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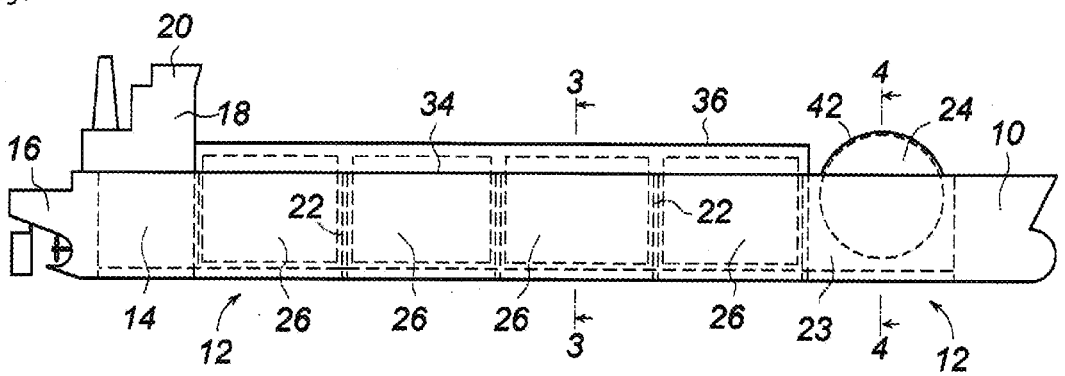
(54) LIQUEFIED NATURAL GAS CARRIER VESSEL, AND MARINE TRANSPORTATION METHOD FOR LIQUEFIED NATURAL GAS

(57) An LNG tanker is provided which can have larger tank capacity for its hull size, be easily built, and reduce the sloshing in membrane type tanks during a heavy weather. The foremost LNG tank is made in a spherical independent type (24), and each of subsequent tanks is made in membrane type (26). The membrane type of tank has heat insulating material on the inner shell of a double hull with its surface covered by membranes. During the voyage, the liquid cargo (LNG) in the spherical independent type tank is transferred to membrane type of tanks, thereby to compensate LNG losses caused by generation of boil-off gas in the membrane type tanks.

Fig. 1



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Description

Technical Field

[0001] The present invention relates to marine transportation of liquefied natural gas (LNG).

Background Art

[0002] There is an increasing demand for LNG as clean energy, since LNG emits less nitrogen oxide and sulfur dioxide during burning. LNG can be produced by cooling the natural gas down to approximately -160°C where it turns into a liquid. A tanker for marine-transporting LNG is provided with cargo tanks which are made of cryogenic materials to withstand extremely low temperature, and have structures to provide for thermal detonation of materials due to temperature differences. Further, most of LNG tankers can sail at sea speed of about 20 knots in order to undertake a role of high-speed and mass transportation. In recent years LNG tankers are getting larger, and there are plans to construct LNG tankers with tank capacity of more than 200,000 m^3.

[0003] In LNG tankers of the prior art, LNG tanks thereon are roughly divided into two types; one is of the spherical free-standing type, and the other is of the membrane type (for example, U.S. Patent No. 5697312 and U.S. Patent No. 7137345).

[0004] A spherical free-standing type of tank is a spherical tank of aluminum alloy which is supported in a ship's hold via a skirt-shaped structure extending downward from the equator of the spherical tank. In this type of tank, both the weight of liquid cargo therein and dynamic force acting on the liquid cargo due to the ship's rolling and pitching motion are carried by the tank itself, and the hull supports the tank via its skirt. Outer circumference of the tank is applied with thermal insulation material.

[0005] Since each of ship's holds has usually a boxlike shape, there can be wasted spaces between the hull and a spherical tank mounted therein. Thus, a tanker with spherical free-standing tanks usually has a drawback that it has less tank capacity for its hull size.

[0006] On the other hand, the membrane type of tank is defined by a double hull structure, the inner surface of which is provided with thermal insulation material, and then covered by liquid-tight membranes. In this type tanks, the weight of LNG freight is carried by the hull structure via the thermal insulation material. The membranes are made of stainless steel or nickel alloy (Invar) which have lower coefficient of thermal expansion.

[0007] A membrane type tank can be formed in accordance with the hold shape, so it can generally get larger tank-capacity and good volumetric efficiency. However, when formed in a narrow space of the fore portion of hull, a membrane tank will take an irregular shape which may require extra time and effort in construction. Basic form for a membrane type of tank is boxy; it is difficult to make the tank into the shape quite far from box form. Therefore, to lessen wave-making resistance at high speed, the cross section of fore part of hull can be formed at most U-shape, but not formed into so fine shape such as V-shape.

[0008] In a membrane type of tank, sloshing of the LNG can be problematic, particularly in heavy weather. That is, the ship's movement may agitate the liquid surface of LNG in tanks, and resultant hydrodynamic loads may damage heat insulation and membrane material. Thus, it is preferable that membrane type tanks are kept in an almost full loaded state to prevent LNG agitation. In a spherical tank, curved tank walls can turn aside the hydrodynamic loads; besides, the thermal insulation material is provided on the outer circumference of the tank. Therefore, sloshing hardly causes a problem.

[0009] Regardless of types of LNG tank, external heat will, more or less, enter into LNG tanks, thereby causing to some extent an increase in the tank temperature. This may accelerate the generation of boil-off gas (BOG) in the tank. Since the gas generation may make the tank pressure higher, it is sucked by a compressor and delivered to a combustion apparatus such as a boiler to be combusted. Combustion energy obtained is used for ship propulsion or the like. A boil-off rate of gas may vary depending on the thermal insulation performance of the LNG tank, and it ranges from approximately 0.10 to 0.25% per day. Due to such gradual decrease of liquid cargo, the risk of sloshing may increase day by day after leaving a loading port.

Disclosure of the Invention

[0010] An object of the present invention is to provide an LNG tanker which has higher volumetric efficiency of a tank and is easy to construct. Another object of the present invention is to reduce sloshing in membrane type of LNG tanks.

[0011] The present invention is to provide an LNG tanker in which the foremost LNG tank is of a spherical free-standing type of tank, and each of other subsequent tanks are of membrane type tanks. By making most of the LNG tanks in a membrane type in this manner, the tanker is able to have a higher volumetric efficiency and thus a larger tank capacity for the size of its hull.

[0012] The foremost LNG tank is formed in a narrow space of the fore portion of the hull. If that tank is made in membrane type, it may become of irregular shape and require laborious heat-insulating works. In the present invention, the foremost tank is made in the spherical free-standing type, the construction works are very easy and done in short period, particularly by making a spherical tank on the work shop and then mounting it on the hull. Further, the foremost spherical tank can be installed even in a narrow space with V shape cross section, thus providing a ship's bow of fine form suitable for high speed sailing.

[0013] The present invention is further to provide a method of marine transporting LNG in which LNG tanks

are made in two different types, one is a membrane type and the other is a spherical free-standing type. During transport, LNG in the spherical free-standing type tank is transferred to the membrane type tank. This can make up for the loss of boil-off gas in the membrane tank and keep them nearly full of LNG, so that the sloshing problem is solved.

Brief Description of Drawings

[0014]

Fig. 1 is a side view of an LNG tanker according to the present invention;
Fig. 2 is a plan view of the LNG tanker shown in Fig. 1;
Fig. 3 is a cross sectional view of a membrane type tank part taken along a line 3-3 in Fig. 1;
Fig. 4 is a cross sectional view of a spherical tank part taken along a line 4-4 in Fig. 1;
Fig. 5 is a transverse sectional view of a foremost membrane tank in a prior art LNG tanker; and
Fig. 6 is a piping diagram for transferring liquid cargo between tanks in the LNG tanker shown in Fig. 1.

Best Mode for Carrying out the Invention

[0015] Referring now to the Fig. 1 and Fig. 2, there is shown an LNG tanker which includes a bow portion 10, a tank section 12, an engine room 14 and a stem portion 16 in succession. On the engine room stands an accommodation space 18 and a steering room 20 thereon. The tank section 12 is divided by transverse bulkheads 22 into a plurality of divisions, the foremost division 23 of which is equipped with a spherical free-standing type tank 24, and each of other subsequent divisions form membrane type tank 26.

[0016] As shown in Fig. 3, each membrane type tank 26 is surrounded by double hull structures; its inner hull 28 are covered with thermally insulation material 30, which is liquid-tightly covered by a membrane materials 32. The membrane tank 26 has a head portion which protrudes upward through an upper deck 34 to increase the tank capacity, and the head portion is covered with a trunk deck 36.

[0017] Fig. 4 shows a transverse sectional view of the foremost division in which the spherical free-standing type tank is provided. The spherical tank 24 is constructed on a workshop and then built onto the hull. The tank has a skirt 40 which extends downward from the equator of the tank and is supported on a double bottom of the hull. An upper part of the spherical tank 24 protrudes upward through an upper deck 34, which is covered with a dome shape cover 42.

[0018] Fig. 5 shows the foremost tank division 23 where the membrane type tank is provided instead of the spherical free-standing type tank shown in Fig. 4. The hull form in this section is so fine (or slender) that the shape of the membrane tank 26 is getting narrower to a fore point as shown with chained lines 44. Thus, it becomes an irregular shape, so the construction thereof is complicated and will take much time and labor. On the other hand, a spherical type tank 24 can be constructed in a workshop and then installed in the foremost tank division 23 of the hull; therefore, adoption of a spherical type tank for the foremost tank division can facilitate construction works and shorten a work periods.

[0019] Basically a membrane type tank will take the form of a cubic or the like as shown in Fig 5; therefore, this type of tank is difficult to locate in a very fine shaped portion of hull. On the other hand, a spherical free-standing tank is of round shape and placed at a little higher position as shown in Fig. 4, therefore this type tank can be installed in the very fine, V-shaped bow portion of the hull. Accordingly, by adopting the spherical free-standing tank for the foremost tank, the bow portion of the hull can get a fine shape, resulting in reduced propulsion resistance of the ship in a high-speed range.

[0020] This tanker starts from a loading port with all of the LNG tanks full of LNG. During a voyage, the temperature of each LNG tank will increase by the ambient heating, thus causing boil-off gas to generate from the LNG cargo. If boil-off gas is left as it is, internal tank pressure may rise gradually. Thus, as shown in Fig. 6, the boil-off gas (BOG) generated in each of the tanks is sucked out of the tank by a compressor 46, so that tank pressure can be kept appropriate. The gas extracted from the tank is warmed and then combusted in a boiler 48 to generate steam, which can drive a turbine for ship propulsion and electric power supply.

[0021] In this way the BOG is extracted from the tank; as a result the liquid amount in each of the tanks will decreases gradually with time. Therefore, the longer a voyage lasts, the greater is the risk of sloshing in the membrane type tank, especially in rough weather. In the LNG tanker of the present invention, the liquid cargo (LNG) in the spherical free-standing type tank 24 is pumped out by a pump 50 installed in the same tank, and it is transferred to other tanks through a pipe 52 in order to recover the liquid amounts of the membrane type tanks 26 to an almost full state. Accordingly, sloshing in the membrane tank is not likely to happen even in rough weather, and damages of the membrane type tank due to sloshing can be prevented. The liquid amount in the spherical tank 24 will decrease gradually owing to the cargo transfer, but sloshing is unlikely to happen in this type of tank as described above.

Claims

1. A liquefied natural gas (LNG) carrying ship comprising:

   a plurality of LNG tanks on board said ship, including a foremost tank and a plurality of subsequent tanks; and

said foremost tank being made in a spherical free-standing type and said subsequent tanks each being made in a membrane type.

2. A method for marine transporting LNG comprising:

providing two different types of LNG tanks on-board, one being of a spherical free-standing type of tank, and the other being of a membrane type of tank; and
transferring LNG from said spherical free-standing type of tank to said membrane type of tank so as to compensate LNG losses caused by generation of boil-off gas in said membrane tank during a voyage.

Fig. 1

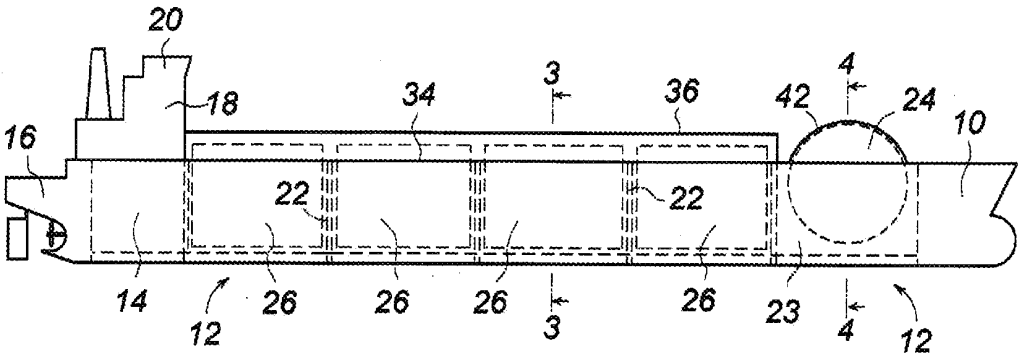


Fig. 2

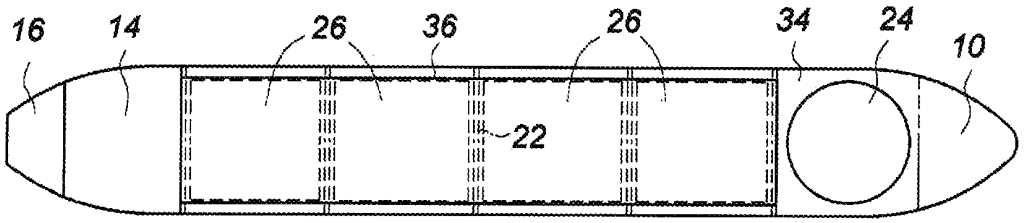


Fig. 3

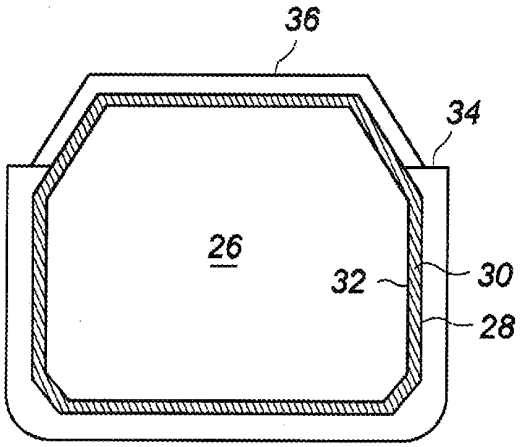


Fig. 4

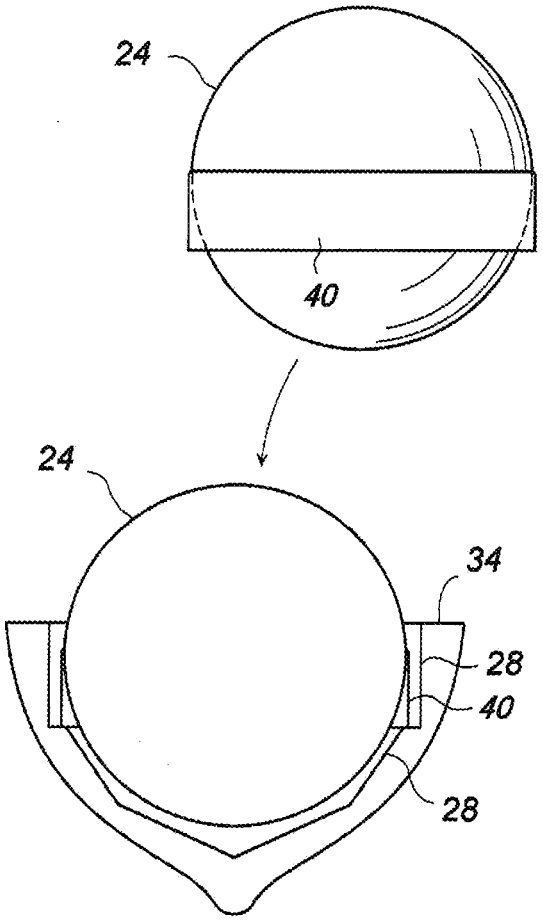


Fig. 5

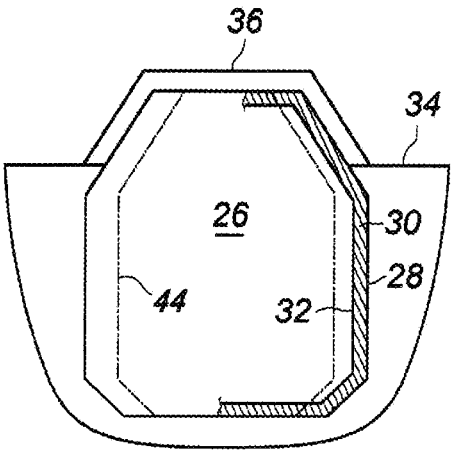
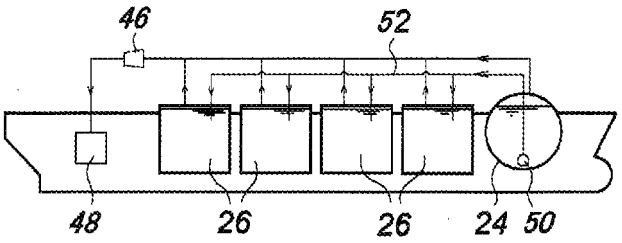


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/061975

A. CLASSIFICATION OF SUBJECT MATTER
B63B25/16(2006.01)i

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)
B63B25/16

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2008
Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 6-270987 A (Hitachi Zosen Corp.), 27 September, 1994 (27.09.94), Full text; all drawings (Family: none)	1,2
A	JP 2002-506960 A (Mobil Oil Corp.), 05 March, 2002 (05.03.02), Full text; all drawings & US 6089022 A & WO 1999/047869 A1	1,2
A	JP 35-26539 Y1 (Uiriamu Kori Ando San Ltd.), 08 October, 1960 (08.10.60), Full text; all drawings (Family: none)	1,2

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

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Date of the actual completion of the international search	Date of mailing of the international search report
22 September, 2008 (22.09.08)	07 October, 2008 (07.10.08)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/061975

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 96422/1986(Laid-open No. 2695/1988) (Mitsubishi Heavy Industries, Ltd.), 09 January, 1988 (09.01.88), Full text; all drawings (Family: none)	2

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 5697312 A **[0003]**
- US 7137345 B **[0003]**