comprising:

a supporting tube, provided with a blow-up on the inner surface thereof and mounted on the inner side of the dome end of the outer shell;

a supporting axle, passing through the blow-up and extending into the supporting tube to be fixed to the small reversed dome end;

a locking element, provided at the end of the supporting axle; and

a first fill block, locked between the locking element and the blow-up;

a second fill block, locked between the small reversed dome end and the blow-up of the supporting tube.

7. The tank according to claim 6, wherein the distance between the dome ends of the inner vessel and the outer shell at the support end to transfer the longitudinal force is determined by required distance for the liquid sealing of the tube to transmit liquid or gas and the compensation for the heat-expansion and cold-shrink effect.

8. The tank according to claim 6, wherein a reinforced tube is further mounted on the dome end of the outer shell, and the reinforced tube is disposed outside the supporting tube.

9. The tank according to claim 8, wherein a reinforced plate is provided between the reinforced tube and the supporting tube.

10. The tank according to claim 1, wherein one of the reversed small dome ends of the inner vessel is provided with a horizontal process tube cooperating with the supporting tube, to realize the guiding and positioning during horizontal or vertical assembly.

11. The tank according to claim 1, wherein a reinforced plate is provided on the inner side of the dome ends of the outer shell and the inner vessel respectively.

12. The tank according to claim 1, wherein the combined support structure is formed of materials with good mechanical character and low coefficient of heat conductivity such as glass-fiber plastic material or the like, to bear and transfer all forces but insulate heat transfer and take advantage of contact thermal resistance to further reduce heat transfer.

13. The tank according to claim 1 or 2, wherein a plurality of reinforced rings is provided outside of the outer shell.

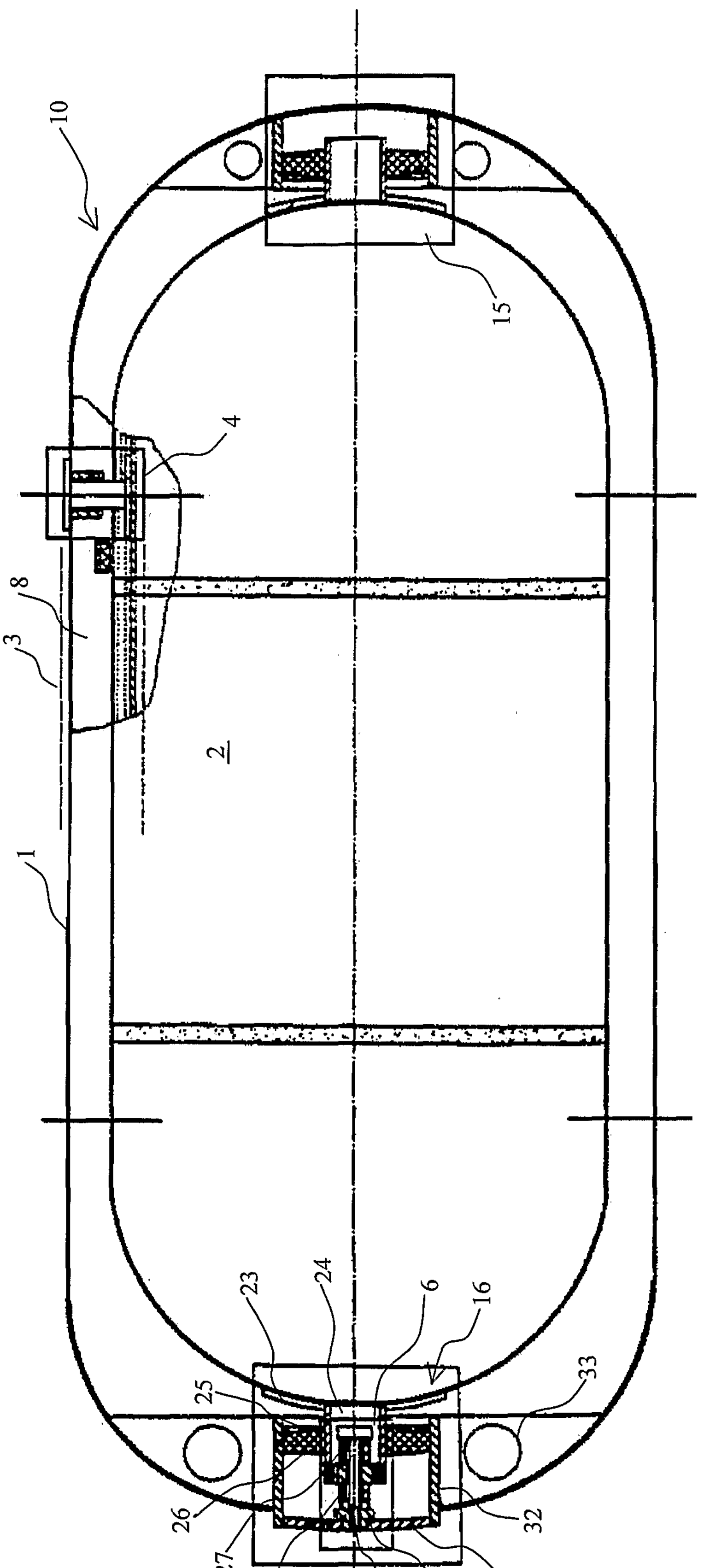

Fig.1

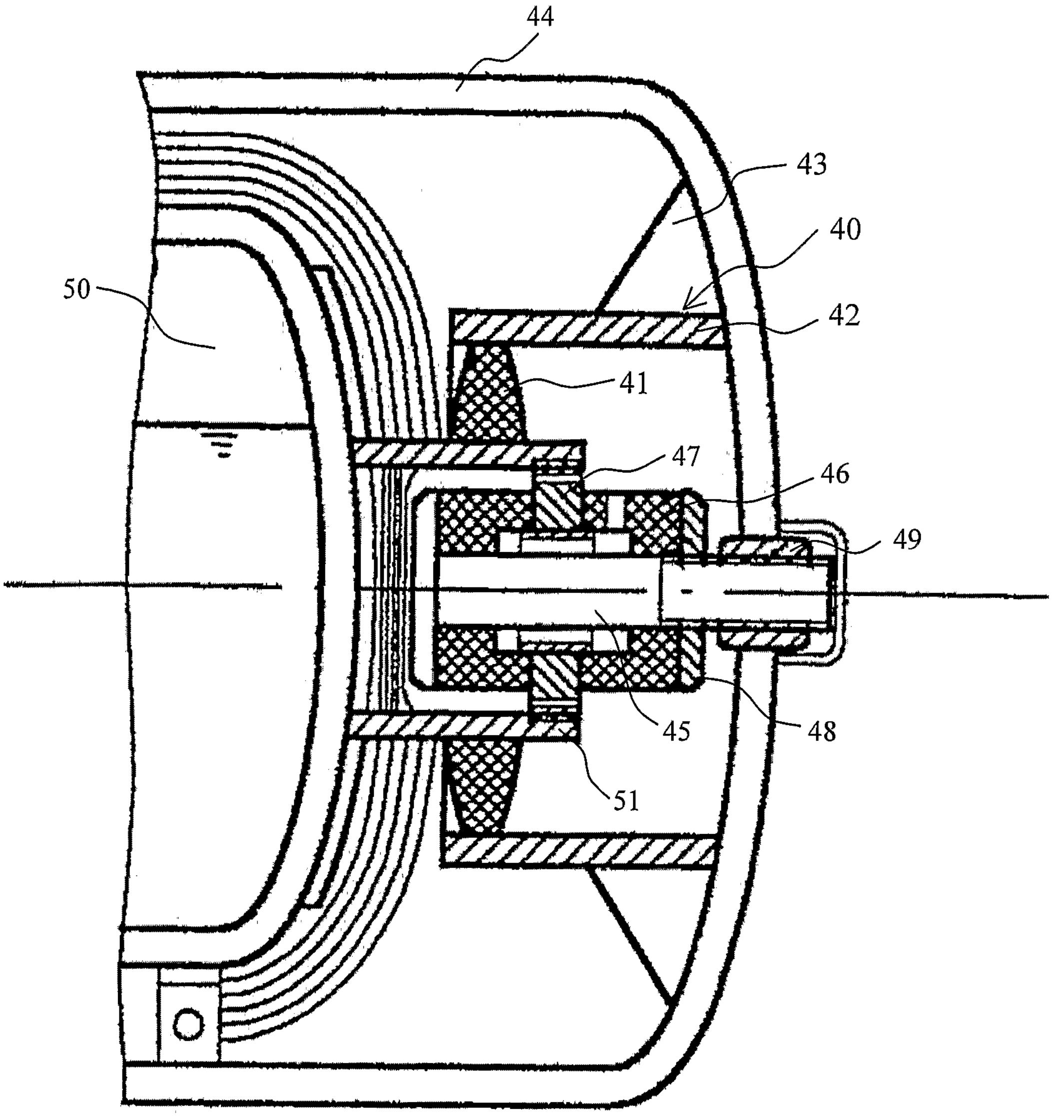

Fig.2

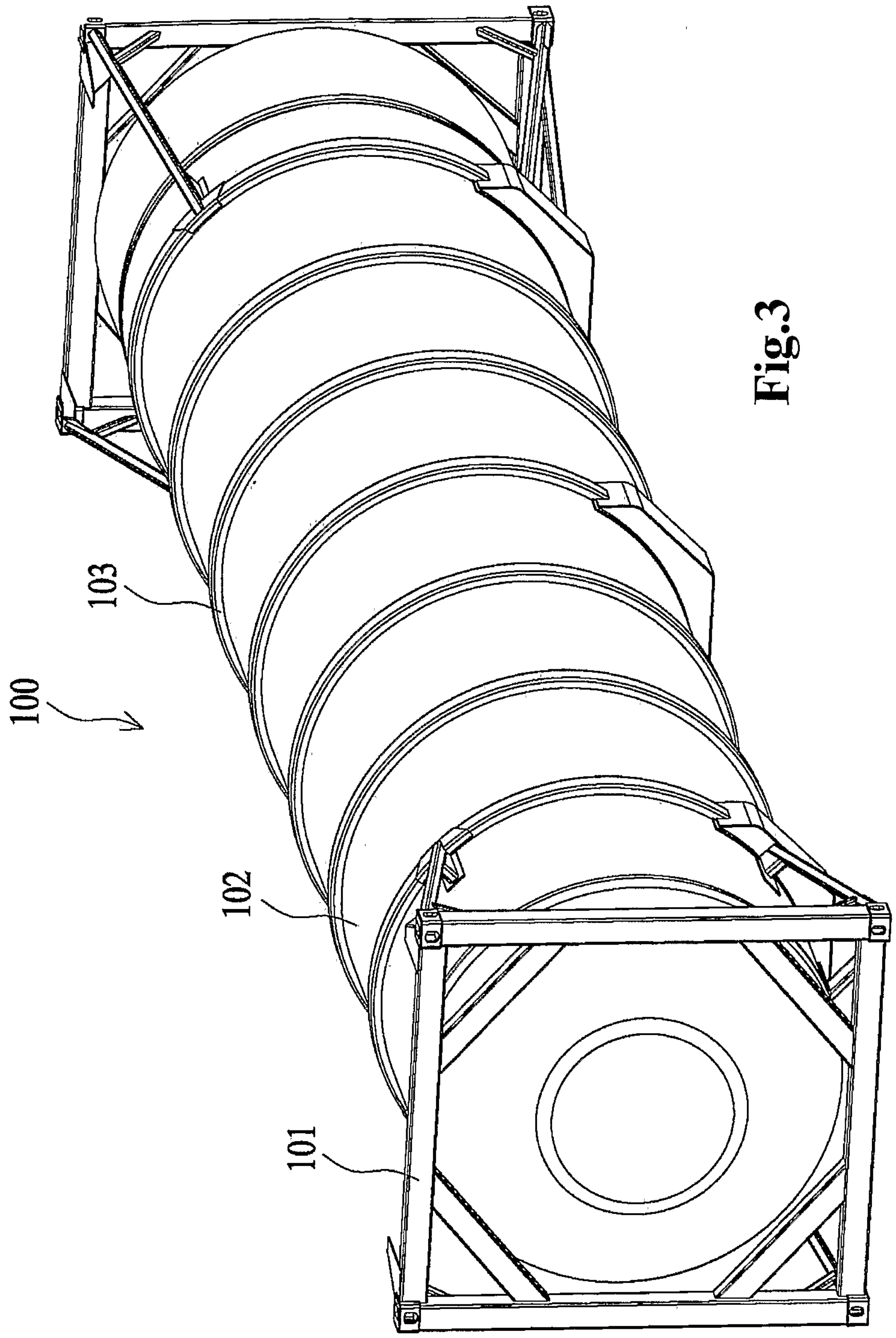

Fig.3

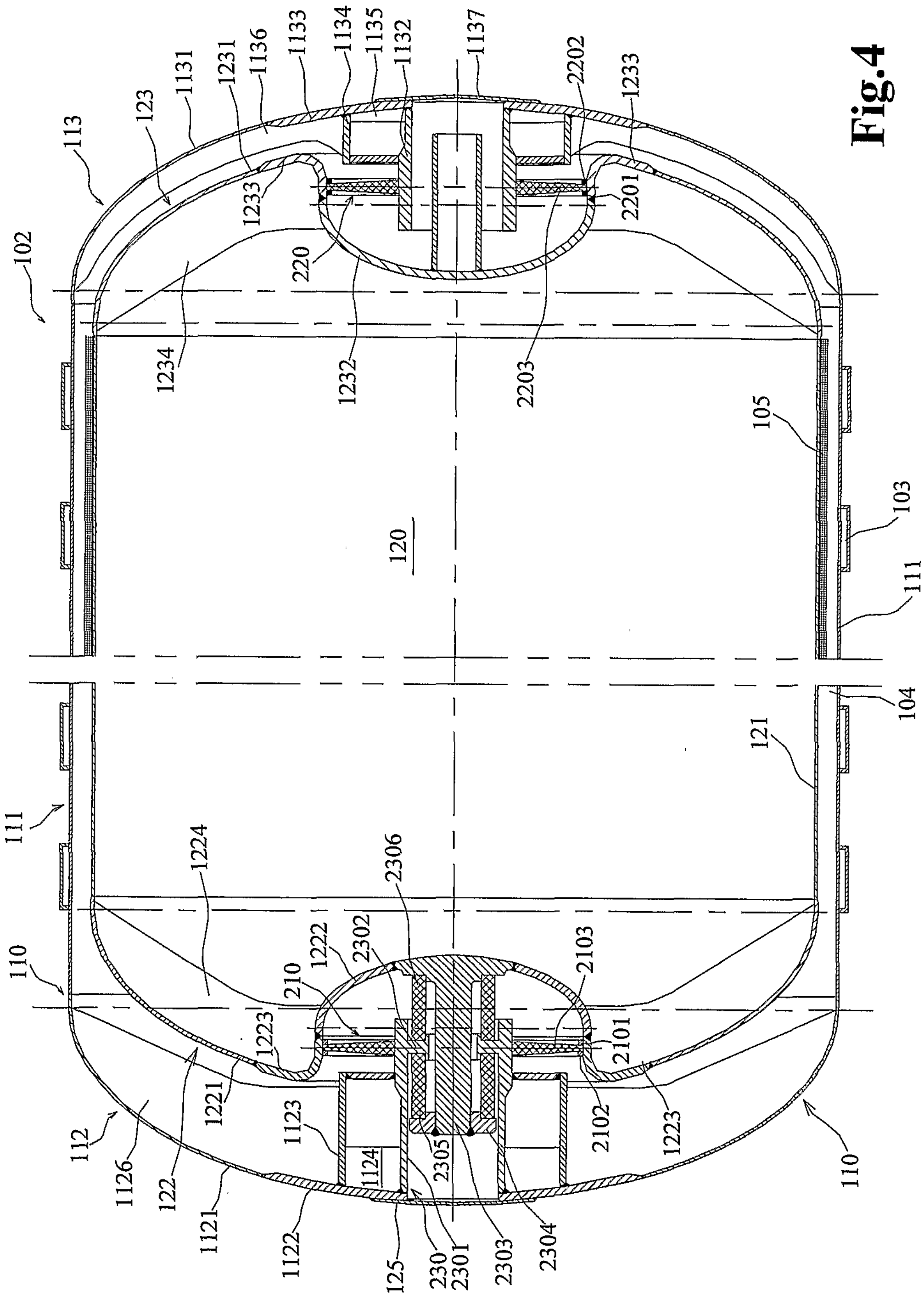
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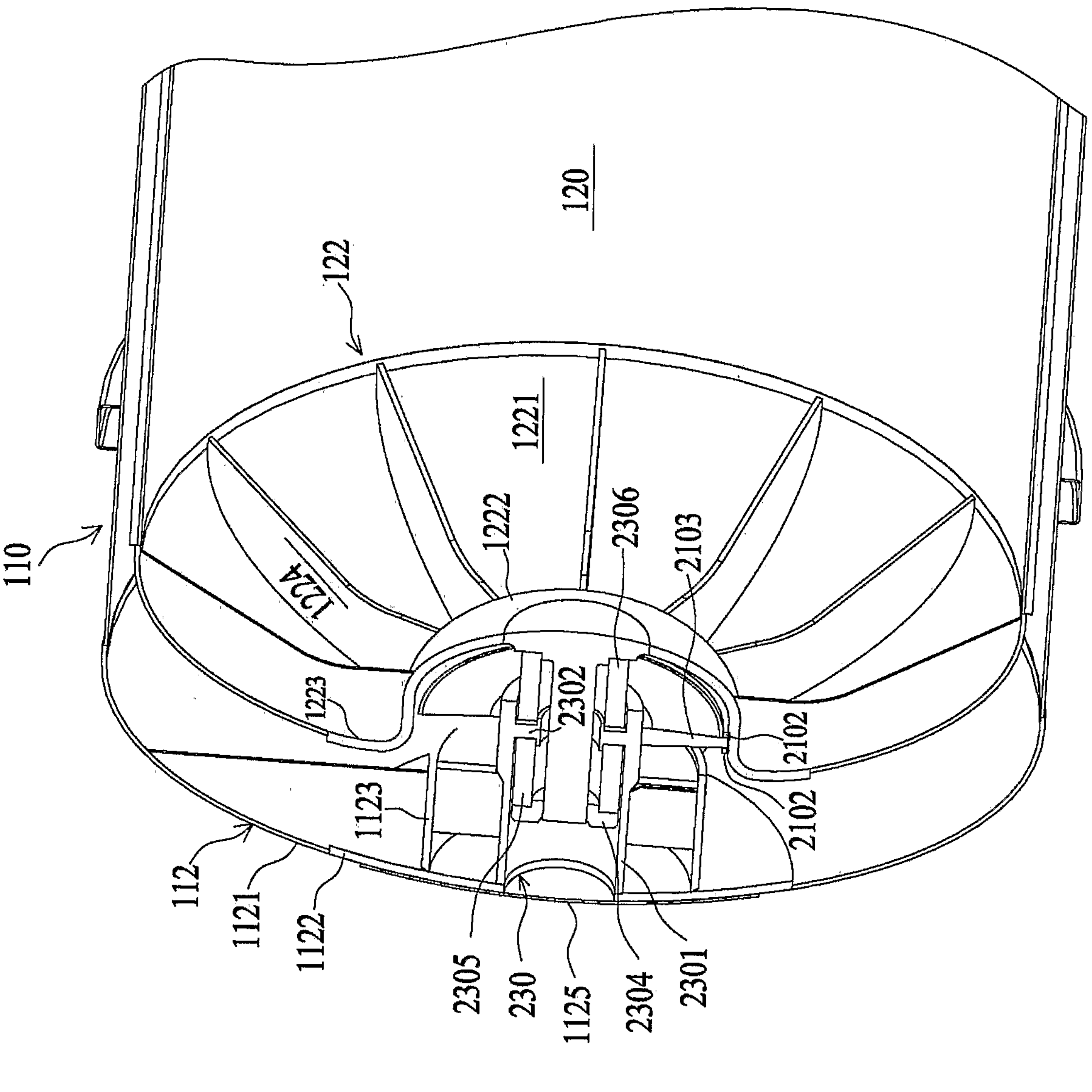
Fig.4

Fig.5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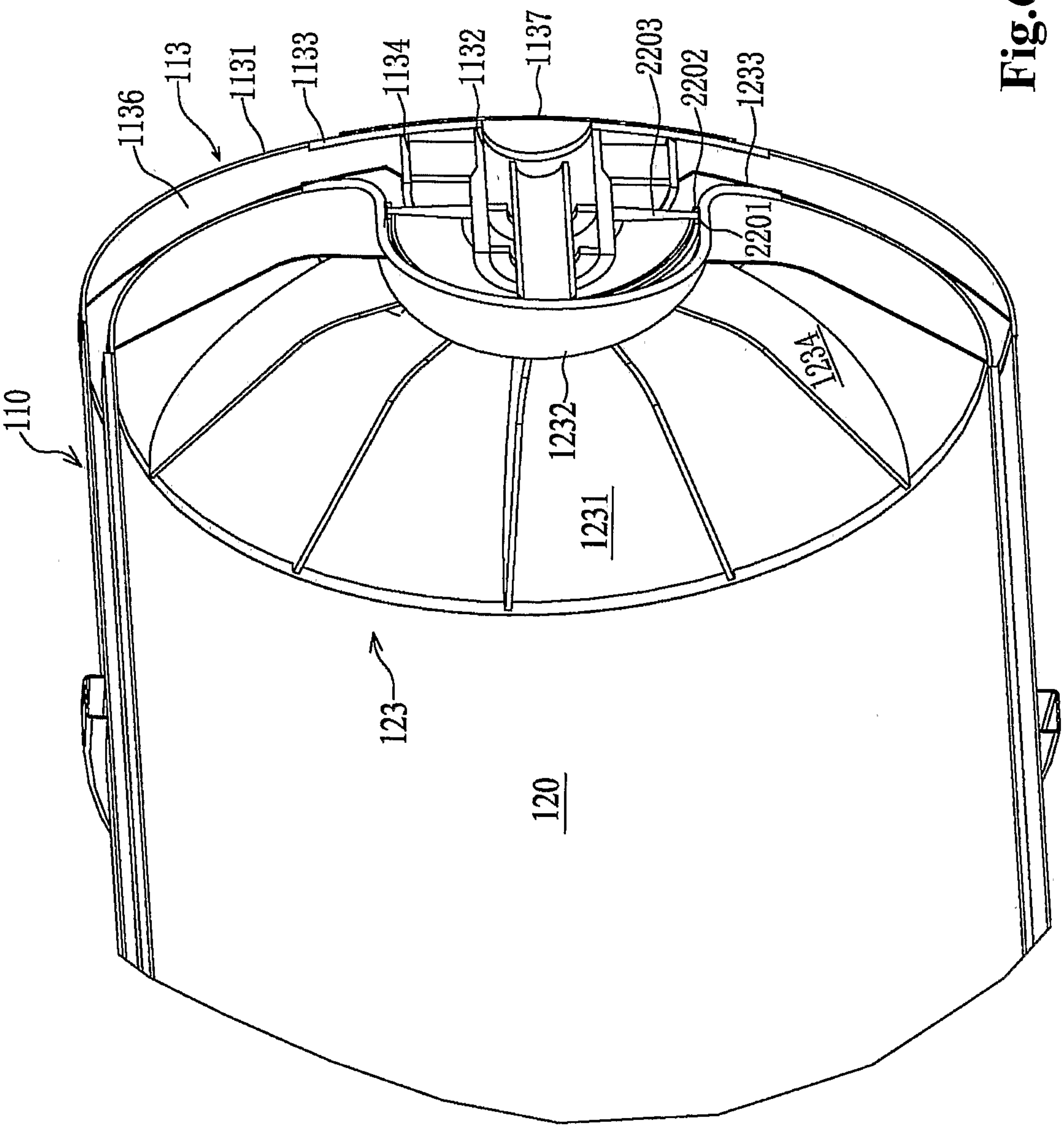
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Fig.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2005/000447

A. CLASSIFICATION OF SUBJECT MATTER

IPC[7] B65D88/00, F17C1/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[7] B65D 81/38,81/00,85/00, 88/00,90/52,90/00 F17C1/12,1/00,3/00,5/00,6/00,7/02,7/00 F23K5/02,5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

CHINESE INVENTION PATENT APPLICATIONS AND CHINESE UTILITY MODELS SINCE 1985

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Data basse: EPODOC, WPI, PAJ, CPRS Search term:tank, liquld+, support, radial, longitudinal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN,Y,2427489 (SHANGHAI JIAOTONG UNIVERSITY) 25.Apr.2001 (25.04.2001), page 1,line 17-page 3,line 8 and figure 1	1-2,10-13
A		3-9
L	CN,Y,2695767 (CHINA INTERNATIONAL MARINE CONTAINERS (GROUP) CO. LTD.) 27.Apr.2005 (27.04.2005), claims 1-12	1-4,6-11,13
L	CN,Y,2702155 (CHINA INTERNATIONAL MARINE CONTAINERS (GROUP) CO. LTD.) 25.May.2005 (25.05.2005), claims 1-10	2-4,6-11

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20.Jun.2005 (20.06.2005)	21 · JUL 2005 (2 1 · 0 7 · 2 0 0 5)

Name and mailing address of the ISA/CN	Authorized officer
The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	GUAN,Shansong Telephone No. 86-10-62085529

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2005/000447

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN,Y,2528733(ZHANGJIAGANG SHENGDAYIN CHEMICAL INDUSTRY MACHINE CO.LTD.) 01.Jan.2003 (01.01.2003), the whole document	1-13
A	CN2451917Y(SHANGHAI JIAOTONG UNIVERSITY) 03.Oct.2001 (03.10.2001) , the whole document	1-13
A	US3782128A(LOX EQUIPMENT COMPANY) 01.Jan.1974 (01.01.1974) , the whole document	1-13

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2005/000447

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN, Y, 2427489	25.Apr.2001 (25.04.2001)	None	
CN, Y, 2695767	27.Apr.2005 (27.04.2005)	None	
CN, Y, 2702155	25.May.2005 (25.05.2005)	None	
CN, Y, 2528733	01.Jan.2003 (01.01.2003)	None	
CN, Y, 2451917	03.Oct.2001 (03.10.2001)	None	
US, A, 3782128	01.Jan.1974 (01.01.1974)	None	