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(71) Applicant: **7innovations b.v.**
2132 MN Hoofddorp (NL)

(72) Inventor: **van der Roest, Wubbo Bart**
9715 NX Groningen (NL)

(74) Representative: **van Dokkum, Willem Gerard Theodoor**
Muller & Eilbracht B.V.
Caballero Fabriek unit 61
Saturnusstraat 60
2516 AH The Hague (NL)

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(54) **HEAT PUMP**

(57) Heat pump system comprising a circulation channel between an evaporator and a condenser via a vapour compressor and back again via an expansion device. A booster heat exchanger is included in the return section of the circulation channel, the secondary circuit of which is connected to a booster vapour inlet of the vapour compressor. Furthermore, a control member, a temperature and/or pressure sensor is provided for measuring the temperature or pressure in the vapour

compressor, and in a control valve controllable by the control member and included in the booster circuit. In an iterative process, the supply of vapour via the booster circuit is stopped by the control valve as soon as the temperature and/or the pressure reaches an extreme limit value. After a certain time t the supply of vapour to the booster vapour inlet is restored by the control valve. The iterative process is repeated as long as required by the heat demand of the device.

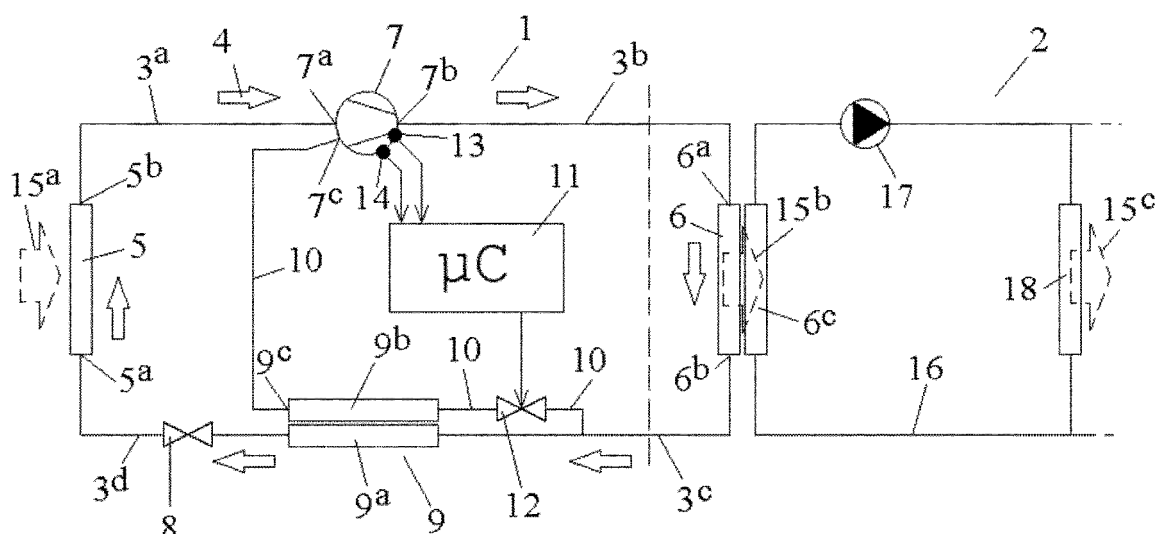


FIG. 1

Description

[0001] The invention relates to a device which is intended and arranged as a heat pump system as a heat source for, for example, a central heating system or other installation.

Related art

[0002] Heat pump systems are generally known (see, for example, https://en.wikipedia.org/wiki/Heat_pump). There is now a renewed interest in heat pump systems due to environmental requirements and energy needs.

Disclosure of the invention

[0003] The object of the present invention is to provide a heat pump system in which substantially higher temperatures can be achieved than up till now are customary. The present invention is based on the insight that in particular the vapour compressor of the installation can be loaded considerably more heavily than when the installation is started. But also during operation, the load capacity of the compressor can be trained, as it were, or "stretched" if, like physical training for humans or animals, the load is increased, for example, stepwise, by applying "stretch/relax" control of the system, whereby the system is able to deliver a substantially higher output, resulting in a higher efficiency and a higher water temperature when the heat pump system is used as a heat source for a central heating system.

[0004] In general, a device intended and arranged as a heat pump system, serving as a heat source for, for example, a central heating system or other installation, comprising a circulation channel of which a supply section is arranged for transporting a heat transfer medium in vapour form, hereinafter referred to as vapour, from the outlet of an evaporator to the inlet of a condenser, by means of a vapour compressor, which is adapted to draw in the vapour from the evaporator through a low-pressure portion of the supply section of the circulation channel and through a low-pressure inlet, and to compress the vapour from a low to a high pressure, and to supply the pressurized vapour to the condenser through a high-pressure portion of the supply section of the circulation channel. The circulation channel also comprises a return section, which is adapted for transporting the heat medium from the outlet of the condenser to the inlet of the evaporator through an expansion member (e.g. an expansion valve, throttle valve, optionally turbine), which is arranged to reduce the pressure of the heat transfer medium originating from the condenser outlet and thereby to flash/expand the heat medium. A primary circuit of a booster heat exchanger comprising a primary and a secondary circuit is included in the return section of the circulation channel, preferably in the high-pressure section of the return section of the circulation channel, i.e. between the outlet of the condenser and the expansion

member. The secondary circuit of the booster heat exchanger is included in a booster circuit between the return section of the circulation channel, on the side of the inlet or outlet of the primary circuit (i.e. in cocurrent or counter-current configuration), and a booster vapour inlet of either the aforementioned vapour compressor or another vapour compressor, which (in both cases) is connected with its high-pressure side to the high-pressure portion of the supply section of the circulation channel.

According to the invention, furthermore a control member is provided, such as a microprocessor or microcontroller, and a temperature and/or pressure sensor for measuring the temperature or pressure in the aforementioned vapour compressor, and a control valve controllable by the control member and included in the booster circuit. During operation, the sensors transmit the measured temperature and pressure to the control member. The control member is arranged or programmed in such a way that, in an iterative process, the supply of vapour through the booster circuit to the booster vapour inlet is stopped or reduced by means of the control valve as soon as the temperature and/or the pressure in the vapour compressor reaches an extreme limit value for the temperature value or the pressure value in the vapour compressor, after which the control member, after a time t determined by the control member, by means of the control valve, restores the supply of vapour through the booster circuit to the booster vapour inlet, after which the iterative process is repeated as long as required by the heat demand of the device.

[0005] Preferably, the aforementioned vapour compressor is of the spiral compressor type (scroll compressor), comprising a low-pressure inlet, a high-pressure outlet and a booster connection, wherein the outlet of the secondary circuit of the booster heat exchanger is connected to the booster connection of the scroll compressor, which is connected with its high-pressure side to the high-pressure portion of the supply section of the circulation channel.

[0006] In an alternative embodiment, the vapour compressor is of a type without a booster connection, wherein the outlet of the secondary circuit of the booster heat exchanger is connected to an (additional) auxiliary or booster compressor which, like the aforementioned vapour compressor, is connected at its high-pressure side to the high-pressure portion of the supply section of the circulation channel.

[0007] Preferably, the compressor used is of the scroll compressor type, which has an (additional) connection for the injection of a vapour (vapour or gaseous heat transfer medium) having an already elevated temperature. The high-temperature vapour, obtained by converting the high-pressure liquid recirculated from the condenser back to vapour by means of an expansion valve, is injected into the secondary circuit of the booster heat exchanger (also called "economizer"). As a result, a vapour with a high temperature is obtained, which subsequently if necessary (depending on the heat demand) is

injected into the compressor through the (additional) booster connection on the compressor, whereby an extra high outlet temperature can be achieved on the high-pressure side of the compressor.

[0008] In order to prevent malfunctioning of the compressor due to the high pressure and/or high temperature, the supply of hot vapour to the booster connection of the compressor is carefully controlled by the microcomputer, which accurately controls the temperature in the compressor by means of data obtained by the various sensors. In order to prevent overheating of the compressor, or that a too high pressure is reached, the temperature sensor records the (head) temperature of the compressor, and the pressure sensor of the compressor records the pressure values prevailing within the compressor, and sends the values to the microcomputer. With these values, the microcomputer calculates if and when cooling is required. If the temperature in the compressor becomes too high or if the pressure dependent on this temperature becomes too high, the microcomputer will close the control valve (solenoid valve) in the booster circuit. As a result, the high-pressure liquid is sent directly and in full to the evaporator, so that only a low-pressure vapour having a low temperature is injected into the compressor. By properly controlling this process, the compressor never gets too hot and never operates with a too high pressure. However, by temporarily raising the temperature in the compressor (see the "training effect" mentioned above), the pressure will become correspondingly higher. By temporarily operating at very high pressures and then allowing the compressor to cool, substantially higher temperatures can be achieved in the condenser than without "training" the device. Because of this step, by means of additional injection through the booster circuit, the high temperature vapour in the compressor, and consequently the compressor itself, is cooled back (just) in time (by interrupting or reducing the booster flow at the booster inlet of the compressor). As a result, the temperature in the condenser is gradually increased until, as tests at working conditions have shown, a temperature of 115 °C instead of about 55 °C, as has been common practice until now, without using the training process according to the invention.

[0009] Also, the following is noted here. The high temperatures in the condenser can only be achieved by operating at high pressures and by injecting hot vapour. However, high vapour temperatures result in high temperatures and high pressures in the compressor. A compressor is able to temporarily handle very high pressures but not for a long time. So, in order to be able to reach high temperatures in a condenser, the time during which the compressor operates under high pressure will have to be monitored, taking the temperature into account. The higher the pressure and temperature in the compressor, the shorter the compressor will be able to perform before the compressor will fail due to (too) long operation at high pressure. The microcomputer calculates very accurately the length of time that can be used to achieve a high

condenser temperature, and switches to the cooling mode for the compressor just in time (shutting down or reducing the hot booster stream through the booster circuit).

5 It is important to provide the cooling mode with a time period, that is just long enough to allow the compressor to cool down sufficiently, but that simultaneously ensures that the temperature in the system is kept high, namely by choosing the compressor's cooling time as short as possible. However, the following operating conditions are essential and crucial: the higher the temperature in the system, the more often the compressor will have to cool down. During operation, this is also observed, because the steps are getting shorter, while the temperature in the system is going up. This increase of the temperatures in the system can be achieved by immediately injecting hot vapour back into the compressor (control valve in the booster circuit open) after cooling the compressor (control valve in the booster circuit closed or minimal open).
10 As a result, no temperature is lost in the system, because the compressor immediately resumes the high flow of compressed hot vapour and does not have to achieve this high temperature solely by its own operation, which latter will result in undesired cooling down of the system resulting in lower temperatures.

25 **[0010]** Finally, when the system is at the desired temperature, the compressor will switch off completely. But to save energy, if there is still a heat demand, the microcomputer will continue to monitor the temperature of the system and when this temperature drops to a temperature difference with a delta T of more than 10 °C (of the central heating system water temperature) with respect to the set desired temperature, the compressor will restart to compensate for the decreased temperature and restore the desired temperature.

30 **[0011]** The invention will now be further discussed with reference to the figure description below.

Figure 1 shows a schematic representation of an exemplary embodiment of a device according to the invention, provided with a spiral compressor with booster inlet;

40 Figure 2 shows a schematic representation of an exemplary embodiment of a device according to the invention, provided with a compressor without booster inlet, wherein use is made of an additional auxiliary compressor/booster compressor;

50 Figure 3 shows an example of a "step diagram" in which the temperature and pressure line chart of the compressor is displayed as a function of time for a device with a substantial heat demand.

55 **[0012]** Figures 1 and 2 both show a schematic representation of an exemplary embodiment of a device 1 ac-

according to the invention, which is intended and arranged as a heat pump system, serving as a heat source for, for example, a central heating system 2 or other installation.

[0013] The device 1, i.e. the actual heat pump system, comprises a circulation channel 3 of which a supply section 3a-b (see also flow direction arrows 4) is adapted for transporting a heat transfer medium in vapour form, hereinafter referred to as vapour, from the outlet 5b of an evaporator 5 to the inlet 6a of a condenser 6, by means of a vapour compressor 7, which is adapted to draw in a vapour from a low-pressure portion 3a of the supply section 3a-b of the circulation channel 3 through a low-pressure inlet 7a, and to compress the vapour from a low to a high pressure, and to press (pump) the high-pressure vapour through a high-pressure portion 3b of the supply section of the circulation channel 3 to the inlet 6a of the condenser 6.

[0014] The circulation channel 3 comprises a return section 3c-d, which is adapted to transport the heat transfer medium from the outlet 6b of the condenser 6 to the inlet 5a of the evaporator 5 through an expansion member 8, which is adapted to reduce the pressure of the heat transfer medium from outlet 6b of the condenser 6 by means of expansion of the heat transfer medium.

[0015] In the return section 3c-d of the circulation channel 3, a primary circuit 9a of a booster heat exchanger 9, comprising a primary 9a and a secondary circuit 9b, is included. The secondary circuit 9b is included in a booster circuit 10 between on the one hand the high-pressure portion 3c of the return section 3c-d of the circulation channel 3 and, on the other hand, a booster vapour inlet 7c, 19a of either the aforementioned vapour compressor 7, as represented in figure 1, or another (auxiliary or booster) vapour compressor 19, as represented in figure 2, which (in both embodiments) are connected with their high-pressure side 7b, 19b to the high-pressure portion 3b of the supply section 3a-b of the circulation channel 3. In the exemplary embodiments shown, the secondary circuit 9b of the booster heat exchanger 9 is connected with the high-pressure portion 3b of the supply section 3a-b of the circulation channel 3 through an expansion/control valve 12, hereinafter referred to as control valve, which is controllable from a control member 11.

[0016] In addition to the control member 11, for example a microprocessor or microcontroller, and to the control valve 12, which is included in the booster circuit 10 and is controlled by the control member 11, furthermore a temperature sensor 13 and a pressure sensor 14 are provided for measuring the temperature and the pressure within the vapour compressor 7.

[0017] The sensors transmit the measured temperature and pressure to the control member 11 during operation of the device. The control member 11 is arranged or programmed in such a way that, in an iterative process (see Figure 3), the supply of the vapour through the booster circuit 10 to the booster vapour inlet 7c by means of the control valve 12 is stopped or reduced as soon as the temperature and/or the pressure within the vapour

compressor reaches an extreme limit value $T_{\max}$ or $p_{\max}$ for the temperature or pressure value within the vapour compressor. After which the control member 11, after a time t determined by the control member 11, restores the supply of vapour through the booster circuit 10 to the booster vapour inlet 7c by means of the control valve 12. This iterative process is repeated as long as required by the heat demand of the device.

[0018] Heat transport, represented by arrows 15a-c, therefore takes place in and by means of device 1 from a heat source with a low temperature, for example ambient air, which is supplied to the evaporator 5; for example by a fan (not shown) (the evaporator 5 thus forms an air/liquid heat exchanger). By means of the device according to the invention, the heat absorbed by the evaporator is substantially increased in temperature, the heat being transferred to the condenser 6 at that high temperature. The condenser 6 forms the primary circuit of (for example) a liquid/liquid heat exchanger, of which the secondary circuit 6c is included as a heat source (with a high temperature) in the circulation circuit 16 of the aforementioned central heating system 2, in which the heat transfer medium (usually water) is circulated through radiators 18 by means of a circulation pump 17, whereby the heat 15c is transferred to the environment of the radiators. Furthermore, the secondary circuit 6c of the liquid/liquid heat exchanger, as is usual in every modern heating installation/system, is used for heating tap water, for example by means of a switch valve (not shown).

[0019] Figure 1 shows, as stated, an exemplary embodiment in which the vapour compressor 7 is of the spiral compressor type (scroll compressor), comprising a low-pressure inlet 7a, a high-pressure outlet 7b and a booster connection (booster vapour inlet 7c), wherein the secondary circuit 9b of the booster heat exchanger 9 has its outlet 9c connected to the booster connection 7c of the spiral compressor 7, which is connected with its high-pressure side 7b to the high-pressure portion 3b of the supply section 3a-b of the circulation channel 3.

[0020] Figure 2 shows an exemplary embodiment wherein the vapour compressor 7' is of a type without booster connection (booster vapour inlet), wherein the secondary circuit 9b of the booster heat exchanger 9 at its outlet 9c is connected to the booster vapour inlet 19a of an auxiliary or booster compressor 19 which, like the vapour compressor 7', has its high-pressure side 19b connected to the high-pressure portion 3b of the supply section 3a-b of the circulation channel 3.

[0021] It is noted that, for example, the housings of both compressors 7' and 19 can be jointly assembled if desired, so that both compressors will assume/adopt approximately the same temperature by means of their joint housing. Therefore, both compressors are cooled by means of the inflow, through the low-pressure compressor inlet 7a, of the relatively cold heat transfer medium from the outlet 5b of the evaporator 5.

[0022] Figure 3 shows an example of a "step diagram", in which the temperature line curve 20 of the compressor

7 is plotted as a function of time for a device according to the invention with a substantial heat demand. Furthermore, the associated temperature line curve 21 is shown of the heat transfer medium (usually water) within the central heating system 2.

Claims

1. Device (1) intended and arranged as a heat pump system, serving as a heat source for, for example, a central heating system or other installation (2), comprising a circulation channel (3) of which a supply section (3a-b) is arranged for transporting a heat transfer medium in vapour form, hereinafter referred to as vapour, from the outlet (5b) of an evaporator (5) to the inlet (6a) of a condenser (6), by means of a vapour compressor (7), which is adapted to compress the vapour from the evaporator through a low-pressure portion (3a) of the supply section of the circulation channel and through a low-pressure inlet (7a) from low to high pressure, and to supply the high-pressure vapour to the condenser through a high-pressure portion (3b) of the supply section of the circulation channel, of which circulation channel (3) a return section (3c-d) is arranged for transporting the heat medium from the outlet (6b) of the condenser to the inlet (5a) of the evaporator through an expansion member (8), which is arranged to reduce the pressure of the heat transfer medium flowing from the condenser outlet, wherein in the return section of the circulation channel a primary circuit (9a) of a booster heat exchanger (9) is included, comprising a primary and a secondary circuit, wherein the secondary circuit (9b) is included in a booster circuit (10) between the return section (3c-d) of the circulation channel and a booster vapour inlet (7c, 19a) of either the aforementioned vapour compressor (7) or another vapour compressor (19), which both are connected with their high-pressure side (7b, 19b) to the high-pressure portion (3b) of the supply section of the circulation channel, wherein furthermore a control member (11) is provided, and a temperature sensor and/or a pressure sensor (13, 14) for measuring the temperature or pressure (T, p) in the aforementioned vapour compressor (7), and a control valve (12) controllable by the control member and included in the booster circuit, wherein the temperature sensor and/or pressure sensor during operation transmits the measured temperature and/or pressure to the control member, wherein the control member is arranged or programmed in such a way that, in an iterative process, the supply of vapour through the booster circuit (10) to the booster vapour inlet by means of the control valve is stopped or reduced as soon as the temperature and/or the pressure in the vapour compressor reaches an extreme limit value for the temperature value and/or the pressure value in the vapour compressor, after which the control member, after a time t determined by the control member, by means of the control valve, restores the supply of vapour through the booster circuit to the booster vapour inlet, after which the iterative process is repeated as long as required by the heat demand of the device.
2. Device according to claim 1, wherein the aforementioned vapour compressor (7) is of the spiral compressor type or scroll compressor type, hereinafter referred to as scroll compressor, comprising a low-pressure inlet (7a), a high-pressure outlet (7b) and a booster connection (7c), wherein the secondary circuit of the booster heat exchanger has its outlet connected to the booster connection of the scroll compressor, which is connected with its high-pressure side to the high-pressure portion of the supply section of the circulation channel.
3. Device according to claim 1, wherein the vapour compressor (7') is of a type without booster connection, wherein the secondary circuit of the booster heat exchanger has its outlet connected to an auxiliary or booster compressor (19), which is connected at its high-pressure side (19b) to the high-pressure portion (3b) of the supply section of the circulation channel.

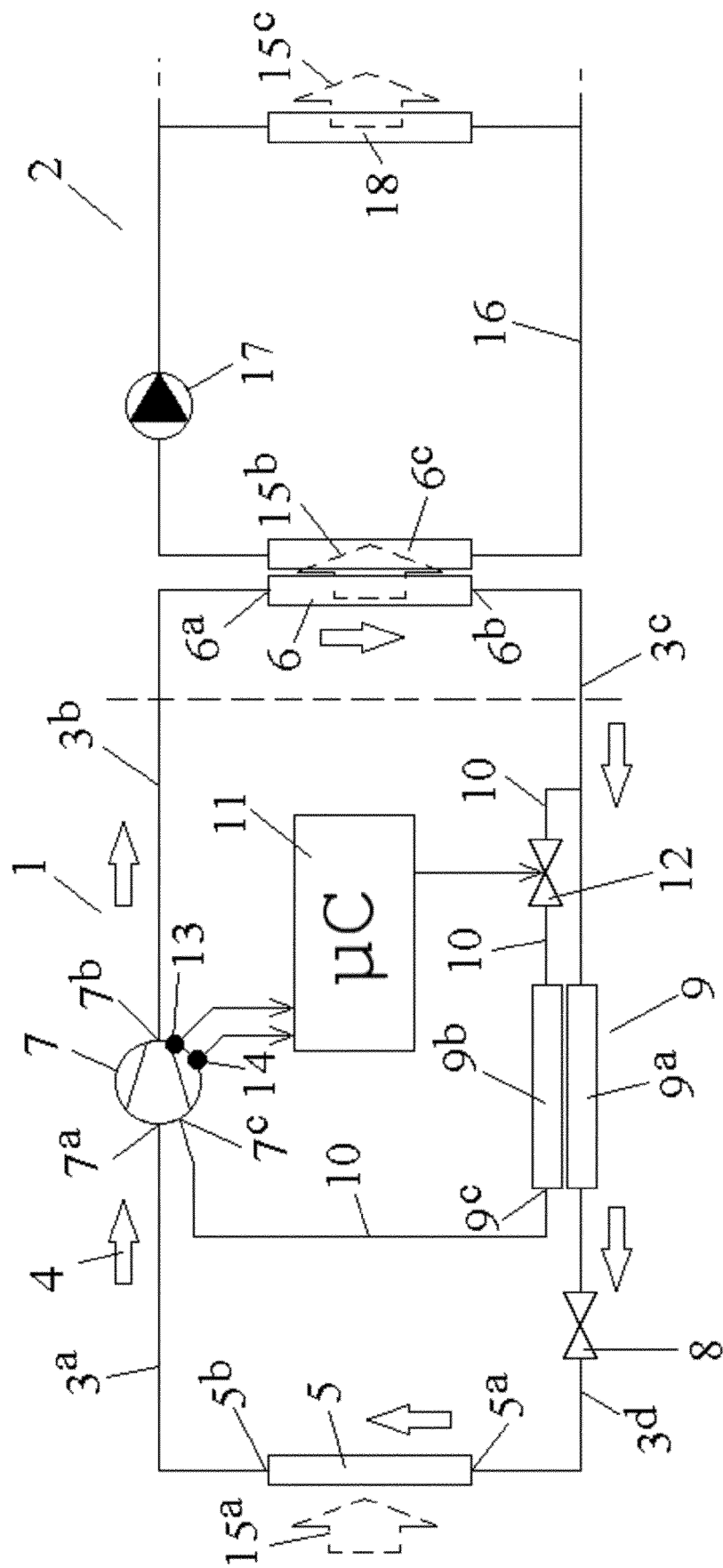


FIG. 1

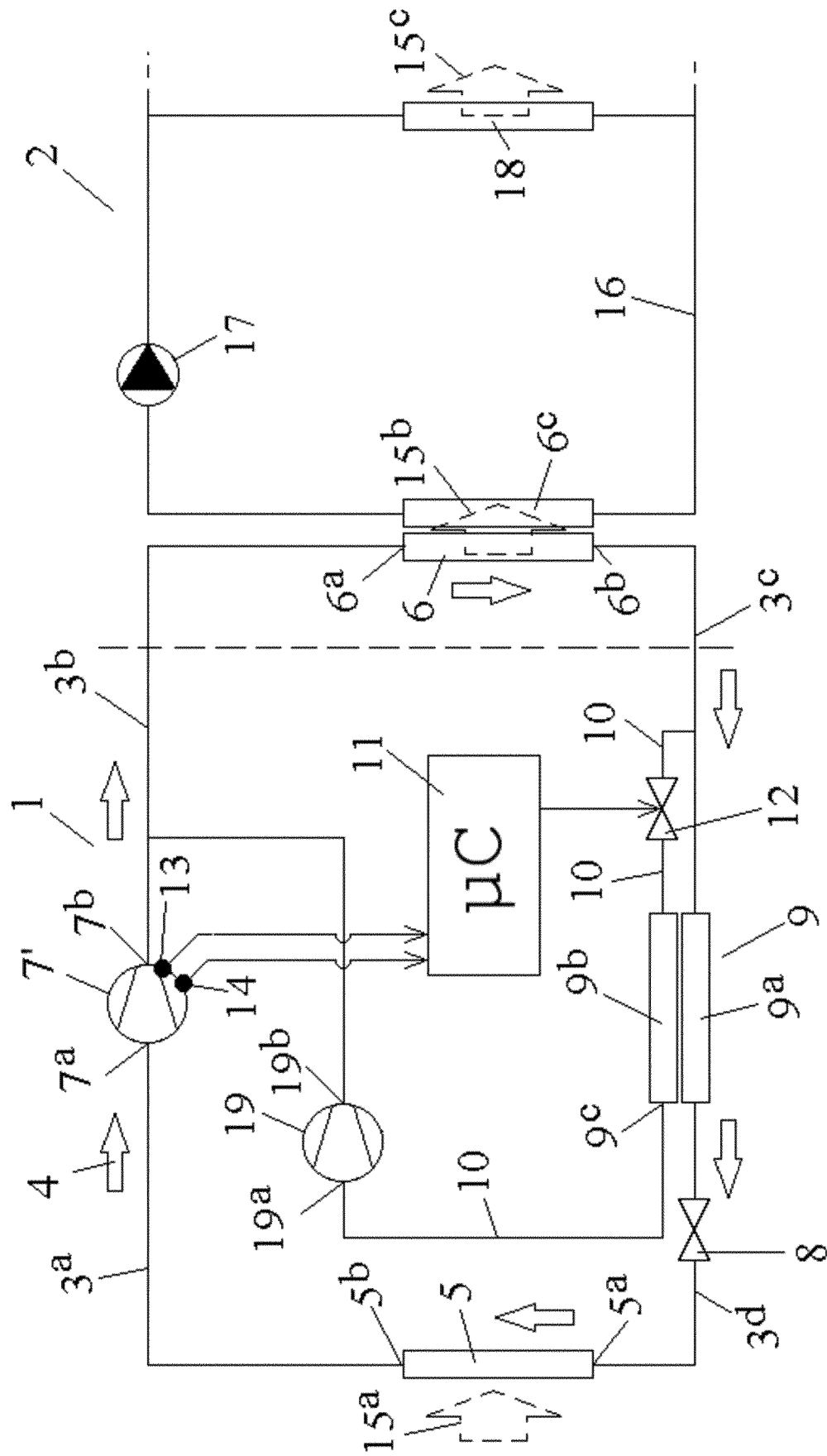


FIG. 2

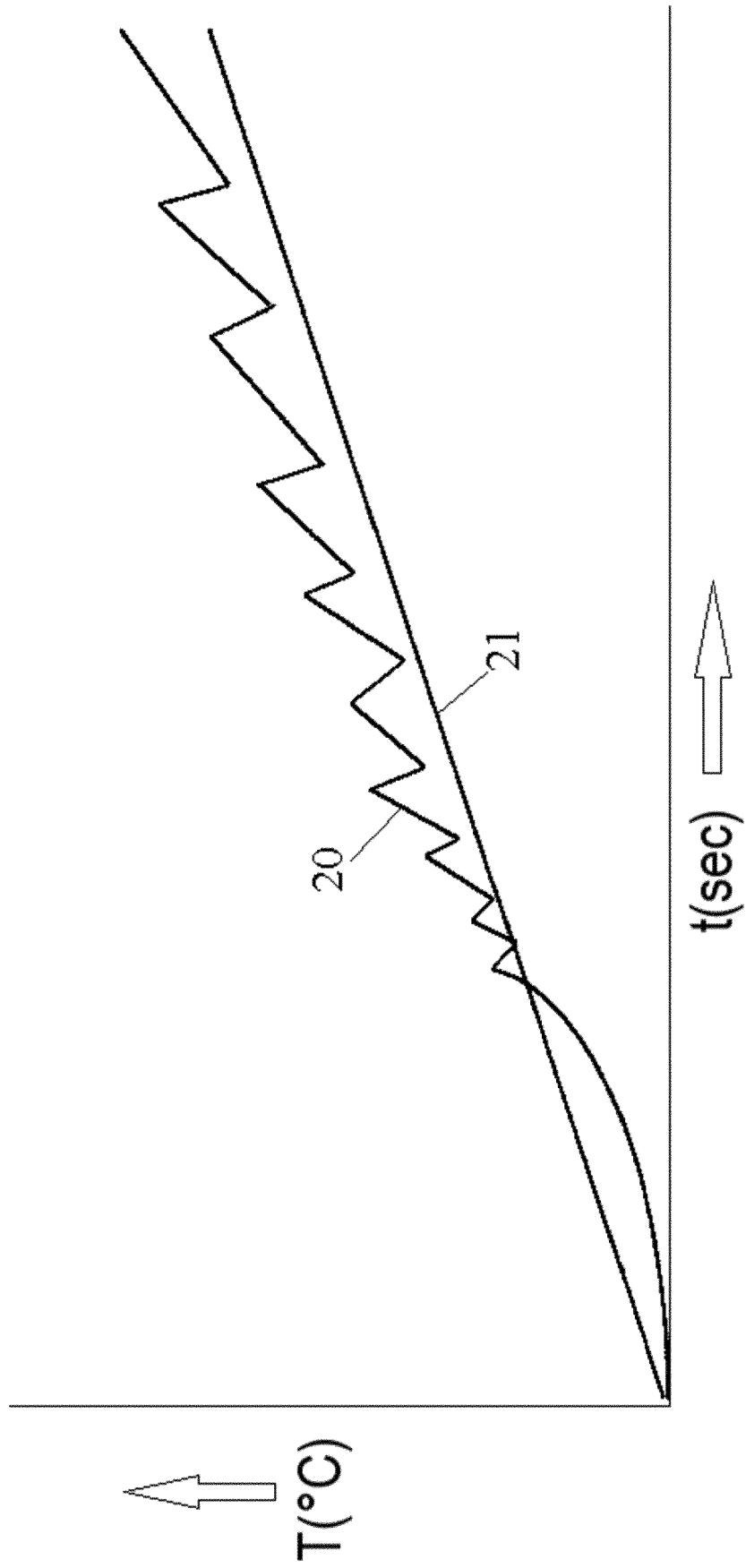


FIG. 3



EUROPEAN SEARCH REPORT

Application Number
EP 19 19 6374

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 20 January 2020	Examiner Weisser, Meinrad
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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**ANNEX TO THE EUROPEAN SEARCH REPORT
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