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(54) **Cryogenic water bath evaporator system and method for heating a cryogenic water bath evaporator**

(57) Cryogenic water bath evaporator system comprising a cryogenic water bath evaporator and a solar

water heating device (120), wherein the solar water heating device (120) provides heated water, which can be fed into the water bath evaporator (110).

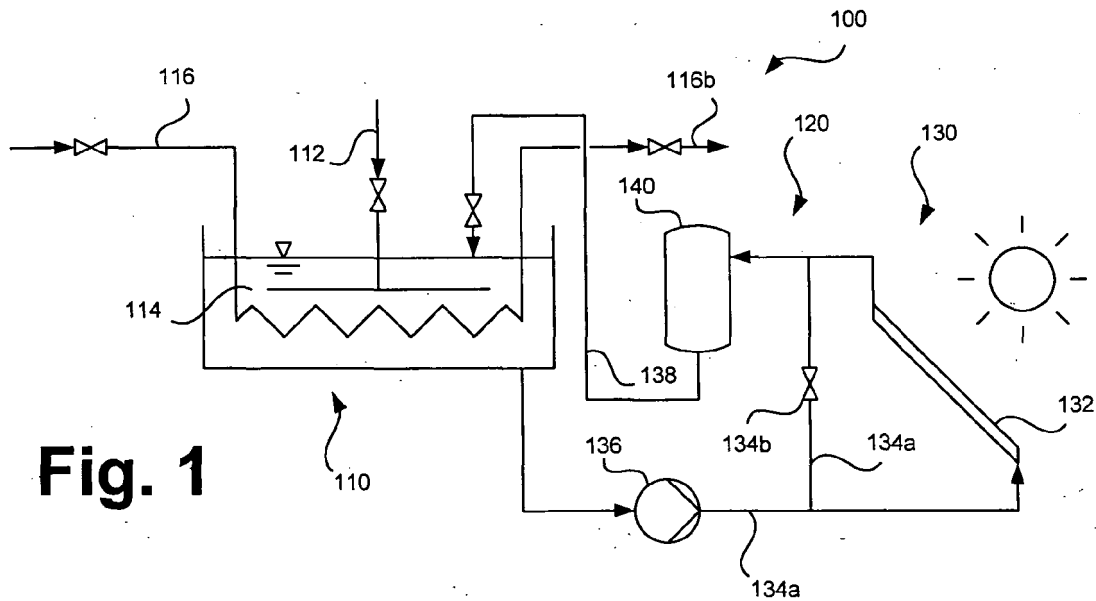


Fig. 1

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Description

Field of the invention

[0001] The present invention refers to a cryogenic water bath evaporator system and a method for heating a cryogenic water bath evaporator.

[0002] In recent years, natural gas has become a major primary source of energy, together with oil and coal. For example, in 2004, natural gas had a share of around 21 % of worldwide primary energy consumption.

[0003] Numerous studies indicate that natural gas will, in future, have a substantial growth compared to other sources of energy.

[0004] The transport of natural gas is advantageously effected in liquid form, as in the liquid state it only takes up about 1/600 of the volume of the gaseous state. Liquefaction of natural gas is performed for example in offshore plants, and its transport in tankers. Liquefied natural gas (LNG) is the lightest of the typically used liquefied gases, which also comprise so called natural gas liquids (NGL, essentially ethane with parts of propane) and liquefied petroleum gas (LPG, essentially propane with significant parts of butane). LNG is not standardised regarding its components, but essentially comprises methane.

[0005] For many applications, natural gas is burned in its gaseous state, for example in power stations. Thus, LNG must typically be evaporated into its gaseous state (i. e. typically warmed up to ambient temperature).

[0006] Similar principals are employed in the liquefaction of gases such as air, e. g. according to the Linde method. Methods and devices for liquefaction of air are for example known from Hausen, H. and Linde, H: Tieftemperaturtechnik, Erzeugung sehr tiefer Temperaturen, Gasverflüssigung und Zerlegung von Gasgemischen, second edition, Berlin, New York: Springer 1985, pages 281-337.

[0007] For numerous applications, cryogenic liquids as mentioned above must be provided to a customer as a gaseous product. To achieve this water bath evaporators are known, which are fed with cryogenic liquids, and, after evaporation of said liquids, provide gaseous products to customers. Water bath evaporators comprise a water bath, the water in which is, during use, i. e. evaporation, heated to a sufficiently high temperature to ensure efficient evaporation.

[0008] In order to guarantee efficient and flexible use, such water bath evaporators should be kept in a standby state at all times. It is thus expedient to maintain water in said water bath evaporator at or above a certain minimum temperature, normally 60-80°C. In the prior art, this is achieved by providing e.g. a continuous or intermittent small flow of steam through the water bath, and/or an occasional start up of a fired heater, in order to ensure that the water temperature in the water bath evaporator does not drop below the required standby temperature.

[0009] The object of the invention is the reduction of operating costs and the increase of the reliability of a

cryogenic water bath evaporator system.

[0010] This object is achieved with a backup cryogenic water bath evaporator system comprising the feature of claim 1, and a method for heating a cryogenic water bath evaporator comprising the features of claim 6.

[0011] According to the invention, for the first time a cryogenic water bath evaporator system is provided with a solar water heating device. The invention provides a significant reduction in steam and fuel consumption during standby periods. The invention provides an energy efficient way of maintaining the water temperature in a standby state, i. e. a standby minimum temperature.

[0012] According to the invention, the solar water heating device provides heated water, which can be fed into the water bath evaporator. The solar water heating device can be arranged separately from the actual water bath evaporator. It is also possible to directly heat water in the water bath evaporator by means of a solar water heating device. The system provides a highly efficient backup system for process plants, for example LNG terminals or air separation plants.

[0013] The invention also offers a simplification for prior art systems, because the usually provided steam facilities or fired heaters must not be employed during standby periods. According to the invention, a steam supply system or a fired heater will be typically be required only during actual use of the water bath evaporator, i. e. during actual evaporation.

[0014] The present invention can also be applied to evaporate liquid natural gas (LNG) for a natural gas supply to the grid. Previously, it has been common to use large fired heaters in connection with water bath evaporators.

[0015] Advantageous embodiments of the invention are the subject matter of the dependent claims.

[0016] Preferably, the system comprises a water tank for storage of water heated by the solar heating device. By means of such a storage tank, periods of intensive sunlight can be optimally used, and periods of bad weather or nighttime efficiently bridged.

[0017] Preferably, the solar water heating device comprises at least one solar collector. The solar water heating device can be provided as a direct or open loop system, circulating water used in the water bath evaporator directly through the collector. Also, indirect systems can be used, which use a heat exchanger for separating the water heated by the solar collector from the water used in the water bath evaporator.

[0018] Also, passive systems, relying on heat-driven convection or heat pipes to circulate water or heating fluid in the system may be used. Also, active systems using one or more pumps to circulate water can be used.

[0019] According to a further embodiment, at least one water recycle pump for pumping water from the water bath evaporator to the solar water heating device is provided.

[0020] According to a further preferred embodiment of the system according to the invention, it is provided with

a steam supply and/or a fired heater. Herewith, the system comprising a solar water heating device can be substituted or supported, if necessary. Also, such devices ensure that the water bath evaporator can be provided with the required temperature during actual use.

[0021] Further advantages and embodiments of the invention will become apparent from the description and the appended figures.

[0022] It should be noted that the previously mentioned features and the features to be further described in the following are usable not only in the respectively indicated combination, but also in further combinations or taken alone, without departing from the scope of the present invention.

Brief description of the figures

[0023]

Figure 1 shows a first preferred embodiment of a cryogenic water bath evaporator system according to the invention, and

Figure 2 shows a second preferred embodiment of a cryogenic water bath evaporator system according to the invention.

[0024] In the figures, identical or similar components are designated with the same reference numerals. For reasons of brevity not all components are described with reference to both figures.

Preferred embodiment of the invention

[0025] In figure 1, a preferred embodiment of a cryogenic water bath evaporator system is generally designated 100. The system comprises a water bath evaporator 110 and a solar water heating system 120.

[0026] The water bath evaporator 110 is provided with a steam supply 112, for heating water 114 within the water bath evaporator 110 to a temperature which is sufficiently high to ensure evaporation of a cryogenic liquid transported through the water bath evaporator in piping 116. Herein, cryogenic liquid enters a piping 116 through an inlet 116a (symbolically designated as a valve), passes through the water bath evaporator, and exits the piping through an exit 116b (also symbolically designated as a valve). From exit 116b, the evaporated gas is 100 is delivered to a customer.

[0027] The steam supply 112 ensures that the water bath evaporator 110 is maintained at a sufficiently high temperature (for example 80-100°C) during evaporation.

[0028] Between periods of use, i. e. between periods of evaporation of cryogenic liquids, the temperature of water 114 in water bath evaporator is maintained at a minimum temperature of for example 60-80°C. During these standby periods, the steam supply 112 can, according to the invention, be shut off, the necessary heat

being provided merely by the solar water heating system 120, as will be explained in the following:

[0029] The solar water heating system 120 is provided with at least one solar collector 132. Water 114 from the water bath evaporator can be pumped through a piping 134 by means of a water recycle pump 136. This water passes through solar collector 132 and is transported back into the water bath evaporator 110 by a return piping 138. Optionally, a water tank 140 can be provided in return piping 138. A bypass piping 134a may be provided, by means of which the solar collector 132 can be bypassed. Expediently, a valve 134b is provided in bypass piping 134a.

[0030] The return flow through return piping 138 can be ensured by the recycle pump 136, or by a thermal syphon effect. The water tank is, as mentioned, optional, and especially expedient if the volume of the evaporator bath is not large enough to store enough heat capacity in the water during the night, or to provide enough heat during start up of the solar water heating system 120.

[0031] A further preferred embodiment of a cryogenic water bath evaporator system is shown in figure 2. Here, the steam supply 112 of the first embodiment is replaced by a fired heater 160, fed by an air supply 161 and a fuel supply 162. By providing such a fired heater, it is possible to provide a totally closed water loop. For such a totally closed water loop it is also possible, depending on the required heat supply, to dispense with any sort of extra heating device, such as a fired heater, and provide all necessary energy by the solar water heating system 120.

Claims

1. Cryogenic water bath evaporator system comprising a cryogenic water bath evaporator and a solar water heating device (120), wherein the solar water heating device (120) provides heated water, which can be fed into the water bath evaporator (110).
2. Cryogenic water bath evaporator system according to claim 1, comprising a water tank (140) for storage of water heated by the solar water heating device (120).
3. Cryogenic water bath evaporator system according to any one of the preceding claims, comprising at least one solar collector (132).
4. Cryogenic water bath evaporator system according to any one of the preceding claims, comprising at least one water recycle pump (136) for pumping water from the water bath evaporator (110) to the solar water heating device (120).
5. Cryogenic water bath evaporator system according to any one of the preceding claims, further comprising a steam supply (112) and/or a fired heater (160).

6. Method for heating a cryogenic water bath evaporator, comprising heating water by means of a solar water heating device and providing the heated water to the water bath evaporator.

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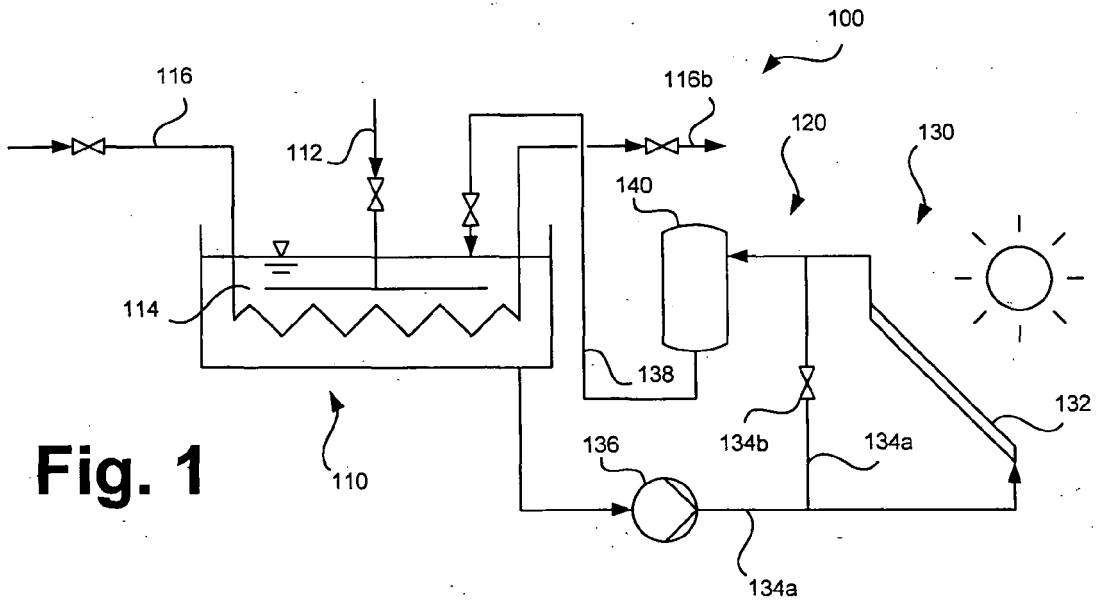


Fig. 1

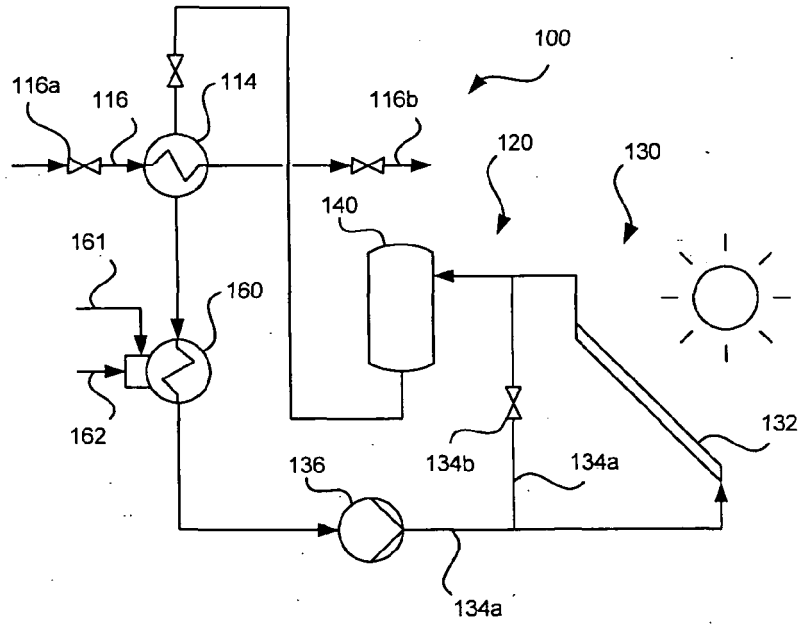


Fig. 2



EUROPEAN SEARCH REPORT

Application Number
EP 12 00 5968

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 331 129 A (HONG CHARLES C ET AL) 25 May 1982 (1982-05-25) * the whole document * -----	1-6	INV. F17C9/02 F17C5/06
			TECHNICAL FIELDS SEARCHED (IPC)
			F17C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 16 January 2013	Examiner Nicol, Boris
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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EPO FORM 1503 03/82 (P04/C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 12 00 5968

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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16-01-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4331129	A	25-05-1982	NONE

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- **HAUSEN, H. ; LINDE, H.** Tieftemperaturtechnik, Erzeugung sehr tiefer Temperaturen, Gasverflüssigung und Zerlegung von Gasgemischen. Springer, 1985, 281-337 **[0006]**