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(54) REFRIGERATION SYSTEM USES CARBON DIOXIDE AS REFRIGERANT AND OPERATION METHOD THEREOF

(57) The present invention relates to a refrigeration system which uses carbon dioxide as a refrigerant, comprising an auxiliary subgroup (13) provided with an adaptive compressor (6) connected in parallel with the gas discharge from one of the compression groups (3,4) and with the gas suction from the liquid receiver (7), said adaptive compressor (6) being configured to operate in at least two modes of operation, a first general mode of operation powered by a general power supply (14) with the compression groups (3,4) in normal operation and configured to suction flash gas continuously, and a second emergency mode of operation wherein the valve (18) opens and the adaptive compressor (6) is powered by an emergency power supply (15) when the one or more compression groups (3,4) are stopped due to a failure of the general power supply (14), thus maintaining a required safety pressure.

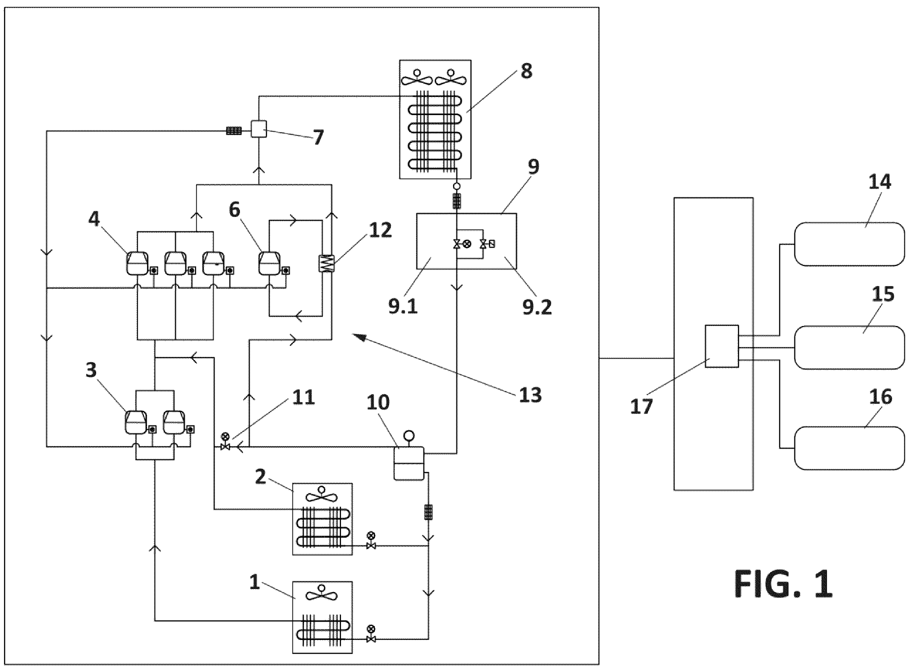

FIG. 1

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Description

OBJECT OF THE INVENTION

[0001] The present invention can be included in the field of refrigeration systems, in particular refrigeration systems that use carbon dioxide as refrigerant. More specifically, the object of the invention relates to a refrigeration system and an associated method, which make it possible to dispense with an emergency condensing unit, since it uses an adaptive compressor that in a normal mode of operation is permanently suctioning flash gas with a lower compression ratio than the medium and high temperature compression group, relieving said compression groups from part of the flash gas refrigerant flow generated in the liquid receiver and which reduces energy efficiency to the installation as a whole and, in an emergency mode of operation, it allows maintaining the pressure of the system being supplied by an emergency source while the rest of the compressor groups are stopped.

BACKGROUND OF THE INVENTION

[0002] The restriction of the use of refrigerants that damage the ozone layer and produce an increase in global warming have promoted the use of refrigerants such as CO2. The physical characteristics of CO2 have in particular that at high ambient temperatures, the pressures are higher than the limits of the safety valves of the refrigeration circuits and if this temperature coincides with a power failure, technical stoppage, or installation failure, the pressure becomes uncontrolled, opening the safety valves of the installation and emptying the CO2 into the atmosphere.

[0003] This effect produces negative effects, since kilograms of CO2 are released back into the atmosphere, and the installation requires an expensive intervention in time and money that can render a refrigeration installation inoperative, causing economic damage and loss of refrigerated products.

[0004] The solution known in the state of the art is to place an auxiliary refrigeration unit with another refrigerant that, in the cases described, would work by receiving an independent electrical power supply to cool the CO2 contained in the refrigeration installation, thus avoiding its increase in pressure and subsequent leakage through the safety valves.

[0005] Said auxiliary units are security elements with a high cost since, in addition to the unit, its corresponding electrical manoeuvre and individual protection panel are required.

DESCRIPTION OF THE INVENTION

[0006] The present invention aims to solve some of the problems mentioned in the state of the art. More specifically, a first aspect of the present invention relates to a refrigeration system that uses carbon dioxide as a refrigerant, wherein said system is of the type comprising:

- a liquid receiver to store the refrigerant,
- one or more heat exchangers configured to use the refrigerant to cool an area,
- at least one valve arranged between the one or more heat exchangers and the supply tank,
- one or more compression groups comprising at least one compressor to compress the discharge from the one or more heat exchangers,
- an oil separator in fluid communication with the one or more compression groups,
- a gas cooler in fluid communication with the oil separator, wherein the liquid receiver is configured to, during normal operation, receive the discharge from the gas cooler.

[0007] In facilities that use CO2 as a refrigerant, whether in operation in the transcritical or subcritical cycle, total condensation is not achieved in the liquefaction phase and a high amount of flash gas is generated that must be suctioned by the compressors of the medium temperature phase. This causes a loss of efficiency in the system since said compressors work with a higher compression ratio than that which is required to maintain optimal pressure in the container.

[0008] For this, in a preferred embodiment of the present invention, a solution is provided embodied in an auxiliary group in fluid communication with at least part of the discharge from the liquid receiver and connected in parallel with one of the compression groups, wherein the auxiliary subgroup comprises an adaptive compressor that is configured to operate in at least two modes of operation, a first general mode of operation powered by a general power supply with the compression groups in normal operation and configured for suctioning flash gas continuously, and a second emergency mode where the adaptive compressor is powered by an emergency power supply when the one or more compression groups are stopped due to a failure of the general power supply, thus maintaining a safety pressure required by the system.

[0009] Therefore, in a first aspect, the object of the invention relates to a refrigeration system that makes it possible to dispense with an emergency condensing unit, since it uses an adaptive compressor that in a normal mode of operation is permanently suctioning flash gas with a lower compression ratio than compression groups, for example medium and high temperature compression groups, relieving said compression groups from part of the flash gas refrigerant flow generated in the liquid receiver and which reduces energy efficiency of the system as a whole and, in addition, in an emergency mode of operation, allows maintaining the pressure of the system being supplied by an emergency source while the rest of the compressor groups are stopped.

[0010] Preferably, the auxiliary group comprises at least one parallel compressor connected in parallel with an adaptive compressor.

[0011] In other words, the adaptive compressor is permanently suctioning the Flash Gas generation from the liquid container with a much lower compression ratio than that which is required when this operation is carried out by the compressors of the medium temperature step of a conventional installation, further having a much lower energy consumption.

[0012] Likewise, by including the adaptive compressor such as the one described above, it is not necessary to add an additional emergency condensing unit as is the case in the known state of the art.

[0013] When the adaptive compressor is in Flash Gas mode, the suction of the saturated vapours from the liquid container can become a problem for the control of oil migration in the compressor crankcase due to the high density of the gas in the conditions present in the container wherein gas can be suctioned into the compressor.

[0014] In addition, acting in the emergency mode of operation, the adaptive compressor can suction liquid from the container if the maximum level limit is exceeded, and reduces oil migration due to low overheating.

[0015] To solve these drawbacks, the system preferably further comprises an auxiliary heat exchanger in fluid communication with the adaptive compressor, said exchanger being configured to be powered by the discharge from the adaptive compressor and flash gas coming from the liquid receiver, so that the output of the discharge stream from the heat exchanger that has been heated is channelled to an oil separator, avoiding oil migration and protecting the adaptive compressor from oil or liquid shocks.

[0016] More preferably, said auxiliary heat exchanger is a static and tubular superheater, provided with two concentric tubes inside of which the discharge of the adaptive compressor and the discharge of the parallel compressor circulate.

[0017] The tubular super heater with static operation, takes advantage of the discharge gases from the compressor to exchange them with the flash gas saturated vapour coming from the CO2 container and overheats it sufficiently to avoid the high migration of oil and the previously described problems.

[0018] The adaptive compressor, through the electronic development of its own control/management module, will select the most efficient power source with the greatest possible renewable penetration at all times, choosing the alternative energy or optimal power source for each case, being able to choose between different types available and selectable energy sources based on the requirements and possibilities of the installation, such as:

- Standard power supply
- Photovoltaic solar power supply
- Power supply through energy accumulation in off-peak hours of energy cost.
- Power supply by virtual battery.
- Emergency power supply (generator set, UPS, etc.)

[0019] Preferably, the system has a single point of supply to the control module, and the same module discriminates what type of power supply it needs at any given time (main network, alternative energy, generator set, UPS, emergency network). Therefore, it allows unloading the adaptive compressor to be powered by an alternative energy unit (solar panel, wind energy, off-peak hour storage battery, etc.). This in turn maintains the pressure of the system in an emergency mode of operation, or even to carry out maintenance in different parts of the system.

[0020] In more detail and in a more detailed and specific preferred embodiment, the refrigeration system can be of the type comprising:

- a storage tank configured to store the refrigerant,
- at least one low-temperature heat exchanger configured to use the refrigerant to cool an area close thereto,
- a first compression subgroup comprising at least one low-temperature compressor configured to compress the refrigerant discharged by the low-temperature heat exchanger,
- at least one medium temperature heat exchanger configured to use the refrigerant to cool an area close thereto,
- a second compression subgroup comprising at least one medium temperature compressor configured to compress the refrigerant discharged by the medium temperature heat exchanger,
- conduits configured to channel part of the discharge from the liquid receiver to the second compression group, and a flash gas valve arranged between both of them.
- an oil separator in fluid communication with the second compression subgroup,
- a gas cooler in fluid communication with the oil separator,
- a liquid receiver configured to receive the discharge from the gas cooler.

[0021] In the system described above, the one additional subgroup may be in fluid communication with at least part of the liquid receiver discharge and connected in parallel with the second medium temperature compression subgroup.

[0022] In addition, to operate in an emergency mode of operation, the flash gas valve and the valve that powers the one or more heat exchangers are closed, such that the adaptive compressor maintains the required safety pressure in the system.

[0023] Note that the system can further comprise high-temperature heat exchangers and third compression groups with at least one high-temperature compressor.

[0024] In a second aspect, the present invention relates to a method for operating the system described above, wherein said method comprises the steps of:

- providing a control module to manage the modes of operation of the adaptive compressor,
- connecting said control module to at least two power sources, an emergency source and a conventional source, said control module being capable of discriminating between both and unloading the adaptive compressor between any of said sources,
- providing at least one sensor to detect a power outage of the conventional power source,
- executing an emergency mode of operation wherein the control module commands the adaptive compressor to be powered by the emergency power source,
- opening the valve when the sensor detects a failure in the conventional power supply.

[0025] Preferably, the control module is connected to a third alternative energy power source, and therefore the control module manages the power supply between the three sources, equipping the adaptive compressor with three modes of operation, a first normal mode of operation, a second emergency mode of operation, and a third mode of operation with alternative energy.

DESCRIPTION OF THE DRAWINGS

[0026] As a complement to the description provided herein, and for the purpose of helping to make the features of the invention more readily understandable, in accordance with a preferred practical exemplary embodiment thereof, said description is accompanied by a set of drawings constituting an integral part of the same, wherein by way of illustration and not limitation, the following has been represented:

Figure 1 shows a schematic diagram of a preferred embodiment of the refrigeration system according to the present invention, where the compression groups, the heat exchangers, and the auxiliary subgroup provided with an adaptive compressor are illustrated.

Figure 2 shows a schematic diagram of a second preferred embodiment of the refrigeration system according to the present invention, wherein the compression groups, the heat exchangers, the control module and the auxiliary subgroup provided with an adaptive compressor and a parallel compressor are illustrated.

Figure 3 shows a schematic view of a preferred embodiment of the auxiliary heat exchanger wherein it is a superheater with two concrete copper tubes.

Figure 4 shows a perspective view of the superheater of Figure 3.

PREFERRED EMBODIMENT OF THE INVENTION

[0027] A detailed description of a preferred exemplary embodiment of the object of the invention is provided below, with the aid of the attached Figures 1-3 described above.

[0028] More specifically, as shown in Figure 1, the subject matter of the invention relates to a refrigeration system which uses carbon dioxide as a refrigerant, wherein said system is of the type comprising a liquid receiver (10) configured to store the refrigerant, one or more heat exchangers (1,2) configured to use the refrigerant to cool an area, at least one valve (18) arranged between the one or more heat exchangers (1,2) and the liquid receiver (10), and one or more compression groups (3,4) comprising at least one compressor to compress the discharge from the one or more heat exchangers (1,2), an oil separator (7) in fluid communication with the one or more compression groups (4), a gas cooler (8) in fluid communication with the oil separator, and a liquid receiver (7) configured to, during normal operation, receive the discharge from the gas cooler (8).

[0029] More particularly, as shown in figure 1, the system further comprises an auxiliary subgroup (13) in fluid communication with at least part of the discharge from the liquid receiver (10) and connected in parallel with one of the compression groups (3,4), wherein the auxiliary subgroup (13) comprises an adaptive compressor (6) that is configured to operate in at least two modes of operation, a first general mode of operation powered by a general power supply (14) with the compression groups (3,4) in normal operation and configured to suction flash gas continuously, and a second emergency mode wherein the adaptive compressor is powered by an emergency power supply (15) when the one or more compression groups (3, 4) are stopped due to a failure of the general power supply (14), thus maintaining a safety pressure required by the system.

[0030] In the preferred embodiment described, the adaptive compressor (6) has a lower compression ratio than the group of compressors (3,4) and is sized to suction flash gas more efficiently and relieving this work for the group of compressors (3, 4).

[0031] In addition, in a preferred embodiment, the system comprises an auxiliary heat exchanger (12) in fluid communication with the adaptive compressor (6), said exchanger being configured to be powered by the discharge from the adaptive compressor (6) and by the flash gas coming from the liquid receiver (10), so that the output of the discharge stream from the heat exchanger (12) that has been heated is channelled to an oil separator (7), avoiding oil migration and protecting the adaptive compressor (6) from oil or liquid shocks.

[0032] As shown in figure 1, the system comprises ducts configured to channel part of the discharge from the liquid receiver (10) to one of the compression groups (4), and a flash gas valve (11) arranged between them. When the adaptive compressor (6) must operate in an emergency mode, the flash gas valve (11) is set to open.

[0033] More particularly, as shown in figure 1, the one or more heat exchangers (1,2) comprise at least one low-temperature exchanger (1) and one medium-temperature exchanger connected in parallel to the liquid receiver (7).

[0034] In addition, the one or more compression groups (3,4) comprise:

- a first compression group comprising at least one low-temperature compressor (3) configured to compress the refrigerant discharged by the low-temperature heat exchanger, and
- a second compression group (4) comprising at least one medium-temperature compressor configured to compress the refrigerant discharged from the medium-temperature heat exchanger (2).

[0035] The second compression group (4) is configured to be supplied and further compress the discharge of the low-temperature compressors of the first compression group (3).

[0036] Figure 1 also shows a preferred embodiment of the control module (17) connected to the adaptive compressor (6), and configured to connect the adaptive compressor (6) with a conventional power source (14), with an alternative power source (16) and/or an emergency power source (15), wherein the control module (17) discriminates between said sources (14,15,16) by means of respective alarm sensors, a first conventional power failure alarm sensor, and a second alternative power failure alarm sensor, so that, when there is a failure in both sources, the adaptive compressor (6) enters the emergency mode of operation maintaining the required safety pressure.

[0037] Figure 2 shows a second preferred embodiment of the system, wherein the auxiliary subgroup (13) further comprises a parallel compressor (5) connected in parallel with the adaptive compressor (6).

[0038] Figure 3 shows a perspective view of an auxiliary heat exchanger (12) that is especially advantageous for working with the adaptive compressor (6), specifically to protect it from oil or liquid shocks and to avoid oil migration. More specifically, according to the preferred embodiment of figure 3, said auxiliary heat exchanger (12) is a static superheater provided with two concentric tubes inside of which the discharge of the adaptive compressor (6) and the discharge of the parallel compressor (5) circulate.

[0039] Figure 4 shows a perspective view of the static super heater of Figure 3.

Claims

1. A refrigeration system which uses carbon dioxide as a refrigerant, wherein said system comprises:

   - the liquid receiver (7) configured to store refrigerant,
   - one or more heat exchangers (1,2) configured to use the refrigerant to cool an area,
   - at least one valve (18) arranged between the one or more heat exchangers (1,2) and the supply tank,
   - one or more compression groups (3,4) comprising at least one compressor to compress the discharge from the one or more heat exchangers (1,2),
   - an oil separator (7) in fluid communication with the one or more compression groups (4),
   - a gas cooler (8) in fluid communication with the oil separator, wherein the liquid receiver (7) is configured to, during normal operation, receive the discharge from the gas cooler (8),

   said system being **characterised in that** it further comprises an auxiliary subgroup (13) in fluid communication with at least part of the discharge from the liquid receiver (10), wherein the auxiliary subgroup (13) comprises an adaptive compressor (6) connected in parallel with the gas discharge from one of the compression groups (3,4) and with the gas suction from the liquid receiver (7), said adaptive compressor (6) being configured to operate in at least two modes of operation, a first general mode of operation powered by a general power supply (14) with the compression groups (3,4) in normal operation and configured for suctioning flash gas continuously, and a second emergency mode of operation wherein the valve (18) opens and the adaptive compressor (6) is powered by an emergency power supply (15) when the one or more compression groups (3,4) are stopped due to a failure of the general power supply (14), thus maintaining a safety pressure required by the system.

2. - The system of claim 1, wherein the auxiliary subgroup (13) further comprises a parallel compressor (5) connected in parallel with the adaptive compressor (6).

3. - The system of claim 1, further comprising an auxiliary heat exchanger (12) in fluid communication with the adaptive compressor (6), said exchanger being configured to be powered by the discharge from the adaptive compressor (6) and flash gas coming from the liquid receiver (10), so that the output of the discharge stream from the heat exchanger (12) that has been heated is channelled to an oil separator (7), avoiding oil migration and protecting the adaptive compressor (6) from oil or liquid shocks.

4. - The system of claim 3, wherein the heat exchanger (12) is a static superheater provided with two concentric tubes inside of which the discharge of the

adaptive compressor (6) and the discharge of the parallel compressor (5) circulate.

5. - The system of claim 1, comprising conduits configured to channel part of the discharge from the liquid receiver (10) to one of the compression groups (4), and a flash gas valve (11) arranged between both.

6. -The system of claim 1, comprising a general power supply failure sensor, and wherein the adaptive compressor (6) is connected to a control module (17) in communication with the sensor, and wherein the control module discriminates between a conventional power supply and an emergency power supply, so that, when there is a general power failure, the adaptive compressor (6) enters the emergency mode of operation, maintaining the required safety pressure.

7. -The system of claim 1, wherein the adaptive compressor (6) is connected to a control module (17) configured to connect with a conventional power source (14), with an alternative power source (16) and to an emergency power source (15), wherein the control module (17) discriminates between said sources (14,15,16) by means of respective alarm sensors, a first conventional power failure alarm sensor, and a second alternative power failure alarm sensor, so that, when there is a failure in both sources, the adaptive compressor (6) enters the emergency mode of operation, maintaining the required safety pressure.

8. - The system of claim 1, wherein the one or more heat exchangers (1,2) comprise at least one low-temperature exchanger (1) and one medium-temperature exchanger connected in parallel to the liquid receiver (7).

9. - The system of claim 8, wherein the one or more compression groups (3,4) comprise:

- a first compression group comprising at least one low-temperature compressor (3) configured to compress the refrigerant discharged by the low-temperature heat exchanger, and
- a second compression group (4) comprising at least one medium-temperature compressor configured to compress the refrigerant discharged from the medium-temperature heat exchanger (2).

10. - The system of claim 9, wherein the second compression group (4) is configured to further compress the discharge from the low temperature compressors of the first compression group (3).

11. - The system of any one of the preceding claims, comprising a group of backpressure valves (9) arranged between the gas cooler (8) and the liquid receiver (10).

12. - The system of any one of the preceding claims, wherein the group of backpressure valves (9) is made up of an expansion safety valve (9.1) and a backpressure valve (9.2)

13. - A method of operation of the system of any of the preceding claims, comprising:

- providing a control module (17) to manage the modes of operation of the adaptive compressor (6),
- connecting said control module (17) to at least two power sources (14,15), an emergency source (14) and a conventional source (15), said control module (17) being capable of discriminating between both (14,15) and unloading the adaptive compressor (6) between any of said sources (14,15),
- providing at least one sensor to detect a power outage of the conventional power source (14),
- executing an emergency mode of operation wherein the control module (17) commands the adaptive compressor to be powered by the emergency power source (15),
- opening the valve (18) when the sensor detects a failure in the conventional power supply (14).

14. - The method of operation of claim 13, wherein the control module is connected to a third power source (16) of alternative energies, and the control module (17) manages the power between the three sources (14,15,16), equipping the adaptive compressor (6) with three modes of operation, a first normal mode of operation, a second emergency mode of operation, and a third mode of operation with alternative energy.

15. - The method of operation of claim 14, wherein the control module (17) executes a command to operate the adaptive compressor (6) in an emergency mode of operation when a failure in the alternative power supply (16) and a failure in the conventional power supply (14) is detected.

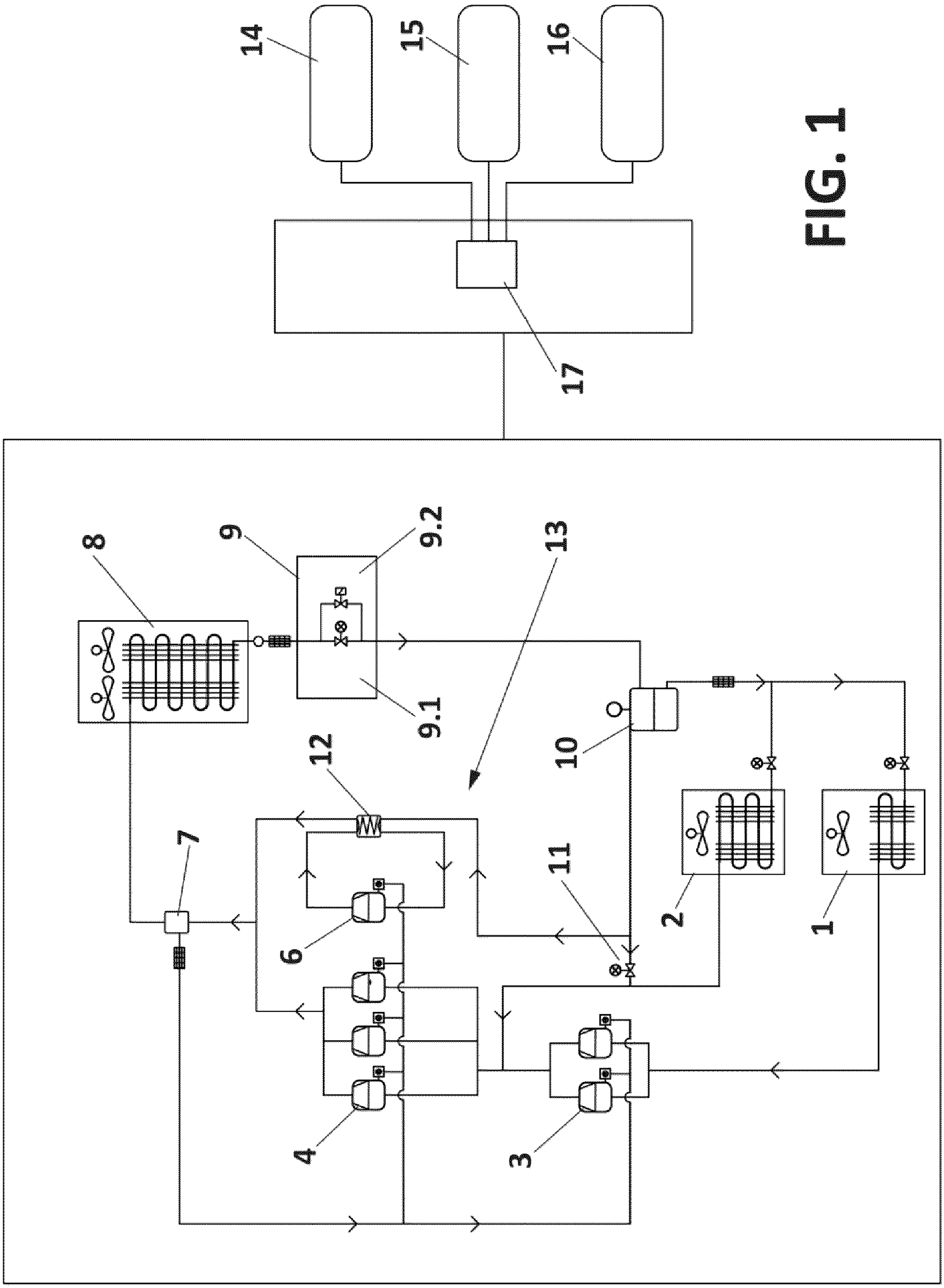

FIG. 1

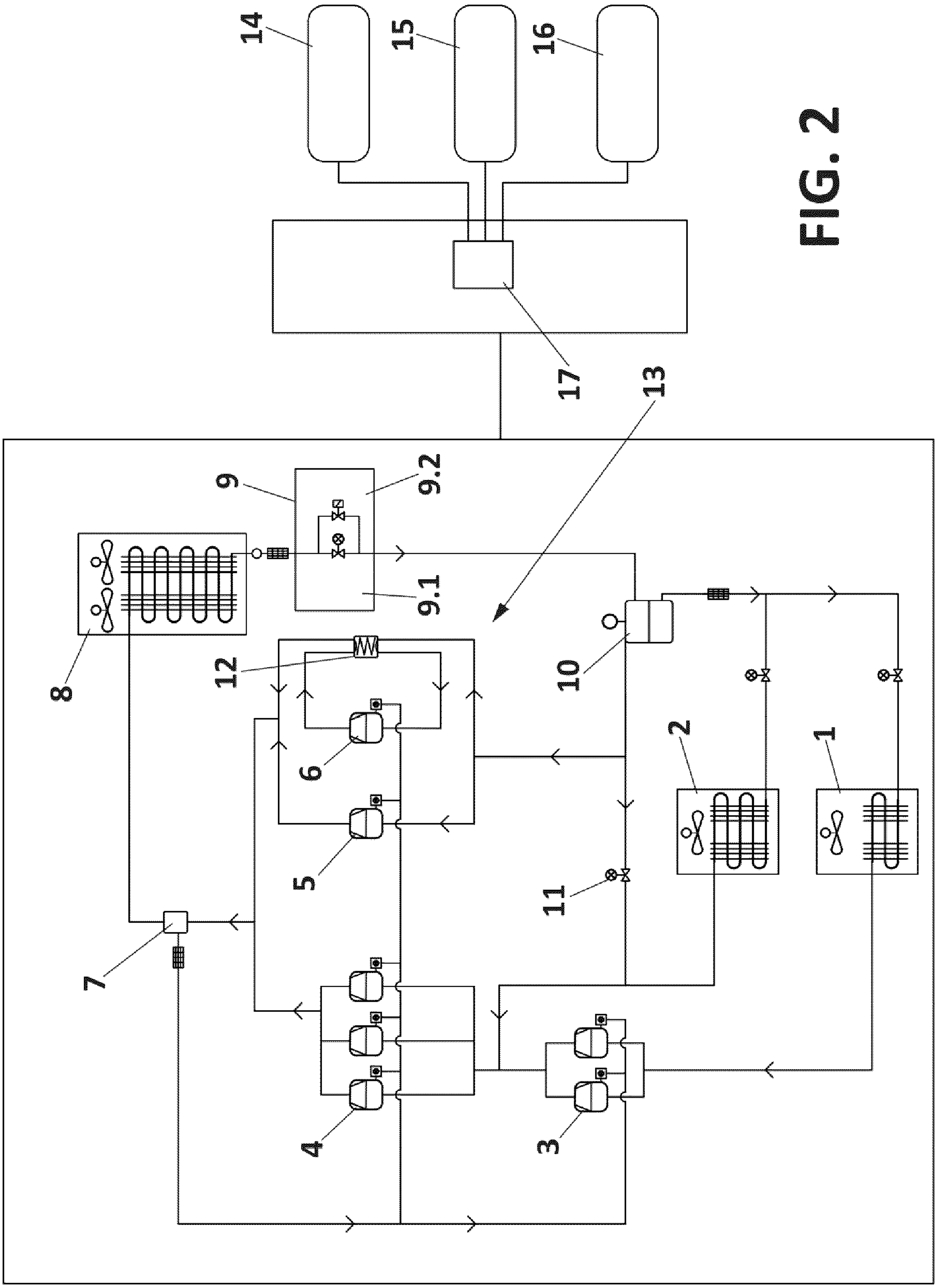

FIG. 2

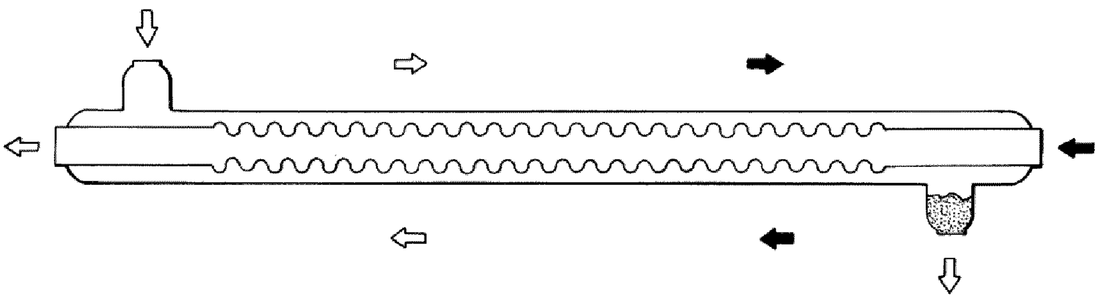

FIG. 3

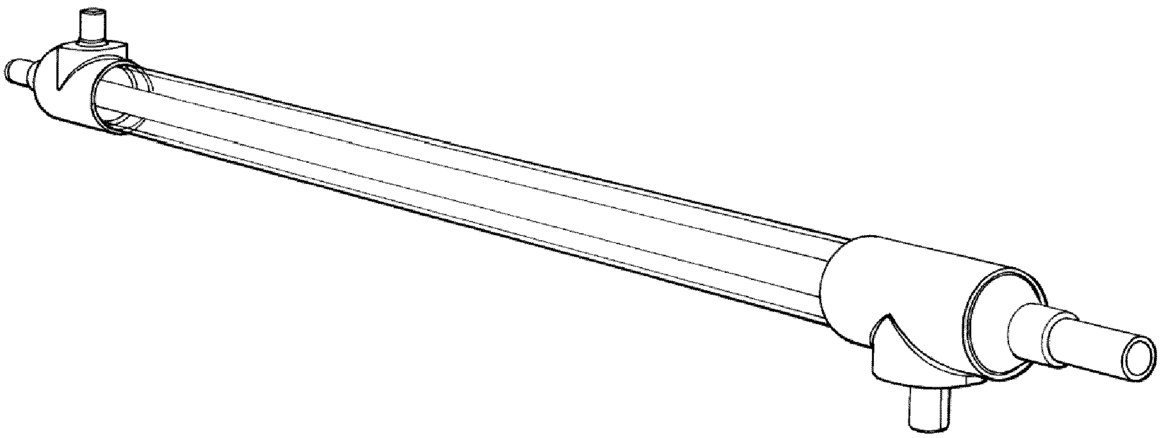

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 22 38 3169

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	WO 2022/053503 A1 (ADVANSOR AS [DK]) 17 March 2022 (2022-03-17) * page 16, line 8 - page 27, line 18; figures 1-2 * -----	1,2,5-7, 11-15 3,4,8-10	INV. F25B1/10 F25B49/02 F25B49/005
Y	US 2021/254864 A1 (CAVALLERI PAOLO [IT] ET AL) 19 August 2021 (2021-08-19) * paragraphs [0053] - [0071]; figures 3a,5 * -----	3,4,8-10	

TECHNICAL FIELDS SEARCHED (IPC)
F25B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	18 April 2023	Weisser, Meinrad

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2022053503 A1	17-03-2022	NONE	
US 2021254864 A1	19-08-2021	AR 121337 A1	11-05-2022
		AU 2021200889 A1	02-09-2021
		EP 3865786 A1	18-08-2021
		IT 202000003019 A1	14-08-2021
		US 2021254864 A1	19-08-2021

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