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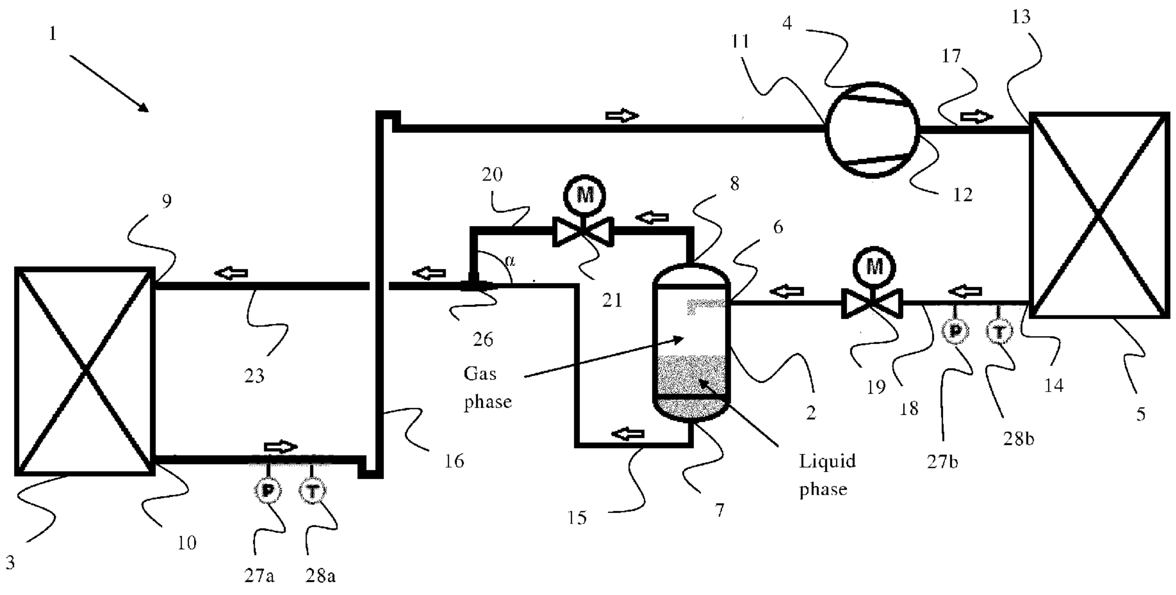

Fig. 2

(57) **Abstract:** The present invention provides a cooling system (1), comprising a receiver tank (2), an evaporator (3), a compressor (4) and a gas cooler (5), wherein the receiver tank (2) comprises a fluid inlet (6), a liquid outlet (7) and a gas outlet (8); the evaporator (3) comprises an evaporator inlet (9) and an evaporator outlet (10), the compressor (4) comprises a compressor inlet (11) and a compressor outlet (12); the gas cooler (5) comprises a cooler inlet (13) and a cooler outlet (14); and the liquid outlet (7) of the receiver tank (2) is connected to the evaporator inlet (9) via a first conduit (15), the evaporator outlet (10) is connected to the compressor inlet (11) via a second conduit (16), the compressor outlet (12) is connected to the cooler inlet (13) via a third conduit (17), and the cooler outlet (14) is connected to the fluid inlet (6) of the receiver via a fourth conduit (18), wherein at least one of the first conduit (15) and the fourth conduit (18) comprises a pressure regulator (19,25), and the gas outlet (8) of the receiver tank is connected to the evaporator inlet (9)

WO 2020/083823 A1

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via a fifth conduit (20) and a gas flow regulator (21,22), such that a flow of liquid refrigerant in the first conduit (15) may be controlled by operating the gas flow regulator (21,22) during use.

Cooling system

Field of the invention

The present invention relates to cooling systems, more particularly direct expansion cooling systems for CO2-refrigerant media.

Background

Direct expansion (DX) cooling systems are a common refrigeration system using the vapor-compression refrigeration cycle.

A typical prior art DX cooling system is shown in fig.1. In the DX cooling system, the pressure and temperature of the liquid refrigerant provided to an evaporator 3 is commonly controlled by use of an expansion valve 25, e.g. a modulating control valve or pressure regulator, arranged between a receiver tank 2 and the evaporator 3. An additional expansion valve 19 is required between a gas cooler 5 and the receiver tank 2 when the refrigerant is transcritical exiting the gas cooler 5, such that subcritical conditions are ensured in the receiver tank 2 to allow separation of the refrigerant into a gas and a liquid phase. In a transcritical DX cooling system the refrigerant is at subcritical conditions when exiting the expansion valve 19 arranged between the receiver and the gas cooler and at transcritical conditions when exiting the compressor 4. In a subcritical DX cooling system, the refrigerant is at subcritical conditions throughout the system, and the expansion valve 19 arranged before the receiver tank 2 is not required.

Commonly, the capacity of the evaporator 3 is controlled by regulating the effect of the compressor 4 and the expansion valve 19 arranged between the gas cooler 5 and the receiver tank 2.

Prior art DX cooling systems have various disadvantages with regards to the control of the cooling capacity, in particular when lower cooling capacities are required.

The aim of the present invention is to provide a DX cooling system which alleviates or removes at least some of the disadvantages of the prior art cooling systems. More particularly, the present invention provides a DX cooling system having an improved control of the cooling capacity, an improved energy efficiency as well as an improved utilization of the evaporator.

Summary of the invention

The present invention is defined by the attached claims and in the following:

In a first aspect, the present invention provides a cooling system comprising a receiver tank, an evaporator, a compressor and a gas cooler, wherein

- the receiver tank comprises a fluid inlet, a liquid outlet and a gas outlet;
- the evaporator comprises an evaporator inlet and an evaporator outlet,
- the compressor comprises a compressor inlet and a compressor outlet;
- the gas cooler comprises a cooler inlet and a cooler outlet; and

the liquid outlet of the receiver tank is connected to the evaporator inlet via a first conduit, the evaporator outlet is connected to the compressor inlet via a second conduit, the compressor outlet is connected to the cooler inlet via a third conduit, and the cooler outlet is connected to the fluid inlet of the receiver tank via a fourth conduit, wherein

at least one of the first conduit and the fourth conduit comprises a pressure regulator, and

the gas outlet of the receiver tank is connected to the evaporator inlet via a fifth conduit and a gas flow regulator, such that a flow of liquid refrigerant in the first conduit may be controlled by operating the gas flow regulator during use. That is, the flow of liquid refrigerant entering the evaporator inlet via the first conduit may be controlled by operating the gas flow regulator during use

In other words, the gas outlet of the receiver tank is connected to the evaporator inlet via the fifth conduit and the gas flow regulator, such that a flow of gaseous refrigerant from the receiver tank may enter the evaporator during use.

The cooling system may be operated as a transcritical cooling system or a subcritical cooling system. In a transcritical cooling system, the pressure and temperature conditions are arranged such that a refrigerant will be transcritical in the gas cooler and subcritical in the receiver tank. In a subcritical cooling system, the refrigerant will be subcritical throughout the cooling system. In a subcritical cooling system, the gas cooler may also be termed a gas condenser.

The gas flow regulator may be defined as a modulating gas control valve. The pressure regulator may be a modulating fluid control valve. In a transcritical cooling system, the pressure regulator may also be termed a modulating high-pressure control valve.

In an embodiment, the cooler outlet is connected to the fluid inlet of the receiver tank via a fourth conduit and a pressure regulator.

In an embodiment of the cooling system, the gas flow regulator is arranged such that a lowering of a flow of gaseous refrigerant in the fifth conduit by operating the gas flow regulator will increase the flow of liquid refrigerant in the first conduit. In other words, a lowering of a flow of gaseous refrigerant in the fifth conduit by operating the gas flow regulator will increase the pressure in the receiver tank and thus increase the flow of liquid refrigerant in the first conduit.

In an embodiment of the cooling system, the gas outlet of the receiver tank is connected to the evaporator inlet via the fifth conduit and the gas flow regulator, such that a mixture of gaseous refrigerant from the fifth conduit and liquid refrigerant from the first conduit may enter the evaporator inlet during use.

In an embodiment of the cooling system, the fifth conduit comprises a first end connected to the gas outlet of the receiver tank and a second end connected to the first conduit, such that gaseous refrigerant from the gas outlet of the receiver tank may be mixed with a liquid refrigerant from the liquid outlet of the receiver tank before entering the evaporator inlet during use.

In an embodiment of the cooling system, the liquid outlet of the receiver tank is arranged such that an increased pressure of gaseous refrigerant in the receiver tank will force liquid out of the receiver tank via the liquid outlet during use.

In an embodiment of the cooling system, the first conduit and the fifth conduit are connected to the evaporator inlet via a sixth conduit.

In an embodiment of the cooling system, the fifth conduit is connected to the evaporator inlet via the first conduit.

In an embodiment of the cooling system, the sixth conduit has an inner cross-sectional area larger than the cross-sectional area of the first conduit.

In an embodiment of the cooling system, the gas flow regulator is a two-way valve. The two-way valve may be a modulating control valve.

In an embodiment of the cooling system, the two-way valve is arranged in, or constitutes a part of, the fifth conduit.

In an embodiment of the cooling system, the first conduit, the fifth conduit and the sixth conduit is interconnected by a three-way coupling featuring a first inlet connected to the fifth conduit, a second inlet connected to the first conduit and an outlet connected to the evaporator inlet or the sixth conduit, wherein the second inlet is arranged at an angle relative to the outlet, such that an ejector effect of a gaseous refrigerant flow from the fifth conduit acting on a liquid refrigerant in the first conduit is minimized during use. The angle may be about 90°.

In an embodiment of the cooling system, the gas flow regulator is a three-way valve. The three-way valve may be a modulating control valve.

In an embodiment of the cooling system, the three-way valve comprises a first inlet connected to the first conduit, a second inlet connected to the fifth conduit and an outlet connected to the evaporator inlet or the sixth conduit.

In an embodiment, the cooling system comprises a first pressure sensor and a first temperature sensor, arranged in the second conduit, and a second pressure sensor and a second temperature sensor arranged in the fourth conduit. The second pressure sensor and the second temperature sensor may be arranged in the fourth conduit upstream a pressure regulator in the fourth conduit.

In an embodiment of the cooling system, the second pressure sensor and the second temperature sensor may be replaced by a pressure transmitter. In embodiments featuring a pressure transmitter, the cooling system may be a subcritical cooling system. The pressure transmitter may be connected to any of a gas cooler/condenser fan or a gas cooler/condenser pump.

In a second aspect, the present invention provides a method of controlling a cooling system, wherein the cooling system comprises a receiver tank, an evaporator, a compressor and a gas cooler, wherein

the receiver tank comprises a fluid inlet, a liquid outlet and a gas outlet;
the evaporator comprises an evaporator inlet and an evaporator outlet,
the compressor comprises a compressor inlet and a compressor outlet;
the gas cooler comprises a cooler inlet and a cooler outlet; and
the liquid outlet of the receiver tank is connected to the evaporator inlet via a first conduit, the evaporator outlet is connected to the compressor inlet via a second conduit, the compressor outlet is connected to the cooler inlet via a third conduit, and the cooler outlet is connected to the fluid inlet of the receiver via a fourth conduit, wherein

at least one of the first conduit and the fourth conduit comprises a pressure regulator, and the gas outlet of the receiver tank is connected to the evaporator inlet via a fifth conduit and a gas flow regulator, and the method comprises the step of:

- increasing a flow of gaseous refrigerant in the fifth conduit by controlling the gas flow regulator to obtain a reduced flow of liquid refrigerant in the first conduit and a reduced cooling capacity in the evaporator (3); or
- reducing a flow of gaseous refrigerant in the fifth conduit (20) by controlling the gas flow regulator (21,22) to obtain an increased flow of liquid refrigerant in the first conduit (15) and an increased cooling capacity in the evaporator (3).

The step of increasing the flow of gaseous refrigerant provides a reduced flow of liquid refrigerant in the first conduit by lowering the pressure of the gaseous refrigerant in the receiver tank.

The step of reducing the flow of gaseous refrigerant provides an increased flow of liquid refrigerant in the first conduit by raising the pressure of the gaseous refrigerant in the receiver tank.

The method of the second aspect may also be termed a method of regulating the cooling capacity of a cooling system.

In an embodiment of the method according to the second aspect, the fourth conduit comprises a pressure regulator and the step of increasing the flow of gaseous refrigerant comprises a step of controlling the pressure regulator to decrease the pressure fall between the cooler outlet and the fluid inlet of the receiver tank. In other words, the step of increasing the flow of gaseous refrigerant comprises controlling the pressure regulator to increase the flow of refrigerant from the gas cooler to the receiver tank.

In an embodiment of the method according to the second aspect, the first conduit comprises a pressure regulator and the step of increasing the flow of gaseous refrigerant comprises controlling the pressure regulator to increase the pressure fall over the first conduit.

In an embodiment, the method according to the second aspect comprises an initial step of:

- measuring the refrigerant temperature in the second conduit to obtain a differential temperature curve relative to the boiling temperature of the liquid refrigerant within the evaporator; and increasing or reducing a flow of gaseous refrigerant in the fifth conduit depending on whether the differential temperature curve shows a falling or rising differential temperature, respectively.

In a third aspect, the present invention provides a method of controlling a transcritical cooling system, wherein the cooling system comprises a receiver tank, an evaporator, a compressor and a gas cooler, wherein
the receiver tank comprises a fluid inlet, a liquid outlet and a gas outlet;
the evaporator comprises an evaporator inlet and an evaporator outlet,
the compressor comprises a compressor inlet and a compressor outlet;
the gas cooler comprises a cooler inlet and a cooler outlet; and
the liquid outlet of the receiver tank is connected to the evaporator inlet via a first conduit, the evaporator outlet is connected to the compressor inlet via a second conduit, the compressor outlet is connected to the cooler inlet via a third conduit, and the cooler outlet is connected to the fluid inlet of the receiver via a fourth conduit and a pressure regulator, wherein

the gas outlet of the receiver tank is connected to the evaporator inlet via a fifth conduit and a gas flow regulator, and the method comprising the step of:

- increasing a flow of gaseous refrigerant in the fifth conduit by controlling the pressure regulator to decrease the pressure fall between the cooler outlet and the fluid inlet of the receiver tank; or
- reducing a flow of gaseous refrigerant in the fifth conduit (20) by controlling the pressure regulator to increase the pressure fall between the cooler outlet and the fluid inlet of the receiver tank.

In other words, by controlling the pressure regulator to decrease or increase the pressure fall between the cooler outlet and the fluid inlet of the receiver tank, the flow of refrigerant to the receiver tank is increased or decreased, and the pressure in the gaseous refrigerant in the receiver tank is increased or decreased, respectively.

The cooling system of the methods according to the second and third aspect may comprise any of the features of the cooling system according to the first aspect.

In an embodiment of any of the aspects of the invention, the cooling system is a direct expansion cooling system, preferably for direct expansion of CO_2 as refrigerant. When CO_2 is used as refrigerant, the cooling system operates at transcritical conditions and the fourth conduit comprises a pressure regulator.

The term “evaporator inlet” is intended to mean an inlet through which a refrigerant must pass to enter a heat-transfer area of an evaporator. The evaporator inlet may be an internally arranged inlet of an evaporator unit, to which unit the first and second conduit are connected, or an external inlet to which the sixth conduit is connected.

Short description of the drawings

The present invention is described in detail below by way of example only and with reference to the following drawings:

Fig. 1 is a schematic drawing of a prior art DX cooling system.

Fig. 2 is a schematic drawing of a first exemplary embodiment of a cooling system according to the invention.

Fig. 3 is a schematic drawing of a second exemplary embodiment of a cooling system according to the invention.

Fig. 4 is a schematic drawing of a third exemplary embodiment of a cooling system according to the invention.

Fig. 5 is a schematic drawing of a fourth exemplary embodiment of a cooling system according to the invention.

Detailed description of the invention

The present invention provides a highly advantageous DX cooling system, wherein the cooling capacity of an evaporator may be regulated/controlled in an improved manner. A particularly preferred refrigerant for use in the inventive cooling system is CO_2. Corresponding or similar features of the cooling systems shown in figs. 1-5 are denoted by the same reference numbers.

A first exemplary cooling system according to the invention is shown in fig. 2. The cooling system features a receiver tank 2, an evaporator 3, a compressor 4 and a gas cooler 5. The receiver tank 2 has a fluid inlet 6, a liquid outlet 7 and a gas outlet 8. The evaporator 3 has an evaporator inlet 9 and an evaporator outlet 10. The compressor 4 has a compressor inlet 11 and a compressor outlet 12, and the gas cooler 5 has a cooler inlet 13 and a cooler outlet 14.

The liquid outlet 7 of the receiver tank 2 is connected to the evaporator inlet 9 via a first conduit 15, the evaporator outlet 10 is connected to the compressor inlet 11 via a second conduit 16, the compressor outlet 12 is connected to the cooler inlet 13 via a third conduit 17, and the cooler outlet 14 is connected to the fluid inlet 6 of the receiver tank via a fourth conduit 18 and a pressure regulator 19.

When the cooling system is a transcritical system, a refrigerant of the cooling system will be at transcritical conditions between the compressor outlet 12 and the pressure regulator 19. The pressure regulator 19 is a modulating control valve arranged to lower the pressure of the transcritical refrigerant flow exiting the gas cooler 5. In this manner, the refrigerant will obtain subcritical conditions and separate into a gas and a liquid phase in the receiver tank 2. The cooling system may also be operated under subcritical conditions throughout the cooling system. The function of the pressure regulator 19 is to optimize the heat removal in the gas cooler in relation to the remaining parts of the cooling system by regulating the high-pressure in the gas cooler. Further, the pressure regulator 19 ensures that the refrigerant in the receiver tank 2 is subcritical. The receiver tank functions as a refrigerant buffer, which is a requirement since the amount of refrigerant in the gas cooler 5 and the evaporator 3 will vary.

The gas outlet 8 of the receiver tank is connected to the evaporator inlet 9 via a fifth conduit 20 and a two-way gas valve 21 (i.e. a gas flow regulator). In this manner, the pressure in the receiver tank 2, and consequently the flow of liquid refrigerant in the first conduit 15, may be controlled/regulated by operating the two-way gas valve 21.

A significant advantage of using the two-way gas valve 21 to control the flow of liquid refrigerant to the evaporator 2, optionally in combination with controlling the pressure regulator 19, is that the cooling system may operate at a higher evaporation temperature and pressure than in the prior art. In this manner, the suction pressure, i.e. the pressure on the suction side of the compressor, is upheld, and the high-pressure side, i.e. the section of the cooling system between the compressor outlet and the pressure regulator 19, may have a lower pressure.

In addition to providing an improved control of the refrigerant flow, the inventive cooling system also ensures an optimal energy efficiency since the refrigerant gas in the receiver tank 2 is utilized as refrigerant in the evaporator 3. The gaseous refrigerant provides a minor additional cooling effect, about 2-5%, which is not possible to obtain in the prior art cooling systems.

The turbulence caused by combining the liquid and the gaseous refrigerant prior to entering the evaporator 3 provides an optimal distribution of the refrigerant in the evaporator and an optimal utilization of the heat transfer area of the evaporator 3. In particular at lower cooling capacities, i.e. low flow of liquid refrigerant to the evaporator 3, the turbulence provides a significant advantage compared to the prior art systems. In the prior art systems, the lower cooling capacity commonly leads to an uneven distribution of the liquid refrigerant, which in turn lowers the evaporation temperature and pressure. The lowered evaporation temperature may be problematic as it may cause temperatures at an external side of the evaporator being too low for its intended use, e.g. goods to be cooled may freeze.

To minimize any ejector-effect the gas flow in the fifth conduit 20 may have on the liquid refrigerant in the first conduit 15, the fifth and first conduit are connected at an angle α of about 90°. The combined refrigerant flow is connected to the evaporator 3 via a common conduit 23 (i.e. a sixth conduit). To further optimize the cooling system, the fifth and first conduit 20,15 are connected to a mixing chamber 26 to obtain an optimum mixing of the gaseous and liquid refrigerant before entering the evaporator. In the present embodiment, the mixing chamber 26 is a three-way pipe connection having a cross-sectional area larger than a cross-sectional area of the first conduit 15. The differences in the cross-sectional areas provides a slight pressure drop of the liquid refrigerant to ensure optimum evaporation conditions in the evaporator. In embodiments not featuring a mixing chamber, the slight pressure drop may be obtained by ensuring that the cross-sectional area of the common conduit is larger than the cross-sectional area of the first conduit. It is noted that it is not essential to have a dedicated arrangement or device to obtain the slight pressure drop in the refrigerant before it enters the evaporator. Depending on the operating conditions, the slight pressure drop caused by the flow resistance in the first and/or common conduit may be sufficient.

In view of the prior art, the cooling system according to the invention is also more cost-efficient in that an expansion valve arranged between the liquid outlet 7 and the evaporator 3 is not required. Expansion valves are expensive and constitutes a significant percentage of the total system cost.

The condition of the refrigerant in the cooling system is monitored by a pressure sensor 27a and a temperature sensor 28a arranged close to the evaporator outlet 10, and a pressure sensor 27b and a temperature sensor 28b arranged between the cooler outlet 14 and the pressure regulator 19.

The cooling system may feature a control system which, depending on the input from the pressure sensors 27a,b, the temperature sensors 28a,b and any optional external temperature data, may control the pressure regulator 19 and the gas valve 21.

The cooling system may be controlled by measuring the refrigerant temperature in the second conduit 16 to obtain a differential temperature curve relative to the boiling temperature of the liquid refrigerant within the evaporator 3. Depending on whether the differential temperature curve shows a falling or rising differential temperature, the flow of gaseous refrigerant in the fifth conduit 15 may be increased or reduced, and the flow of liquid refrigerant respectively reduced or increased, by regulating the two-way gas valve and/or the pressure regulator 19. In prior art DX cooling systems, the flow of liquid refrigerant is also increased when the differential temperature curve increases (i.e. shows an increased overheating of the refrigerant) and decreased when the differential temperature curve decreases, but a flow of gaseous refrigerant entering the evaporator may not be controlled.

The evaporator 3 may be used to cool any suitable external medium, such as air or a liquid. Similarly, any suitable external medium may be used to obtain the required cooling effect in the gas cooler 5.

The operating conditions may vary within a large temperature and pressure range dependent on the type of refrigerant. Suitable operating conditions will be apparent to the skilled person based on the present disclosure.

A second exemplary cooling system according to the invention is shown in fig. 3. The second exemplary cooling system is substantially similar to the cooling system in fig. 2 and provides the same advantages as described above. The second exemplary cooling system features a second modulating control valve 25 in the first conduit 15. The second control valve is not essential for controlling the cooling system but may provide an additional control strategy in that the pressure and temperature of the liquid refrigerant may be controlled before being mixed with the gaseous refrigerant from the fifth conduit. Further, the second modulating control valve 25 may be used to prevent condensation of refrigerant in the evaporator when the cooling system is shut down.

A third exemplary cooling system according to the invention is shown in fig. 4. The function of the third exemplary cooling system is substantially similar to the cooling system in fig. 3 and provides the same advantages as described above. However, in the third exemplary cooling system, the two-way gas valve 21 and the second modulating control valve 25 in fig. 3, are replaced by a single three-way control valve 22.

A fourth exemplary cooling system according to the invention is shown in fig. 5. Most features of the cooling system are similar to the cooling system shown in fig. 3, except that the pressure regulator 19 has been removed and the second pressure sensor and the second temperature sensor are replaced by a pressure transmitter 29. The cooling system is adapted for use with a refrigerant having subcritical conditions throughout the cooling system, and the pressure regulator 19 shown in figs. 2-4 is consequently not required to lower the pressure of the refrigerant before entering the receiver tank 2. Further, the pressure transmitter 29 may be arranged to control a gas cooler (or gas condenser) valve or pump to regulate the cooling capacity of the gas cooler. A required pressure drop in the liquid refrigerant may be provided by a modulating control valve 25 (i.e. a pressure regulator) or any suitable expansion valve/device. The cooling system may be controlled as described for the cooling systems in figs. 2 and 3 by regulating the gas flow in the fifth conduit 20 by use of the two-way gas valve 21, and optionally by use of the modulating control valve 25.

Claims

1. A cooling system (1), comprising a receiver tank (2), an evaporator (3), a compressor (4) and a gas cooler (5), wherein
   - the receiver tank (2) comprises a fluid inlet (6), a liquid outlet (7) and a gas outlet (8);
   - the evaporator (3) comprises an evaporator inlet (9) and an evaporator outlet (10),
   - the compressor (4) comprises a compressor inlet (11) and a compressor outlet (12);
   - the gas cooler (5) comprises a cooler inlet (13) and a cooler outlet (14); and

   the liquid outlet (7) of the receiver tank (2) is connected to the evaporator inlet (9) via a first conduit (15), the evaporator outlet (10) is connected to the compressor inlet (11) via a second conduit (16), the compressor outlet (12) is connected to the cooler inlet (13) via a third conduit (17), and the cooler outlet (14) is connected to the fluid inlet (6) of the receiver via a fourth conduit (18), wherein

   at least one of the first conduit (15) and the fourth conduit (18) comprises a pressure regulator (19,25), and

   the gas outlet (8) of the receiver tank is connected to the evaporator inlet (9) via a fifth conduit (20) and a gas flow regulator (21,22), such that a flow of liquid refrigerant in the first conduit (15) may be controlled by operating the gas flow regulator (21,22) during use.

2. A cooling system according to claim 1, wherein the gas flow regulator (21,22) is arranged such that a lowering of a flow of gaseous refrigerant in the fifth conduit (20) by operating the gas flow regulator will increase the flow of liquid refrigerant in the first conduit (15).

3. A cooling system according to claim 1 or 2, wherein the gas outlet (8) of the receiver tank is connected to the evaporator inlet (9) via the fifth conduit (20) and the gas flow regulator (21,22), such that a mixture of gaseous refrigerant from the fifth conduit (20) and liquid refrigerant from the first conduit (15) may enter the evaporator inlet (9) during use.

4. A cooling system according to any of the preceding claims, wherein the fifth conduit (20) comprises a first end connected to the gas outlet (8) of the receiver and a second end connected to the first conduit (15), such that gaseous refrigerant from the gas outlet (8) of the receiver may be mixed with

a liquid refrigerant from the liquid outlet (7) of the receiver before entering the evaporator inlet (9) during use.

5. A cooling system according to any of the preceding claims, wherein the first conduit and the fifth conduit is connected to the evaporator inlet via a sixth conduit (23).

6. A cooling system according to any of the preceding claims, wherein the gas flow regulator is a two-way valve (21).

7. A cooling system according to any of the preceding claims, wherein the first conduit, the fifth conduit and the evaporator inlet (9) is interconnected by a three-way coupling (24) featuring a first inlet connected to the fifth conduit (20), a second inlet connected to the first conduit (15) and an outlet connected to the evaporator inlet (9), wherein the second inlet is arranged at an angle (α) relative to the outlet, such that an ejector effect of a gaseous refrigerant flow from the fifth conduit (20) acting on a liquid refrigerant in the first conduit (15) is minimized during use.

8. A cooling system according to claim 9, wherein the angle (α) is about 90°.

9. A cooling system according to any of claims 1-5, wherein the gas flow regulator is a three-way valve (22).

10. A cooling system according to claim 9, wherein the three-way valve (22) comprises a first inlet connected to the first conduit (15), a second inlet connected to the fifth conduit (20) and an outlet connected to the evaporator inlet (9).

11. A cooling system according to any of the preceding claims, comprising a first pressure sensor (27a) and a first temperature sensor (28a), arranged in the second conduit (16), and a second pressure sensor (27b) and a second temperature sensor (28b), or a pressure transmitter (29), arranged in the fourth conduit upstream a pressure regulator (19,25).

12. A method of controlling a cooling system, wherein the cooling system comprises comprising a receiver tank (2), an evaporator (3), a compressor (4) and a gas cooler (5), wherein
the receiver tank (2) comprises a fluid inlet (6), a liquid outlet (7) and a gas outlet (8);
the evaporator (3) comprises an evaporator inlet (9) and an evaporator outlet (10),

the compressor (4) comprises a compressor inlet (11) and a compressor outlet (12);
the gas cooler (5) comprises a cooler inlet (13) and a cooler outlet (14); and
the liquid outlet (7) of the receiver tank (2) is connected to the evaporator inlet (9) via a first conduit (15), the evaporator outlet (10) is connected to the compressor inlet (11) via a second conduit (16), the compressor outlet (12) is connected to the cooler inlet (13) via a third conduit (17), and the cooler outlet (14) is connected to the fluid inlet (6) of the receiver via a fourth conduit (18), wherein

at least one of the first conduit (15) and the fourth conduit (18) comprises a pressure regulator (19,25), and

the gas outlet (8) of the receiver is connected to the evaporator inlet (9) via a fifth conduit (20) and a gas flow regulator (21,22), and the method comprising the step of:

- increasing a flow of gaseous refrigerant in the fifth conduit (20) by controlling the gas flow regulator (21,22) to obtain a reduced flow of liquid refrigerant in the first conduit (15) and a reduced cooling capacity in the evaporator (3); or
- reducing a flow of gaseous refrigerant in the fifth conduit (20) by controlling the gas flow regulator (21,22) to obtain an increased flow of liquid refrigerant in the first conduit (15) and an increased cooling capacity in the evaporator (3).

13. A method according to claim 12, wherein the fourth conduit (18) comprises a pressure regulator (19) and the step of increasing the flow of gaseous refrigerant comprises controlling the pressure regulator (19) to decrease the pressure fall between the cooler outlet (14) and the fluid inlet (6) of the receiver tank (2).

14. A method according to claim 12, wherein the first conduit (15) comprises a pressure regulator (25) and the step of increasing the flow of gaseous refrigerant comprises controlling the pressure regulator (25) to increase the pressure fall over the first conduit (15).

15. A method according to claim 12, comprising an initial step of:

- measuring the refrigerant temperature in the second conduit (16) to obtain a differential temperature curve relative to the boiling temperature of the liquid refrigerant within the evaporator (3); and increasing or reducing a flow of gaseous refrigerant in the fifth conduit (15) depending on whether the differential temperature curve shows a falling or rising differential temperature, respectively.

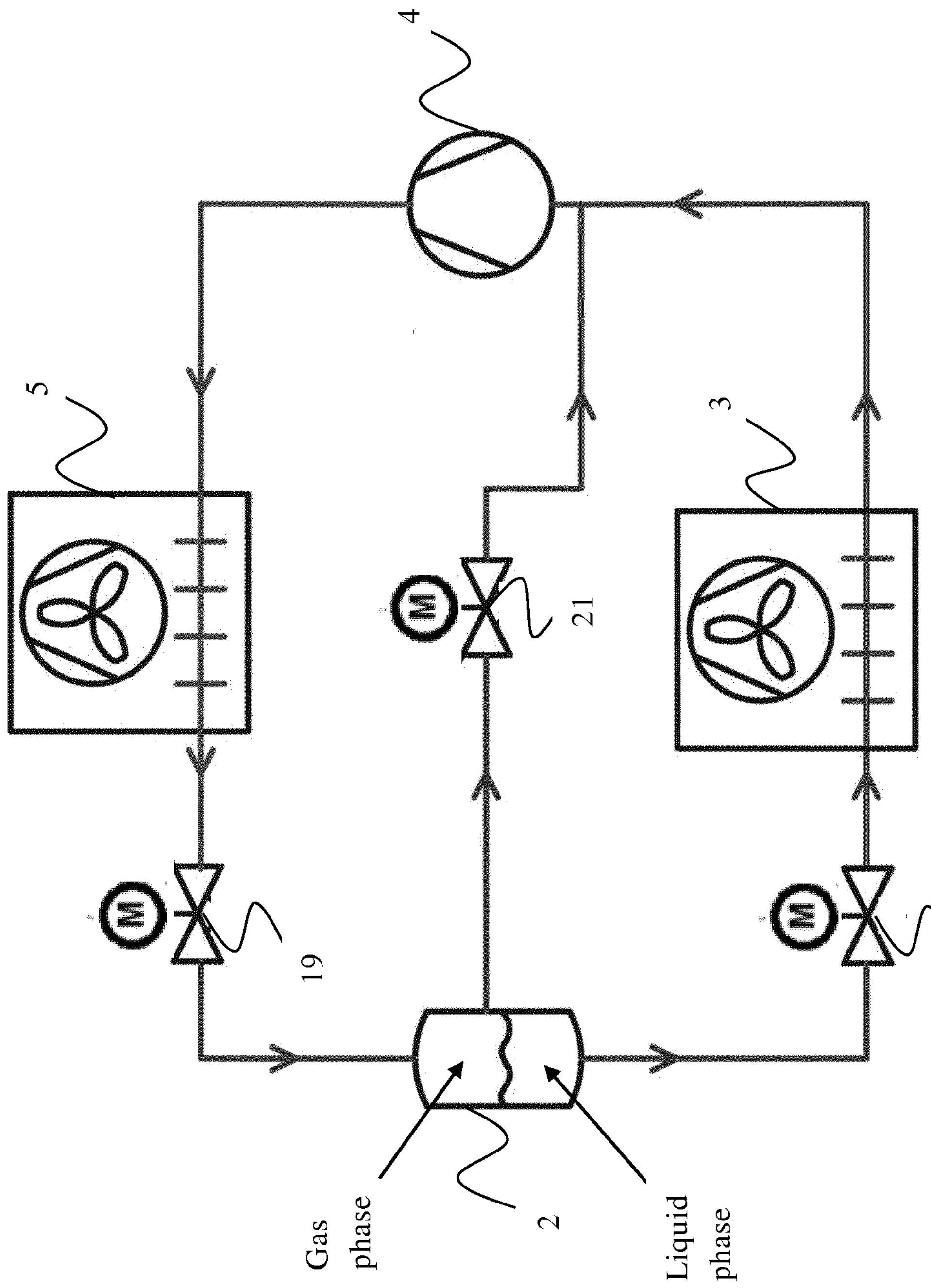
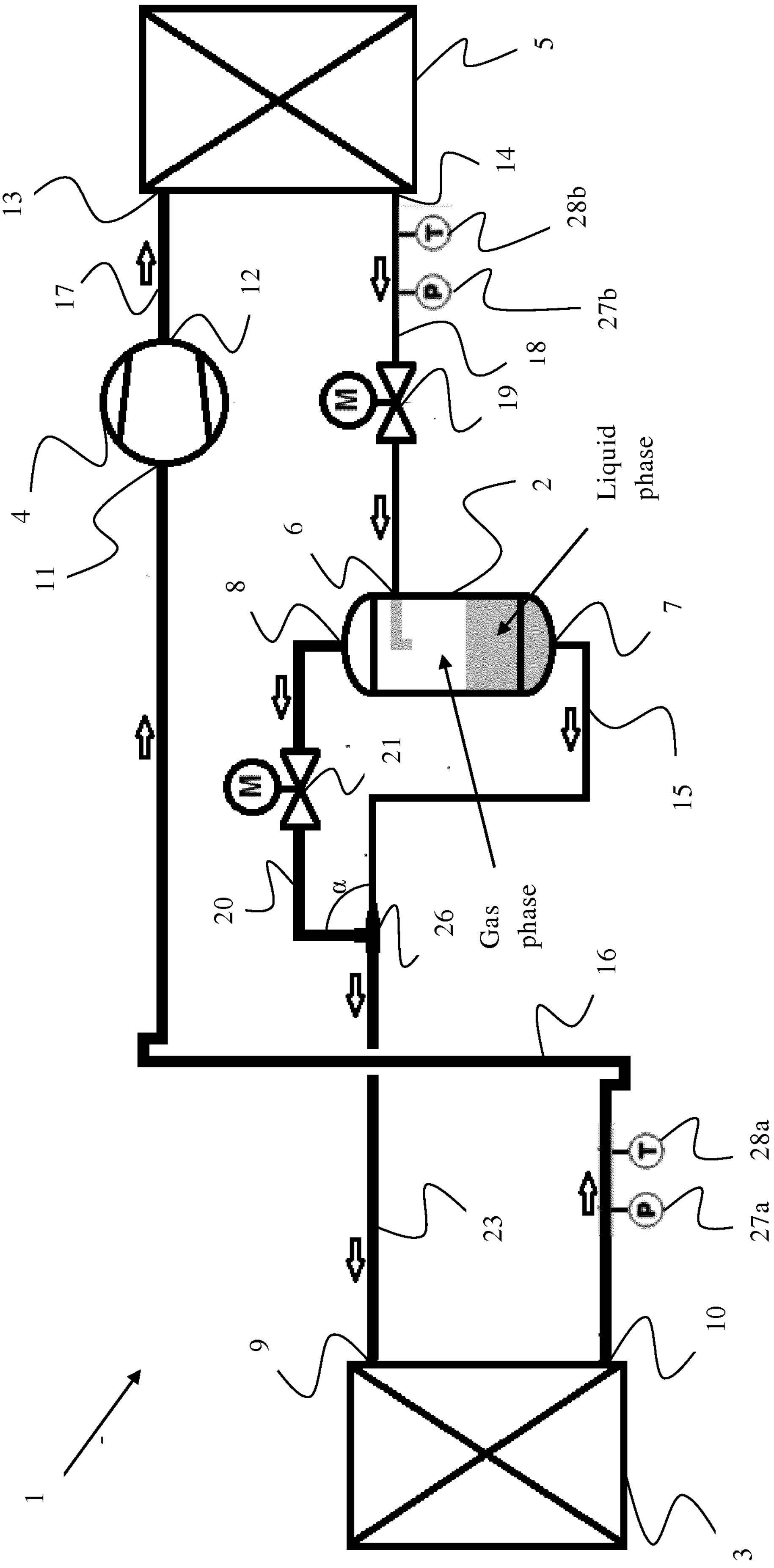


Fig. 1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28b
17
12
27b
18
19
4
2
Liquid phase
6
11
8
7
21
15
Gas phase
α
20
26
16
23
28a
27a
10
9
1
3

Fig. 2

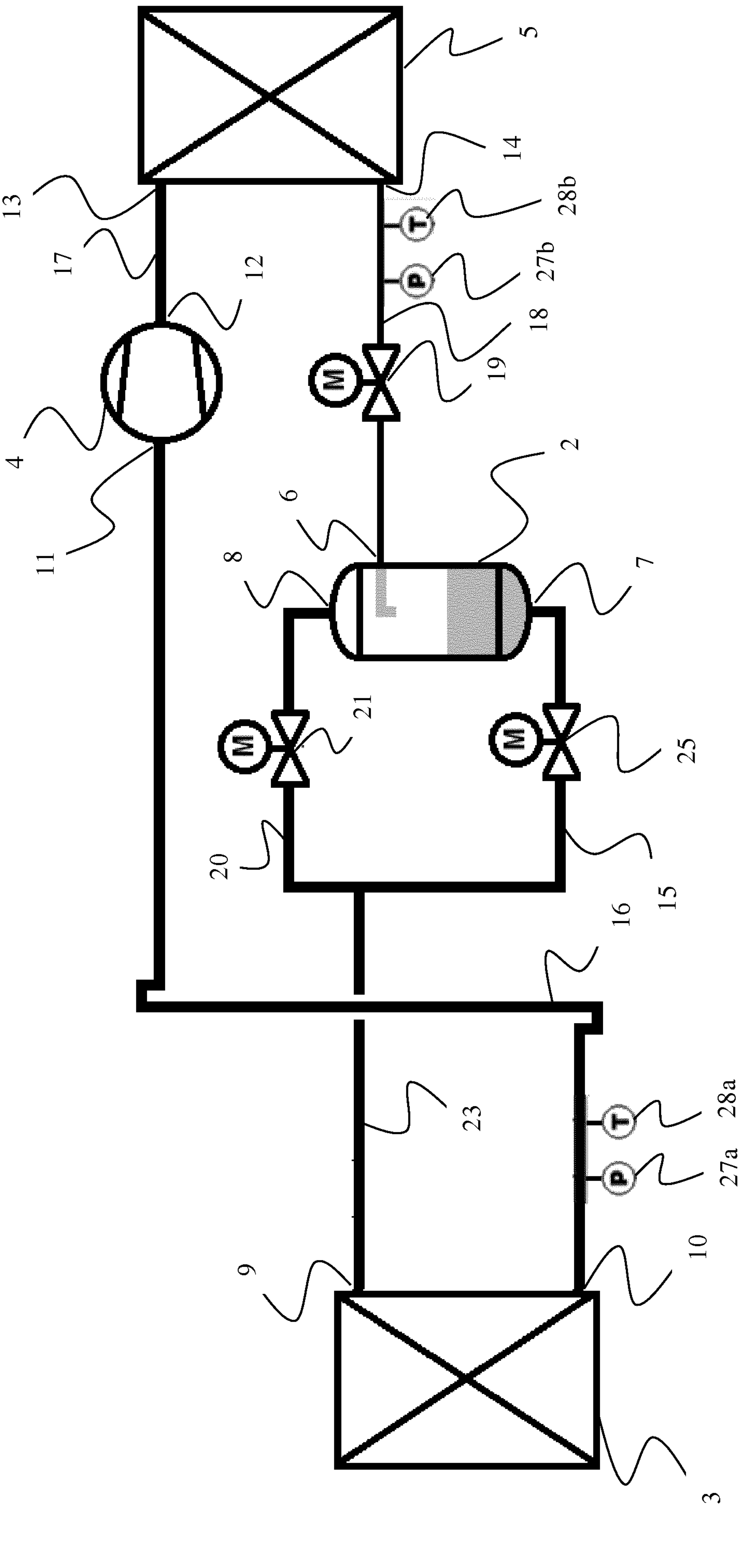

Fig. 3

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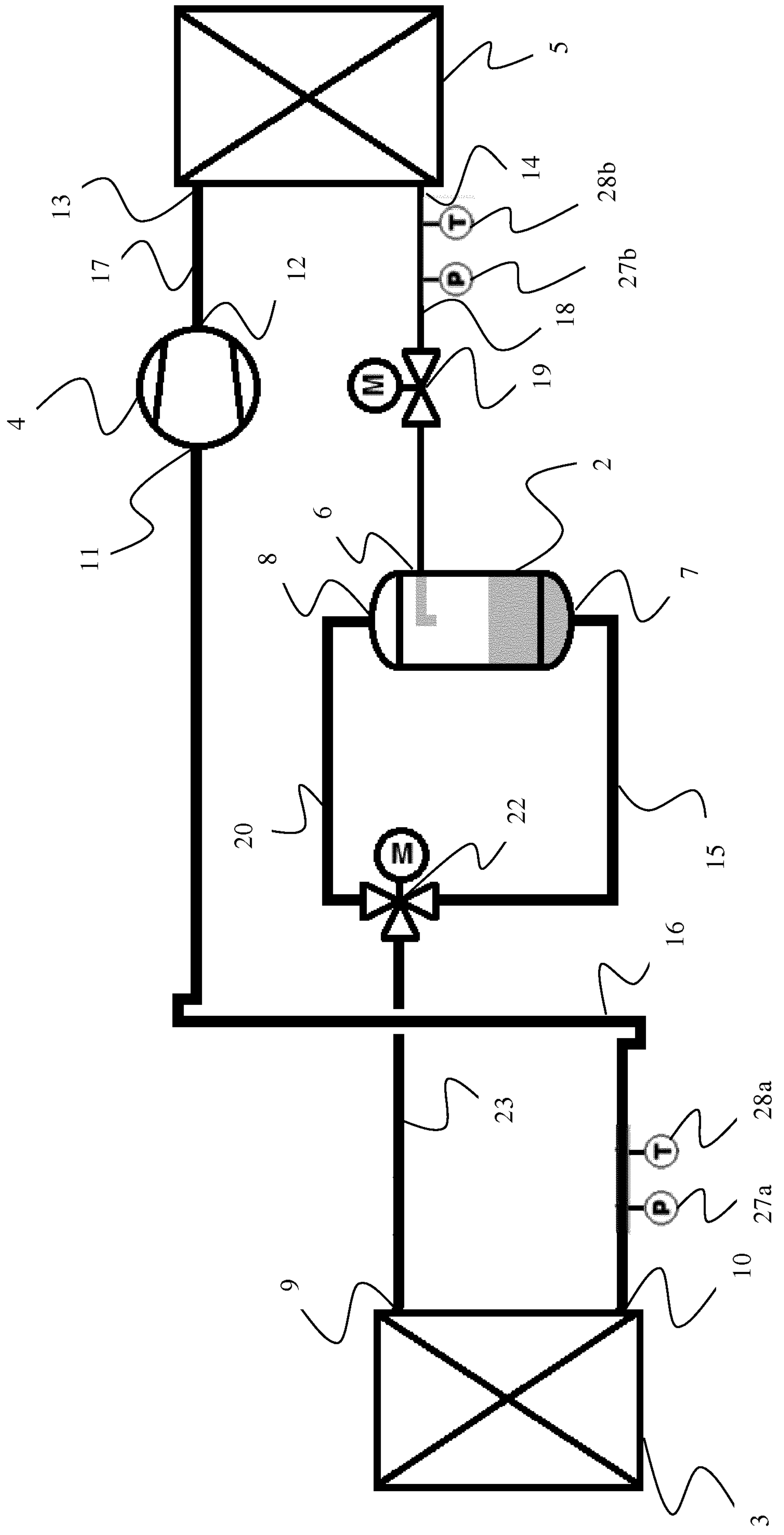
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27a
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3

Fig. 4

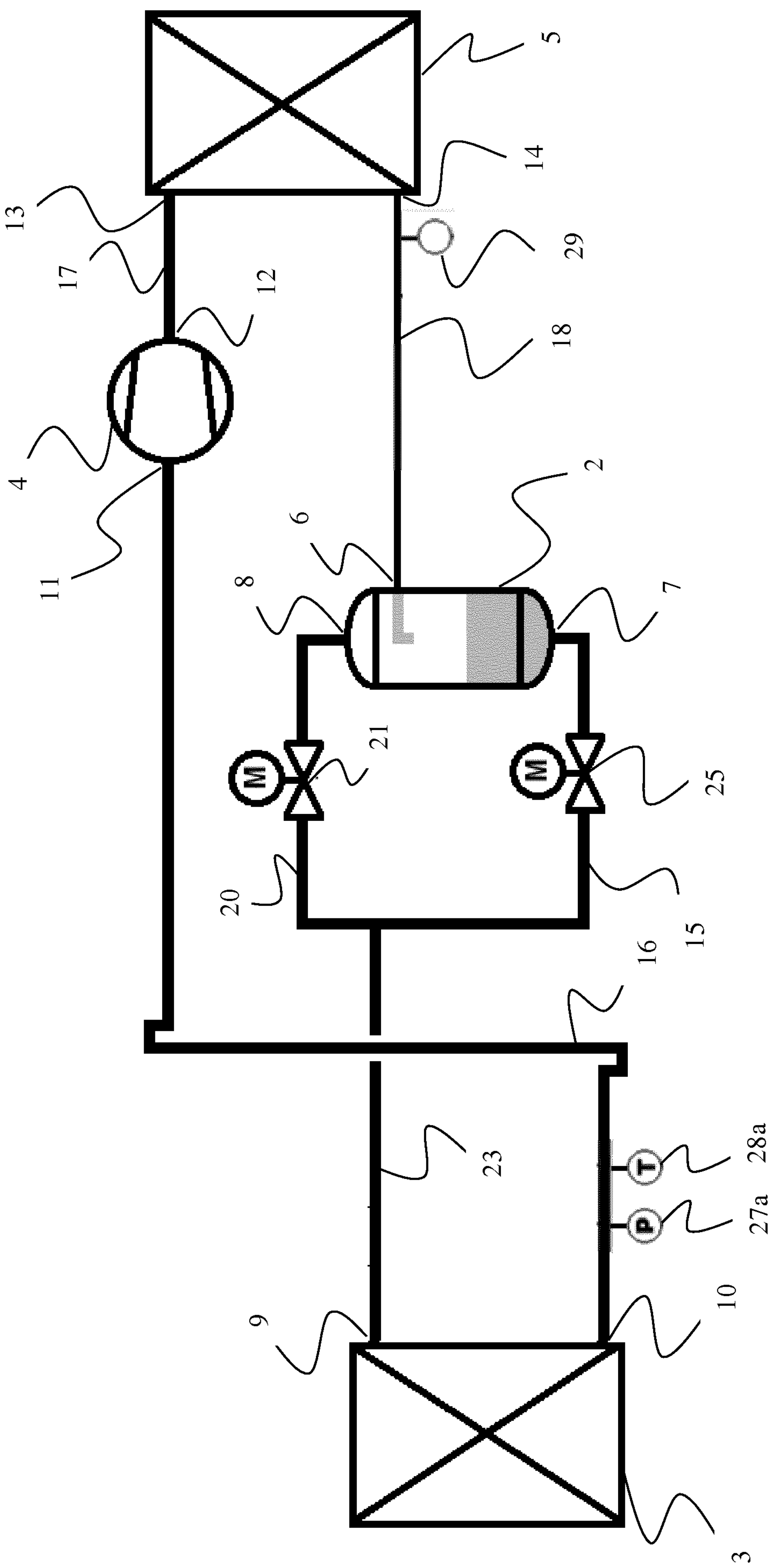

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/078537

A. CLASSIFICATION OF SUBJECT MATTER
INV. F25B41/00 F25B41/04 F25B49/02
ADD. F25B9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 1 441 214 A (UNIV SHANGHAI JIAOTONG [CN]) 10 September 2003 (2003-09-10)	1-14
A	the whole document	15

X	WO 2018/025900 A1 (MITSUBISHI HEAVY IND THERMAL SYSTEM LTD) 8 February 2018 (2018-02-08)	1-14
A	paragraph [0040] - paragraph [0112]; figures 1-13	15
X,P	& EP 3 462 108 A1 (MITSUBISHI HEAVY IND THERMAL SYSTEMS LTD [JP]) 3 April 2019 (2019-04-03)	1-14
A,P	paragraph [0040] - paragraph [0112]; figures 1-13	15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 January 2020	15/01/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Szilagyi, Barnabas

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/078537

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
CN 1441214	A	10-09-2003	NONE		
WO 2018025900	A1	08-02-2018	EP 3462108	A1	03-04-2019
			JP 2018021721	A	08-02-2018
			WO 2018025900	A1	08-02-2018