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(54) Method for operating a total energy apparatus, and pumpless high pressure total energy apparatus

(57) The invention relates to a method for controlling a total energy apparatus comprising a high-pressure vapor reservoir (1) and a condenser reservoir (5) provided with a heat exchanger (9). The high-pressure vapor reservoir (1) is connected via a first fluid connection (3) with the condenser reservoir (5). The method comprises at least the following step in a heat generation phase of the total energy apparatus:

- supplying heat to a medium in liquid form (ML) which is contained in the high-pressure vapor reservoir (1) and transporting the medium in vapor form (MD) from the high-pressure vapor reservoir (1) through the first fluid connection (3) to the condenser reservoir (5), whereafter the medium condenses against the heat exchanger (9), while the heat of

condensation absorbed by the heat exchanger (9) is removed to a heat consuming process.

The method is characterized in that between successive heat generation phases, in a high-pressure vapor reservoir filling phase, at least the following step is carried out:

- increasing the pressure in the condenser reservoir (5) and/or lowering the pressure in the high-pressure vapor (1), such that medium in liquid form (ML) flows back from the condenser reservoir (5) to the high-pressure vapor reservoir (1).

The invention further relates to a total energy apparatus for carrying out the method according to the invention.

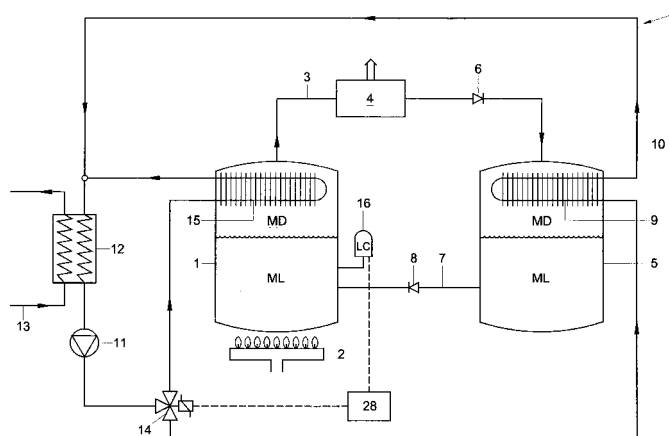


Fig. 1

Description

[0001] This invention relates to a method for operating a total energy apparatus comprising a high-pressure vapor reservoir and a condenser reservoir provided with a heat exchanger, the high-pressure vapor reservoir being connected via a first fluid connection with the condenser reservoir, while in the fluid connection an energy conversion device is included for at least partly converting the energy contained in the vapor being under high pressure into a different form of energy, such as, for instance, mechanical energy or a local reduced pressure, the method comprising at least the following step in a heat generation phase of the total energy apparatus:

- supplying heat to a medium in liquid form which is contained in the high-pressure vapor reservoir and transporting the medium in vapor form from the high-pressure vapor reservoir through the first fluid connection via the energy conversion device to the condenser reservoir, whereafter the medium condenses against the heat exchanger, while the heat of condensation absorbed by the heat exchanger is removed to a heat consuming process.

[0002] This invention further relates to a total energy apparatus comprising a high-pressure vapor reservoir, a heating source for heating medium contained in the high-pressure vapor reservoir, and a condenser reservoir, the high-pressure vapor reservoir being connected via a first fluid connection with the condenser reservoir, while the high-pressure vapor reservoir and the condenser reservoir are arranged to comprise a medium in vapor form and liquid form, the condenser reservoir being provided with a heat exchanger for the purpose of removing the heat released by condensation of vapor to a heat consuming process, while in the first fluid connection an energy conversion device is included for at least partly converting the energy contained in the vapor being under high pressure into a different form of energy, such as, for instance, mechanical energy or a local reduced pressure.

[0003] Such a method and apparatus are known from practice, for instance for use in total energy plants where by means of the energy conversion device electricity is generated and where the heat is used for heating processes and buildings. In these known apparatuses, during operation, the medium in liquid form in the high-pressure vapor reservoir is continuously replenished with the aid of a feed pump. For this purpose, high-pressure pumps are used because the water must be supplied against the pressure prevailing in the high-pressure vapor reservoir. For the use of a total energy apparatus in a house or a small office, where typically a thermal power of less than about 20 kW suffices, it is necessary, to obtain a reasonable efficiency, to work with very high pressures in the high-pressure vapor reservoir. To be considered here are pressures of 30 bars and more,

preferably more than 50 bars. For such pressures, no small high-pressure pumps are available. Multistage centrifugal pumps are not available for such small capacities and plunger pumps are expensive, are subject to wear and produce noise.

[0004] The invention contemplates meeting the problem mentioned and to that end provides a method which is characterized in that between successive heat generation phases, in a high-pressure vapor reservoir filling phase, at least the following step is carried out:

- increasing the pressure in the condenser reservoir by stopping the removal of heat of condensation via the heat exchanger in the condenser reservoir and/or lowering the pressure in the high-pressure vapor reservoir by stopping the heating of the medium in the high-pressure vapor reservoir and actively cooling the medium being in vapor form in the vapor reservoir, such that the medium in liquid form flows back from the condenser reservoir to the high-pressure vapor reservoir.

[0005] In this way, it is possible to fill the high-pressure vapor reservoir with the medium in liquid form without using a high-pressure pump. The method according to the invention therefore comprises two phases: a heat generation phase and a high-pressure vapor reservoir filling phase.

[0006] In the heat generation phase of the total energy apparatus, the medium in liquid form in the high-pressure vapor reservoir is evaporated and subsequently transported in vapor form to the condenser reservoir. In the energy conversion device, the energy contained in the hot vapor under high pressure is converted into a different form of energy, such as, for instance, mechanical energy, by means of a steam engine or steam turbine, or into a local reduced pressure using an ejector. The medium in vapor form condenses against a heat exchanger in the condenser reservoir, and the heat of condensation thereby absorbed by the heat exchanger is removed from the condenser reservoir to a heat consuming process.

[0007] In the high-pressure vapor reservoir filling phase, the high-pressure vapor reservoir is filled with medium in liquid form. To that end, medium in liquid form is recycled from the condenser reservoir to the high-pressure vapor reservoir. This is achieved according to the invention by increasing the pressure in the condenser reservoir by stopping the removal of heat in the condenser reservoir and/or by lowering the pressure in the high-pressure vapor reservoir by stopping the heating of the medium in the high-pressure vapor reservoir and actively cooling the medium being in vapor form in the vapor reservoir. As a result, a reduced pressure is generated in the high-pressure vapor reservoir, and the medium in liquid form will automatically flow from the condenser reservoir to the high-pressure vapor reservoir. The removed heat of condensation from the high-pres-

sure vapor reservoir can here be conducted to a heat consuming process.

[0008] The high-pressure vapor reservoir filling phase can be started after the medium in liquid form in the high-pressure vapor reservoir has reached a predetermined minimum level. That the minimum level has been reached can be signaled by a warning device which proceeds to deliver a 'minimum level signal' to the total energy apparatus.

[0009] As has already been indicated hereinbefore, the energy conversion device can comprise an ejector with the aid of which the energy stored in the vapor being under high pressure is converted into a local reduced pressure with the aid of an ejector or thermocompressor. The high-pressure vapor reservoir then constitutes a primary vapor source.

[0010] According to a further elaboration of the invention, the local reduced pressure in the ejector can be used for sucking vapor from a secondary vapor source, such as, for instance, an evaporation heat exchanger which is disposed in a flue duct, in the bottom, on the roof in the form of a solar collector, in a ventilating air duct for extracting heat from spent ventilating air or for cooling fresh ventilating air to be supplied. With this last option, therefore, an air conditioning is obtained. Thus, medium in vapor form can be sucked in which already possesses a certain residual heat. The sucked-in medium is further heated by mixing it with medium in vapor form coming from the primary vapor source, and the thus obtained vapor mixture condenses in the condenser reservoir at a higher pressure and temperature than those of the secondary vapor source. Thus, renewable energy coming from the secondary vapor source can be utilized by the total energy apparatus, without necessitating the use of auxiliary energy and/or further aids. Indeed, there is no electricity needed for keeping a pump running. If the secondary vapor source is used for cooling purposes, for instance for air conditioning, the heat absorbed and the heat generated by combustion will have to be removed, for instance by emitting it to the outside air.

[0011] The methods mentioned hereinbefore can be used in total energy apparatuses for the purpose of providing heat to central heating installations and for extracting heat in air conditioning installations for households and offices.

[0012] The total energy apparatus of the type described in the preamble is characterized, according to the invention, by a second fluid connection which extends between the condenser reservoir and the high-pressure vapor reservoir, while in the second fluid connection a non-return valve is arranged which prevents flow of medium from the high-pressure vapor reservoir to the condenser reservoir, while for the purpose of the transport of the medium in liquid form from the condenser reservoir to the high-pressure vapor reservoir, the apparatus is provided with a control which is arranged for periodically increasing the pressure in the condenser

reservoir by stopping the removal of heat of condensation via the heat exchanger in the condenser reservoir and/or lowering the pressure in the high-pressure vapor reservoir by stopping the heating of the medium in the high-pressure vapor reservoir and actively cooling the medium being in vapor form in the vapor reservoir, such that the medium in liquid form flows from the condenser reservoir via the second fluid connection back to the high-pressure vapor reservoir.

[0013] The total energy apparatus according to the invention therefore does not utilize a pump for recycling medium in liquid form from the condenser reservoir to the high-pressure vapor reservoir. This is of interest in particular for smaller vapor and steam systems involving work at a vapor pressure of 30 bars and higher, because for such systems no suitable high-pressure feed pump is available.

[0014] According to a further elaboration of the invention, the total energy apparatus is characterized in that the first connection too is provided with a non-return valve, while, in use, the non-return valve in the first connection is in the closed condition if the vapor pressure in the condenser reservoir is higher than the vapor pressure in the high-pressure vapor reservoir. If the vapor pressure in the condenser reservoir is higher than the vapor pressure in the high-pressure vapor reservoir, the medium in liquid form can flow back from the condenser reservoir to the high-pressure vapor reservoir exclusively through the second fluid connection.

[0015] In a further elaborated embodiment of the total energy apparatus according to the invention, in the high-pressure vapor reservoir, a heat exchanger is arranged for removing heat of condensation to a heat consuming process. As a result, for a limited time, the total energy apparatus can simultaneously remove heat of condensation via the heat exchanger in the high-pressure vapor reservoir and heat of condensation via the heat exchanger in the condenser reservoir to a heat consuming process. Thus, a relatively high thermal power can be provided by the total energy apparatus.

[0016] A still further elaborated embodiment of the total energy apparatus according to the invention is characterized in that the total energy apparatus comprises a circuit for a liquid for the heat transport from the total energy apparatus to the heat consuming process, which circuit is provided with a valve system, whereby, in use, in a first position of the valve system liquid in the circuit flows through the heat exchanger in the condenser reservoir, while hardly any or no liquid flows through the heat exchanger in the high-pressure vapor reservoir, and in a second position of the valve system liquid in the circuit flows through the heat exchanger in the high-pressure vapor reservoir and hardly any or no liquid flows through the heat exchanger in the condenser reservoir.

[0017] According to a still further elaboration, in a third position of the valve system liquid in the circuit can flow through the heat exchanger of the high-pressure vapor

reservoir, while at the same time liquid in the circuit can flow through the heat exchanger of the condenser reservoir.

[0018] The first position of the valve system can be used in the heat generation phase of the total energy apparatus and the second position of the valve system can be used in the high-pressure vapor reservoir filling phase. Further, it is possible to set the valve system in the third position in order to provide, with the burner switched on, a maximum power in a heat generation phase.

[0019] According to a further elaboration of the invention, the energy conversion device can be a steam engine, a steam turbine or an ejector or thermocompressor, while in the case of an ejector, the ejector is connected via a vapor supply pipe to a secondary vapor source such as an evaporation heat exchanger or a solar collector.

[0020] A further elaborated embodiment of a total energy apparatus according to the invention is characterized in that the high-pressure vapor reservoir is provided with means for delivering a signal when reaching a predetermined minimum level of the medium in liquid form in the high-pressure vapor reservoir.

[0021] According to a further elaboration of the invention, the total energy apparatus can be characterized by a second high-pressure vapor reservoir and a second condenser reservoir, which are connected with each other via a third fluid connection in which the energy conversion device is included, while a fourth fluid connection extends between the second condenser reservoir and the high-pressure vapor reservoir, and in the fourth fluid connection a non-return valve is arranged, which prevents flow of medium from the second high-pressure vapor reservoir to the second condenser reservoir, while the control is arranged, in use, during the generation of vapor in the first high-pressure vapor reservoir, to fill the second high-pressure vapor reservoir from the second condenser reservoir and, during the generation of vapor in the second high-pressure vapor reservoir, to fill the first high-pressure vapor reservoir from the first condenser reservoir, such that, continuously, vapor under high pressure is available for energizing the energy conversion device. With such an apparatus, therefore, converted energy, such as electricity, mechanical work or local partial vacuum is continuously available without this necessitating the use of a high-pressure pump.

[0022] Moreover, in the vapor-carrying pipe system, no operable valves need to be present to enable the apparatus according to the invention to function. The use of such operable high-pressure valves is undesired in view of the high costs of such valves.

[0023] The invention will presently be further elucidated with reference to the drawing. In the drawing:

Fig. 1 schematically shows a first embodiment of a total energy apparatus;

Fig. 2 schematically shows a second embodiment

of a total energy apparatus according to the invention; and

Fig. 3 shows a total energy apparatus according to the invention, provided with an ejector.

[0024] Fig. 1 shows a total energy apparatus according to the invention. The total energy apparatus shown comprises a high-pressure vapor reservoir 1 arranged to contain a medium in liquid form ML and a medium in vapor form MD. The total energy apparatus is further provided with a heating source 2 for heating the high-pressure vapor reservoir 1. The heating source 2 in this example is a gas burner. It will be clear that a different heating source can be utilized as well, for instance an electric heating element. The high-pressure vapor reservoir 1 is connected via a first fluid connection 3 with an energy conversion device 4 and a condenser reservoir 5. The fluid connection 3 is provided with a non-return valve 6. This non-return valve 6 prevents the medium from flowing back from the condenser reservoir 5 through the energy conversion device 4 to the high-pressure vapor reservoir 1 when the pressure in the condenser reservoir 5 is higher than the pressure in the high-pressure vapor reservoir 1. The condenser reservoir 5 is further connected via a second fluid connection 7 with the high-pressure vapor reservoir 1. The second fluid connection 7 is provided with a non-return valve 8 to prevent medium flowing through the second fluid connection 7 from the high-pressure vapor reservoir 1 to the condenser reservoir 5 when the pressure in the high-pressure vapor reservoir 1 is higher than the pressure in the condenser reservoir 5.

[0025] Hereinbelow, the heat generation phase is described, in which, in operation, the total energy apparatus generates heat and removes it to a heat consuming process. In the heat generation phase, the gas burner 2 heats the medium in the high-pressure vapor reservoir 1, so that medium in liquid form ML in the high-pressure vapor reservoir 1 evaporates. As a result, the vapor pressure in the high-pressure vapor reservoir 1 will rise. This has as a consequence that medium in vapor form MD flows via the first fluid connection 3 through the energy conversion device 4 to the condenser reservoir 5. In the condenser reservoir 5, this medium in vapor form will condense against the heat exchanger 9 incorporated in the condenser reservoir. The condensate is subsequently collected in the condenser reservoir 5 and the heat of condensation released is absorbed via the heat exchanger 9. The heat exchanger 9 is connected to a pipe 10 of a circuit in which a liquid is pumped round by a circulation pump 11. The heat exchanger 9 delivers the absorbed heat of condensation to the liquid in the circuit, after which the heat of condensation is transported in the circuit to a heat exchanger 12. The heat exchanger 12 delivers the transported heat of condensation to a second circuit 13. This second circuit 13, finally, removes the heat of condensation to a heat consuming process. It should be noted that the pipe 10 can also

form part of the heating circuit of a house or office, in which case the heat exchanger 12 and the circuit 13 can be omitted.

[0026] The circuit of the total energy apparatus in Fig. 1 comprises a three-way valve 14 which has three positions. Also, a heat exchanger 15 is connected to the circuit. The heat exchanger 15 is incorporated in the high-pressure vapor reservoir 1. When the circulation pump 11 is switched on, in a first position of the three-way valve 14, liquid in the circuit flows through the heat exchanger 9 while no liquid flows through the heat exchanger 15. In the second position of the three-way valve 14, liquid in the circuit flows through the heat exchanger 15 while no liquid flows through the heat exchanger 9. The third position of the three-way valve 14 is a position in which liquid flows both through the heat exchanger 9 and through the heat exchanger 15.

[0027] In the heat generation phase described, the level of the medium in liquid form ML decreases, while the level of the medium in liquid form ML in the condenser reservoir 5 rises. As soon as the level of the medium in liquid form ML in the high-pressure vapor reservoir 1 falls below a particular minimum level, this will be signaled by the level sensor 16. Thereupon, the heat generation phase will be discontinued, whereafter the high-pressure vapor reservoir filling phase is started.

[0028] In the high-pressure vapor reservoir filling phase, the gas burner 2 is switched off, so that less medium in liquid form ML evaporates in the high-pressure vapor reservoir 1. Further, the three-way valve 14 will be set in the second position, so that the removal of the heat of condensation via the heat exchanger 9 is discontinued, as a result of which the pressure will run up. Also, the circulation pump 11 is switched off for a short time. After that, the circulation pump 11 is switched on again, and the removal of the heat of condensation via the heat exchanger 15 in the high-pressure vapor reservoir 1 is started. As a result of these measures, the pressure in the high-pressure vapor reservoir 1 will rapidly decrease. At the moment when the pressure in the condenser reservoir 5 is higher than the pressure in the high-pressure vapor reservoir 1, medium in liquid form ML will flow from the condenser reservoir 5 via the second fluid connection 7 through the non-return valve 8 to the high-pressure vapor reservoir 1. As a result, the high-pressure vapor reservoir 1 will be filled with medium in liquid form ML, while the condenser reservoir 5 is drained. As soon as the high-pressure vapor reservoir 1 is sufficiently filled with the medium in liquid form ML, the high-pressure vapor reservoir filling phase will be stopped. The total energy apparatus can then switch to the heat generation phase, whereby heat is supplied to the second circuit 13 and energy is converted in the energy conversion device 4.

[0029] When the three-way valve 14 is switched to the third position, then, if the total energy apparatus is in operation, at the same time heat of condensation will be removed via the heat exchanger 9 and heat of conden-

sation will be removed via the heat exchanger 15. As a result, the total energy apparatus in Fig. 1 can briefly furnish a relatively high power of heat to a heat consuming process.

[0030] The energy conversion device 4 which is incorporated in the total energy apparatus is driven by the medium which, in the heat generation phase, flows in vapor form via the first fluid connection 3 to the condenser reservoir 5. The energy conversion device 4 can be a steam engine, a steam turbine, an ejector or thermocompressor or a like appliance energized by expansion of the vapor, or a combination thereof. With the aid of a steam engine or a steam turbine, for instance electric current can be generated, or a machine, for instance a water pump or compressor, can be driven directly. Thus, with the energy conversion device, thermal energy is converted into mechanical energy.

[0031] In Fig. 2 another embodiment of the total energy apparatus according to the invention is shown. For parts corresponding to the parts of the total energy apparatus in Fig. 1, identical reference numerals have been used. The total energy apparatus in Fig. 2 is a micro-total energy system which is alternately in a heat generation phase and a high-pressure vapor reservoir filling phase, as already described in relation to Fig. 1. In the total energy apparatus of Fig. 2, the energy conversion device is a turbine 4', by which, in the heat generation phase, flow energy of the medium flowing in vapor form via the fluid connection 3 through the turbine 4' is converted into mechanical energy. Thereupon, this mechanical energy is converted, in a generator 17 coupled to the turbine, into electricity which is supplied via the cable 18 to the electricity grid. After the medium in vapor form has expanded in the turbine 4', the medium flows to the condenser reservoir 5 where it condenses while delivering heat of condensation to the heat exchanger 9.

[0032] In the heating apparatus in Fig. 2, the residual heat of the flue gases R of the gas burner 2 is utilized, so that an optimum efficiency of the apparatus is obtained. This is achieved by allowing these flue gases R to flow along a heat exchanger 19 and a heat exchanger 20 of the circuit. Thus, the liquid in the circuit is after-heated. By cooling the flue gases R, as shown in Fig. 2, in the heat exchanger 20 countercurrently to the coldest water of a supply pipe of the circuit, a highly favorable efficiency can be achieved. It should be noted that the controllable three-way valve 14 of Fig. 1 has been replaced in Fig. 2 with two loose control valves 14A, 14B, with which the same three-position control can be realized.

[0033] In the exemplary embodiment of Fig. 3, corresponding parts have again been provided with the same reference numerals as in Figs. 1 and 2. The energy conversion device 4 in this example is designed as an ejector 4".

[0034] The high-pressure vapor reservoir 1 is a primary vapor source which can be heated by the heating

source 2. The heating source 2 can be, for instance, a gas burner or electric heating element. Connected to the pressure reservoir 1 is an ejector 4" which terminates in a venturi 21. The venturi 21 is provided with a diverging portion 21" and a converging portion 21'. In the outlet of the diverging portion 21", or downstream thereof, a heat exchanger 9 designed as a condenser 9 is arranged. In use, vapor coming from the pressure reservoir 1 (primary vapor source) will flow at high velocity via the ejector 4" through the converging part 21' of the venturi 21. This high flow velocity creates a reduced pressure in an area in the venturi to which a vapor supply pipe 22 is connected. The vapor supply pipe 22 in this case is connected to two secondary vapor sources 23 and 24. Due to the partial vacuum generated, vapor coming from the secondary vapor sources 23 and 24 is sucked towards the venturi 21. This sucked-in vapor will subsequently mix in the venturi 21 and in the condenser reservoir 5 with vapor coming from the pressure reservoir 1 (primary vapor source). Due to the increase of the pressure in the diverging part 21" of the venturi 21, the temperature of the vapor mixture will rise. The mixture will then condense against the heat exchanger 9, whereby the heat of condensation released is absorbed by the heat exchanger 9. The heat of condensation absorbed by the heat exchanger 9 is delivered to a circuit 10, after which the circuit 10 transfers the heat to a heat consuming process.

[0035] The temperature of the vapor to be condensed in the condenser reservoir 5 can be, for instance, 20-40 °C higher than the temperature of the vapor in the secondary vapor sources 23, 24. This means that the vapor coming from the secondary vapor sources 23 and 24 (by compressing it in the diverging part 21" of the venturi 21) is heated such that the residual heat of this vapor can be utilized by the total energy apparatus.

[0036] The liberated heat of condensation is passed from the condenser reservoir 5 to the heat consuming process via the circuit 10. For this purpose, a primary side of the heat exchanger 9 forms part of the circuit 10. In the circuit 10, a liquid is pumped round by a circulation pump 11, so that the heat of condensation absorbed by the liquid in the heat exchanger 9 is transported through the circuit 10. Often, the heat of condensation will be removed to a central heating installation for heating houses or offices. Other possible applications are, for instance, the heating of tap water or process water for the purpose of a chemical process.

[0037] The first secondary vapor source 23 is a solar collector which is arranged to vaporize medium in liquid form. For this purpose, solar energy 5 is collected by the solar collector 23. The vapor generated is sucked by the ejector 4" via the vapor supply pipe 22 to the condenser reservoir 5. Thus, the total energy apparatus can utilize residual energy (renewable energy) without necessitating the use of auxiliary energy and auxiliary pumps.

[0038] The second vapor source 24 is a heat exchanger which is in thermal contact with flue gases R of

the gas burner 2 that are discharged via the flue duct 25. Using the absorbed heat from the flue gases R, medium in liquid form ML is evaporated in the vapor source 24, whereafter the vapor MD is passed via the vapor supply pipe 22' to the heat exchanger 9 in the condenser reservoir 5. The flue gases R of the gas burner 2 can be cooled to a temperature below the condensation temperature to achieve a favorable efficiency. Any condensate in the flue duct 25 is removed via a siphon 26.

[0039] The total energy apparatus in Fig. 3 is further provided with a fluid connection 27, 27' between the condenser reservoir 5 and the secondary vapor sources 23 and 24. Via this fluid connection 27, 27', the secondary vapor sources 23 and 24 can be provided with medium in liquid form ML, whereafter this medium can subsequently evaporate in the respective vapor sources.

[0040] For a proper operation of the total energy apparatus, it is required that air and other non-condensable gases be removed from the heating installation. To that end, the condenser reservoir 5 is provided with a degassing valve 28. Optionally, the total energy apparatus can be automatically degassed with the aid of the ejector 4" without making use of auxiliary equipment.

[0041] In the total energy apparatus according to the invention, various liquids, or mixtures of liquids, can be used as medium. To be considered here are, for instance, alcohol or propane. The use of other liquids is also possible when the requirement is met that these liquids have a useful vapor pressure and vapor volume in the desired temperature range. When using water as medium, the vapor pressures in the high-pressure vapor reservoir 1 and in the condenser reservoir 5 will mostly be lower than 1 bar absolute, corresponding to a temperature of 100°C, so that these processes will take place at a partial vacuum.

[0042] The invention has been described on the basis of a few preferred embodiments. However, as will be evident to one skilled in the art, various embodiments are possible which also fall within the scope of the invention. Finally, it is noted that it is also possible to use an assembly of two total energy apparatuses according to the invention. It is then possible to have these total energy apparatuses cooperate in such a manner that when one total energy apparatus is in the heat generation phase, the other is in the high-pressure vapor reservoir filling phase. It is then advantageous that the two total energy apparatuses share a single energy conversion device, so that this typically expensive part does not need to be made of double design. It is thus possible, with a total energy apparatus according to the invention, to continuously provide heat to heat consuming processes and/or, with a total energy apparatus according to the invention, to continuously convert thermal energy into mechanical energy.

Claims

1. A method for operating a total energy apparatus comprising a high-pressure vapor reservoir (1) and a condenser reservoir (5) provided with a heat exchanger (9), while the high-pressure vapor reservoir (1) is connected via a first fluid connection (3) with the condenser reservoir (5), and in the fluid connection (3) an energy conversion device (4, 4', 4'') is included for at least partly converting the energy contained in the vapor being under high pressure into a different form of energy, such as, for instance, mechanical energy or a local reduced pressure, the method comprising at least the following step in a heat generation phase of the total energy apparatus:
 - supplying heat to a medium in liquid form (ML) which is contained in the high-pressure vapor reservoir (1) and transporting the medium in vapor form (MD) from the high-pressure vapor reservoir (1) through the first fluid connection (3) via the energy conversion device (4, 4', 4'') to the condenser reservoir (5), whereafter the medium condenses against the heat exchanger (9), while the heat of condensation absorbed by the heat exchanger (9) is removed to a heat consuming process,

characterized in that

between successive heat generation phases, in a high-pressure vapor reservoir filling phase, at least the following step is carried out:

 - increasing the pressure in the condenser reservoir (5) by stopping the removal of heat of condensation via the heat exchanger (9) in the condenser reservoir (5) and/or lowering the pressure in the high-pressure vapor reservoir (1) by stopping the heating of the medium in the high-pressure vapor reservoir (1) and actively cooling the medium being in vapor form in the vapor reservoir (1), such that the medium in liquid form (ML) flows back from the condenser reservoir (5) to the high-pressure vapor reservoir (1).
2. A method according to claim 1, **characterized in that** the step in the high-pressure vapor reservoir filling phase is carried out after the medium in liquid form (ML) in the high-pressure vapor reservoir (1) reaches a predetermined minimum level.
3. A method according to any one of the preceding claims, **characterized in that** in the high-pressure vapor reservoir filling phase, the cooling of the vaporous medium (MD) in the high-pressure vapor reservoir (1) is carried out by passing cooling medium through a heat exchanger (15) disposed in the high-pressure vapor reservoir (1).
4. A method according to claim 3, **characterized in that** the heat which is removed via the heat exchanger (15) in the high-pressure vapor reservoir (1) is passed to the heat consuming process.
5. A method according to any one of the preceding claims, **characterized in that** in the energy conversion device (4, 4') the energy stored in the vapor being under high pressure is converted into mechanical energy with the aid of a steam engine or a steam turbine (4').
6. A method according to any one of claims 1-4, **characterized in that** in the energy conversion device (4, 4') the energy stored in the vapor being under high pressure is converted into a local reduced pressure with the aid of an ejector or thermocompressor (4'').
7. A method according to claim 6, **characterized in that** the local reduced pressure in the ejector (4'') is used for sucking vapor from a secondary vapor source (23, 24), such as, for instance, an evaporation heat exchanger (23, 24), which is disposed in a flue duct (25), in the bottom, on the roof in the form of a solar collector (23), in a ventilating air duct for extracting heat from spent ventilating air or for cooling fresh ventilating air to be supplied.
8. A method according to any one of the preceding claims, **characterized in that** use is made of at least two high-pressure vapor reservoirs (1) and two condenser reservoirs (5), while at any particular time a high-pressure vapor reservoir (1) is in the heat generation phase while another high-pressure vapor reservoir (1) is in the high-pressure vapor reservoir filling phase.
9. A method according to any one of the preceding claims, **characterized in that** with the total energy apparatus heat is supplied to a central heating installation.
10. A method according to any one of the preceding claims, **characterized in that** the medium is water.
11. A method according to any one of the preceding claims, **characterized in that** in the heat generation phase in the high-pressure vapor reservoir a vapor pressure of 30 bars is achieved.
12. A total energy apparatus comprising a high-pressure vapor reservoir (1), a heating source (2) for heating medium contained in the high-pressure vapor reservoir, and a condenser reservoir (5), the

high-pressure vapor reservoir (1) being connected via a first fluid connection (3) with the condenser reservoir (5), while the high-pressure vapor reservoir (1) and the condenser reservoir (5) are arranged to comprise a medium in vapor form (MD) and liquid form (ML), the condenser reservoir (5) being provided with a heat exchanger (9) for the purpose of removing the heat released by condensation of vapor to a heat consuming process, while in the first fluid connection (3) an energy conversion device (4, 4', 4'') is included for at least partly converting the energy contained in the vapor being under high pressure into a different form of energy, such as, for instance, mechanical energy or a local reduced pressure, **characterized in that** a second fluid connection (7) extends between the condenser reservoir (5) and the high-pressure vapor reservoir (1), while in the second fluid connection a non-return valve (8) is arranged which prevents flow of medium from the high-pressure vapor reservoir (1) to the condenser reservoir (5), while for the purpose of the transport of the medium in liquid form (ML) from the condenser reservoir (5) to the high-pressure vapor reservoir (1), the apparatus is provided with a control (28) which is arranged for periodically increasing the pressure in the condenser reservoir (5) by stopping the removal of heat of condensation via the heat exchanger (9) in the condenser reservoir (5) and/or lowering the pressure in the high-pressure vapor reservoir (1) by stopping the heating of the medium in the high-pressure vapor reservoir (1) and actively cooling the medium being in vapor form in the vapor reservoir (1), such that the medium in liquid form (ML) flows back from the condenser reservoir (5) via the second fluid connection (7) to the high-pressure vapor reservoir (1).

13. An apparatus according to claim 12, **characterized in that** the first connection (3) too is provided with a non-return valve (6), while, in use, the non-return valve (6) in the first connection (3) is in the closed condition if the vapor pressure in the condenser reservoir (5) is higher than the vapor pressure in the high-pressure vapor reservoir (1).

14. An apparatus according to claim 12 or 13, **characterized in that** in the high-pressure vapor reservoir (1) a heat exchanger (15) is disposed for removing heat of condensation to a heat consuming process.

15. An apparatus according to claim 14, **characterized in that** the total energy apparatus comprises a circuit (10) for a liquid for the heat transport from the total energy apparatus to the heat consuming process, which circuit is provided with a valve system (14, 14A, 14B) whereby, in use, in a first position of the valve system (14, 14A, 14B), liquid in the circuit flows through the heat exchanger (9) in the con-

denser reservoir (5) while hardly any or no liquid flows through the heat exchanger (15) in the high-pressure vapor reservoir (1), and in a second position of the valve system (14, 14A, 14B), liquid in the circuit (10) flows through the heat exchanger (15) in the high-pressure vapor reservoir (1) and hardly any or no liquid flows through the heat exchanger (9) in the condenser reservoir (5).

16. An apparatus according to claim 15, **characterized in that**, in a third position of the valve system (14, 14A, 14B), liquid in the circuit flows through the heat exchanger (15) of the high-pressure vapor reservoir (1), while at the same time liquid in the circuit flows through the heat exchanger (9) of the condenser reservoir (5).

17. An apparatus according to any one of claims 12-16, **characterized in that** the energy conversion device (4) is a steam engine.

18. An apparatus according to any one of claims 12-16, **characterized in that** the energy conversion device (4) is a steam turbine (4').

19. An apparatus according to any one of claims 12-16, **characterized in that** the energy conversion device (4) is an ejector or a thermocompressor (4''), which is connected via a vapor supply pipe (22) to a secondary vapor source (23, 24), such as, for instance, an evaporation heat exchanger which is disposed in a flue duct (25), in the bottom, on the roof in the form of a solar collector, in a ventilating air duct for extracting heat from spent ventilating air or for cooling ventilating air to be supplied.

20. An apparatus according to any one of claims 12-19, **characterized in that** the high-pressure vapor reservoir (1) is provided with means (16) for delivering a signal when a predetermined minimum level of the medium in liquid form in the high-pressure vapor reservoir is reached.

21. A total energy apparatus according to any one of claims 12-20, **characterized by** a second high-pressure vapor reservoir and a second condenser reservoir, which are connected with each other via a third fluid connection in which the energy conversion device (4) is included, while a fourth fluid connection extends between the second condenser reservoir and the high-pressure vapor reservoir, and in the fourth fluid connection a non-return valve is arranged which prevents flow of medium from the second high-pressure vapor reservoir to the second condenser reservoir, while the control is arranged, in use, during the generation of vapor in the first high-pressure vapor reservoir, to fill the second high-pressure vapor reservoir from the second con-

denser reservoir, and, during the generation of vapor in the second high-pressure vapor reservoir, to fill the first high-pressure vapor reservoir from the first condenser reservoir, such that continuously vapor under high pressure is available for energizing the energy conversion device.

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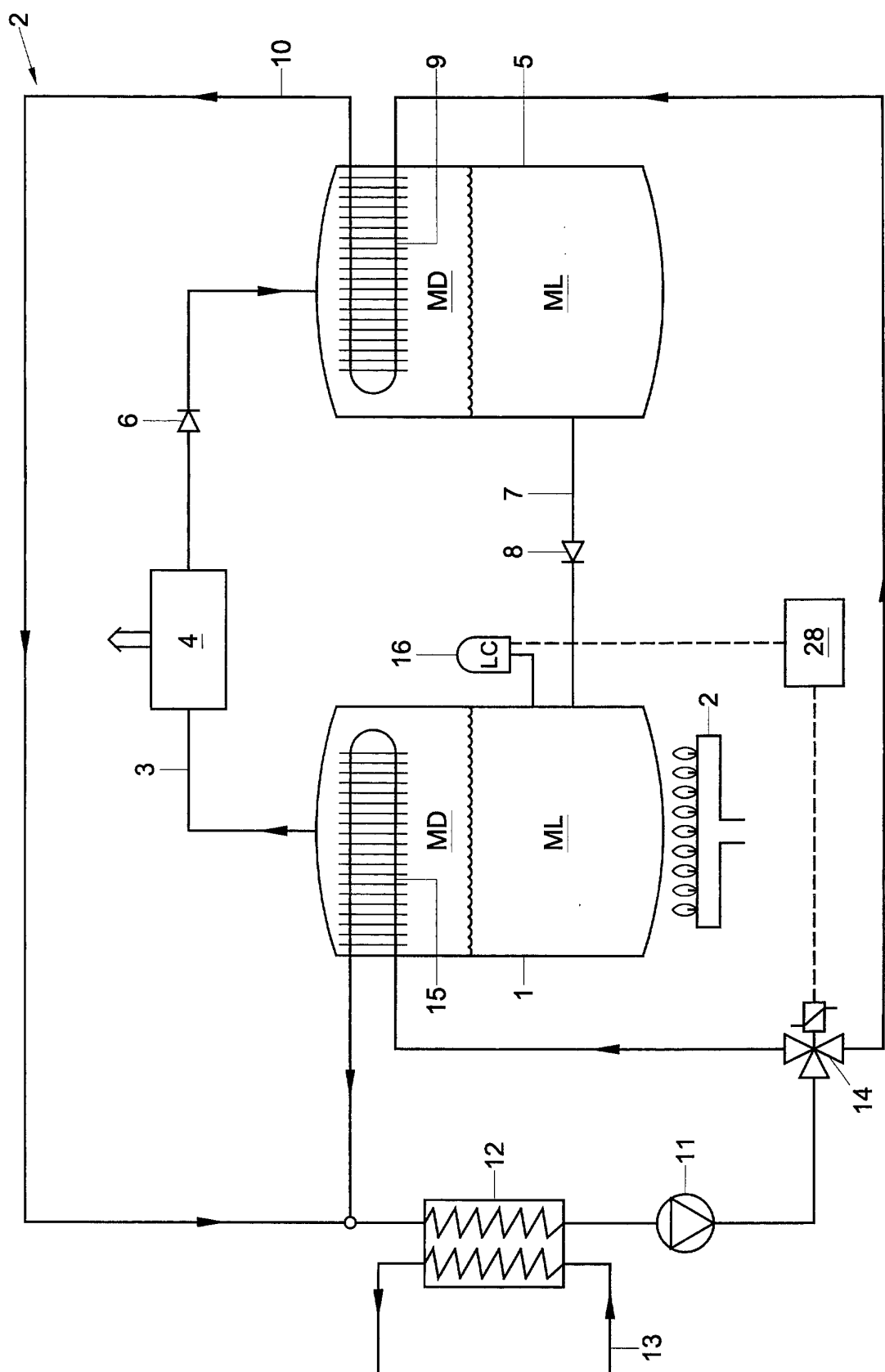


Fig. 1

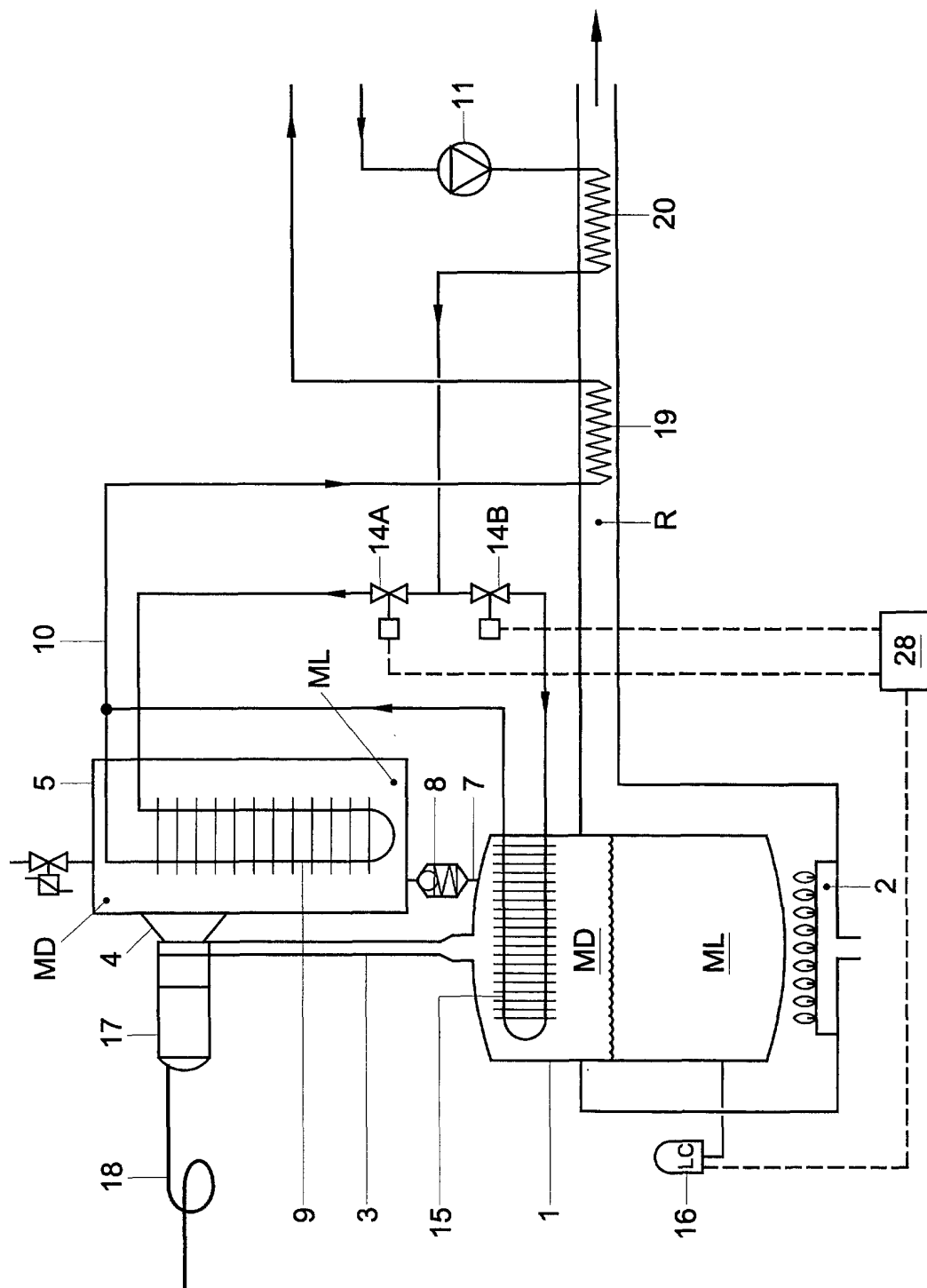


Fig. 2

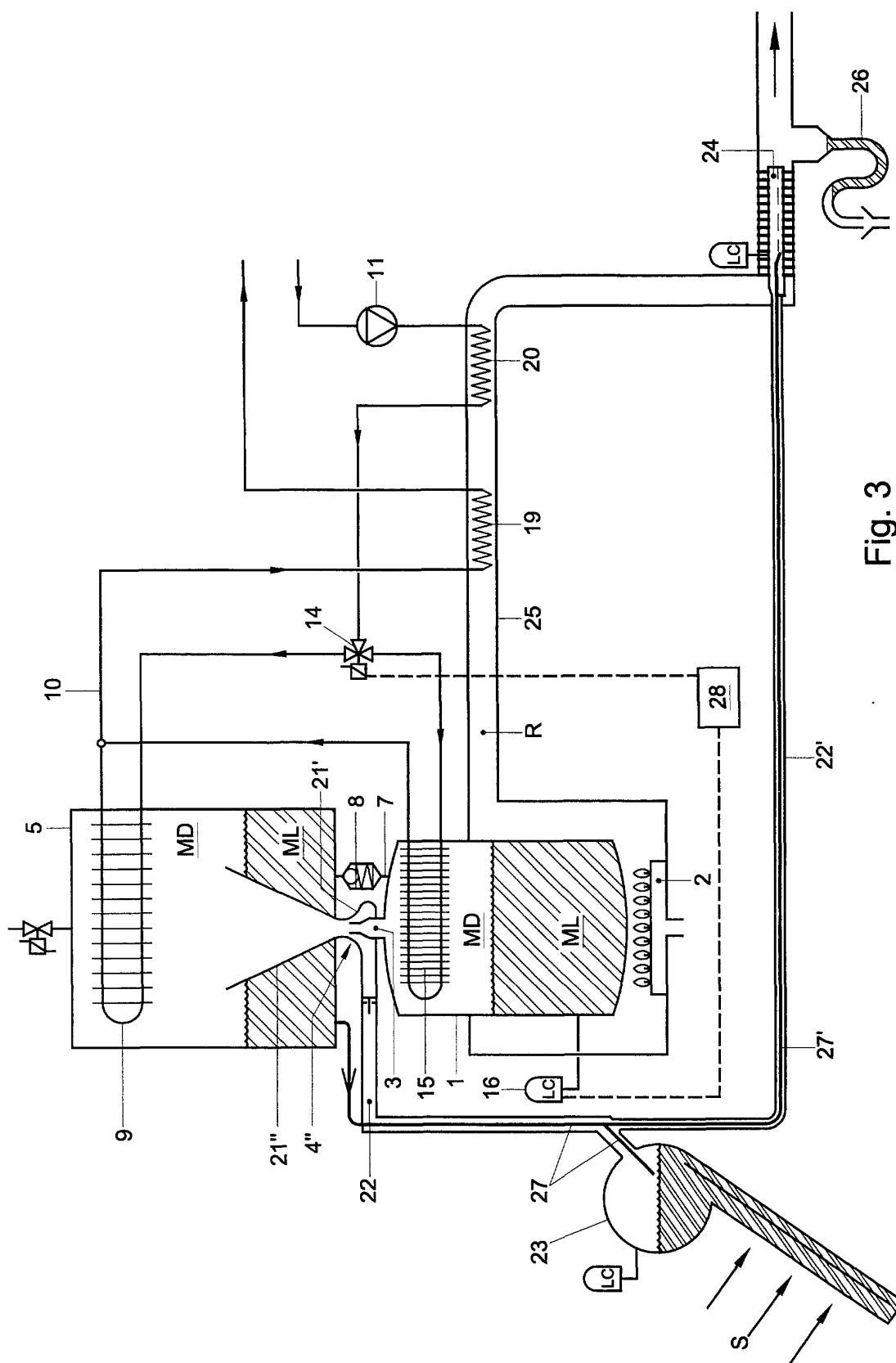


Fig. 3



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EUROPEAN SEARCH REPORT

Application Number
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			F22D F01K F24H F25B F28D F24J
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 8 March 2002	Examiner Van Gheel, J
CATEGORY OF CITED DOCUMENTS 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 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			

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