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(71) Applicant (*for all designated States except US*): KNUTSEN OAS SHIPPING AS [NO/NO]; P.O. Box 2017, N-5504 Haugesund (NO).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): LOTHE, Per [NO/NO]; Snauhammar, N-5563 Førdesfjorden (NO).

(74) Agent: HÅMSØ PATENTBYRÅ ANS; P.O. Box 171, N-SANDNES 4302 (NO).

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(54) Title: METHOD AND DEVICE FOR TRANSPORT OF GAS

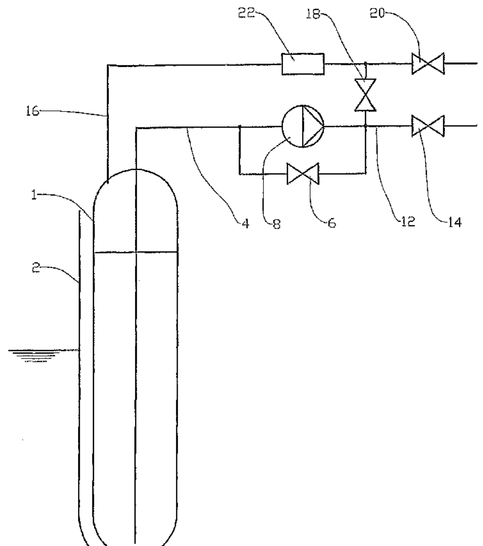

Fig. 1

(57) Abstract: A method and device for the sea transport of liquefied gas, in particular carbon dioxide, the method comprising: - placing at least one cargo pressure tank (1) in a vessel (2); - filling liquefied gas, having ambient temperature, into the cargo pressure tank (1); - pumping, when unloading, liquid gas from the cargo pressure tank (1) into a receiving facility; - evaporating and conveying liquid gas into the cargo pressure tank (1) to fill the volume after the exiting liquid gas.

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METHOD AND DEVICE FOR TRANSPORT OF GAS

This invention relates to a method of transporting gas. More particularly, it relates to a method for the sea transport of liquefied gas, in particular carbon dioxide, comprising: placing at least one cargo pressure tank in a vessel; filling liquefied gas, having approximately ambient temperature, into the cargo pressure tank; pumping, when unloading, liquid gas from the cargo pressure tank to a receiving facility; evaporating and conveying liquid gas into the cargo pressure tank to fill the volume after the exiting liquid. The invention also comprises a device for practising the invention.

The invention is particularly well suited for the sea transport of liquid carbon dioxide and the invention is described, in what follows, with reference to carbon dioxide. However, the invention is well suited also for transporting other liquefied gases, for example so-called LPG (Liquefied Petroleum Gas) in pure phases or in mixtures.

Prior to the sea transport of carbon dioxide it is usual to cool the carbon dioxide gas to near minus 56,6°C at a pressure which must exceed 5,2 bars to avoid the formation of a solid phase in the form of dry ice.

In a phase chart for carbon dioxide the state at minus 56,6°C and 5,2 bars is shown as a triple point, at which carbon dioxide may stably be present as gas, liquid or dry ice. It is emphasized that the carbon dioxide is in liquid form to achieve a favourable density, while at the same time the formation of dry ice must be avoided.

Today only limited tonnage exists which is adapted for the transport of liquefied carbon dioxide. The transport tanks of so-called LPG tankers are normally designed to receive only a limited overpressure, and are thus, without a relatively extensive modification, unsuitable for transporting liquefied carbon dioxide.

As mentioned, to enable its transport in liquid form at an overpressure somewhat above 5 bars, the carbon dioxide needs to be cooled towards minus 56°C. This cooling is relatively expensive and environmentally questionable because an extensive cooling plant is required, while at the same time the energy expenditure is substantial.

The invention has for its object to remedy or reduce at least one of the drawbacks of the prior art.

The object is achieved in accordance with the invention through the features which are specified in the description below and in the claims that follow.

A method for the sea transport of liquefied gas, in particular carbon dioxide, in accordance with the invention is characterized by the method comprising:
- placing at least one cargo pressure tank in a vessel;
- filling liquefied gas, having approximately ambient temperature, into the cargo pressure tank;
- pumping, when unloading, liquid gas from the cargo pressure tank to a receiving facility;
- evaporating and conveying liquid gas into the cargo pressure tank to fill the volume after the exiting liquid.

The liquid gas is evaporated mainly at a constant pressure and temperature, as it is explained referring to a phase chart in the specific part of the application.

During the loading and unloading of liquid gas it is vital that the pressure within the cargo pressure tanks is maintained at a particular level. If the pressure should fall, dry ice might form within the cargo pressure tanks.

It is expected that transport may take place at temperatures between minus 20°C and plus 30°C, most commonly at temperatures between 0 and 25°C. However, the method is applicable at all temperatures above minus 57°C. The method and device are best suited for application with below-critical pressures and temperatures, but may also be used even if the carbon dioxide is in an above-critical state. An above-critical state could occur for carbon dioxide only at temperatures above 31°C.

During loading into the cargo pressure tanks, the gas which is in the cargo pressure tanks is normally conveyed back into the associated loading facility, for example to replenish the storage tanks, out of which the liquid carbon dioxide is flowing.

When unloading, it is necessary to provide for the cargo pressure tanks to be replenished with gas at the same rate as that at which the liquid gas is being pumped out of the cargo pressure tanks.

According to the invention, a balancing line extending between the pressure side of an unloading pump and the pressure tanks is provided with a heater to supply energy to the gas and, thereby, convert the gas from liquid form into gaseous form at a substantially constant pressure and temperature. The balancing line forms a separate pipe bore relative to other loading and unloading lines.

Depending on the pipe line from the unloading pump to the receiving facility, the pressure from the unloading pump may be somewhat higher than the pressure within the cargo pressure tanks. In that case the pressure in the balancing line needs to be reduced to the pressure of the cargo pressure tank.

By means of this relatively simple and energy-conserving method and device carbon dioxide, for example, may be transported in vessels, as the replenishing with gas to maintain full pressure in the cargo pressure tanks is provided in a simple manner.

Since the transport takes place at ambient temperature it is unnecessary to heat-insulate tanks and pipes. Hoses may be used for the connection between the vessel and onshore facility, which simplifies, to a substantial degree, loading and unloading relative to the prior art.

In what follows, there is described an example of a preferred method and embodiment which is visualized in the accompanying drawings, in which:

Figure 1 shows schematically a conveyance plant for carbon dioxide according to the invention; and

Figure 2 shows schematically a pressure-enthalpy chart for carbon dioxide.

In the drawings the reference numeral 1 denotes a cargo pressure tank placed in a vessel 2. A loading and unloading line 4 which is connected to a filling valve 6 and an unloading pump 8 ends near the bottom portion 10 of the cargo pressure tank 1.

The filling valve 6 and the discharge line 12 of the unloading pump 8 communicate with a first shut-off valve 14. A balancing line 16 connects the upper portion of the cargo pressure tank 1 via a balancing valve 18 to the pressure side of the unloading pump 8 via the discharge line 12.

The balancing line 16 is also connected to a second shut-off valve 20.

In this preferred exemplary embodiment the balancing line 16 extends through a heater 22.

The first shut-off valve 14 communicates with an unloading or loading facility, not shown.

In a pressure-enthalpy chart (PI chart) for carbon dioxide, see figure 2, the enthalpy of the material is indicated along the abscissa, whereas the pressure is indicated along the ordinate. If the carbon dioxide is in solid form, it is in a state which falls within an area A in the chart. Correspondingly, the carbon dioxide takes the form of a mixture of solid form and liquid in an area B, a mixture of solid form and gas in an area C, a mixture of liquid and gas in an area D, liquid in an area E and gas in an area F. At a pressure higher than 73,8 bars a critical state may arise, in which gas and liquid cannot exist as separate phases. The correspondingly critical temperature is near 31°C.

It is obvious that states falling within the areas A, B and C in figure 2 must be avoided during transport and also loading and unloading, because carbon dioxide in solid or partly solid form would be difficult to unload.

According to the invention, the part of the area D, and also the portions of the areas E and F nearest to the area D, falling within the constant temperature curves marked L and H, constitute a working area for the carbon dioxide when the invention is being practised.

The temperature curve L represents the lowest ambient temperature which may be expected, for example 0°C, whereas the temperature curve H represents the highest ambient temperature which may be expected, for example 25°C.

The liquid in the cargo pressure tank 1 is essentially in a state at the transition between the areas D and E and between the constant temperature curves L and H, for example at the point M1, see figure 2.

The gas F in the cargo pressure tank 1 is substantially in a state at the transition between the areas D and F and between the constant temperature curves L and H, for example at the point M2, see figure 2. Thus, the gas and liquid within the cargo pressure tank 1 assumes the same temperature and are exposed to the same overpressure.

During filling of the cargo pressure tank 1 liquefied carbon dioxide flows in from the loading facility, not shown, via the first shut-off valve 14, discharge line 12, filling valve 6, loading and unloading line 4 and into the cargo pressure tank 1.

The carbon dioxide gas which is in the cargo pressure tank 1 flows via the balancing pipe 16 and the second shut-off valve 20 back into the loading facility, not shown.

During unloading, the unloading pump 8 pumps liquid carbon dioxide from the cargo pressure tank 1 via the loading and unloading line 4, the discharge line 12, the first shut-off valve 20 and to the unloading facility, not shown.

A smaller portion of carbon dioxide, which is in the state M1 of figure 2, flows from the discharge pipe 12 via the balancing valve 18, heater 22, balancing pipe 16 and to the cargo pressure tank 1. In the heater 22 the carbon dioxide is supplied with energy so that its state at a substantially constant temperature and pressure is shifted from state M1 to state M2 in the chart of figure 2. In state M2 the carbon dioxide is in the gaseous phase, thereby filling, per unit of weight, a considerably larger volume than when being in the liquid phase at M1.

The vessel 2 may be provided with a separate loading line, not shown. Thus, the loading and unloading line 4 might be just a loading line.

Claims

1. A method for the sea transport of liquefied gas, in particular carbon dioxide, characterized in that the method comprises:
- placing at least one cargo pressure tank (1) in a vessel (2);
- filling liquefied gas, having ambient temperature, into the cargo pressure tank (1);
- pumping, when unloading, liquid gas from the cargo pressure tank (1) to a receiving facility;
- evaporating and conveying liquid gas into the cargo pressure tank (1) to fill the volume after the exiting liquid gas.

2. The method in accordance with claim 1, characterized in that gas in the gaseous phase which is in the cargo pressure tank (1) during loading is conveyed back to a loading facility.

3. The method in accordance with claim 1, characterized in that during the evaporation, liquid gas is heated before it is conveyed to the cargo pressure tank (1).

4. The method in accordance with claim 3, characterized in that the liquid gas is evaporated substantially at a constant pressure and temperature.

5. A device for the transport of liquefied gas, in particular carbon dioxide, in at least a cargo pressure tank (1) in a vessel (2), characterized in that a balancing pipe (16) for supplying gaseous fluid to the cargo pressure tank (1) is provided with a heater (22) and is separate from other loading and unloading lines.

6. The device in accordance with claim 5, c h a r a c - t e r i z e d i n that a loading and unloading line (4) ends at the bottom portion of the cargo pressure tank (1).

7. The device in accordance with claim 6, c h a r a c - t e r i z e d i n that the loading and unloading line (4) is connected to an unloading pump (8) and communicates with the balancing pipe (16).

8. The device in accordance with claim 1, c h a r a c - t e r i z e d i n that the balancing pipe (16) extends between the cargo pressure tank (1) and the pressure side of the unloading pump (8).

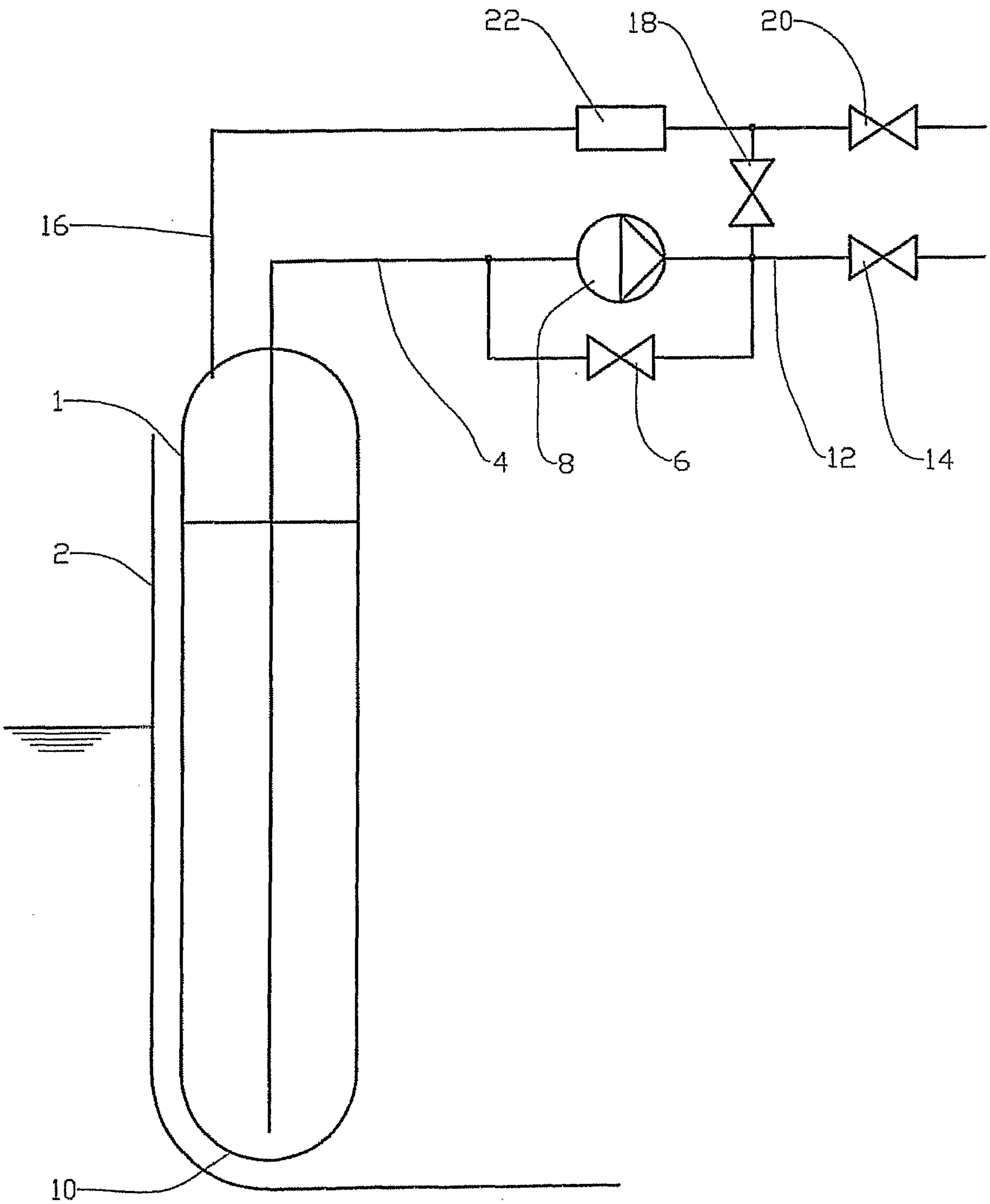

Fig. 1

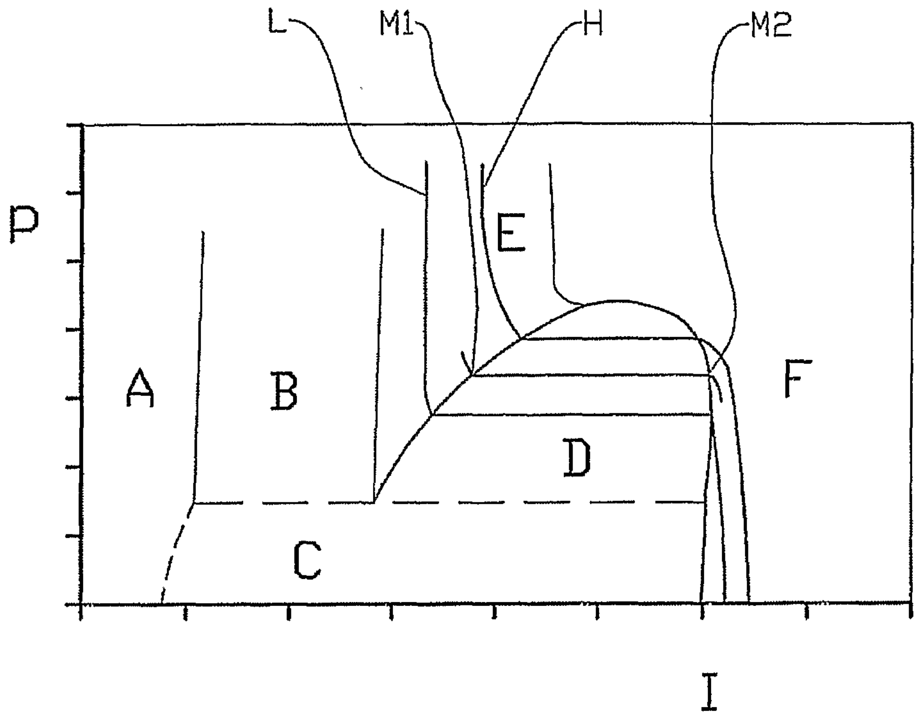

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO2008/000040

A. CLASSIFICATION OF SUBJECT MATTER
F17C 5/02, 7/04

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: F17C, B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NO, DK, FI, SE

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6644039 B2 (CORKEN, INC) 11. November 2003 (11-11-2003) abstract, fig 1, column 2 lines 12-15, column 3 lines 46-52, claim 1.	1, 3, 4, 5, 8
A	US 6644039 B2 (CORKEN, INC) 11. November 2003 (11-11-2003)	2, 6, 7
A	WO 2006/008486 A2 (STATOIL ASA) 26. January 2006 (26-01-2006) abstract, fig 1	1-8
A	JP 11037396 A (TOYO ENG WORKS LTD) 12. February 1999 (12-02-1999) abstract	1-8

☐ 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
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"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
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
28.04.2008	05.05.2008
Name and mailing address of the ISA/ Nordic Patent Institute Helgeshøj Allè 81, DK-2630 Taastrup, Denmark Facsimile No. (45) 53508008	Authorized officer Kanja Bah Telephone No. (47) 22 38 75 44

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NO2008/000040

US 6644039 B2	11-11-2003	NONE			
WO 2006008486 A2	26.01.2006	GB	2416390	B	25-01-2006
		AU	2005263932	A	26-01-2006
		CA	2574038	A	26-01-2006
		NO	20070900	A	16-02-2007
		KR	20070048194	A	08-05-2007
		EP	1787057	A	23-05-2007
		CN	101036020	A	12-09-2007
		JP	2008506899	T	06-03-2008
JP 11037396	12-02-1999	NONE			