

**FLOATING LOW-TEMPERATURE LIQUEFIED GAS FILLING
EQUIPMENT AND LOW-TEMPERATURE LIQUIFIED GAS
DELIVERY METHOD USING SAME**

5 Technical Field

[0001] The present invention relates to a floating low-temperature
liquified gas filling apparatus, and a method of delivering low-temperature
liquified gas using the apparatus. In particular, the present invention relates to a
floating low-temperature liquified gas filling apparatus, and a method of
10 delivering a low-temperature liquified gas using the apparatus that make it
possible to directly and simultaneously fill low-temperature liquified gas into
containers placed on a plurality of transport trucks on the ground. Also, the
apparatus and method make it possible to easily and efficiently deliver low-
temperature liquified gas to the places where there are no facilities to receive
15 low-temperature liquified gas.

Background Art

[0002] A country that produces oil and gas within its own territory can export surplus oil and gas after consuming the required amount of these if it produces an amount exceeding its own consumption. If the amount of oil and gas produced in a country is less than the amount consumed there, a required amount of oil and gas must be imported from other countries. It is desirable in such a case, that the gas or oil to be purchased as fuel is one that has a low environmental load, such as liquefied petroleum gas (LPG) or liquefied natural gas (LNG). In particular, because LNG emits less CO₂, and sells at a lower price compared with petroleum products, LNG is expected to be used more in the future than petroleum products.

[0003] Low-temperature liquified gas liquefied by low temperature is transported by sea using a specialized large transport ship (LNG carrier). The transported low-temperature liquified gas is usually transferred to a storage facility on the receiving side, which is a primary terminal. From this storage facility, the liquified gas is either transported on the ground to another storage

facility, which is a secondary terminal, or gasified by a gasification facility to be delivered directly to consumers through pipelines. If there is no storage facility or gasification facility serving as a primary terminal at the receiving side, the following distribution methods are also used practically: transported

5 low-temperature liquified gas is transferred from a large transport ship to a Floating Storage and Regasification Unit (FSRU) (i) to be stored therein instead of being stored in the primary terminal, or (ii) to be supplied to pipelines on the ground after regasification.

[0004] However, a limited number of ports are equipped with port facilities

10 that are large and deep enough to allow LNG carriers or FSRUs to be berthed, and there are a limited number of areas that are prepared to receive low-temperature liquified gas. It is not realistic to build such large, dedicated infrastructures in countries that consist of scattered islands, or in developing countries, where resources are limited, even if people in those areas want to use

15 low-temperature liquified gas.

[0005] Patent Document 1 (Japanese Unexamined Patent Application

Publication No. 2009-191860) discloses a low-temperature liquified gas delivery device to deliver gas to remote islands, which includes a floating transport facility provided on a floating structure. The floating transport facility includes

- (1) a storage facility to store low-temperature liquified gas,
- 5 (2) a pump that takes stored low-temperature liquified gas out of the storage facility, and sends the taken-out gas to a receiving facility, and
- (3) a supply facility having a vaporizer that sends out the low-temperature liquified gas as a vaporized gas to a receiving facility, by which the transport facility can supply the low-temperature liquified gas to the receiving facility as a liquid or as a vaporized gas.

[0006] The invention of Patent Document 1 has an advantage that a gasification facility can be eliminated from the receiving facility because the floating transport facility can supply the low-temperature liquified gas as a liquid or as a vaporized gas, which provides options for means of receiving that the receiving facility can utilize. However, the invention of Patent Document 1 presupposes that the port that receives low-temperature liquified gas is provided

with such a receiving facility.

[0007] Accordingly, the invention of Patent Document 1 has disadvantages as follows:

- (1) Even if the facility is small, the cost of constructing a receiving facility is
5 high, so that it is not easy to build a receiving facility at each port to
which low-temperature liquified gas is to be delivered; and
- (2) If the distance between the port to which the low-temperature
liquified gas is to be delivered and the area where low-temperature
liquified gas is consumed as fuel is far apart, a long pipeline must be
10 constructed, which is not easily realized.

Thus, there is a need for an apparatus and method that allow for delivering
low-temperature liquified gas easily and efficiently to a port to which
low-temperature liquified gas is to be delivered including to the port where there
is no receiving facility for the low-temperature liquified gas.

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Prior-art Document

Patent Document

[0008] Patent Document 1: Japanese Unexamined Patent Application

Publication No. 2009-191860

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SUMMARY OF THE INVENTION

Technical Problem

[0009] The present invention addresses the problems involving the conventional floating low-temperature liquified gas filling apparatus and the method of delivering low-temperature liquified gas. Objectives of the present invention are to provide a floating low-temperature liquified gas filling apparatus, and a method of delivering low-temperature liquified gas using the apparatus that make it possible to directly and simultaneously fill low-temperature liquified gas into containers placed on a plurality of transport trucks on the ground, and also make it possible to easily and efficiently deliver

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low-temperature liquified gas to the places where there are no facilities to receive low-temperature liquified gas.

Solution to Problem

5 [0010] In order to achieve the aforementioned objectives, the present invention provides a floating low-temperature liquified gas filling apparatus. The floating low-temperature liquified gas filling apparatus that delivers low-temperature liquified gas from sea to land includes a barge tank to be filled with low-temperature liquified gas to temporarily store the liquified gas, a hose for
10 transferring low-temperature liquified gas from a liquified gas supply facility to the barge tank, and for transferring low-temperature liquified gas from the barge tank to one or more containers placed on one or more transport trucks on the ground, a distribution unit of low-temperature liquified gas to be attached detachably to an end of the hose, a crane that holds the hose at a predetermined
15 height while low-temperature liquified gas is being transferred, and a filling means for filling the one or more containers with low-temperature liquified gas.

The distribution unit of low-temperature liquified gas includes an inflow port of low-temperature liquified gas, the inflow port being connected to an end of the hose, a plurality of discharge ports that simultaneously discharge low-temperature liquified gas to the plurality of containers, on-off valves, each of which selectively opens and closes each of the discharge ports, a plurality of injection hoses, each one end of which being connected to one of the discharge ports, and each another end of which being connected to each inlet of the plurality of containers, and a hook with which the crane lifts the distribution unit of low-temperature liquified gas. If low-temperature liquified gas is simultaneously filled into the plurality of containers, the distribution unit of low-temperature liquified gas is attached to the end of the hose, and is lifted to a predetermined height by the crane to be used. The distribution unit of low-temperature liquified gas is formed into a funnel shape, or a disk shape, the plurality of discharge ports are arranged at equal intervals in concentric circles so that low-temperature liquified gas outflowing each discharge port has equal outflow characteristics, and the degree of valve opening of each on-off valve is

adjusted so that the discharge flow rate of low-temperature liquified gas from each discharge port becomes equal. The injection hose is provided with, on the side thereof to be connected with the container, a sensor that detects the connection of the hose to the container, or a switch that is activated when the

5 hose is connected to the container, and if the injection hose is not connected to the container, the on-off valve of the discharge port to which the injection hose is connected is not opened.

[0011] It is preferable that the distribution unit of low-temperature liquified gas comprises a flow rate detecting means that detects each flow rate of

10 low-temperature liquified gas, which is discharged from the respective discharge ports. The distribution unit is capable of adjusting each of the discharge flow rates of the low-temperature liquified gas by the on-off valves, or by a flow rate adjusting means that is provided instead of the respective on-off valves, based on each of the detected flow rates of the low-temperature liquified gas.

15 [0012] It is preferable that low-temperature liquified gas is directly transferred by the filling means from the barge tank to one or more containers via the hose,

and via the distribution unit for low-temperature liquified gas.

[0013] It is preferable that the low-temperature liquified gas is Liquefied Natural Gas (LNG), the liquified gas supply facility is a liquefied natural gas carrier, or a Floating Storage Regasification Unit (FSRU), and the filling means
5 is a pressurized evaporator or a pump.

[0014] A method of delivering low-temperature liquified gas in order to achieve the aforementioned objectives includes a receiving stage comprising mooring a floating low-temperature liquified gas filling apparatus to a liquified gas supply facility, and transferring low-temperature liquified gas from
10 the liquified gas supply facility to a barge tank of the floating low-temperature liquified gas filling apparatus via a hose, a transporting stage comprising moving the floating low-temperature liquified gas filling apparatus to a place where low-temperature liquified gas is to be delivered, a filling stage comprising directly filling low-temperature liquified gas from the barge tank into one or
15 more containers that are placed on one or more transport trucks on the ground via the hose, and a connecting stage comprising connecting, prior to the filling

stage, a distribution unit of low-temperature liquified gas to an end of the hose from which low-temperature liquified gas is discharged, the distribution unit of low-temperature liquified gas being provided with a plurality of discharge ports, if low-temperature liquified gas is simultaneously filled in the containers.

- 5 [0015] It is preferable that the distribution unit of low-temperature liquified gas comprises an inflow port that is to be connected to the hose, a plurality of discharge ports from which low-temperature liquified gas is simultaneously discharged to the plurality of containers, on-off valves that selectively open and close the respective discharge ports, and flow rate detecting
- 10 means that detects each flow rate of low-temperature liquified gas discharged from respective discharge ports. It is preferable that the filling stage comprises selecting the required number of the on-off valves of the discharge ports to be opened corresponding to the number of the containers that are to be filled, and adjusting each of the discharge flow rates of the low-temperature liquified gas
- 15 by the on-off valves, or a flow rate adjusting means that is provided instead of the respective on-off valves, based on each of the flow rates of the low-

temperature liquified gas detected by the flow rate detecting means.

[0016] It is preferable that the low-temperature liquified gas is Liquefied Natural Gas (LNG), the liquified gas supply facility is a liquefied natural gas carrier, or a Floating Storage Regasification Unit (FSRU), and the filling means
5 is a pressurized evaporator or a pump.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0017] According to a floating low-temperature liquified gas filling apparatus,
and a method of delivering low-temperature liquified gas using the apparatus of
10 the present invention, low-temperature liquified gas is filled directly from the
floating low-temperature liquified gas filling apparatus into a container placed
on a transport truck, which makes it possible to transfer low-temperature
liquified gas to a port that is to receive low-temperature liquified gas as long as
there is an area where a transport truck can be parked. This eliminates need to
15 build expensive facilities for receiving low-temperature liquified gas, whereby
the apparatus and method of the present invention make it possible to deliver

low-temperature liquified gas to many areas where there are no such facilities for receiving low-temperature liquified gas.

[0018] Also, according to a floating low-temperature liquified gas filling apparatus, and a method of delivering low-temperature liquified gas using the apparatus of the present invention, the flow of low-temperature liquified gas is selectively branched off from the floating low-temperature liquified gas filling apparatus into a plurality of injection hoses by a distribution unit of low-temperature liquified gas, so that the flow of low-temperature liquified gas is divided into the number of transport trucks to receive the low-temperature liquified gas, which makes it possible to fill containers simultaneously. This allows for efficient filling of low-temperature liquified gas. Further, there are provided a flow rate detecting means that detects each flow rate of low-temperature liquified gas discharged from each discharge port of a distribution unit of low-temperature liquified gas and a flow rate adjusting means, so that in the case that low-temperature liquified gas is simultaneously filled into a plurality of containers, the variation in filling time can be eliminated, and filling

work can be performed efficiently.

[0019] Moreover, the floating low-temperature liquified gas filling apparatus of the present invention is provided with a hose that is used for both receiving and delivering. Therefore, there is no need for a liquified gas supply facility
5 such as a liquefied natural gas carrier, or a floating storage and regasification unit to be provided with a hose or a crane used for transferring liquefied natural gas. Similarly, there is no need for a receiving side that receives low-temperature liquified gas to be provided with a hose or a crane. Accordingly, as long as there are areas at a port where trucks can be parked, a single floating
10 low-temperature liquified gas filling apparatus can fill containers on trucks at a plurality of areas with low-temperature liquified gas. In addition, in the case that there is no need for those containers to be filled directly with low-temperature liquified gas any more in the future because a primary terminal having a facility to fill containers on trucks with low-temperature liquified gas is constructed on
15 the ground, the floating low-temperature liquified gas filling apparatus can move to other areas or islands by being towed or by self-propulsion, and can perform

delivering low-temperature liquified gas to the areas where there is no primary terminals.

[0020] Containers filled with low-temperature liquified gas can be transported by truck, rail, or cargo ship, making it possible to deliver low-temperature
5 liquified gas to small-scale users that are scattered over a wide area, which eliminates equipment such as pipelines, dedicated facilities, and primary or secondary terminals.

BRIEF DESCRIPTION OF THE DRAWINGS

10 [0021]

FIG. 1 is a schematic view of a floating low-temperature liquified gas filling apparatus and a method of delivering low-temperature liquified gas using the apparatus according to an embodiment of the present invention.

FIG. 2 is a schematic plan view showing a method of transferring
15 low-temperature liquified gas to a container on the ground using a floating low-temperature liquified gas filling apparatus according to an embodiment of the

present invention.

FIG. 3 is a schematic diagram that depicts the structure of a distribution unit of low-temperature liquified gas.

FIG. 4 is a flow chart that explains a method of delivering low-temperature
5 liquified gas according to an embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

[0022] Next, embodiments of a floating low-temperature liquified gas filling
apparatus, and a method of delivering low-temperature liquified gas using the
10 apparatus according to the present invention will be described in detail with
reference to the drawings. FIG. 1 is a schematic view of a floating low-
temperature liquified gas filling apparatus and a method of delivering low-
temperature liquified gas using the apparatus according to an embodiment of the
present invention. As shown in FIG. 1, a floating low-temperature liquified gas
15 filling apparatus 10 according to an embodiment of the present invention
includes a floating body 11 floating on the sea, wherein the floating body 11

includes a barge tank 12, a hose 13, a crane 14, a filling means 15, and a distribution unit of low-temperature liquified gas 20, which are provided thereon.

[0023] The floating low-temperature liquified gas filling apparatus 10 makes possible easy delivery of low-temperature liquified gas to delivery destinations that do not have low-temperature liquified gas receiving facilities. This is achieved in such a way that:

- (1) low-temperature liquified gas is transferred from a liquified gas supply facility to the barge tank 12 where liquified gas is temporarily stored,
- 10 (2) the floating low-temperature liquified gas filling apparatus 10 moves to a port of a delivery destination, and
- (3) low-temperature liquified gas is directly delivered from the barge tank 12 to a container placed on a transport truck waiting on the ground by the filling means 15.

15 The floating low-temperature liquified gas filling apparatus 10 according to an embodiment makes possible simultaneous delivery of low-temperature

liquefied gas to a plurality of containers on the ground of delivery destinations using the distribution unit of low-temperature liquefied gas 20. This allows for efficient delivery of low-temperature liquefied gas in a short time.

[0024]

5 FIG. 1(a) depicts a step of the process of delivering low-temperature liquefied gas from a liquefied gas supply facility to containers on the ground, in which low-temperature liquefied gas is transferred from the liquefied gas supply facility 1 to the barge tank 12 of the floating low-temperature liquefied-gas filling apparatus 10 at
10 sea;

FIG. 1(b) depicts a step in which the floating low-temperature liquefied gas filling apparatus 10, which temporarily stores low-temperature liquefied gas, moves to a delivery destination; and

FIG. 1(c) depicts a step in which low-temperature liquefied gas stored in
15 the barge tank 12 is filled into containers placed on transport trucks waiting on the ground.

[0025] As shown in FIG. 1(a), the floating low-temperature liquified gas filling apparatus 10 is moored alongside the liquified gas supply facility 1 that waits at sea wherein the barge tank 12 of the floating low-temperature liquified gas filling apparatus 10 is connected to a low-temperature liquified gas storage tank of the liquified gas supply facility 1 by a hose 13. According to an embodiment, the low-temperature liquified gas is Liquefied Natural Gas (LNG), and the liquified gas supply facility 1 is a liquefied natural gas carrier, or a Floating Storage and Regasification Unit (FSRU). Because there are waves on the sea, in the case that the floating low-temperature liquified gas filling apparatus 10 is moored alongside the liquified gas supply facility 1, a buffer 18 including a cushioning member such as rubber is disposed between the floating apparatus 10 and the supply facility 1 to prevent the floating apparatus 10 from directly colliding with the supply facility 1. If the floating low-temperature liquefied-gas filling apparatus 10 has a cushioning member at the side thereof, the buffer 18, which serves as a cushioning element, is not required separately. The buffer 18 shown in FIG. 1(a) is an air fender formed such that a plurality of

tire-shaped rubbers are provided on the periphery of a cylindrical body thereof.

However, as long as the buffer 18 prevents the floating apparatus 10 from directly colliding with the supply facility 1 while the floating apparatus 10 is moored, any shape or material can be used for the buffer 18.

5 [0026] According to an embodiment, the liquefied gas supply facility 1 is moored to a mooring measure above the sea such as a mooring cable, an underwater pier, or a harbor pier while the supply facility 1 stands by. The floating low-temperature liquefied-gas filling apparatus 10 moves back and forth between the liquefied gas supply facility 1 and each of delivery destinations
10 where low-temperature liquefied gas is to be delivered. Therefore, the buffer 18 is provided as a permanent facility at a place where the floating low-temperature liquefied gas filling apparatus 10 is to be moored. In this way, the floating low-temperature liquefied gas filling apparatus 10 can be quickly moored to the liquefied gas supply facility 1. The mooring of the floating low-temperature
15 liquefied-gas filling apparatus 10 to the liquefied gas supply facility 1 should be performed steadily by using a mooring line 19 so that the liquefied gas supply

facility 1 and the floating low-temperature liquefied gas filling apparatus 10 are correctly aligned.

[0027] Liquefied natural gas needs to be kept below -162°C to maintain its liquid phase at normal pressure, and a hose used as the hose 13 is a flexible one.

- 5 The liquefied gas supply facility 1 is very large, and a discharge port to discharge low-temperature liquefied gas from the storage tank of the supply facility 1 is located high above the sea surface. Therefore, because the difference of the height between the discharge port and the barge tank 12 is large, in order to connect the hose 13 between the discharge port and the barge tank 12, a crane
- 10 14, which is provided to the floating low-temperature liquefied-gas filling apparatus 10, is used. Providing the crane 14 to the floating low-temperature liquefied gas filling apparatus 10 eliminates installing a dedicated crane 14 on the liquefied gas supply facility 1 to connect a transfer hose. This allows the floating low-temperature liquefied gas filling apparatus 10 to receive
- 15 liquefied gas from various types of liquefied gas supply facility 1. Because the crane 14 is used for suspending the hose 13, or the distribution unit of low-

temperature liquified gas 20 to be connected to the tip of the hose 13, the weight that the crane 14 suspends is limited. Therefore, the crane 14 is not necessarily large enough to be capable of suspending a heavy object, but because the crane 14 needs to lift the hose 13 high, its height is preferably tall enough to reach a high place. The crane 14 can be a telescopic type.

[0028] If the hose 13 comes in contact with the sea surface, the heat input from the seawater may raise the temperature of the liquefied natural gas. Therefore, the crane 14 suspends and holds the hose 13 at a predetermined height so that it does not hang down on the sea surface. According to another embodiment, the floating low-temperature liquified gas filling apparatus 10 includes a hose support 16 that supports the hose 13 from below at a predetermined height so as to prevent the hose 13 from hanging down.

[0029] It is preferable that the capacity of the barge tank 12 not be needlessly large because the floating apparatus 10 is mainly used to deliver low-temperature liquified gas to small ports that do not have receiving facilities of low-temperature liquified gas. According to an embodiment, the barge tank 12

has a size of about 3 m in diameter and about 20 m in length, the size of which corresponds to the volume of four containers on transport trucks. The size of the container, however, is not limited to this, but can be determined in consideration of the area's topography and facility conditions where low-temperature liquified gas is to be delivered, the number of transport trucks that will receive low-temperature liquified gas, and the traffic conditions surrounding the trucks. Therefore, the size of the barge tank 12 can be larger or smaller than the above specified one.

[0030] As shown in FIG. 1(b), the floating low-temperature liquified gas filling apparatus 10 that has stored low-temperature liquified gas moves by sea to the port that will receive the liquified gas. In the embodiment in FIG. 1(b), the floating body 11 is a barge ship that does not have power for navigation such as an engine, so that it is connected to a tugboat 30 via a tow rope 31 so as to be towed. The floating body 11 may be provided with an engine to navigate under its own power.

[0031] As shown in FIG. 1(c), when the floating low-temperature liquified gas

filling apparatus 10 docks at a port of a transportation destination, the barge tank 12 is connected by the hose 13 to containers 41 placed on transport trucks 40 waiting on the ground, and the low-temperature liquified gas in the barge tank 12 is filled into the containers 41 by the filling means 15.

- 5 [0032] The filling means 15 is a pressurized evaporator or a pump. In an embodiment utilizing a pressurized evaporator, the pressurized evaporator vaporizes a portion of the low-temperature liquified gas to return the portion to the barge tank 12. The vaporized portion raises the internal pressure of the barge tank 12, so that the low-temperature liquified gas is sent out from the barge tank
- 10 12. In an embodiment utilizing a pump, because the pump directly raises the pressure of the low-temperature liquified gas, it must be disposed on the flow path from a barge tank 12 to a container 41, and the hose 13 is arranged so as to connect the pump to the container 41. As long as the filling means 15 can send out low-temperature liquified gas, the filling means 15 may be a pressurized
- 15 evaporator or a pump. However, as the filling means 15 can be shaken by waves at sea, the pressurized evaporator is preferable as the filling means 15 because it

can pressurize low-temperature liquified gas more stably than a pump.

[0033] If the number of the container 41 to receive low-temperature liquified gas is one, the end of the hose 13 on the side of the container 41 is directly connected to the inlet of the container 41. If there are a plurality of
5 containers 41 to receive the low-temperature liquified gas, a distribution unit of low temperature liquified gas 20 is used, to which the end of the hose 13 is connected. The distribution unit of low-temperature liquified gas 20 has a single inflow port that is connected to the hose 13, which is located on the upstream side of low-temperature liquified gas flow of the distribution unit of low
10 temperature liquified gas 20. The flow channel from the single inlet branches off into a plurality of flow channels inside the distribution unit of low-temperature liquified gas 20 so that the low-temperature liquified gas is discharged from a plurality of discharge ports.

[0034] Further, the distribution unit of low-temperature liquified gas 20 is
15 provided with on-off valves each of which selectively opens and closes each exit of the discharge ports, and each on-off valve is connected to an injection hose 22

that connects each discharge port to each container 41. Among the plurality of discharge ports, the on-off valves of the discharge ports connected to the containers 41 to be simultaneously filled with are selected and opened. Thus, a plurality of containers 41 are simultaneously filled with low-temperature
5 liquified gas.

[0035] It takes about one hour to fill one typical-size container 41 with low-temperature liquified gas. For example, it takes four hours or more to fill four containers 41 with low-temperature liquified gas if the conventional technology is used, by which only one container can be filled at a time. Use of
10 the distribution unit of low-temperature liquified gas 20 makes it possible to finish simultaneous filling of four containers 41 in about one hour.

[0036] In the case that low-temperature liquified gas is filled from the barge tank 12 to the container 41, the hose 13 connecting both is suspended by the crane 14 and held at a predetermined height. If the distribution unit of low-temperature liquified gas 20 is connected to the hose 13, as shown in FIG. 1(c),
5 the distribution unit of low-temperature liquified gas 20 is suspended by the crane 14, eliminating the injection hose 22 from being in contact with the ground, so that the passage of traffic is not interfered, preventing a decrease in workability.

[0037] According to another embodiment, the floating low-temperature
10 liquified gas filling apparatus 10 includes a hose support 17 that supports the hose 13 from below at a predetermined height so as to prevent the hose 13 from hanging down. FIG. 1(c) depicts an embodiment in which a floating body 11 includes a hose support 16 on one edge thereof, and a hose support 17 on the edge opposite to the hose support 16. However, if the hose 13 is connected
15 fixedly in any one direction, a hose support is limited to either of the hose support 16 or 17. In such a case, the hose support is preferably configured such

that the height to support the hose 13 is variable.

[0038] FIG. 2 is a schematic plan view showing a method of transferring low-temperature liquified gas to a container on the ground using a floating low-temperature liquified gas filling apparatus according to an embodiment of the present invention. FIG. 2 depicts a state where low-temperature liquified gas is simultaneously filled into four transport trucks 40 parked on the ground. The transport truck 40 shown as an example in the FIG. 2 is a trailer type configured such that a towing vehicle 42 tows a wheeled platform on which a container 41 is placed.

10 [0039] The distribution unit of low-temperature liquified gas 20 includes a distributor of low-temperature liquified gas 21 and an injection hose 22. The distributor of low-temperature liquified gas 21 includes single inflow port that is connected to the hose 13, through which low-temperature liquified gas flows, and four discharge ports, forming a substantially home-base type enclosure. The distributor of low-temperature liquified gas 21 is suspended by the crane 14 at a predetermined height, the distributor 21 being positioned behind four transport

trucks 40. Four injection hoses 22 respectively connected to the four discharge ports are connected to respective containers 41.

[0040] According to an embodiment, in the case that low-temperature liquified gas is filled into seven containers 41, as shown in FIG. 2, four
5 containers 41 are connected to respective injection hoses 22 the first time, so that low-temperature liquified gas is simultaneously filled into the four containers 41. Then, the second filling is performed, where three containers 41 are connected to the injection hoses 22. As will be explained later with reference to FIG. 3, an on-off valve is provided to each discharge port of the distribution
10 unit of the low-temperature liquified gas 20. In the second time filling, one on-off valve of the discharge port that is not connected to the container 41 is closed, so that it is possible to selectively fill three containers 41 with low-temperature liquified gas simultaneously.

[0041] The container 41 can be transported under various transportation forms
15 in response to the traffic conditions at the site that receives the container 41. For example, the transport truck 40 can directly transport the container 41 that was

filled with low-temperature liquified gas to the next destination. Also, the container 41 can be transferred to a freight car at the nearest station to be transported by rail. Further, the container 41 can be transferred to a container freighter at the nearest cargo port to be transported by sea.

5 [0042] FIG. 3 is a schematic diagram that depicts the structure of a distribution unit of low-temperature liquified gas. Because the distribution unit of low-temperature liquified gas 20 is attached detachably to one end of the hose 13, the inflow port of the distributor of low-temperature liquified gas 21, into which low-temperature liquified gas flows, is provided with an end portion to which a
10 hose 13 is connected. FIG. 3 depicts a configuration in which a flange is provided to the end portion of the hose 13, and the inflow port is also provided with a flange, which is to be fixed to the flange of the hose 13 with bolts and nuts. The connection between the end portion of the hose 13 and the inflow port is not limited to this configuration if the structure makes it possible to
15 detachably connect the end portion to the inflow port. For example, instead of the bolts and nuts, screws can be used such that if the end portion of the hose 13

is provided with a female screw, the inflow port is provided with a male screw to match the female screw.

[0043] The distributor of low-temperature liquified gas 21 is provided with a flow channel structure in which a flow channel branches off into a plurality of flow channels. The flow channel in the distributor of low-temperature liquified gas 21 shown in FIG. 3 branches off into four flow channels, so that the distributor 21 has four discharge ports. The four discharge ports each have on-off valves 23, so that the distributor 21 can select the discharge ports that are to discharge low-temperature liquified gas by selecting the on-off valves 23 that are to be opened.

[0044] The on-off valves 23 may be operated manually or powered electrically. If powered electrically, power is supplied from a power supply means such as a storage battery provided on the floating low-temperature liquified gas filling apparatus 10 to the on-off valves 23 via a power supply line that is wired along the hose 13. Further, if powered electrically, the operation of the on-off valves 23 can be controlled wirelessly or by wire.

[0045] According to an embodiment, an indicator lamp is provided in the vicinity of each on-off valve 23, or at a position where what lamp corresponding to what on-off valve 23 is identified so that whether the on-off valve 23 is opened or closed can be visually checked. The indicator lamp indicates whether
5 each on-off valve 23 is opened or closed by turning the lamp on or off, or by changing the color of the lamp according to the state of the valve 23. Providing the indicator lamp prevents an erroneous operation of the on-off valves 23 in such a way that even if an on-off valve 23 of a discharge port that is not connected to a container 41 is opened, a user can easily confirm by the indicator
10 lamp that the discharge port is not connected to a container 41, so that the user can close the on-off valve 23 before a filling is performed.

[0046] Each on-off valve 23 is further provided with a flow rate detecting means 24 on the downstream side thereof. The discharge flow rate of low-temperature liquified gas from the respective discharge ports can differ
15 depending on the shape of the flow channel, and on how the on-off valves 23 are selected. If the discharge flow rate differs, even if the containers 41 are filled

simultaneously, the time required for filling will differ between the containers 41, which may lead to a decrease in work efficiency. Therefore, according to an embodiment, the flow rate detecting means 24 detects each discharge flow rate of low-temperature liquified gas discharged from the respective discharge ports, 5 and based on the detection results, the degree of valve opening of each on-off valve 23 is individually adjusted so that each discharge flow rate of low-temperature liquified gas from each discharge port becomes equal. In order to adjust the discharge flow rate of low-temperature liquified gas, a flow rate adjusting means that is different from the on-off valve 23 may be provided. In 10 such a case, the discharge flow rate of low-temperature liquified gas is adjusted by the flow rate adjusting means based on the discharge flow rate detected by the flow rate detecting means 24.

[0047] The injection hose 22 is a flexible hose as with the hose 13. The injection hose 22 does not need to be connected and disconnected as frequently 15 as the hose 13. But the injection hose 22 is replaced when it deteriorates, and therefore the end portion of the injection hose 22 may be formed, for example,

into a flange shape so that the end portion is attached detachably to the distributor of low-temperature liquified gas 21 using bolts and nuts.

[0048] The distributor of low-temperature liquified gas 21 is provided with a hook 25 on the top thereof. When filling of low-temperature liquified gas is performed, the distributor of low-temperature liquified gas 21 is suspended with the hook 25 by the crane 14 to be lifted as shown in FIG 1(c) and FIG. 2, and is held at a height providing a good workability, so as to facilitate filling work. Providing the hook 25 also allows for adjusting the height of the hose 13 when the hose 13 is detached from the container 41 after a filling of low-temperature liquified gas is finished, so that the low-temperature liquefied does not remain in the hose 13, and is transferred into the barge tank 12 completely.

[0049] Although FIG. 3 illustrates the distribution unit of low-temperature liquified gas 20 having four discharge ports, the number of the discharge ports is not limited to four. The number can be more or less than four. FIG. 3 depicts a structure in which the discharge ports are arranged in a horizontal row. According to an embodiment, a plurality of discharge ports may be arranged at

equal intervals in concentric circles so that low-temperature liquified gas outflowing each discharge port has equal outflow characteristics. At this time, if the discharge ports are installed diagonally from the inflow port, the distributor of low-temperature liquified gas 21 is formed so as to have a funnel shape, and
5 if the discharge ports are arranged radially from the inflow port, the distributor of the low-temperature liquified gas 21 is formed so as to have a disk shape.

[0050] FIG. 4 is a flow chart that explains a method of delivering low-temperature liquified gas according to an embodiment of the present invention. As shown in FIG. 4, a receiving stage includes steps (S400 to S420)
10 in which a floating low-temperature liquified gas filling apparatus 10 receives low-temperature liquified gas, wherein low-temperature liquified gas is transferred from a liquified gas supply facility 1 to a barge tank 12 of the floating low-temperature liquified gas filling apparatus 10 via a hose 13.

[0051] In S400, the floating low-temperature liquified gas filling apparatus 10
15 is moored to the liquified gas supply facility 1 so as to sandwich a buffer 18 between them. According to an embodiment, the buffer 18 is permanently

provided to the liquified gas supply facility 1 at the position where the floating low-temperature liquified gas filling apparatus 10 is moored. Therefore, there is no need to prepare the buffer 18 every time the floating low-temperature liquified gas filling apparatus 10 is to receive low-temperature liquified gas from the liquified gas supply facility 1. The floating low-temperature liquified gas filling apparatus 10 is moored securely to the liquified gas supply facility 1 such that the floating apparatus 10 is connected to the supply facility 1 at several points by mooring lines 19.

[0052] In S405, the liquified gas supply facility 1 is connected with a hose 13 of the floating low-temperature liquified gas filling apparatus 10. At this time, the hose 13 is lifted by a crane 14 provided to the floating low-temperature liquified gas filling apparatus 10 to be connected to the supply facility 1, so that the crane 14 holds the hose 13 at a predetermined height while low-temperature liquified gas is transferred from the supply facility 1 to the floating apparatus 10. This makes it possible for the floating apparatus 10 to directly receive low-temperature liquified gas from a large ship that does not have a crane 14 and a

hose 13 used for delivering low-temperature liquified gas.

[0053] In S410, the transfer of low-temperature liquified gas from liquified gas supply facility 1 to the barge tank 12 of the floating low-temperature liquified gas filling apparatus 10 is started. In S415, the required
5 amount of low-temperature liquified gas is transferred to complete the transfer of the low-temperature liquified gas. Then, in S420, the hose 13 of the floating low-temperature liquified gas filling apparatus 10 is disconnected from the liquified gas supply facility 1. The disconnected hose 13 is recovered to the floating low-temperature liquified gas filling apparatus 10 using the crane 14,
10 and finally the mooring lines 19 are removed, when the receiving stage is completed.

[0054] The stage succeeding the receiving stage is a transporting stage including the steps of S425 and S430, in which the floating low-temperature liquified gas filling apparatus 10 moves to the port where low-temperature
15 liquified gas is delivered. In S425, the floating low-temperature liquified gas filling apparatus 10 moves toward the position where a transport truck 40 waits

on the ground in a port, which is the delivery destination of low-temperature
liquified gas. According to an embodiment, the floating low-temperature
liquified gas filling apparatus 10 does not have a means of power for
self-navigation, so that the floating apparatus 10 is towed by a tugboat 30. For
5 this purpose, the floating apparatus 10 is provided with tow-rope hooks at the
front and rear thereof, on each of which a tow rope 31 is to be hung. This makes
it possible to connect a plurality of floating apparatuses for filling low-
temperature liquified gas 10 to be lined up behind one another using tow ropes
31. Thus, the tugboat 30 tows the lead apparatus, which makes it possible to
10 move the floating low-temperature liquified gas filling apparatuses 10 together
at one time.

[0055] According to another embodiment, the floating low-temperature
liquified gas filling apparatus 10 is provided with a means of power for self-
navigation, so that the floating apparatus 10 can move by itself to a delivery
15 destination without the tugboat 30.

In S430, whether the floating low-temperature liquified gas filling apparatus 10

is towed by a tugboat 30, or moves by itself, when it arrives at the port of a delivery destination, it berths at the pier where a transport truck 40 waits.

[0056] This stage is succeeded by a filling stage including the steps of S435 to S470, in which by using a filling means 15, low-temperature liquefied gas is filled directly from a barge tank 12 to a container 41 placed on a transport truck 40 on the ground via a hose 13. In S435, it is determined first whether a plurality of containers 41 are to be filled simultaneously. If a plurality of containers 41 are to be filled simultaneously, in S440, one end of the hose 13 is connected with a distribution unit of low-temperature liquefied gas 20.

10 [0057] Next in S445, among the injection hoses 22 of the distribution unit of low-temperature liquefied gas 20, the hoses corresponding to the number of containers 41 that are to be simultaneously filled with low-temperature liquefied gas are connected to the containers 41 on trucks in the port. The distribution unit of low-temperature liquefied gas 20 has a plurality of discharge
15 ports, and each discharge port can be opened and closed by each on-off valve 23 provided thereto. Accordingly, even if the number of the containers 41 to be

simultaneously filled is less than the number of the discharge ports of the distribution unit of low-temperature liquified gas 20, the on-off valves 23 of the unused discharge ports can be closed, which allows only the connected containers 41 to be filled. In S455, for the distribution unit of low-temperature
5 liquified gas 20 corresponding to the containers 41 to be filled, the on-off valves 23 are opened.

[0058] According to an embodiment, the end portion of an injection hose 22 on the side to be connected with a container 41 is provided with a sensor that detects the connection of the hose 22 to the container 41, or with a push-in type
10 switch that is activated when the hose 22 is connected to the container 41. The sensor or switch is configured such that if an injection hose 22 is not connected to a container 41, the on-off valve 23 of the discharge port to which that injection hose 22 is connected is not opened. This prevents low-temperature liquified gas from discharging accidentally into the injection hose 22 that is not
15 connected to the container 41.

[0059] After completion of the preparation of filling low-temperature

liquified gas, in S460, a filling means 15 of the floating low-temperature
liquified gas filling apparatus 10 is activated to fill a container 41 with low-
temperature liquified gas. There are cases where gas filling is not completed at
one time, for example, the case that the parking space of the transport trucks 40
5 is small, so that the number of containers 41 that can be filled simultaneously is
limited, or the case that the demand for low-temperature liquified gas is so large
that one-time simultaneous filling performed by the distribution unit of low-
temperature liquified gas 20 cannot meet that demand. In such cases, the on-off
valves 23 are closed once when the first filling is completed, then the transport
10 trucks 40 are replaced by new ones, and new containers 41 are connected to the
distribution unit 20. After that, the filling operations in S435 to S460 are
repeated.

[0060] Furthermore, in the case that the discharge flow rate of
low-temperature liquified gas is adjusted by using flow rate detecting means 24,
15 in S460 where the filling of the low-temperature liquified gas is started, each
discharge flow rate of the low-temperature liquified gas flowing through the

respective discharge ports is detected, and based on the detecting results, each discharge flow rate of the low-temperature liquified gas is adjusted by the respective on-off valves 23, or other flow rate adjusting means provided instead of the on-off valves 23. This is achieved such that:

- 5 (1) a floating low-temperature liquified gas filling apparatus 10 is provided with a control device that remotely controls the on-off valves 23 or the flow rate adjusting means,
- (2) the output from the flow rate detecting means 24 is inputted into the control device by wire or wirelessly, and
- 10 (3) the control signals based on the inputted values are outputted from the control device by wire or wirelessly to the respective on-off valves 23 or flow rate adjusting means.

[0061] If the number of the containers 41 to be filled is one, in S435, the distribution of low-temperature liquified gas is not required. Therefore, in S450,

15 the hose 13 is directly connected to the container 41 instead of being connected to the distribution unit of low-temperature liquified gas 20. Then, in S460, the

filling means 15 of the floating low-temperature liquified gas filling apparatus

10 is operated so as to fill the container 41 with low-temperature liquified gas.

[0062] In the case that the low-temperature liquified gas filled into the barge

tank 12 is to be delivered to a plurality of destinations in succession, it may

5 occur that at the first delivery destination, the filling is performed while the

distribution unit of low-temperature liquified gas 20 is connected to the tip of

the hose 13, and at the next delivery destination, the filling starts in the state

where the distribution unit of low-temperature liquified gas 20 is connected to

the tip of the hose 13. If low-temperature liquified gas is filled into a single

10 container 41 in this state, the filling of low-temperature liquified gas may be

performed as follows: (i) the distribution unit of low-temperature

liquified gas 20 is disconnected so that the hose 13 is directly connected to the

container 41; or (ii) while the distribution unit of low-temperature liquefied

gas 20 remains to be connected, one injection hose 22 is selectively connected to

15 the container 41, and the on-off valve 23 connected to the injection hose 22 is

opened.

[0063] Further, depending on the delivery state of low-temperature liquified gas, if low-temperature liquified gas is delivered to a plurality of containers 41 more frequently, the same hose 13 is not to be used both for receiving low-temperature liquified gas from liquified gas supply facility 1, and
5 for filling the low-temperature liquified gas into the container 41. Instead, the hose 13 is separately configured to be two types of a hose 13-1, which is dedicated for receiving low-temperature liquified gas from the liquified gas supply facility 1, and a hose 13-2, to which the distribution unit of low-temperature liquified gas 20 is permanently connected. In this case, the seps
10 of S435, S440, and S450 are unnecessary.

[0064] When the filling of low-temperature liquified gas into containers 41 that are to be filled with the liquified gas is completed in S465, a hose 13 or injection hoses 22 connected to the containers 41 are disconnected in S470, and they are stored in the floating low-temperature liquified gas filling apparatus 10.
15 After that, the floating apparatus 10 goes to a next delivery destination to fill container(s) with low-temperature liquified gas, or returns to the liquified gas

supply facility 1 to receive low-temperature liquified gas from the supply facility 1 to repeat the steps of the receiving stage mentioned above.

[0065] In addition, if an empty container 41 is filled with low-temperature liquified gas, because the temperature inside the container 41 is usually not cooled to the temperature of the low-temperature liquified gas, a portion of low-temperature liquified gas will gasify, and further residual gas such as methane gas usually remains inside the container 41, whereby the pressure inside the container 41 is temporarily increased during the initial stage of filling. However, as the filling of the low-temperature liquified gas progresses, and the temperature inside the container 41 decreases, the pressure inside the container 41 decreases accordingly.

[0066] In order to suppress the effect caused by the pressure increase in the container 41 in accordance with filling of low-temperature liquified gas, the gas in the container 41 may be returned to the barge tank 12, from which liquified gas is supplied, while the filling is being performed. However, this method has a disadvantage such that the final composition of the filled low-

temperature liquified gas may change because the components that are easily gasified are recovered to the barge tank 12.

[0067] If the gas in the container 41 can be cooled and dissolved into the low-temperature liquified gas, the pressure increases inside the container 41 can be suppressed. Because this method does not recover the gas components into the barge tank 12, the final component composition of the low-temperature liquified gas does not change. This also eliminates the need to install a hose that is dedicated to recovering the gas.

[0068] While particular embodiments of the present invention have been shown and described with reference to the drawings, it will be appreciated by those skilled in the art that changes and modifications may be made thereto without departing from the invention in its broader aspects.

DESCRIPTION OF REFERENCE NUMERALS

[0069]

1. liquified gas supply facility
10. floating low-temperature liquified gas filling apparatus
- 5 11. floating body
12. barge tank
13. hose
14. crane
15. filling means
- 10 16., 17. hose support
18. buffer
19. mooring line
20. distribution unit of low-temperature liquified gas
21. distributor of low-temperature liquified gas

22. injection hose

23. on-off valve

24. flow rate detecting means

25. hook

5 30. tugboat

31. tow rope

40. transport truck

41. container

42. towing vehicle

10

CLAIMS

1. A floating low-temperature liquified gas filling apparatus that delivers low-temperature liquified gas from sea to land, the apparatus comprising:
 - 5 a barge tank to be filled with low-temperature liquified gas to temporarily store the same;

a hose for transferring low-temperature liquified gas from a liquified gas supply facility to the barge tank, and for transferring low-temperature liquified gas from the barge tank to at least one container placed on at least one
10 transport truck on earth;

a distribution unit of low-temperature liquified gas to be attached detachably to an end of the hose;

a crane that holds the hose at a predetermined height while low-temperature liquified gas is being transferred; and
 - 15 a filling means for filling the at least one container with low-temperature liquified gas;

wherein the distribution unit comprises an inflow port of low-temperature
liquified gas, the inflow port being connected to an end of the hose; a plurality
of discharge ports that simultaneously discharge low-temperature liquified gas
to the plurality of containers; on-off valves, each of which selectively opens and
5 closes each of the discharge ports, a plurality of injection hoses, each one end of
which being connected to one of the discharge ports, and each another end of
which being connected to each inlet of the plurality of containers; and a hook
with which the crane lifts the distribution unit of low-temperature liquified gas;

wherein if low-temperature liquified gas is simultaneously filled into the
10 plurality of containers, the distribution unit of low-temperature liquified gas is
attached to the end of the hose, and is lifted to a predetermined height by the
crane to be used,

wherein the distribution unit of low-temperature liquified gas is formed into a
funnel shape, or a disk shape, the plurality of discharge ports are arranged at
15 equal intervals in concentric circles so that low-temperature liquified gas
outflowing each discharge port has equal outflow characteristics, and the degree

of valve opening of each on-off valve is adjusted so that the discharge flow rate of low-temperature liquified gas from each discharge port becomes equal,

wherein the injection hose is provided with, on the side thereof to be connected with the container, a sensor that detects the connection of the hose to the container, or a switch that is activated when the hose is connected to the container, and

wherein if the injection hose is not connected to the container, the on-off valve of the discharge port to which the injection hose is connected is not opened.

10

2. The floating low-temperature liquified gas filling apparatus according to claim 1, wherein the distribution unit of low-temperature liquified gas comprises a flow rate detecting means that detects each flow rate of low-temperature liquified gas being discharged from the respective discharge ports, the distribution unit being capable of adjusting each of the discharge flow rates of the low temperature liquified gas by the on-off valves, or by flow rate adjusting

means that is provided instead of the respective on-off valves based on each of the detected flow rate of the low-temperature liquified gas.

3. The floating low-temperature liquified gas filling apparatus according to
5 claim 2, low-temperature liquified gas is directly transferred by the filling means from the barge tank to one or more containers via the hose, and via the distribution unit of low-temperature liquified gas.

4. The floating low-temperature liquified gas filling apparatus according to
10 any one of the preceding claims, wherein the low-temperature liquified gas is Liquefied Natural Gas (LNG), the liquified gas supply facility is a liquefied natural gas carrier, or a Floating Storage Regasification Unit (FSRU), and the filling means is a pressurized evaporator or a pump.

15 5. A method of delivering low-temperature liquified gas using the floating

low-temperature liquified gas filling apparatus of claim 1, the method comprising:

a receiving stage comprising mooring floating low-temperature liquified gas filling apparatus to a liquified gas supply facility, and transferring low-
5 temperature liquified gas from the liquified gas supply facility to a barge tank of the floating low-temperature liquefied-gas filling apparatus via a hose;

a transporting stage comprising moving the floating low-temperature liquified gas filling apparatus to a place where low-temperature liquified gas is to be delivered;

10 a filling stage comprising directly filling low-temperature liquified gas from the barge tank into at least one container that is placed on at least one transport truck on earth via the hose; and

a connecting stage comprising connecting, prior to the filling stage, a distribution unit of low-temperature liquified gas to an end of the hose from
15 which low-temperature liquified gas is discharged, the distribution unit of low-temperature liquified gas being provided with a plurality of discharge ports, if

low-temperature liquified gas is simultaneously filled in the plurality of containers.

6. The method of delivering low-temperature liquified gas according to claim

5 5,

wherein the distribution unit of low-temperature liquified gas comprises an inflow port that is to be connected to the hose, a plurality of discharge ports from which low-temperature liquified gas is simultaneously discharged to the plurality of containers, on-off valves that selectively open and close the respective discharge ports, and flow rate detecting means that detect each flow rate of low-temperature liquified gas discharged from respective discharge ports,

wherein the filling stage comprises selecting required number of the on-off valves of the discharge ports to be opened corresponding to the number of the containers that are to be filled, and adjusting each of the discharge flow rates of the low-temperature liquified gas by the on-off valves, or flow rate adjusting means that is provided instead of the respective on-off valves based on each of

the flow rates of the low-temperature liquified gas detected by the flow rate detecting means.

7. The method according to claim 5 or claim 6, wherein the low-temperature
- 5 liquified gas is Liquefied Natural Gas (LNG), the liquified gas supply facility is a liquefied natural gas carrier, or a Floating Storage Regasification Unit (FSRU), and the filling means is a pressurized evaporator or a pump.