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(54) NATURAL GAS RECOVERY SYSTEM AND VEHICLE COMPRISING SAID SYSTEM

(57) A natural gas recovery system for a liquefied natural gas vehicular supply system, the vehicular supply system comprising a first tank (1), intended to store liquefied natural gas, a liquid phase and a gaseous phase of said natural gas coexisting in the first tank, the recovery system of natural gas comprising a second tank (2) intended to store compressed natural gas, a compressor (CP), adapted to compress in the second tank (2) an excess gaseous phase of the first tank.

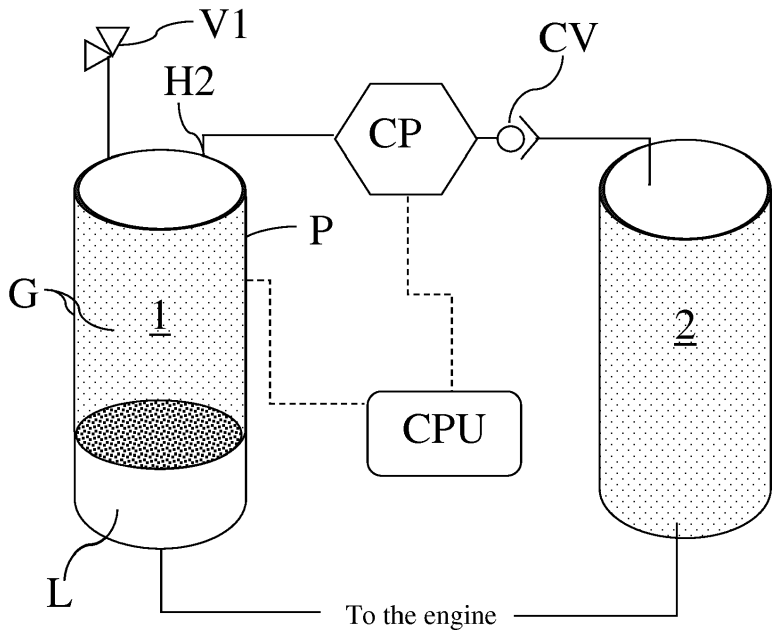

Fig.1

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Description

Field of application of the invention

[0001] The present invention relates to the field of natural gas systems for vehicles and in particular to liquefied natural gas systems.

State of the art

[0002] A tank adapted to store LNG (Liquefied Natural Gas), tends to release towards the atmosphere a certain amount of gas which depends on the pressure and temperature of the gas in the tank. In general it is estimated that after about 180h the first releases of gases to the outside occur.

[0003] This happens mainly for safety reasons, in that, over time, the gaseous phase in the tank tends to increase, resulting in an increase in pressure. Therefore, in order to prevent the pressures from exceeding given values, the excess gaseous phase is released into the environment.

[0004] Such gas contributes to the calculation of the emissions of a vehicle, since natural gas is a greenhouse gas similar to carbon dioxide.

Summary of the invention

[0005] The purpose of the present invention is to reduce the overall emissions of a vehicle fuelled with liquefied natural gas. Indeed, the basic idea of the present invention is to recover the natural gas released from the liquefied natural gas tank and to store it in another appropriate tank.

[0006] Another purpose is to reduce the overall emissions of a vehicle fuelled with liquefied natural gas thanks to an intrinsically safe system.

[0007] Such purposes is reached by a system and a related method as claimed in the appended set of claims.

Brief description of the figures

[0008] Further purposes and advantages of the present invention will be clear from the detailed description below of an example of embodiment thereof (and of its variants) and the appended drawings provided merely by way of a nonlimiting example, wherein:

- Figure 1 shows a diagram of a first variant of the present invention; and
- Figure 2 shows a diagram of a second variant of the present invention.

Detailed description of embodiments

[0009] Figure 1 shows a first preferred variant of the present invention wherein a first tank 1 is of the type intended to store liquefied natural gas.

[0010] Introduced into the tank 1 at very low temperature, about -120°C, over time it tends to gasify, so that a liquid phase L and a gaseous phase G are identified in the tank.

[0011] A first safety valve V1 places the tank 1 in communication with the environment. Generally, this valve is connected to a first opening placed in the upper part of the tank, so as to intercept only the gaseous phase.

[0012] A second opening H2, different from the first opening, is connected to an inlet of a compressor CP. The outlet of the compressor CP is connected to a second tank 2 intended to store compressed natural gas.

[0013] Consequently the safety valve V1 and the fluid line connecting the first tank 1 with the second tank 2 are independent of each other, see figures 1 and 2.

[0014] A check valve CV is placed upstream or downstream of the compressor CP, depending on the direction of circulation of the gas aspirated from the tank 1 and introduced into the tank 2.

[0015] A pressure sensor P is housed in the first tank 1.

[0016] A CPU processing unit is connected to said pressure sensor P and when the pressure measured by it exceeds a predefined threshold, the processing unit orders the activation of the compressor which aspirates natural gas in the gaseous phase from the first tank 1 compressing it in the second tank 2.

[0017] Clearly, said predefined threshold is appropriately below an activation threshold of the first safety valve V1.

[0018] Both the first tank and the second tank comprise respective openings towards the injection device of the natural gas supply system fuelling the internal vehicular combustion engine, not shown.

[0019] The English term "to the engine" indicates said operational connection between the tanks 1 and 2 and the internal combustion engine.

[0020] Figure 2 shows another preferred variant of the invention in which the first and second tank are present, as in the previous example.

[0021] The connection between the first tank is made in succession through an expansion chamber EX and the compressor CP.

[0022] The first tank, as before, comprises a first safety valve V1 which places the tank 1 in communication with the environment. In addition, the first tank comprises a second safety /overpressure valve V2 which connects the first tank with the expansion chamber EX.

[0023] The compressor CP has an inlet connected with the expansion chamber EX and an outlet connected with the second tank 2.

[0024] A check valve CV is placed between the expansion chamber EX and the compressor CP, or downstream of it, i.e. between the compressor CP and the second tank 2.

[0025] A pressure sensor P is housed in the expansion chamber EX.

[0026] A CPU processing unit is connected to said pressure sensor P and when the pressure measured by

it exceeds a predefined threshold, the processing unit orders the activation of the compressor which aspirates natural gas in the gaseous phase from the expansion chamber compressing it in the second tank 2.

[0027] Clearly, the pressure thresholds that determine both the opening of the overpressure/safety valve V2 and the activation of the compressor are appropriately below an activation threshold of the first safety valve V1.

[0028] The compressor CP is preferably an electro-compressor.

[0029] For both examples, it may be advantageous to introduce a second pressure sensor inside the second tank, so as to inhibit the activation of the electro-compressor when the pressure measured in the second tank exceeds a further predefined threshold.

[0030] This avoids having to activate the compressor unnecessarily, which if electric would consume electricity without any real benefit to the system or which could lead to excessive pressure in the second tank.

[0031] The second tank too, for safety reasons, may be fitted with a safety valve not shown.

[0032] It is worth pointing out that the implementation of a pressure sensor is completely optional, as it is possible to estimate the excess gaseous phase in the first tank in different ways, for example on the basis of the quantity and temperature of the liquid phase present in the first tank.

[0033] The quantity may be determined indirectly based on the capacity of the first tank 1 based on the consumption of liquefied natural gas.

[0034] Other rough estimates may be made by knowing the time elapsed since refuelling, the environmental temperature, the capacity of the tank 1 and the amount of liquefied natural gas consumed.

[0035] It is clear that modifications can be made to the described system and method, which do not extend beyond the scope of protection defined by the appended claims.

Claims

1. A natural gas recovery system for a liquefied natural gas supply system configured to be mounted on a vehicle, such supply system comprising a first tank (1), configured to store liquefied natural gas, a liquid phase and a gaseous phase of said natural gas coexisting in the first tank,
   the recovery system of natural gas comprising a second tank (2) intended to store compressed natural gas, a compressor (CP), adapted to compress in said second tank (2) an excess of gaseous phase of said first tank,
   wherein said compressor has an inlet operatively connected with said first tank (1) and an outlet operatively connected with said second tank (2) and wherein the system further comprises connection means suitable to connect said first and second tanks to an engine of the vehicle,
   said first tank (1) further comprises a first safety valve (VI) adapted to place in communication said first tank (1) with the environment, when a pressure inside said first tank (1) exceeds a first predefined pressure threshold and wherein said first safety valve is connected to said first tank independently of an interconnection between said first and second tank.

2. The system according to claim 1, further comprising an expansion chamber (EX) operatively connected with said first tank (1) and wherein said compressor has an inlet operatively connected with said expansion chamber (EX) and an outlet operatively connected with said second tank (2).

3. The system according to claim 1 or 2, further comprising estimation means (P, CPU) of said excess gaseous phase and processing means configured to activate said compressor (CP) coherently with said excess of gaseous phase estimation.

4. The system according to claim 3, wherein said estimation means of said excess gaseous phase comprise a pressure sensor (P), and wherein said pressure sensor (P) is installed in said first tank (1) or, if said expansion chamber (EX) is provided, in said expansion chamber (EX).

5. The system according to claim any of claims 2 to 4, wherein said expansion chamber (EX) is operatively connected to said first tank (1) by means of a second safety valve (V2).

6. The system of claim 5, wherein said second safety valve (V2) is calibrated at an opening pressure value lower than said first predefined pressure threshold of said first over-pressure valve (VI)

7. The system according to any of the preceding claims, wherein said processing means (CPU) are configured to activate said compressor (CP) when a pressure measured by said pressure sensor (P) exceeds a second predefined pressure threshold lower than said first predefined pressure threshold.

8. The system according to any one of the previous claims, further comprising a check valve arranged between said compressor (CP) and said second tank.

9. A liquefied natural gas vehicular supply system comprising a first tank (1) intended to store liquefied natural gas, a liquid phase and a gaseous phase of said natural gas coexisting in the first tank, and comprising a recovery system of natural gas according to any one of the previous claims.

10. The system according to claim 9, comprising means for withdrawing liquefied natural gas from said first tank (1) and compressed natural gas from said second tank (2).

11. A land vehicle equipped with an internal combustion engine and with a liquefied natural gas supply system supplying the internal combustion engine, wherein said liquefied natural gas supply system comprises a natural gas recovery system according to one of claims 8 or 9.

12. A method of recovery of natural gas from a liquefied natural gas supply system on a vehicle, the method comprising providing a natural gas recovery system according to any of claims 1 to 8 , such method comprising a step of recovering an excess gaseous phase of said first tank (1) and compressing it in a second tank (2).

13. The method according to claim 12, wherein said step is performed progressively as said excess gaseous phase forms.

14. The method according to one of claims 12 or 13, further comprising a step of adopting said liquefied natural gas and said compressed natural gas to supply an internal combustion engine.

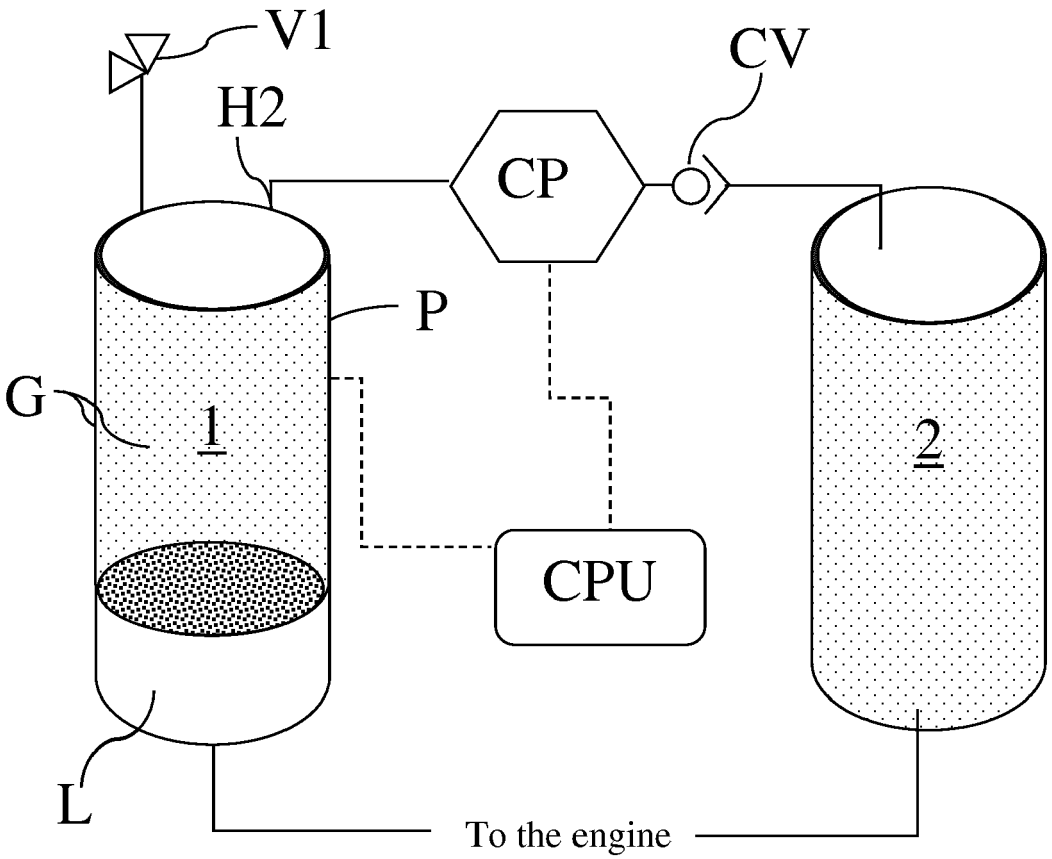

Fig.1

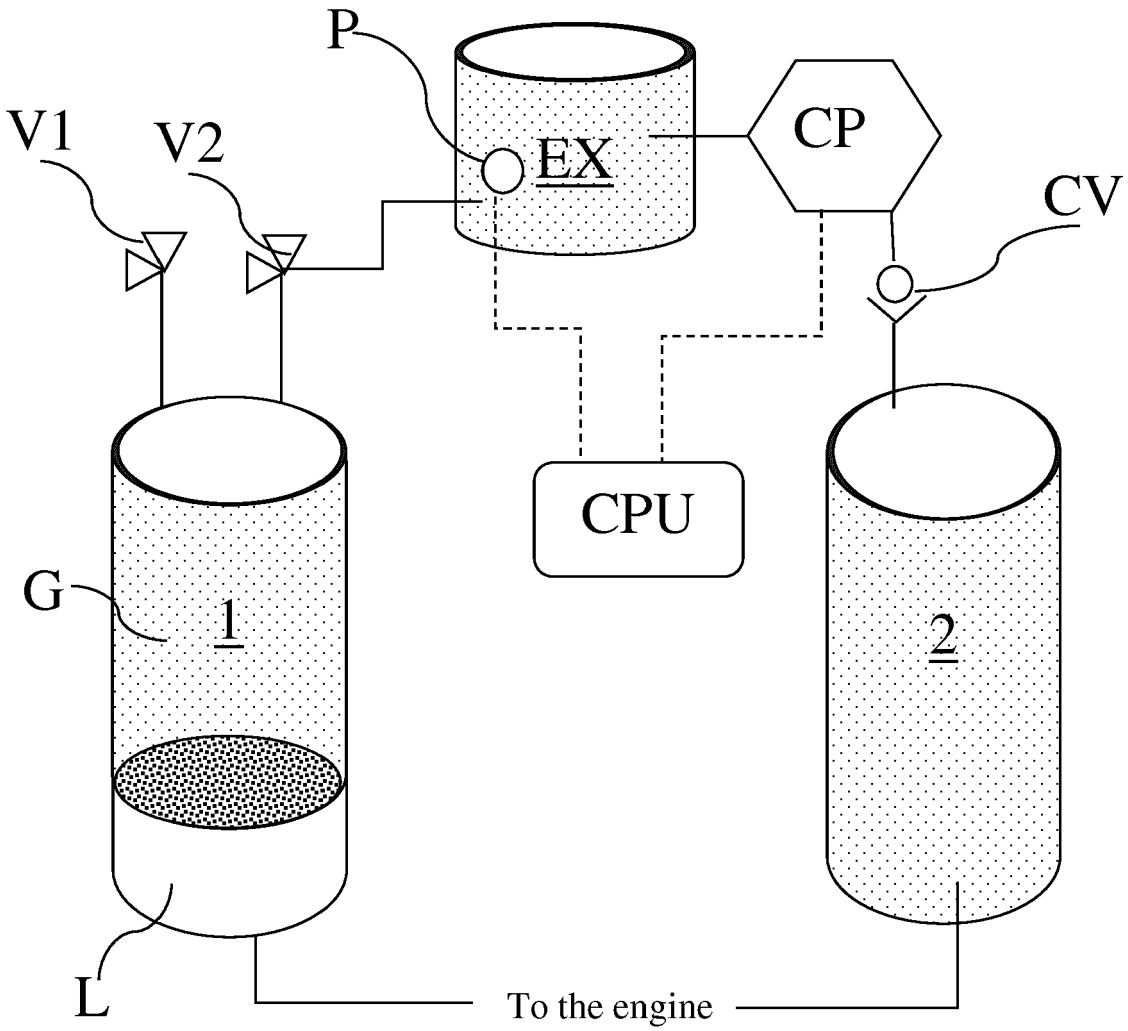

Fig.2

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EUROPEAN SEARCH REPORT

Application Number
EP 19 18 7952

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	WO 2014/006265 A1 (LNGTAINER AB [FI]) 9 January 2014 (2014-01-09) * page 2 *	1-14	
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TECHNICAL FIELDS SEARCHED (IPC)

F17C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 January 2020	Ott, Thomas

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 18 7952

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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