(19) DANMARK

(10) **DK/EP 3631280 T3**

Patent- og
Varemærkestyrelsen

(12) Oversættelse af
europæisk patentskrift

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(51) Int.Cl.: ***F 17 C 5/00 (2006.01)*** ***F 17 C 5/06 (2006.01)*** ***F 17 C 7/04 (2006.01)***
F 17 C 13/02 (2006.01)

(45) Oversættelsen bekendtgjort den: **2021-06-21**

(80) Dato for Den Europæiske Patentmyndigheds
bekendtgørelse om meddelelse af patentet: **2021-03-31**

(86) Europæisk ansøgning nr.: **18720335.1**

(86) Europæisk indleveringsdag: **2018-04-16**

(87) Den europæiske ansøgnings publiceringsdag: **2020-04-08**

(86) International ansøgning nr.: **FR2018050949**

(87) Internationalt publikationsnr.: **WO2018220303**

(30) Prioritet: **2017-05-31 FR 1754787**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

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(54) Benævnelse: **STATION OG FREMGANGSMÅDE TIL PÅFYLDNING AF TANK(E) MED GAS UNDER TRYK**

(56) Fremdragne publikationer:
EP-A2- 2 175 187
DE-A1-102009 039 645

Description

The invention relates to an installation and a method for filling a tank or tanks.

The invention relates more particularly to an installation for filling a tank or tanks with pressurized gas, in particular with hydrogen, comprising a liquefied fluid store, a filling line comprising an upstream end connected to the liquefied fluid store and a downstream end intended to be connected to a tank to be filled, the filling line comprising, arranged in series, a vaporizer, a main compressor and a heat exchanger for cooling the compressed fluid downstream of the main compressor before transferring it into a tank to be filled.

The filling of tanks with gas at high pressure, in particular with hydrogen, can be carried out starting from liquefied gas which is vaporized. See for example WO 02/064395 A2. Another example of a station is disclosed in document EP 2 175 187.

The known solutions are, however, unsatisfactory because either they do not allow fast filling with gas with pre-cooling or they do not make it possible to optimize the efficiency of the installation (optimization of energy or gas).

It is an object of the present invention to alleviate all or some of the above-mentioned disadvantages of the prior art.

To this end, the installation according to the invention, furthermore in accordance with the generic definition given in the preamble above, is essentially characterized in that it comprises a cooling circuit comprising a transfer line having an upstream end connected to the outlet of the vaporizer and a downstream end connected to the heat exchanger, the transfer line being configured to transfer fluid leaving the vaporizer into the heat exchanger and to carry out an exchange of heat between this vaporized fluid and the compressed gas that is transferred into the tank to be filled.

Moreover, embodiments of the invention may comprise one or more of the following features:

- the cooling circuit comprises a recovery line comprising an upstream end connected to the heat exchanger and a downstream end connected to the filling line, for reinjecting into the filling line the fluid which has exchanged thermally with the compressed gas,

- the downstream end of the recovery line is connected to the filling line upstream of the vaporizer,

- the installation comprises at least one buffer storage connected to the filling line downstream of the main compressor and upstream of the heat exchanger,

- the installation comprises two buffer storages connected in parallel to the filling line downstream of the main compressor and upstream of the heat exchanger,

- the installation comprises an auxiliary compressor having a suction inlet connected to a first buffer storage and an outlet connected to the second buffer storage to allow transfer and compression of gas from the first to the second buffer storage.

The invention also relates to a method for filling a tank or tanks with pressurized gas, in particular with hydrogen, by means of an installation in accordance with any one of the above characteristics above or below wherein the liquefied fluid is heated in the vaporizer to a temperature of between -250°C and 0°C and preferably between -180°C and -90°C and in particular between -150°C and -100°C.

According to other possible specific features:

- at the inlet of the main compressor, the fluid to be compressed has a temperature of between -250°C and 0°C and preferably of between -180°C and -90°C and a pressure of between 2 and 20 bar and preferably of between 8 and 12 bar,

- the method comprises a step of transferring fluid vaporized by the vaporizer into the heat exchanger for cooling the relatively hot compressed gas transferred to the tank to be filled by heat exchange with said relatively cooler vaporized fluid,
- the method comprises a step of reinjecting, into the filling line, the vaporized fluid exchanged thermally in the heat exchanger with the compressed gas,

- the vaporized fluid which has exchanged thermally in the heat exchanger with the compressed gas is reinjected upstream of the vaporizer,

- at the outlet of the main compressor, the gas has a pressure of between 200 and 700 and preferably between 400 and 600 bar,

- the method comprises a step of transferring the fluid compressed by the main compressor into a first buffer storage (9),

- the method comprises a step of heating gas taken from the gaseous headspace of the store in the vaporizer and a step of compressing this heated gas.

The invention may also relate to any alternative device or method comprising any combination of the features above or below.

Other specific features and advantages will become apparent from reading the following description, given with reference to the single figure which depicts a schematic and partial view of one example of the structure and operation of an installation according to the invention.

The installation for filling a tank or tanks with a pressurized gas illustrated in the single figure comprises a liquefied fluid store 1, for example a cryogenic tank of liquid hydrogen.

The installation comprises a filling line 2 comprising an upstream end connected to the liquefied fluid store 1 and at least one downstream end intended to be connected to a tank 6 to be filled (for example via at least one hose).

The filling line 2 comprises, arranged in series, a vaporizer 3, a main compressor 4 and a heat exchanger 5.

The installation also comprises a cooling circuit 7, 8 comprising a transfer line 7 having an upstream end connected to the outlet of the vaporizer 3 and a downstream end connected to the heat exchanger 5. This transfer line 7 is configured to transfer fluid leaving the vaporizer 3 into the heat exchanger 5 and to achieve heat exchange (preferably indirect heat exchange) between this relatively cold vaporized fluid and the relatively hot compressed gas which is transferred into the tank 6 to be filled.

For example, the installation comprises a system of valve(s), that are preferably controlled, for controlling the flow rate of cold cooling fluid in the cooling line 7. For example, the transfer line 7 is connected as a bypass to the filling line 2. One or more valves (two-way or three-way valves) may be provided for distributing the flow of fluid between the transfer line 7 and the inlet of the compressor 4. For example, these valves can be controlled by an electronic control member comprising a microprocessor. This control can be slaved for example to a temperature setpoint of the gas transferred into the tank 6.

The cooling circuit 7, 8 preferably also comprises a recovery line 8 having an upstream end connected to the heat exchanger 5 and a downstream end connected to the filling line 2. This makes it possible to reinject into the filling line 2 the relatively cold fluid that has exchanged thermally with the compressed gas.

As shown, the downstream end of the recovery line 8 can be connected to the filling line 2 upstream of the vaporizer 3.

As also illustrated, the installation may comprise at least one buffer storage 9, 10 connected to the filling line 2 downstream of the main compressor 4 and upstream of the heat exchanger 5. For example, two (or more) buffer storages 9, 10 are connected in parallel to the filling line 2 downstream of the main compressor 4 and upstream of the heat exchanger 5.

These buffer storages 9, 10 can store gas compressed by the main compressor 4.

The installation may comprise an additional auxiliary compressor 11 having a suction inlet connected to a first buffer storage 9 and an outlet connected to the second buffer storage 10, to permit transfer and compression of gas from the first to the second buffer storage 10.

The auxiliary compressor 11 may be a high-pressure compressor, i.e. a compressor configured to compress gas at a higher pressure than the main compressor 4.

The buffer storages 9, 10 can be used to transfer gas into the tank 6 to be filled by pressure equalizing (in particular cascade). In addition at least one of these buffer tanks 9, 10 may where appropriate be used to serve as a source of gas for the compressor 11 for the purpose of filling the tank 6.

Thus, liquid hydrogen can be vaporized through the vaporizer 3 (such as an atmospheric heater for example) to reach a temperature below -100°C, for example of the order of -150°C.

This relatively cold hydrogen, at a pressure for example of the order of 10 bar, can in form can be compressed at medium pressure (between 100 and 600 bar for example) in the main compressor 4.

At the inlet of the main compressor 4, the fluid to be compressed has for example a temperature of between -250°C and 0°C and preferably of between -180°C and -90°C, in particular between -150°C and -100°C. This fluid has for example a pressure of between 2 and 20 bar and preferably of between 8 and 12 bar.

This medium-pressure hydrogen can be transferred into a buffer storage 9 at medium pressure and/or compressed via the auxilliary compressor 11 at high pressure 5. This high-pressure gas (for example 700 to 1100 bar) can be stored in a high-pressure buffer storage 10.

In order to cool the relatively hot compressed gas (for example at ambient temperature from the buffer storages 9, 10), before filling the tank 6, a portion of the cold hydrogen at the outlet of the vaporizer/heater 3 can thus be brought into the cooling exchanger 5.

This cold hydrogen which has yielded frigories and has been heated in the exchanger 5 can be reinjected via the recovery line 8 upstream of the vaporizer 3 in order to be mixed with the cold hydrogen coming from the liquid store 1.

This contributes to the heating of the liquid before it passes into the vaporizer/atmospheric heater 3.

It should be noted that the hydrogen in the gas headspace of the liquid store 1 can be used while being heated in the vaporizer/atmospheric heater 3 before being compressed in the cold compressor 3 (for example via the filling line 2 or another dedicated line not shown).

Thus, while being simple in structure and inexpensive, the installation allows efficient recovery of all or part of the losses of the liquid hydrogen tank. In addition, the frigories of the liquid hydrogen are advantageously used to cool the gas, just before filling the tank 6.

Patentkrav

1. Station til påfyldning af tank(e) med gas under tryk, især hydrogen, hvilken station omfatter en reserve (1) af fortættet fluidum, en påfyldningsledning (2), der omfatter en opstrømsende, som er forbundet med reserven (1) af fortættet fluidum, og en nedstrømsende, der er beregnet til at blive forbundet med en tank (6), der skal fyldes, hvilken påfyldningsledning (2) omfatter, placeret efter hinanden, en fordamper (3), en hovedkompressor (4) og en varmeveksler (5) til afkøling af det komprimerede fluidum nedstrøms for hovedkompressoren (4), inden det overføres ind i en tank (6), der skal fyldes, hvilken station omfatter et kølekredsløb (7, 8), der omfatter en overførselsledning (7), som har en opstrømsende, der er forbundet med udløbet af fordamperen (3), og en nedstrømsende, der er forbundet med varmeveksleren (5), hvilken overførselsledning (7) er konfigureret til at overføre fluidum, der kommer ud af fordamperen (3), til varmeveksleren (5) og udføre en varmeveksling mellem dette fluidum i dampform og den komprimerede gas, som overføres til den tank (6), der skal fyldes, kendetegnet ved, at kølekredsløbet (7, 8) omfatter en genvindingsledning (8), der omfatter en opstrømsende, som er forbundet med varmeveksleren (5), og en nedstrømsende, som er forbundet med påfyldningsledningen (2), for at sprøjte det fluidum, som har udvekslet varme med den komprimerede gas, ind i påfyldningsledningen (2) igen.

2. Station ifølge krav 1, kendetegnet ved, at genvindingsledningens (8) nedstrømsende er forbundet med påfyldningsledningen (2) opstrøms for fordamperen (3).

3. Station ifølge et hvilket som helst af kravene 1 til 2, kendetegnet ved, at den omfatter mindst et bufferlager (9, 10), der er forbundet med påfyldningsledningen (2) nedstrøms for hovedkompressoren (4) og opstrøms for varmeveksleren (5).

4. Station ifølge krav 3, kendetegnet ved, at den omfatter to bufferlagre (9, 10), der er forbundet parallelt med

påfyldningsledningen (2) nedstrøms for hovedkompressoren (4) og opstrøms for varmeveksleren (5).

5. Station ifølge krav 4, kendetegnet ved, at den omfatter en hjælpekompressor (11), som har et sugeindløb, der er forbundet med et første bufferlager (9), og et udløb, der er forbundet med det andet bufferlager (10), for at muliggøre overførsel og komprimering af gas fra det første (9) til det andet (10) bufferlager.

6. Fremgangsmåde til påfyldning af tank(e) med gas under tryk, især hydrogen, ved hjælp af en station ifølge et hvilket som helst af de foregående krav, hvorved det fortættede fluidum opvarmes i fordamperen (3) til en temperatur på mellem og -250 °C og 0 °C, fortrinsvis mellem -180 °C og -90 °C og især mellem -150 °C og - 100 °C, hvilken fremgangsmåde omfatter et trin med overførsel af fluidum, der er blevet fordampet ved hjælp af fordamperen (3), til varmeveksleren (5) for at foretage afkøling af den relativt varme komprimerede gas, som er blevet overført til den tank (6), der skal fyldes, ved varmeveksling med det relativt køligere fordampede fluidum, hvilken fremgangsmåde omfatter et trin med at sprøjte det fordampede fluidum, som i varmeveksleren (5) har udvekslet varme med den komprimerede gas, ind i påfyldningsledningen (2) igen.

7. Fremgangsmåde ifølge krav 6, kendetegnet ved, at det fluidum, der skal komprimeres, ved indløbet til hovedkompressoren (4) har en temperatur på mellem og -250 °C og 0 °C og fortrinsvis mellem -180 °C og -90 °C og et tryk mellem 2 og 20 bar og fortrinsvis mellem 8 og 12 bar.

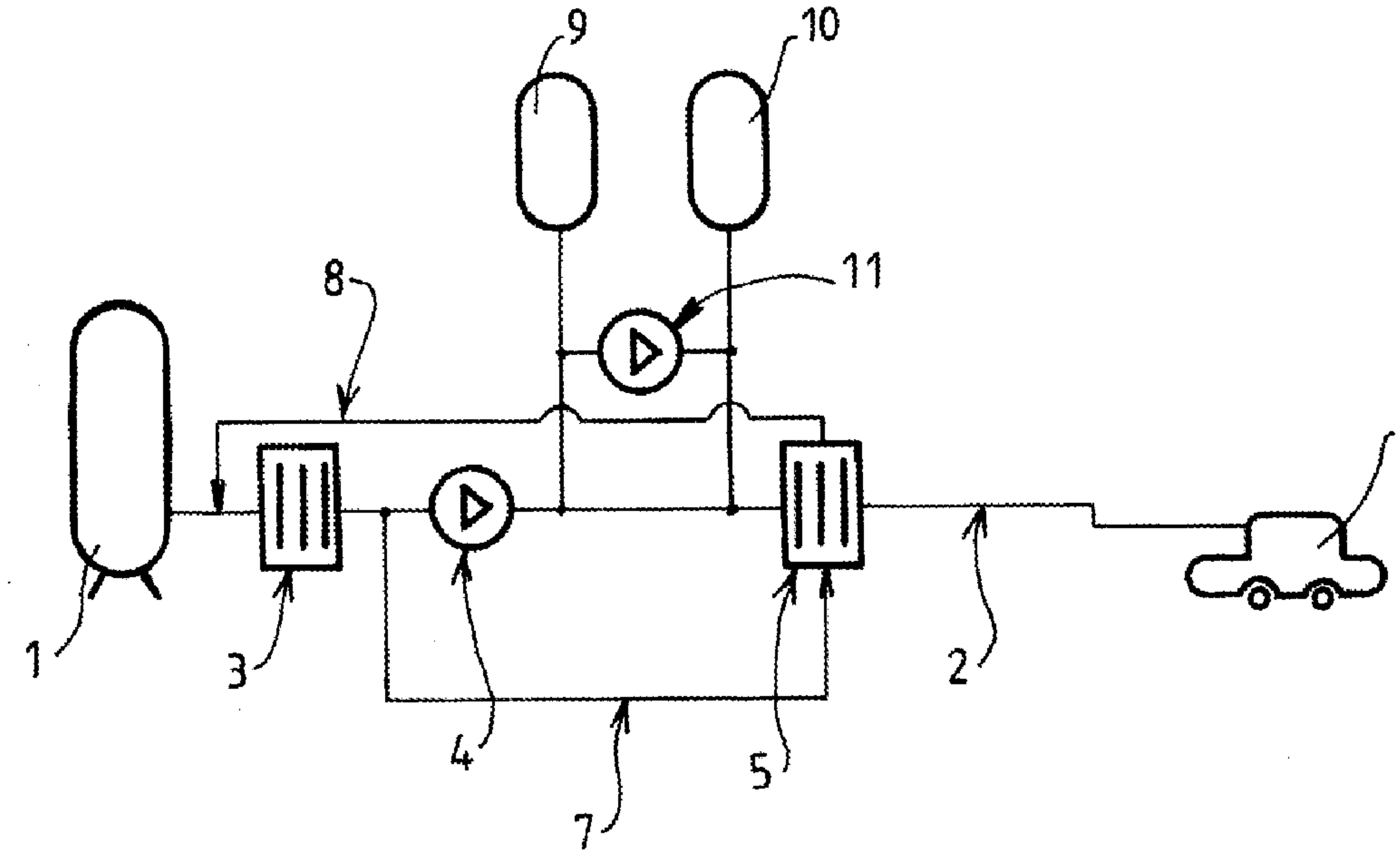
8. Fremgangsmåde ifølge krav 6 eller 7, kendetegnet ved, at det fordampede fluidum, som i varmeveksleren (5) har udvekslet varme med den komprimerede gas, sprøjtes ind igen opstrøms for fordamperen (3).

9. Fremgangsmåde ifølge et hvilket som helst af kravene 6 til 8, kendetegnet ved, at gassen ved udløbet af hovedkompressoren

(4) har et tryk på mellem 200 og 700 og fortrinsvis mellem 400 og 600 bar.

10. Fremgangsmåde ifølge et hvilket som helst af kravene 6 til 9, kendetegnet ved, at den omfatter et trin med at overføre det ved hjælp af hovedkompressoren (4) komprimerede fluidum ind i et første bufferlager (9).

11. Fremgangsmåde ifølge et hvilket som helst af kravene 6 til 10, kendetegnet ved, at den omfatter et trin med opvarmning af gas, der tages fra damprummet i reserven (1), i fordamperen (3), og et trin med komprimering af denne opvarmede gas.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