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(54) **METHOD FOR MANAGING A REFRIGERATING PLANT AND REFRIGERATING PLANT**

(57) A method for managing a refrigerating plant consisting of one or more refrigerating units (22) supplied by a coolant fluid, comprising setting or detecting, for each refrigerating unit (22) of said one or more refrigerating units, a set temperature range within which each refrigerating unit (22) has to remain during operation of the plant; setting up, for each refrigerating unit (22) of said one or more refrigerating units, a respective control unit (23) configured to manage the operation of the refrigerating unit (22); setting up a central control unit (24) operationally connected to each refrigerating unit (22) of said one or more refrigerating units, and a central management unit (25) operationally connected to said central control unit (24); the method further comprises a first step that includes detecting, by said respective control unit (23), an operating temperature of each refrigerating unit (22) of said one or more refrigerating units, and verifying, by said central control unit (24), if said operating temperature is comprised in the set temperature range; a second step that includes increasing by a set amount an evaporation temperature of the coolant fluid in each refrigerating unit (22) of said one or more refrigerating units, by said central management unit (25), if the operating temperature of each refrigerating unit (22) is within said set range. A refrigerating plant comprising a coolant fluid, at least one compressor (1) a refrigerating unit (22) supplied with said coolant fluid, or several refrigerating units (22) supplied in parallel with said coolant fluid, in which each refrigerating unit (22) of said one or more refrigerating units comprises an evaporator (6) supplied with said coolant fluid through a respective expansion valve (5), in which each refrigerating unit (22) of said one or more refrigerating units is provided with a control unit (23) configured to detect parameters that define the work conditions of the refrigerating unit (22) and vary the work conditions of the refrigerating unit (22), in which each control unit (23) is operationally associated with a central control unit (24) configured to receive from each control unit (23) data relating to the work conditions of each refrigerating unit (22) of said one or more refrigerating units, and communicate the data to a central management unit (25), configured to regulate operating parameters of each refrigerating unit (22) on the basis of the data received from the central control unit (24).

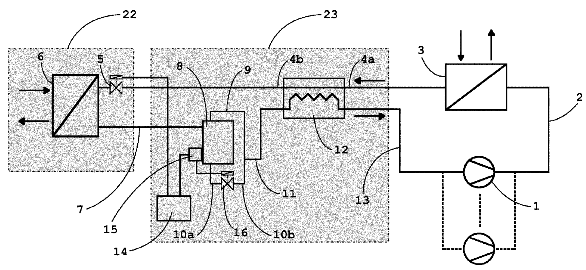

Fig. 1

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Description

[0001] The present invention relates to a method for managing a refrigerating plant that is used, in particular, in the field of commercial or industrial refrigeration, for managing refrigerating units like, for example, refrigerated counters, refrigerated display cases, refrigerated cabinets, and cold rooms in retail outlets, or industrial plants in general, even if use thereof can extend to any refrigerating plant, including refrigerating plants in transport equipments.

Prior art

[0002] So-called dry expansion refrigerating plants are known from the prior art that consist of a compressor, a first heat exchanger that acts as a condenser of the coolant fluid and of a second heat exchanger that acts as an evaporator of the coolant fluid. The coolant fluid, which is in a superheated steam state, is compressed at high pressure by the compressor and sent to the condenser, where it releases heat to the external environment, condensing in the form of high-pressure liquid. An expansion valve is interposed between the condenser and the evaporator. The coolant liquid coming from the condenser passing through the expansion valve expands adiabatically and cools down before entering the evaporator. In the evaporator, the low-pressure coolant liquid absorbs heat from the environment, is transformed into superheated steam and is returned, via the suction line, to the inlet of the compressor.

[0003] The most widespread type of plants that supply a plurality of refrigerating units manages the evaporator, which is integrated into each unit, by using thermostatic expansion valves whose task is to control the flow of coolant through the evaporators.

[0004] Different types of thermostatic expansion valves are used: the most common are mechanical and electronic valves and the operating/control principle is common to both.

[0005] As mentioned previously, the coolant liquid is injected into the evaporator and evaporating removes heat from the surrounding environment.

[0006] After the expansion valve is opened, a good part of the coolant in the initial portion of the evaporator is in liquid state. As the liquid flows through the evaporator, the liquid/gas ratio decreases through evaporation of the liquid.

[0007] Control of the expansion valves is conventionally designed to maintain a certain degree of super heating at the outlet from the evaporator to avoid a return of liquid to the compressors; so, in the final portion of the evaporator only superheated gas is present (dry zone).

[0008] This type of management does not however enable the potential of heat exchange to be fully exploited because in the end part of the evaporator the coolant fluid is in a superheated steam condition, which has a much lower heat exchange coefficient than a saturated vapour, and because, in said end part, the temperature difference decreases between the coolant fluid and the environment to be refrigerated. This all has a negative impact on the efficiency of the refrigeration system and entails an increase in energy consumption.

[0009] In order to overcome this drawback, liquid-recirculation refrigerating plants have been proposed, which are also known as "flooded" plants, in which a collecting receptacle is interposed between the expansion valve and the evaporator, called "liquid separator", provided with a first inlet through which it receives the coolant fluid coming from the expansion valve, with a first outlet through which the coolant fluid is sent to the evaporator, with a second inlet through which the collecting receptacle receives the coolant fluid exiting the evaporator and a second outlet through which the coolant fluid is sucked by the compressor of the refrigerating plant.

[0010] The coolant fluid exiting the evaporator and delivered to said collecting receptacle is in the saturation condition (liquid and steam in equilibrium). Inside the receptacle, the liquid phase, and the gaseous phase of the saturated fluid separate, with the liquid phase that remains inside the collecting receptacle and is pumped or recirculated in the evaporator, whilst the gaseous phase is sucked by the compressor through said second outlet.

[0011] In this type of plant, the potential of the evaporator is fully exploited because the coolant fluid falls outside the evaporator in the state of wet saturated vapour and the entire exchange surface, being wet by the liquid, is accordingly active for the purposes of evaporation.

[0012] These plants nevertheless have the drawback of requiring a heavy load of coolant fluid because the degree of vacuum inside the evaporator is rather high, because the titre of wet saturated vapour at the outlet of the evaporator is significantly less than 1. In addition to the greater retention of liquid of the evaporator there is the quantity of liquid present in the separator. As a result, the load of coolant fluid that is necessary in a plant with a flooded evaporator is significantly greater than the load that would be strictly necessary on the basis of the refrigerating power of the plant.
From WO2008/081273, a refrigerating plant is known, comprising a coolant fluid, a compressor, a condenser, an expansion valve, an evaporator, a collecting receptacle of the coolant fluid, and means for piloting the expansion valve, wherein the collecting receptacle is interposed between an outlet of the evaporator and an inlet of the compressor.

[0013] In this refrigerating plant, the liquid fraction of the saturated vapour exiting the evaporator can be minimized, compared with a refrigerating plant with a flooded evaporator, but maintaining the advantage of fully exploiting the potential of the evaporator, to which the advantage is added of considerably reducing the quantity of coolant fluid loaded into the plant.

[0014] Retail refrigerating units are generally divided into two types according to the storage temperature of the goods: positive temperature units, i.e. with refrigerating air temperature > 0 °C; negative temperature units, i.e. with refrigerating air temperature < 0°C.

[0015] Each of the two types of units is characterized by a different level of evaporation.

Summary of the invention

[0016] One object of the present invention is to increase energy efficiency in a refrigerating plant that can supply both a single refrigerating unit and a plurality of refrigerating units.

[0017] A further object of the present invention is to increase the overall energy efficiency of a refrigerating plant that supplies one or more refrigerating units.

[0018] A still further object of the present invention is to increase the energy efficiency of the single refrigerating units of a refrigerating plant and the energy efficiency of the entire plant, both when the refrigerating plant comprises only positive temperature units, or only negative temperature units, and when the refrigerating plant comprises positive temperature units and negative temperature units.

[0019] The objects of the present invention are achieved by a method according to claim 1 and by a plant according to claim 6.

[0020] Owing to the invention, it is possible to significantly improve the energy efficiency of refrigerating plants that manage a single unit or a plurality of units, dynamically adjusting the single refrigerating units, so as to optimize at any moment both the energy efficiency of the single units and the energy efficiency of the entire plant.

Brief description of the drawings

[0021] The invention will now be disclosed below, merely by way of non-limiting example, with reference to the appended drawings, in which:

figure 1 is a diagram of a refrigerating plant consisting of a single unit, which uses a coolant fluid (for example synthetic coolant or CO_2 in a subcritical configuration, i.e. with evaporation pressure that is less than the pressure of the critical point), and is manageable with the method according to the invention;

figure 1a is a variant on the diagram in figure 1 where a management control is also present for managing the expansion valve of traditional type according to the state of the art (possibile, for example, for installations in existing plants);

figure 2 is a diagram of a refrigerating plant consisting of a single unit, which uses CO_2 as a coolant fluid in a transcritical configuration, i.e. with evaporation pressure above the pressure of the critical point, the plant being manageable with the method according to the invention;

figure 2a is a variant on the diagram in figure 2 where a management control is also present for managing the expansion valve of traditional type according to the state of the art (possibile, for example, for installations in existing plants);

figure 3 is a diagram of a refrigerating plant that supplies a plurality of units, managed by the method according to the invention;

figure 3a is a variant on the diagram of figure 3 where a central control is not present, and the functions thereof are performed entirely by one of the controls introduced by the method according to the invention.

figure 4 is a further variant on the diagram in figure 1 where several evaporators are connected in parallel to one another, and for reasons of simplification of the plant or for needs dictated by the configuration of an installation preceding the introduction of the invention the steam titre is checked on an outlet portion common to said evaporators connected in parallel rather than on the outlet of the single evaporator;

figure 4a is a variant on the diagram in figure 4 where management control is also present for controlling the expansion valve of traditional type according to the state of the art (possibile, for example, for installations in existing plants) on each evaporator;

figure 5 is a conceptual diagram of a refrigerating plant, which uses CO_2 as a coolant in a transcritical configuration, with two evaporation levels, and that supplies a plurality of units, managed by the method according to the invention;

figure 5a is a variant on the diagram of figure 5 where an existing central control is not present and the functions of which are performed entirely by one of the controls introduced by the method according to the invention.

Detailed description of the invention

[0022] The refrigerating plant illustrated in figure 1 comprises at least one compressor 1 that compresses a coolant fluid entering the at least one compressor 1 in a superheated steam state and sends the coolant fluid, via a first conduit 2, to a condenser 3 in which the coolant fluid condenses, transferring heat to the external environment.

[0023] The coolant fluid, exiting the condenser 3, goes in a second conduit 4a, 4b at the outlet of which an expansion valve 5 is located, passing through which the coolant fluid reduces pressure, cooling down.

[0024] The second conduit 4a, 4b delivers the coolant fluid to an evaporator 6 via the expansion valve 5, in which the coolant fluid evaporates, removing heat from an environment to be cooled.

[0025] The coolant fluid, which exits the evaporator 6 in wet saturated vapour state, with titre just below 1, for example with titre equal to 0,9, is sent, via a third conduit 7, to a collecting receptacle 8, interposed between the outlet of the evaporator 6 and the portion of plant that leads to the inlet of the at least one compressor 1.

[0026] The collecting receptacle 8 has the function of separating and receiving possible liquid particles exiting the evaporator or possible temporary excesses of liquid that could reach the end of the evaporator during control of the plant and/or following variations in the load of the refrigerating unit.

[0027] In the collecting receptacle 8, the liquid fraction of the coolant fluid then separates from the gaseous fraction, collecting on the bottom of the collecting receptacle 8, whereas the gaseous fraction collects in the upper part of the collecting receptacle 8. The collecting receptacle 8 communicates, above, with a first outlet conduit 9, through which the gaseous phase of the coolant fluid exits, and below, with a second outlet conduit 10a, 10b through which the liquid phase of the coolant fluid exits.

[0028] The collecting receptacle 8 is provided with a level sensor 15, that detects the level of the liquid fraction of the coolant fluid in the collecting receptacle 8.

[0029] The second conduit 10a, 10b is provided with a discharge solenoid valve 16 that is operationally connected to an electronic control device 14 or to a level sensor 15. The level sensor 15 is operationally connected also to the electronic control device 14 that is in turn operationally connected also to the expansion valve 5. If the expansion valve 5 is of electronic type, the electronic control 14 controls the expansion valve 5 directly adjusting the degree of opening by a digital signal (for example PWM) or an analogue signal depending on the type of valve 5. If the expansion valve 5 is thermostatic, the control 14 operates so as to modify the degree of opening of the valve 5, controlling a heating element placed in contact with the thermal bulb of the thermostatic valve 5, that is connected to the outlet of the evaporator. In particular, activating the heating element will cause the temperature of the bulb to increase with a consequent greater passage of coolant fluid through the valve. This type of control enables superheating of the evaporator to be reduced and coolant fluid to be obtained that falls outside the evaporator 6 in wet saturated vapour state with titre just below 1 as indicated previously in paragraph [0025], without modifying the superheating setting preset on the thermostatic valve.

[0030] It should be noted that the liquid that is collected in the collecting receptacle 8 is used to supply a reference to the electronic control device that, together with the level sensor 15, forms part of a control unit 23 of the liquid level, to adjust the degree of opening of the expansion valve 5.

[0031] The flowrate of coolant fluid into the evaporator 6 is adjusted by the expansion valve 5, the degree of opening of which determines the flowrate of the coolant fluid that is sent to the evaporator 6. The degree of opening of the expansion valve 5 is adjusted by the electronic control device 14 according to the liquid level in the collecting receptacle 8. The liquid level in the collecting receptacle 8 is detected by the level sensor 15, preferably an infrared-ray electro-optical sensor associated with the collecting receptacle 8. The signal generated by the level sensor 15 is sent to the electronic control device 14 that, in response to said signal, adjusts the degree of opening of the expansion valve 5, increasing the degree of opening if the liquid level in the collecting receptacle 8 decreases and decreasing the degree of opening if the liquid level increases.

[0032] The presence of the discharge solenoid valve 16, operationally connected to the level sensor 15 or to the electronic control device 14, enables the control of the liquid level in the collecting receptacle 8 to be optimized so as to be able to reduce the quantity of liquid in the collecting receptacle 8 to the minimum indispensable for ensuring correct operation of the control unit 23.

[0033] Consequently, the titre of the wet saturated vapour exiting the evaporator can be maintained very near 1 (thus with a very small mass of liquid in the form of suspended droplets).

[0034] The first outlet conduit 9 and the second outlet conduit 10 merge into a fourth conduit 11 in which the gaseous phase and the liquid phase of the coolant fluid mix. The fourth conduit 11 sends the coolant fluid to a heat exchanger 12 in which the liquid fraction of the coolant fluid is so evaporated that the coolant fluid exits the exchanger 12 in the form of superheated steam.

[0035] The coolant fluid exiting the heat exchanger 12 is sent through a fifth conduit 13 to at least one compressor 1, to restart the refrigerating cycle.

[0036] The heat for evaporating the liquid fraction of the coolant fluid in the heat exchanger 12 is supplied by the coolant fluid coming from the condenser 3 via the second conduit 4, which passes through the heat exchanger 12.

[0037] It should be noted that introducing the regenerative heat exchanger 12 into the plant, in addition to ensuring the safety of the compressor 1/of the compressors 1, enables the coolant entering the expansion valve 5 to be subcooled with the resulting advantages that are known to a skilled person.

[0038] The electronic control device 14 deals with detecting parameters that define the work conditions of the plant (like by way of non-limiting example: the delivery temperature, the resumption temperature, the activation of the cold call command, the activation of the defrosting command, etc.) with monitoring the presence and the quantity of liquid inside the collecting receptacle 8 and with controlling other parameters like the temperatures entering/exiting the regenerative heat exchanger 12 and entering/exiting the collecting receptacle 8 so as to suitably control the expansion valve 5 and the integrated discharge valve 16 in order to maximize heat-exchange efficiency, avoiding at the same time negative effects on the at least one compressor 1 to ensure that in the conduit 13 exiting the regenerative heat exchanger there is only superheated steam and no liquid enters the compressor 1/the compressors 1.

[0039] Figure 1a is a variant on the diagram in figure 1 where there is also a management control 6a of the expansion valve of traditional type, according to the state of the art. This configuration (which is for example typical of installations in existing plants), provides for the operating connection between the expansion valve 5 and the existing management control 6a to be intercepted by the electronic control device 14 according to the invention. The electronic control device 14 is moreover connected to the existing management control 6a, so as to acquire some operating parameters (like by way of non-limiting example: the activation of the cold call command, the activation of the defrosting command, etc.) so as to detect and self-teach the work conditions set on the management control 6a without any need for the user having to reset the work conditions, thus simplifying introducing the invention into already existing plants. The electronic control device 14 according to the invention will thus work to bring the advantages disclosed below.

[0040] Figure 4 is a further variant on the diagram in figure 1 in which several evaporators are connected in parallel to one another, but in order to simplify the plant or for needs dictated by the configuration of an existing installation the superheated steam titre is controlled on the outlet portion common to all the evaporators 7 of said group of parallel-connected evaporators. It is pointed out that this configuration is usable to also manage only some of the units of a refrigerating plant. The group of evaporators connected in parallel could however include all the units of the refrigerating plant (but having less effective management of the plant itself). This configuration is manageable according to the invention by adding a further electronic control device 14a for each evaporator. Each further electronic control device 14a is connected operationally to the expansion valve 5 present on the relative unit and all the further electronic control devices 14a are connected to the electronic control device 14 by a serial interface using a communication bus (for example a serial communication bus) that can be a dedicated bus or can exploit serial communication buses that possibly already exist in the plant (for example in the case of installation in existing plants with interconnected counters). The communication protocol used can be standard (for example Modbus RTU or Modbus ASCII) or proprietary. The remaining parts of the plant illustrated in figure 4 are identical to those of the plant illustrated in figure 1 and will accordingly not be disclosed further.

[0041] Figure 4a is a variant on the diagram in figure 4 where in each unit a management control 6a, of traditional type, of the expansion valve 5 according to the prior art is also present. This configuration (which is typical, for example, of installations in existing plants), provides for the operational connection between the expansion valve 5 and the existing management control 6a being intercepted by the further electronic control device 14a according to the invention. The remarks regarding figures 1, 1a and 4 thus apply. The remaining parts of the plant illustrated in figure 4a are identical to those of the plant illustrated in figures 1, 1a, 4 and will therefore not be disclosed further.

[0042] Figure 2 illustrates a refrigerating plant which uses carbon dioxide CO_2 as a coolant fluid in a transcritical configuration, i.e. with evaporation pressure above the pressure of the critical point.

[0043] The refrigerating plant illustrated in figure 2 differs from the refrigerating plant illustrated in figure 1 in that at the outlet of the at least one compressor 1, instead of the condenser 3 there is a gas cooler 3a in which the carbon dioxide exiting the at least one compressor 1 is cooled by transferring heat to the outer environment.

[0044] The gas cooler 3a is connected, by a high-pressure throttle valve 3b, to a coolant receptacle 3c that supplies the regenerative heat exchanger 12, via the conduit 4a, and the evaporator 6 via the conduit 4b and the expansion valve 5.

[0045] The remaining parts of the plant illustrated in figure 2 are identical to those of the plant illustrated in figure 1 and will accordingly not be disclosed further.

[0046] Figure 2a is a variant on the diagram in figure 2 where a management control 6a of the expansion valve, of traditional type, according to the prior art, is also present. All the remarks apply regarding the difference between figure 1 and figure 1a. The remaining parts of the plant illustrated in figure 2a are identical to those of the plant illustrated in figure 2 and will therefore not be disclosed further.

[0047] In figure 3 a refrigerating plant according to the invention is illustrated that can supply a single refrigerating unit or a plurality of refrigerating units.

[0048] For the sake of simplicity, the configuration illustrated in Figure 3 relates to a plant with just one level of evaporation, but implementing the invention does not vary even in the case of plants with several evaporation levels, that are independent or connected together in any configuration, without any limit and independently of the coolant used.

[0049] The plant comprises at least one compressor 1, which compresses the coolant fluid and sends the coolant fluid to a condenser 3 in which the coolant fluid is cooled and condensed.

[0050] The condenser 3 supplies a single refrigerating unit 22 or a plurality of refrigerating units 22, each of which comprises at least one evaporator 6 at the inlet of which a respective expansion valve 5 is placed. It is pointed out that each refrigerating unit 22 can be characterized by a single evaporator (as indicated in figure 1/1a) or by several evaporators connected in parallel (as indicated in figure 4/4a).

[0051] Each refrigerating unit 22 comprises a respective control unit 23 of the type disclosed previously.

[0052] The control unit of each refrigerating unit is operationally connected to a central control unit 24.

[0053] All the control units 23 of the refrigerating units 22 are connected together and to the central control unit 24 via a communication bus (for example a serial communication bus) that can be a dedicated bus or can exploit serial communication buses that possibly already exist in the plant (for example in the event of installation in existing plants, with counters interconnected for systems of supervision and remote management). The communication protocol used can be standard (for example Modbus RTU or Modbus ASCII) or proprietary.

[0054] Owing to the action of the control units 23 of each refrigerating unit, with the same evaporator 6, it is possible to reduce overheating of the coolant fluid in the evaporator 6 by increasing the actual heat-exchange surface and thus the efficiency of the evaporator.

[0055] In order to enhance the efficiency of the refrigerating plant at the system level, action will be taken to increase the evaporation temperature of the plant compared with prior-art refrigerating systems and this will be more possibile owing to the action of the control units 23 of each refrigerating unit.

[0056] In order to perform this task, the central control unit 24 communicates constantly with all the control units 23 installed in the refrigerating units 22 of the plant.

[0057] By receiving the confirmation that all the units 22 are working correctly (that is the temperature of each unit remains within a set temperature range) the central control unit 24 communicates to a central management unit 25 of the plant by an analogue signal (that can be for example of the type 4-20 mA, 0-20 mA, 0-10 V), digital signal (for example PWM) or a serial interface, to increase by a set amount, which can be set by the person using the plant, the value of the evaporation temperature.

[0058] Following this variation, the central control unit 24 verifies that all the control units 23 of each refrigerating unit 22 confirm the correct operation of the whole the plant.

[0059] Once this confirmation has been received, the central control unit 24 interfaces again with the central management unit 25 to increase further by said preset amount the evaporation temperature of all the refrigerating units operating at the same evaporation temperature.

[0060] This process is repeated until one of the control units 23 communicates the impossibility of maintaining the operating temperature of the respective refrigerating unit within the set temperature range. In this case, the central control unit 24 interfaces with the central management unit 25 to decrease by a preset amount the evaporation pressure of the coolant fluid, in all the refrigerating units that work at the same evaporation pressure.

[0061] Once all the control units 23 communicate correct operation of all the refrigerating units, the central control unit 24 interfaces with the central management unit 25 to increase again the evaporation temperature of the refrigerating units.

[0062] In this manner, it is possible to follow constantly and dynamically the maximum evaporation temperature value permitted by the configuration and by the work conditions of the plant, simultaneously ensuring the correct operation of all the refrigerating units 22. The architecture of the invention further enables the unit or the units to be identified that limit the increase of the evaporation temperature (and thus the energy efficiency of the system), providing the user with an indication of where to operate to achieve a further energy saving.

[0063] The invention is thus reliable, simple to implement and to manage. The structure, the design and the components of the refrigeration system can in fact remain the same as traditional ones.

[0064] It is in fact sufficient to introduce a control unit 23 at the outlet of the evaporator 6 of each refrigerating unit 22, connect the control units 23 of the single refrigerating units 22 to the central control unit 24 and interface the latter with the central management unit 25, which is already known in a conventional plant, in order to be able to benefit from the advantages arising from the introduction of the invention. This makes the invention applicable to both existing plants and to new plants.

[0065] The present invention is applicable to any dry expansion refrigerating plant comprising a coolant fluid, at least one compressor 1, a condenser 3 or alternatively a gas cooler 3a with a high-pressure throttle valve 3b and a coolant liquid receptacle3c, an expansion valve 5 and at least one evaporator 6.

[0066] Figure 3a illustrates a variant on the refrigerating plant of figure 3, in which a central management unit 25 is not present, the functions of which are performed entirely by the central control unit 24. The remaining parts of the plant illustrated in figure 3a are identical to those of the plant illustrated in figure 3 and will therefore not be disclosed further.

[0067] Figure 5 is a conceptual diagram of a refrigerating plant, managed with the method according to the invention, which uses carbon dioxide CO_2 in a transcritical configuration as a coolant fluid, like the plant of figure 2, with a circuit comprising a first section with a first plurality of refrigerating units 22 supplied in parallel and a second section with a second plurality of refrigerating units 22 supplied in parallel, in which the evaporation temperature of the coolant fluid in the first plurality of refrigerating units is different from the evaporation temperature of the coolant fluid in the second plurality of refrigerating units. The plant can also comprise three or more sections each of which comprises a respective plurality of refrigerating units 22 supplied in parallel, in which the evaporation temperature of the coolant fluid of the refrigerating units of each section of refrigerating units is different from the evaporation temperature of the coolant fluid of the other sections of refrigerating units. The diagram is shown merely by way of non-limiting example of a plant configuration with several evaporation levels to show how the invention can be integrated into this type of plant.

[0068] What is illustrated in figure 3 applies to the integration of the invention in the plant illustrated in figure 5, so the details will not be disclosed any further.

[0069] Figure Sa is a variant on the plant of figure 4, in which a central management unit 25 is not present, the functions of which are performed entirely by one of the central control units 24 according to the invention. The remaining parts of the plant illustrated in figure 4a are identical to those of the plant illustrated in figure 5 and will therefore not be disclosed further.

[0070] The main advantages provided by the invention are:

- elimination of the inefficiency of the plants known from the prior art, due to the need to have high superheating values at the evaporator outlet, permitting better use of the surface of the evaporator;
- possibility of increasing the evaporation temperature and consequent reduction of the energy consumption of the compressors and of the central refrigerating unit;
- possibility of reducing the number and/or the duration of the defrosting operations depending on the configuration of the plant in which the invention is installed;
- decrease of the suction temperature of the compressors, with consequent greater safeguarding of the compressors, which are less stressed;
- decrease of the work temperature of the compressors by virtue of the reduction in the pressure difference across the compressors: with the same delivery pressure, owing to the invention it is possible to increase suction pressure, by reducing the pressure difference with which the compressor operates;
- elimination of the need to provide a liquid/steam separator phase upstream of the suction of the compressors and/or devices for recirculating the liquid in the plant, making implementation of the invention in the plant simpler, with equivalent advantages with respect to flooded plants according to the state of the art;
- a smaller amount of coolant to be delivered to the plant in comparison with flooded plant types with equivalent advantages;
- possibility of implementing the invention on both existing plants (retrofit) and on new plants.

Claims

1. Method for managing a refrigerating plant consisting of one or more refrigerating units (22) supplied by a coolant fluid, comprising:

- setting or detecting, for each refrigerating unit (22) of said one or more refrigerating units, a set temperature range within which each refrigerating unit (22) has to remain during operation of the plant;
- providing, for each refrigerating unit (22) of said one or more refrigerating units, a respective control unit (23) configured to manage the operation of the refrigerating unit (22);
- providing a central control unit (24) operationally connected to each refrigerating unit (22) of said one or more refrigerating units, and a central management unit (25) operationally connected to said central control unit (24);

characterized in that it further comprises the following steps:

- a first step that includes detecting, by said respective control unit (23), an operating temperature of each refrigerating unit (22) of said one or more refrigerating units, and verifying, by said central control unit (24), if said operating temperature is comprised in the set temperature range;
- a second step that includes increasing by a set amount an evaporation temperature of the coolant fluid in each refrigerating unit (22) of said one or more refrigerating units, by said central management unit (25), if the operating temperature of each refrigerating unit (22) is within said set range.

2. Method according to claim 1, further comprising the following steps:

- a third step, following said second step, which includes detecting again the operating temperature of each refrigerating unit (22) of said one or more refrigerating units and verifying again whether said operating temperature is comprised in the set temperature range;
- a fourth step that includes further increasing by said set amount the evaporation temperature of the coolant fluid in each refrigerating unit (22) of said one or more refrigerating units (22).

3. Method according to claim 2, wherein said third and fourth step are repeated until the operating temperature of one of the refrigerating units (22) of said one or more refrigerating units falls outside the set temperature range.

4. Method according to claim 3, further comprising a fifth step that includes decreasing the evaporation pressure of the coolant fluid in all the refrigerating units (22) of said one or more refrigerating units, which operate at the same evaporation pressure, and verifying that the operating temperature of all the refrigerating units (22) of said one or more refrigerating units, falls again within the set temperature range.

5. Method according to claim 4, further comprising, after said fifth step, a sixth step that includes increasing again by said preset amount the evaporation temperature of each refrigerating unit (22) of said one or more refrigerating units.

6. Refrigerating plant comprising a coolant fluid, at least one compressor (1) in which said coolant fluid is compressed, a refrigerating unit (22) supplied with said coolant fluid, or several refrigerating units (22) supplied in parallel with said coolant fluid, wherein each refrigerating unit (22) of said one or more refrigerating units comprises an evaporator (6) supplied with said coolant fluid through a respective expansion valve (5), **characterized in that** each refrigerating unit (22) of said one or more refrigerating units is provided with a control unit (23) configured to detect parameters that define the work conditions of the refrigerating unit (22) and vary the work conditions of the refrigerating unit (22), wherein each control unit (23) is operationally associated with a central control unit (24) configured to receive from each control unit (23) data relating to the work conditions of each refrigerating unit (22) of said one or more refrigerating units, and communicate the data to a central management unit (25), configured to regulate operating parameters of each refrigerating unit (22) on the basis of the data received from the central control unit (24).

7. Refrigerating plant according to claim 6, that further comprises a condenser (3) in which the coolant fluid compressed by the at least one compressor (1) is condensed, wherein the condenser (3) supplies the respective evaporator (6) of said one or more refrigerating units (22).

8. Refrigerating plant according to claim 6, which uses carbon dioxide as a coolant fluid and further comprises a gas cooler (3a), in which the carbon dioxide compressed by the at least one compressor (1) is cooled, wherein the gas cooler (3a) is connected, by a high-pressure throttle valve (3b), to a receptacle (3c) for receiving coolant fluid, which supplies the respective evaporator (6) of said one or more refrigerating units (22)

9. Plant according to one of claims 6 to 8, wherein said data on the work conditions include the operating temperature of each refrigerating unit (22) of said one or more refrigerating units, the evaporation temperature of the coolant fluid in the evaporator (6) of each refrigerating unit and the steam titre of the coolant fluid exiting the evaporator (6) of each refrigerating unit (22).

10. Plant according to one of claims 6 to 9, wherein said operating parameters include the evaporation temperature and the evaporation pressure of the coolant fluid in each refrigerating unit (22) of said one or more refrigerating units.

11. Plant according to one of claims 6 to 10, including a first section that includes a first plurality of refrigerating units (22) configured to operate at a first evaporation temperature of the coolant fluid, wherein the refrigerating units (22) of said first section of refrigerating units are supplied in parallel with said coolant fluid, and one or more further sections, each of which comprises a further plurality of refrigerating units, wherein the refrigerating units of each further section of said one or more further sections of refrigerating units are configured to operate at a respective evaporation temperature of the coolant fluid, different from said first evaporation temperature, wherein the refrigerating units of said one or more further sections of refrigerating units are supplied in parallel with said coolant fluid.

12. Plant according to one of the preceding claims, wherein the central control unit (24) and the central management unit are integrated into a single unit.

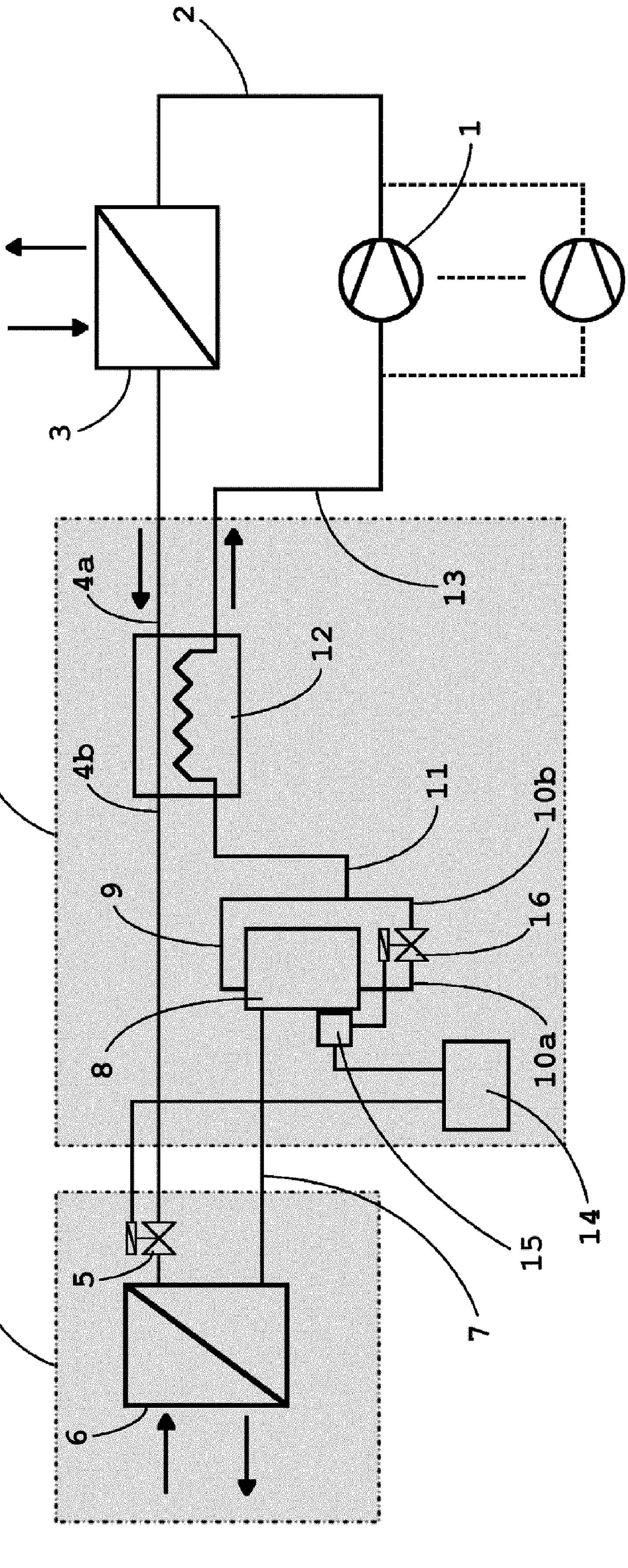

Fig. 1

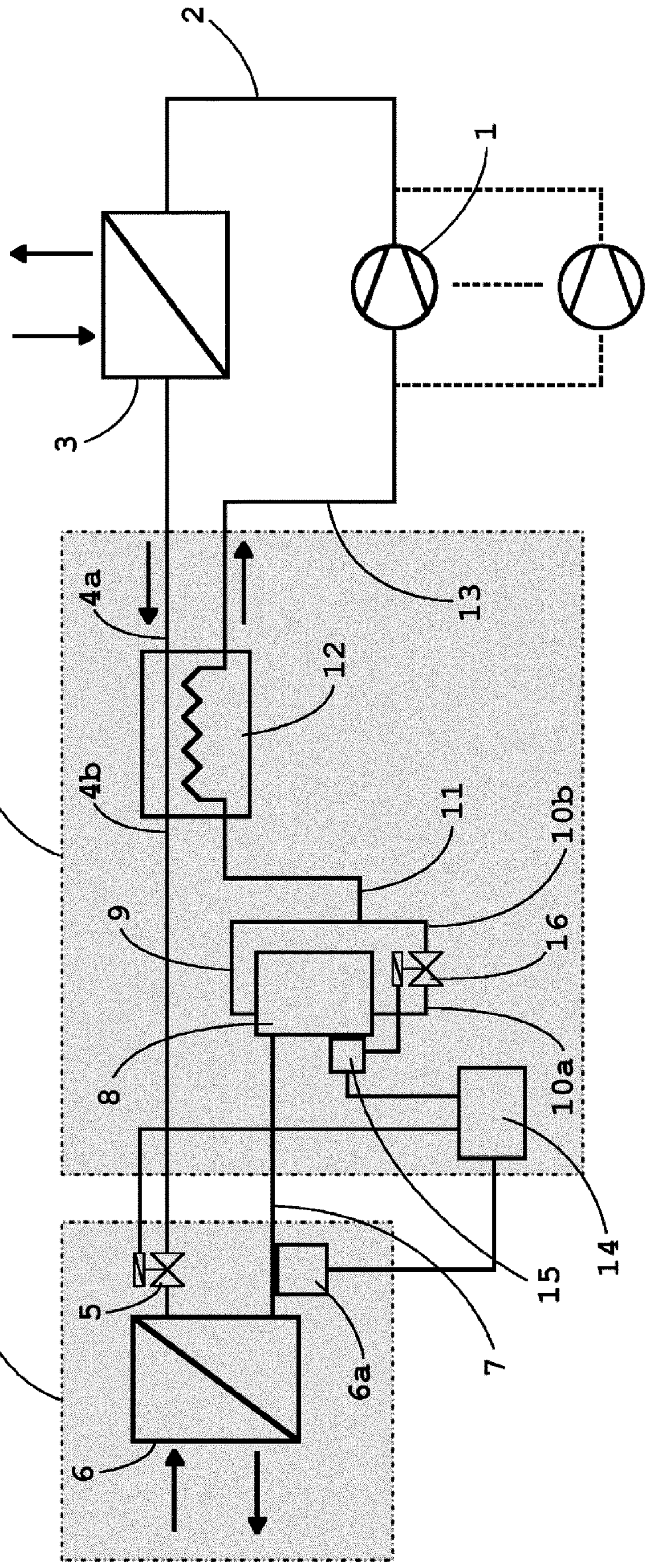

Fig. 1a

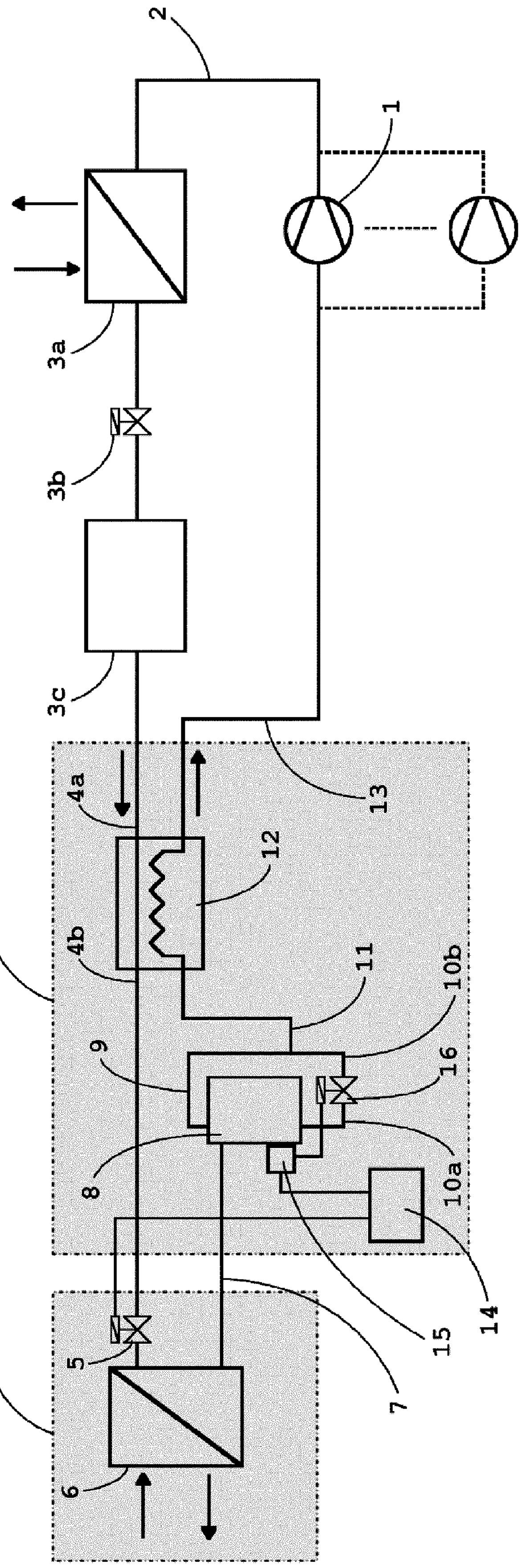

Fig. 2

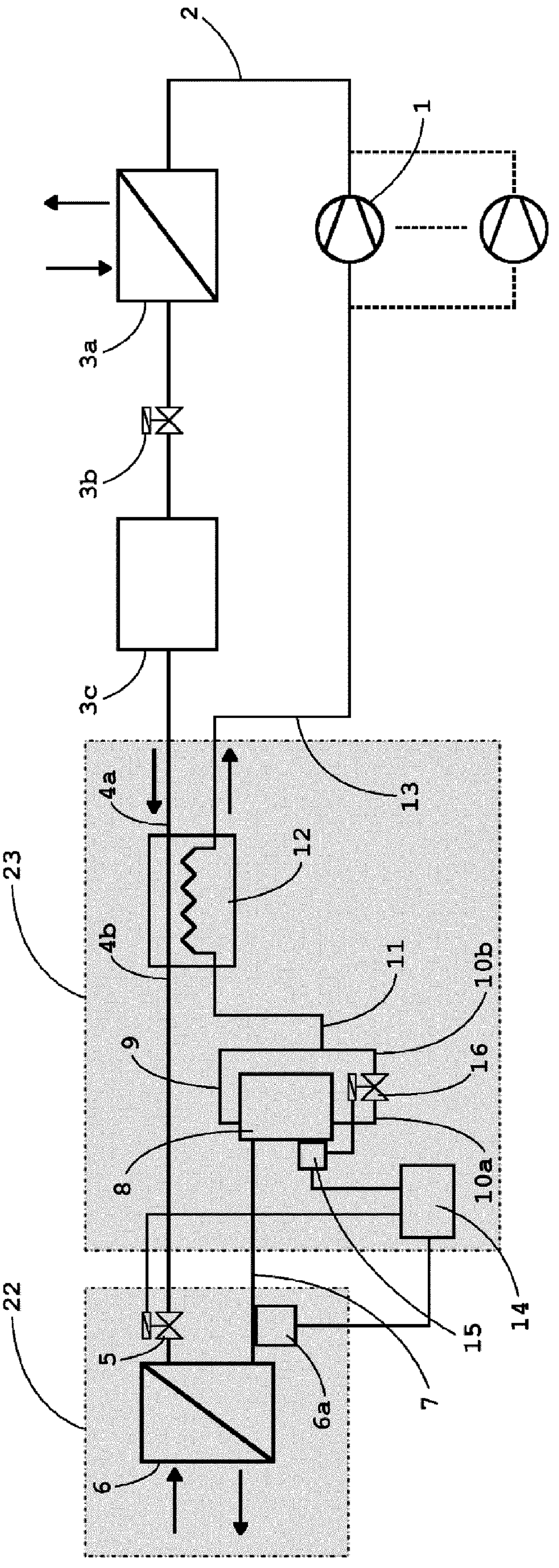

Fig. 2a

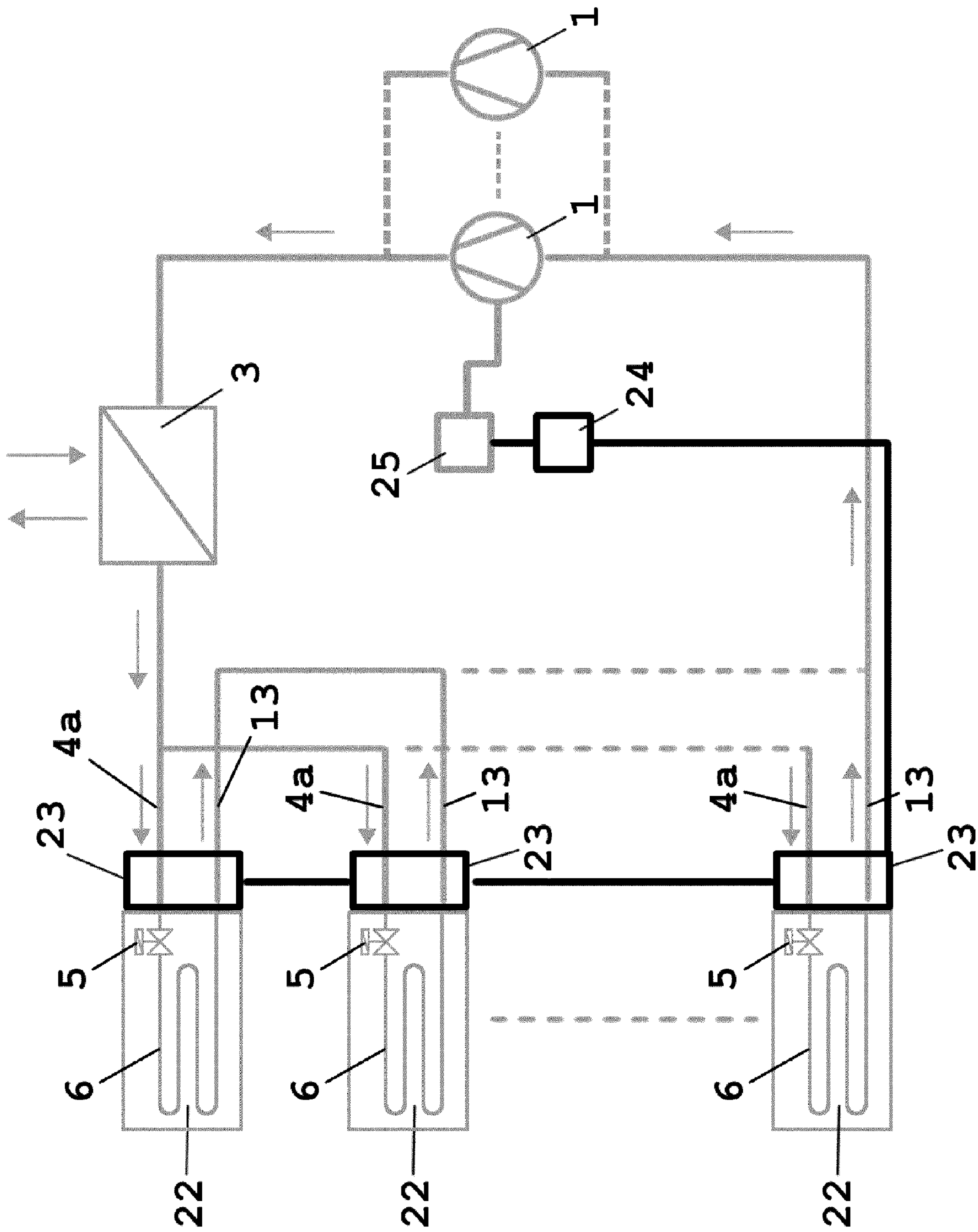

Fig. 3

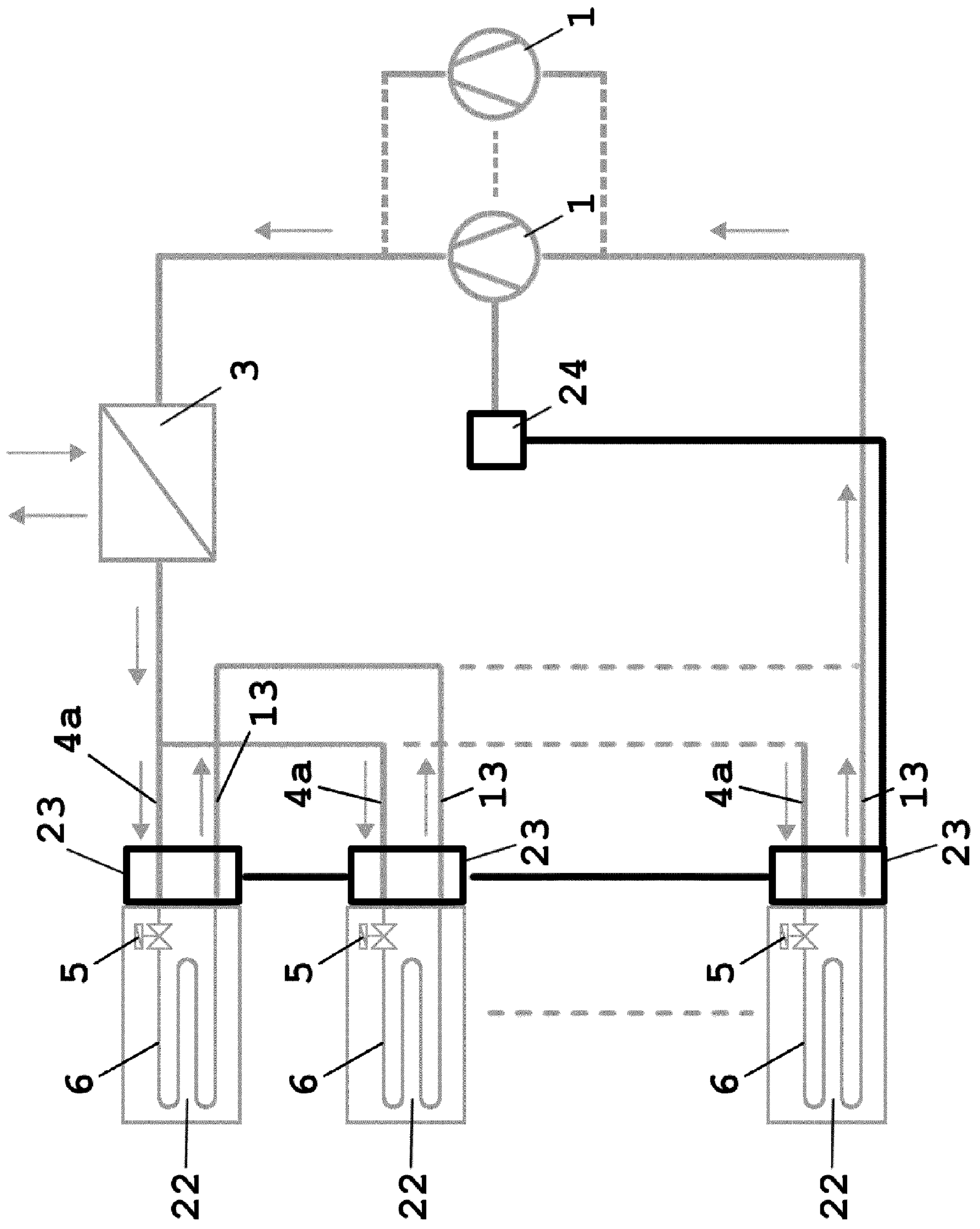

Fig. 3a

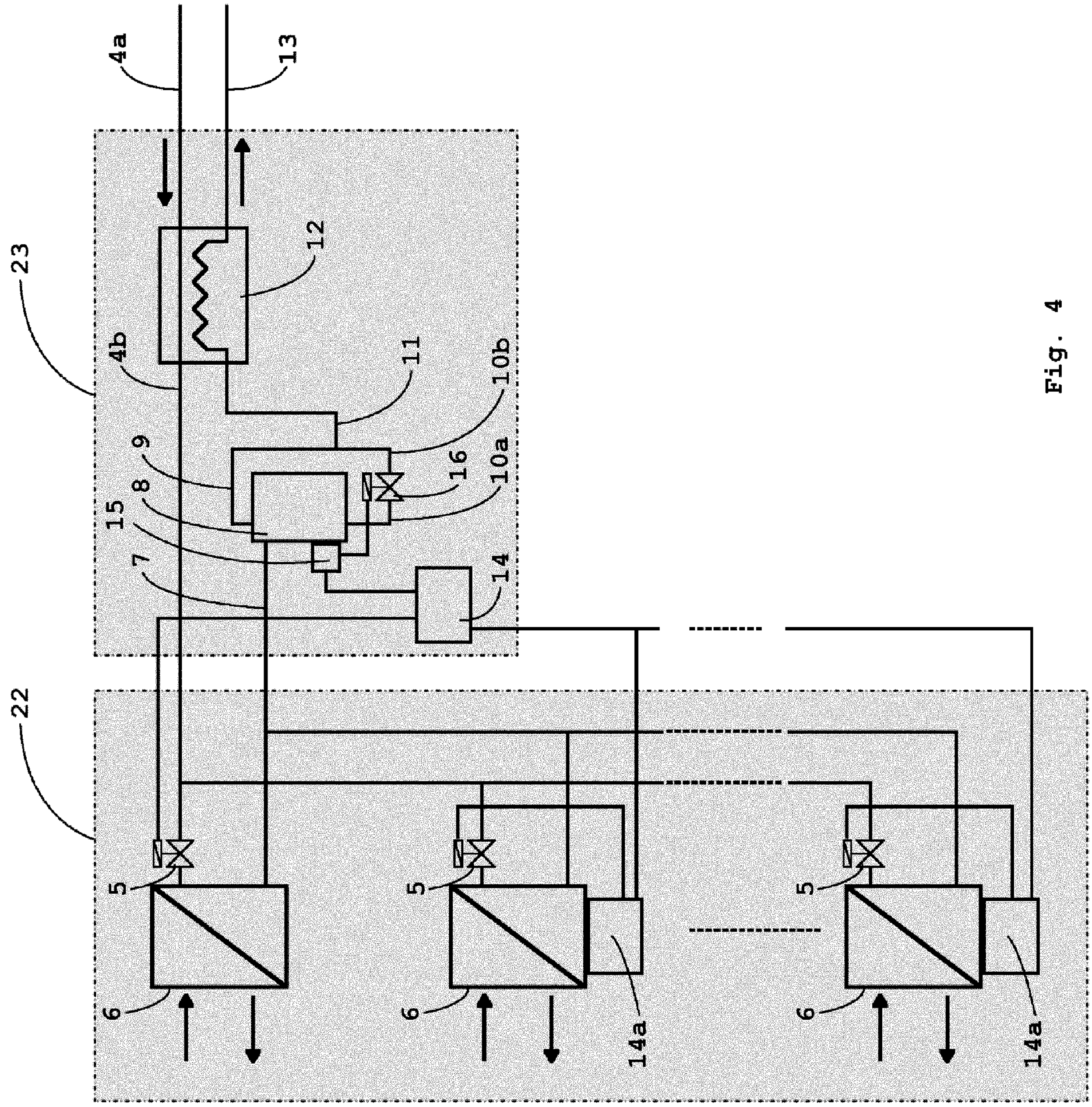

Fig. 4

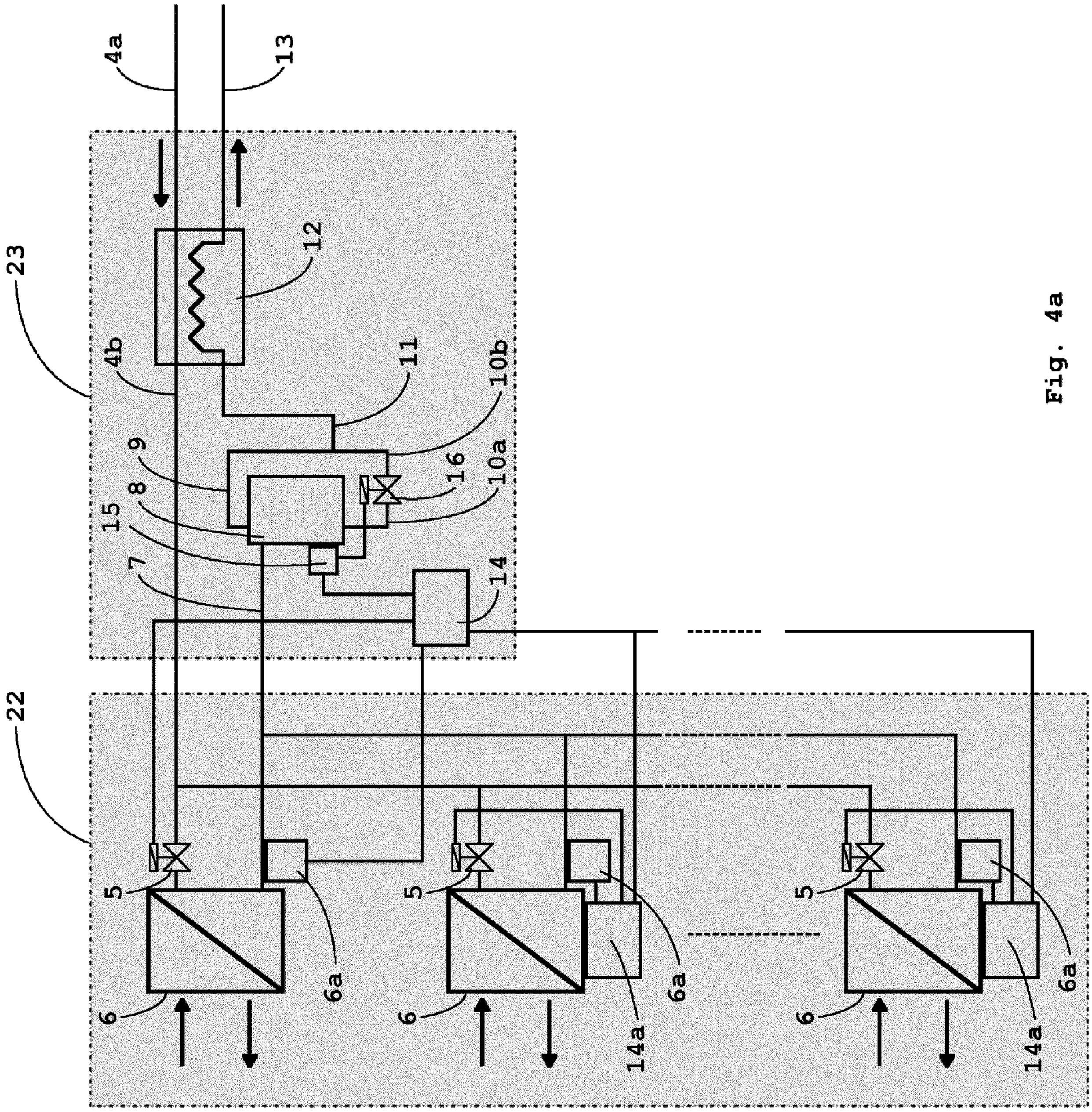

Fig. 4a

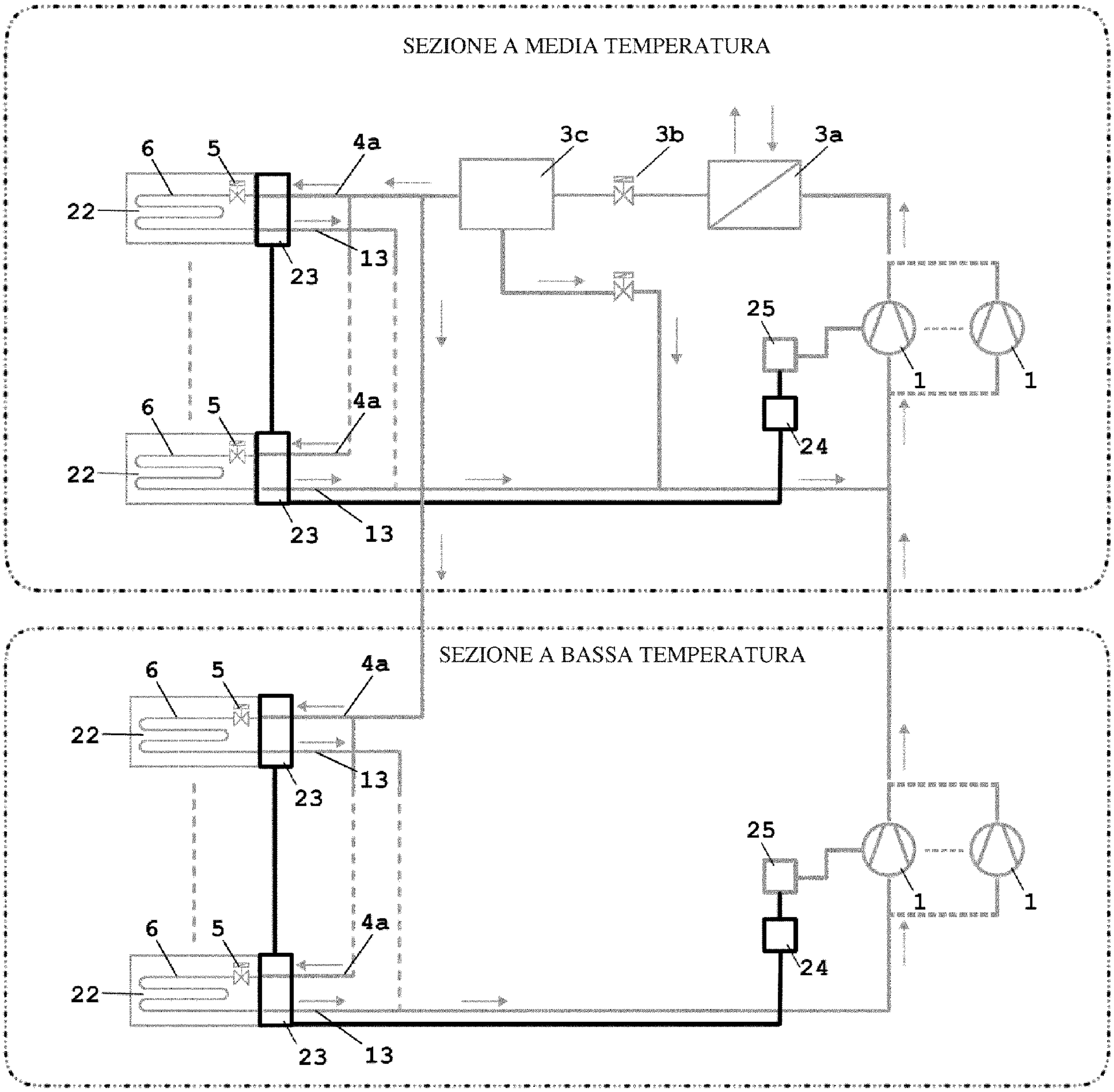
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Fig. 5

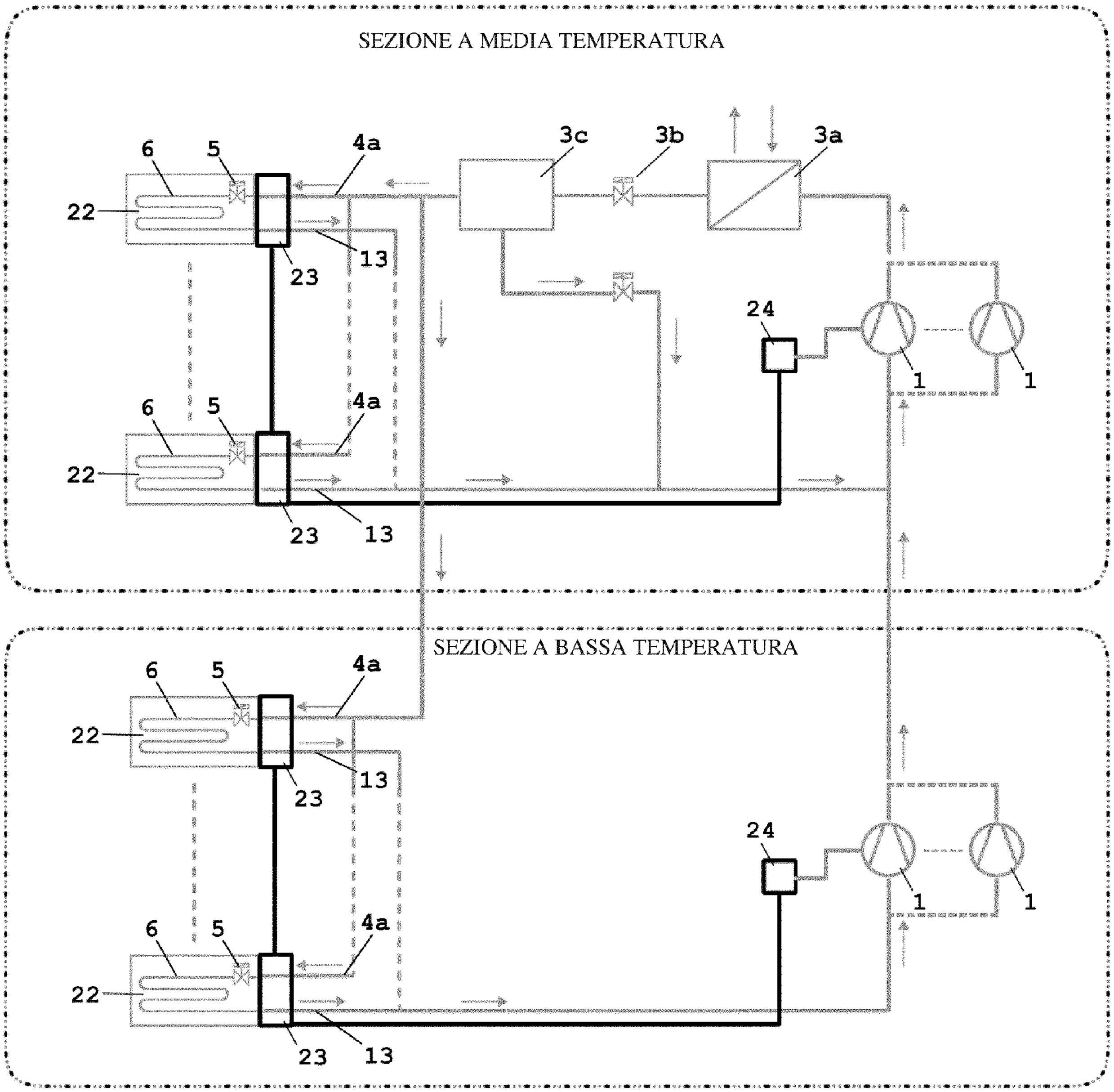
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Fig. 5a

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EUROPEAN SEARCH REPORT

Application Number
EP 23 21 6556

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	JP 2015 014439 A (SANDEN CORP) 22 January 2015 (2015-01-22) * the whole document * -----	6-12 1-5	INV. F25B49/02 F25B5/02 F25B40/00 F25D13/02 F25D13/04
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F25B
F25D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	22 April 2024	Lucic, Anita

CATEGORY OF CITED DOCUMENTS

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22-04-2024

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