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(71) Applicant: **Onnera Laundry Barcelona S.A.**
08504 Sant Julià de Vilatorta (ES)

(72) Inventors:
- **ALGILAGA SADURNI, Romualdo**
  08552 Taradell (ES)
- **VIDAL SAEZ GARCIA, Antonio**
  08208 Sabadell (ES)

(74) Representative: **Igartua, Ismael**
Galbaian S. Coop.
Garaia Parke Teknologikoa
Goiru Kalea 1
20500 Arrasate-Mondragón (ES)

(54) CLOTHES DRYER AND METHOD OF DRYING CLOTHES

(57) Clothes dryer (1) and method of drying clothes, said dryer (1) comprising a drum (2) through which there circulates an airflow through an air conduit (14), and a heat pump through which there circulates a coolant in a closed circuit. The method of drying clothes comprises a standard drying program and a quick drying program. The heat pump comprises an evaporator (3) which, in a first step of the method, cools and dehumidifies the air exiting the drum (2), a compressor (5), a condenser (6) which, in a second step of the method, heats the air circulating through the air conduit (14) before entering the drum (2), an expansion valve (12), and a fan (4). The heat pump also comprises a heat exchanger (7) arranged downstream of the condenser (6) according to the direction of the airflow circulating through the air conduit (14). In the quick drying program, the coolant circulates through the heat exchanger (7) before reaching the condenser (6), the coolant being in the gaseous state both at the inlet and at the outlet of the heat exchanger (7), with a further heat input being provided to the air circulating through the air conduit (14) in a third step of the method.

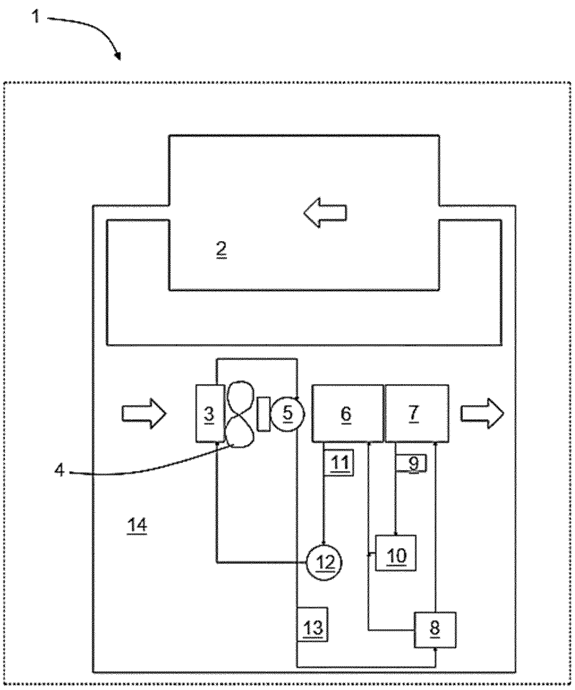

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to clothes dryers and methods of drying clothes.

PRIOR ART

[0002] Clothes dryers that can run different drying programs are known. WO2009016173A1, for example, describes a clothes dryer that can run a drying program with a low energy consumption but a prolonged duration, or a quick drying program. To that end, the clothes dryer of WO2009016173A1 comprises a drum in which the clothes to be dried are placed, contacting with an airflow circulating through the drum and through an air conduit that form a closed circuit. The clothes dryer also comprises a heat pump through which there circulates a coolant in a closed circuit. The heat pump comprises an evaporator that cools and dehumidifies the air exiting the drum, a compressor that pumps the coolant circulating through the heat pump, a condenser that heats the air circulating through the air conduit and can be divided in two, a fan that provides the airflow through the drum and the air conduit, and two expansion valves. As the air advances through the air conduit, the air is gradually heated so as to enter the drum again.

DISCLOSURE OF THE INVENTION

[0003] One object of the invention is to provide a clothes dryer, as defined in the claims.

[0004] Another object of the invention is to provide a method of drying clothes in a clothes dryer.

[0005] The clothes dryer of the invention comprises a drum adapted so that the clothes to be dried contact with an airflow circulating through the drum and through an air conduit that form a closed circuit, and a heat pump through which there circulates a coolant in a closed circuit. The heat pump comprises an evaporator that cools and dehumidifies the air exiting the drum and circulating through the air conduit, a compressor that pumps the coolant circulating through the heat pump, a condenser arranged downstream of the evaporator according to the direction of the airflow, said condenser heating the air circulating through the air conduit before entering the drum, an expansion valve, and a fan that provides the airflow through the drum and the air conduit.

[0006] The heat pump also comprises a heat exchanger arranged downstream of the condenser according to the direction of the airflow circulating through the air conduit, wherein, in a quick drying program, the coolant circulates through the heat exchanger before reaching the condenser, said coolant being in the gaseous state both at the inlet and at the outlet of said heat exchanger, such that a further heat input is provided to the air circulating through the air conduit before entering the drum, such that a further increase in the temperature of the air circulating through the air conduit is provided right before the air enters the drum.

[0007] The method of drying clothes of the invention comprises at least two drying programs, a standard drying program and a quick drying program. The clothes dryer comprises a drum in which the clothes to be dried are arranged, an air conduit through which there circulates an airflow and which forms a closed circuit with the drum, and a heat pump through which there circulates a coolant in a closed circuit, the method comprising a first step in which the air exiting the drum is cooled and dehumidified by means of an evaporator of the heat pump arranged in the air conduit, and a second step in which the air circulating through said air conduit is heated before entering the drum by means of a condenser arranged in the air conduit downstream of the evaporator according to the direction of the airflow circulating through the air conduit. The first step and the second step are common for the standard drying program and the quick drying program. However, the quick drying program further comprises a third step which is performed after the second step, with a further heat input being provided in said third step to the air circulating through the air conduit through a heat exchanger of the heat pump arranged in the air conduit, causing the coolant to circulate through said heat exchanger before reaching the condenser. The coolant is in the gaseous state both at the inlet and at the outlet of the heat exchanger.

[0008] The clothes dryer and the method of the invention enable, in the quick drying program, an even further increase in the temperature of the air circulating through the air conduit right before entering the drum, such that the drying time of the dryer can be shortened. In the quick drying program, the temperature of the coolant is higher in the heat exchanger than in the condenser given that after exiting the compressor, the coolant is routed directly to the heat exchanger, and since in the heat exchanger the coolant is in the gaseous state both at the inlet and at the outlet, i.e., the coolant does not change phase, there is greater exchange of heat with the air circulating through the air conduit. Furthermore, since the heat exchanger is arranged downstream of the condenser according to the direction of the airflow circulating through the air conduit, the heat input is greater at the end of the path of the air circulating through the air conduit right before entering the drum, and therefore, the air reaching the drum of the clothes dryer gets there hotter than in the case of the air which follows the standard drying program, for example.

[0009] These and other advantages and features of the invention will become apparent in view of the figures and the detailed description of the invention.

DESCRIPTION OF THE DRAWINGS

[0010]

Figure 1 shows a diagram of one embodiment of the clothes dryer according to the invention.

Figure 2 shows a diagram of another embodiment of the clothes dryer according to the invention.

DETAILED DISCLOSURE OF THE INVENTION

[0011] Figure 1 shows a diagram of one embodiment of the clothes dryer 1 according to the invention.

[0012] The clothes dryer 1 of the invention comprises a drum 2 adapted so that the clothes to be dried, not shown in the drawings, contact with an airflow circulating through the drum 2 and through an air conduit 14 that form a closed circuit, i.e., the drum 2 and the air conduit 14 form a closed channel through which said airflow circulates. The clothes dryer 1 also comprises a heat pump through which a coolant circulates in a closed circuit.

[0013] The clothes dryer 1 of the invention is adapted for performing the method of drying clothes of the invention, as described throughout the description. The method of drying clothes of the invention comprises at least two drying programs, a standard drying program and a quick drying program.

[0014] The heat pump of the invention comprises an evaporator 3 arranged in the air conduit 14 which, in a first step of the method of the invention, cools and dehumidifies the air exiting the drum 2 and circulating through the air conduit 14, a compressor 5 that pumps the coolant circulating through the heat pump, a condenser 6 arranged in the air conduit 14 downstream of the evaporator 3 according to the direction of the airflow, said condenser 6 heating, in a second step of the method of the invention, the air circulating through the air conduit 14 before entering the drum 2, an expansion valve 12, and a fan 4 that provides the airflow through the drum 2 and the air conduit 14.

[0015] The heat pump also comprises a heat exchanger 7 arranged in the air conduit 14 downstream of the condenser 6 according to the direction of the airflow circulating through the air conduit 14, the heat exchanger 7 being activated only in the quick drying program, as will be described in detail below. In the quick drying program of the clothes dryer 1 of the invention, the coolant circulates through the heat exchanger 7 before reaching the condenser 6.

[0016] The first step and the second step are common for the standard drying program and the quick drying program. However, the quick drying program further comprises a third step which is performed after the second step, with a further heat input being provided to the air circulating through the air conduit 14 through the heat exchanger 7 of the heat pump in said third step, given that the coolant is caused to circulate through said heat exchanger 7 before reaching the condenser 6. The coolant is in the gaseous state both at the inlet and at the outlet of the heat exchanger 7, such that in the quick drying program, a further heat input is provided to the air circulating through the air conduit 14 before entering the drum 2.

[0017] The clothes dryer 1 and the method of the invention therefore enable, in the quick drying program, an even further increase in the temperature of the air circulating through the air conduit 14 right before entering the drum 2, such that the drying time of the dryer 1 can be shortened. In the quick drying program, the temperature of the coolant is higher in the heat exchanger 7 than in the condenser 6, given that after exiting the compressor 5, the coolant is routed directly to the heat exchanger 7, and since in the heat exchanger 7 the coolant is in the gaseous state both at the inlet and at the outlet, i.e., the coolant does not change phase in the heat exchanger 7, there is greater exchange of heat between the coolant and the air circulating through the air conduit 14. Furthermore, since the heat exchanger 7 is arranged downstream of the condenser 6 according to the direction of the airflow circulating through the air conduit 14, the coolant is caused to circulate through the heat exchanger 7 before reaching the condenser 6, and therefore the heat input into the air circulating through the air conduit 14 in the third step is greater than the heat input in the second step, such that as the air advances to the drum 2, it is even further heated.

[0018] In other words, in the quick drying program, the air circulating through the air conduit 14 is first heated by the condenser 6 (second step) and then, as said air advances upon passage through the heat exchanger 7 (third step), the temperature of the air recently heated by the condenser 6 rises even further, the heat exchanger 7 constituting a greater heat source than the heat source provided by the condenser 6. Taking into consideration that the air is routed directly to the drum 2 after passing through the heat exchanger 7, the air reaching the drum 2 of the clothes dryer 1 gets there hotter than in the case of the air which follows the standard drying program, i.e., with an increase in temperature that does not occur in the standard drying program.

[0019] In the standard drying program, the passage of coolant to the heat exchanger 7 is blocked, the coolant being rerouted, after exiting the compressor 5, directly to the condenser 6, without passing through the heat exchanger 7.

[0020] To that end, the heat pump of the invention comprises a bypass valve 8, arranged downstream of the compressor 5 according to the direction of flow of the coolant, which, in the quick drying program, blocks the passage of coolant from the compressor 5 to the condenser 6, rerouting it to the heat exchanger 7, such that in the quick drying program, after exiting the compressor 5, the coolant is routed directly to the heat exchanger 7. However, in the standard drying program, the bypass valve 8 blocks the passage of coolant from the compressor 5 to the heat exchanger 7, rerouting it to the condenser 6, such that in the standard drying program the coolant, after exiting the compressor 5, is routed directly to the condenser 6. Therefore, the quick drying program and

the standard drying program are switched through said bypass valve 8 arranged downstream of the compressor 5 and upstream of the heat exchanger 7 and the condenser 6, according to the coolant circuit, the coolant circulating through said bypass valve 8 from the outlet of the compressor 5 to the heat exchanger 7 in the quick drying program and to the condenser 6 in the standard drying program.

[0021] The heat pump of the invention also comprises a non-return valve 10 arranged between the heat exchanger 7 and the condenser 6 according to the flow of the coolant, said non-return valve 10 allowing the passage of coolant from the heat exchanger 7 to the condenser 6 when the quick drying program is run, and blocking the passage of coolant in the reverse direction to the heat exchanger 7 when the standard drying program is run. In other words, when the bypass valve 8 routes the coolant from the compressor 5 to the condenser 6 according to the standard drying program, the non-return valve 10 prevents the coolant from being able to branch off to the condenser 6 and to the heat exchanger 7 (according to a reverse path) after passing through the bypass valve 8, thereby ensuring that all of the coolant is routed to the condenser 6 in the standard drying program.

[0022] In the preferred embodiment of the invention, the compressor 5 is arranged between the evaporator 3 and the condenser 6, inside the air conduit 14, and the fan 4 is also arranged inside the air conduit 14, preferably between the evaporator 3 and the compressor 5, although it could be arranged in another location inside the air conduit 14.

[0023] The heat pump of the invention also comprises a temperature sensor 9 which measures the temperature of the coolant at the outlet of the heat exchanger 7 in the quick drying program, i.e., when the heat exchanger 7 is active, and a pressure sensor 11 which measures the pressure of the coolant at the outlet of the condenser 6.

[0024] In the preferred embodiment of the invention, when the quick drying program is being run, it is possible to switch to the standard drying program when the difference between the temperature of the coolant measured at the outlet of the heat exchanger 7 and the temperature of the dew point corresponding to the pressure of the coolant measured at the outlet of the condenser 6 is less than a threshold value, said threshold value preferably being four degrees Kelvin, and more preferably three degrees Kelvin. This condition ensures that the coolant does not change phase in the heat exchanger 7, thereby benefitting from greater exchange of heat between the coolant and the air circulating to the drum 2 through the air conduit 14. To that end, the clothes dryer 1 of the invention comprises a control unit which, when the quick drying program is being run, switches automatically to the standard drying program when said condition is met, i.e., when it cannot be assured that the coolant does not change phase in the heat exchanger 7, acting on the bypass valve 8 to reroute the coolant to the condenser 6 after exiting the compressor 5, blocking the passage to the heat exchanger 7.

[0025] In a general manner, to be able to run quick drying program, it is necessary to meet the condition that the temperature of the coolant at the outlet of the compressor 5 must exceed the temperature of the dew point corresponding to the pressure of the coolant measured at the outlet of the condenser 6 by at least an initial threshold value, said initial threshold value preferably being ten degrees Kelvin and more preferably twenty degrees Kelvin. In other words, the difference between the temperature of the coolant at the outlet of the compressor 5 and the temperature of the dew point corresponding to the pressure of the coolant measured at the outlet of the condenser 6 must be greater than or equal to said initial threshold value. In order to control the temperature of the coolant at the outlet of the compressor 5, the heat pump of the clothes dryer 1 comprises a temperature sensor 13 arranged at the outlet of the compressor 5.

[0026] If this condition is not met, the quick drying program cannot be run, and the standard drying program will be run instead. If, conversely, this condition is in fact met, the clothes dryer 1 can run the quick drying program. However, as long as the quick drying program is being run, the temperature of the coolant at the outlet of the heat exchanger 7 must be controlled, as mentioned above, to prevent the coolant from changing phase in the heat exchanger 7.

[0027] In the preferred embodiment of the invention, as shown in Figure 1, the elements of the heat pump of the clothes dryer 1 are arranged inside the air conduit 14, i.e., the evaporator 3, the compressor 5, the condenser 6, the heat exchanger 7, the fan 4, the expansion valve 12, and even the bypass valve 8, the non-return valve 10, the temperature sensor 9 which measures the temperature of the coolant at the outlet of the heat exchanger 7, the temperature sensor 13 which measures the temperature of the coolant at the outlet of the compressor 5, and the pressure sensor 11 which measures the equivalent pressure of the coolant at the outlet of the condenser 6.

[0028] In a variant of the invention, some elements of the heat pump of the clothes dryer 1' can be arranged outside of the air conduit 14, as shown in Figure 2. In this case, at least the evaporator 3, the compressor 5, the condenser 6, the heat exchanger 7, and the fan 4 are arranged inside the air conduit 14, and the rest of the elements are arranged outside of the air conduit 14, such as, for example, the expansion valve 12, the bypass valve 8, the non-return valve 10, the temperature sensor 9 which measures the temperature of the coolant at the outlet of the heat exchanger 7, the temperature sensor 13 which measures the temperature of the coolant at the outlet of the compressor 5, and the pressure sensor 11 which measures the equivalent pressure of the coolant at the outlet of the condenser 6.

Claims

1. Clothes dryer comprising a drum (2) adapted so that the clothes to be dried contact with an airflow circulating through the drum (2) and through an air conduit (14) that form a closed circuit, and a heat pump through which there circulates a coolant in a closed circuit, the heat pump comprising

   - an evaporator (3) that cools and dehumidifies the air exiting the drum (2) and circulating through the air conduit (14),
   - a compressor (5) that pumps the coolant circulating through the heat pump,
   - a condenser (6) arranged downstream of the evaporator (3) according to the direction of the airflow, said condenser (6) heating the air circulating through the air conduit (14) before entering the drum (2),
   - an expansion valve (12), and
   - a fan (4) that provides the airflow through the drum (2) and the air conduit (14),

   characterized in that the heat pump also comprises a heat exchanger (7) arranged downstream of the condenser (6) according to the direction of the airflow circulating through the air conduit (14), wherein, in a quick drying program, the coolant circulates through the heat exchanger (7) before reaching the condenser (6), said coolant being in the gaseous state both at the inlet and at the outlet of said heat exchanger (7), such that a further heat input which causes a further increase in the temperature of the air circulating through the air conduit (14) before entering the drum (2) is provided.

2. Clothes dryer according to claim 1, wherein the heat pump also comprises a bypass valve (8) arranged downstream of the compressor (5) according to the direction of flow of the coolant which, in the quick drying program, blocks the passage of the coolant from the compressor (5) to the condenser (6) and reroutes it to the heat exchanger (7).

3. Clothes dryer according to claim 2, wherein the heat pump also comprises a non-return valve (10) arranged between the heat exchanger (7) and the condenser (6) according to the flow of the coolant, said non-return valve (10) allowing the passage of coolant from the heat exchanger (7) to the condenser (6) in the quick drying program, said non-return valve (10) blocking the passage of coolant from the compressor (5) to the heat exchanger (7) in a standard drying program.

4. Clothes dryer according to any of claims 1 to 3, wherein the elements of the heat pump are arranged inside the air conduit (14).

5. Clothes dryer according to any of claims 1 to 3, wherein at least the evaporator (3), the compressor (5), the condenser (6), the heat exchanger (7), and the fan (4) are arranged inside the air conduit (14), the rest of the elements of the heat pump being arranged outside of the air conduit (14).

6. Clothes dryer according to any of the preceding claims, wherein the heat pump also comprises a temperature sensor (9) which measures the temperature of the coolant at the outlet of the heat exchanger (7) in the quick drying program, and a pressure sensor (11) which measures the pressure of the coolant at the outlet of the condenser (6), the clothes dryer (1) comprising a control unit adapted for blocking the passage of coolant to the heat exchanger (7) in the event that the difference between the temperature measured in the temperature sensor (9) and the temperature of the dew point corresponding to the pressure of the coolant measured in the pressure sensor (11) is less than a threshold value, said threshold value preferably being four degrees Kelvin, and more preferably three degrees Kelvin.

7. Clothes dryer according to any of the preceding claims, wherein the compressor (5) is arranged between the evaporator (3) and the condenser (6) inside the air conduit (14).

8. Clothes dryer according to claim 7, wherein the fan (4) is arranged between the evaporator (3) and the compressor (5) inside the air conduit (14).

9. Method of drying clothes in a clothes dryer (1), comprising at least two drying programs, a standard drying program and a quick drying program, the dryer (1) comprising a drum (2) in which the clothes to be dried are arranged, an air conduit (14) through which there circulates an airflow and which forms a closed circuit with the drum (2), and a heat pump through which there circulates a coolant in a closed circuit, the method comprising

   - a first step in which the air exiting the drum (2) is cooled and dehumidified by means of an evaporator (3) of the heat pump arranged in the air conduit (14), and
   - a second step in which the air circulating through said air conduit (14) is heated before entering the drum (2) by means of a condenser (6) arranged in the air conduit (14) downstream of the evaporator (3) according to the direction of the airflow circulating through the air conduit (14),

   the first step and second step being common for the standard drying program and the quick drying program,

characterized in that the quick drying program further comprises a third step, which is performed after the second step, wherein a further heat input is provided to the air circulating through the air conduit (14) through a heat exchanger (7) of the heat pump arranged in the air conduit (14), causing a further increase in the temperature of said air, causing the coolant to circulate through said heat exchanger (7) before reaching the condenser (6), the coolant being in the gaseous state both at the inlet and at the outlet of the heat exchanger (7).

10. Method according to claim 9, wherein in the standard drying program the passage of coolant to the heat exchanger (7) is blocked, the coolant being rerouted, after exiting the compressor (5), directly to the condenser (6) without passing through the heat exchanger (7).

11. Method according to claim 9 or 10, wherein the heat exchanger (7) is arranged downstream of the condenser (6) according to the direction of the airflow, such that by causing the coolant to circulate through the heat exchanger (7) before reaching the condenser (6) in the quick drying program, the heat input into the air circulating through the air conduit (14) in the third step is greater than the heat input in the second step.

12. Method according to any of claims 9 to 11, wherein the quick drying program and the standard drying program are switched through a bypass valve (8) arranged downstream of the compressor (5) and upstream of the heat exchanger (7) and the condenser (6), according to the coolant circuit, the coolant circulating through said bypass valve (8) from the outlet of the compressor (5) to the heat exchanger (7) in the quick drying program and to the condenser (6) in the standard drying program.

13. Method according to any of claims 9 to 12, wherein the heat pump comprises a non-return valve (10) arranged between the heat exchanger (7) and the condenser (6) according to the flow of the coolant, said non-return valve (10) allowing the passage of coolant from the heat exchanger (7) to the condenser (6) when the quick drying program is run, and blocking the passage of coolant in the reverse direction to the heat exchanger (7) when the standard drying program is run.

14. Method according to any of claims 9 to 13, wherein when the quick drying program is being run, it is possible to switch to the standard drying program when the difference between the temperature of the coolant measured at the outlet of the heat exchanger (7) and the temperature of the dew point corresponding to a pressure of the coolant measured at the outlet of the condenser (6) is less than a threshold value, said threshold value being preferably four degrees Kelvin, and more preferably three degrees Kelvin.

15. Method according to claim 14, wherein when the temperature of the coolant at the outlet of the compressor (5) exceeds the temperature of the dew point corresponding to the pressure of the coolant measured at the outlet of the condenser (6) by at least an initial threshold value, preferably ten degrees Kelvin, more preferably twenty degrees Kelvin, the quick drying program is allowed to be run, with the standard drying program otherwise being run.

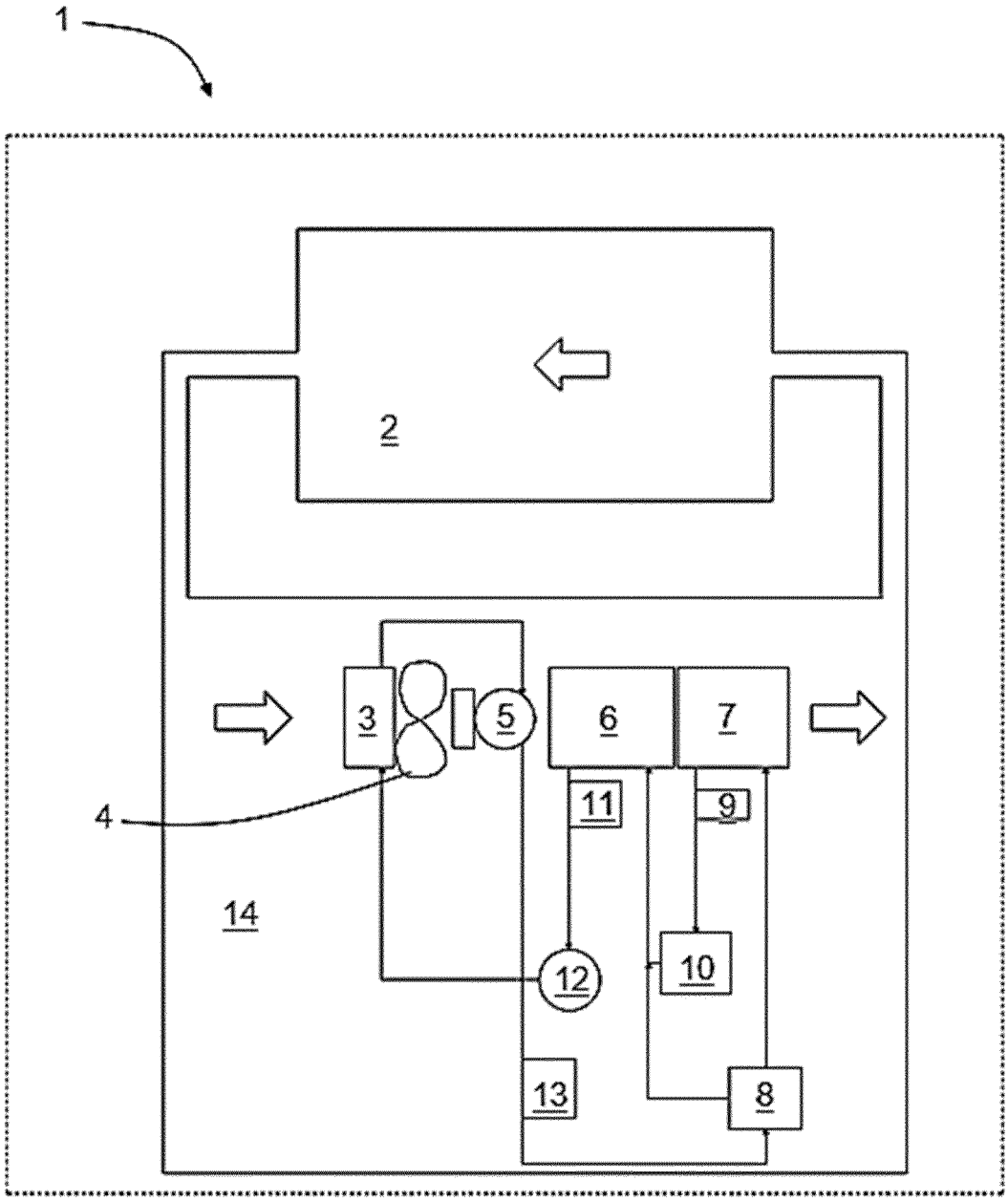

Fig. 1

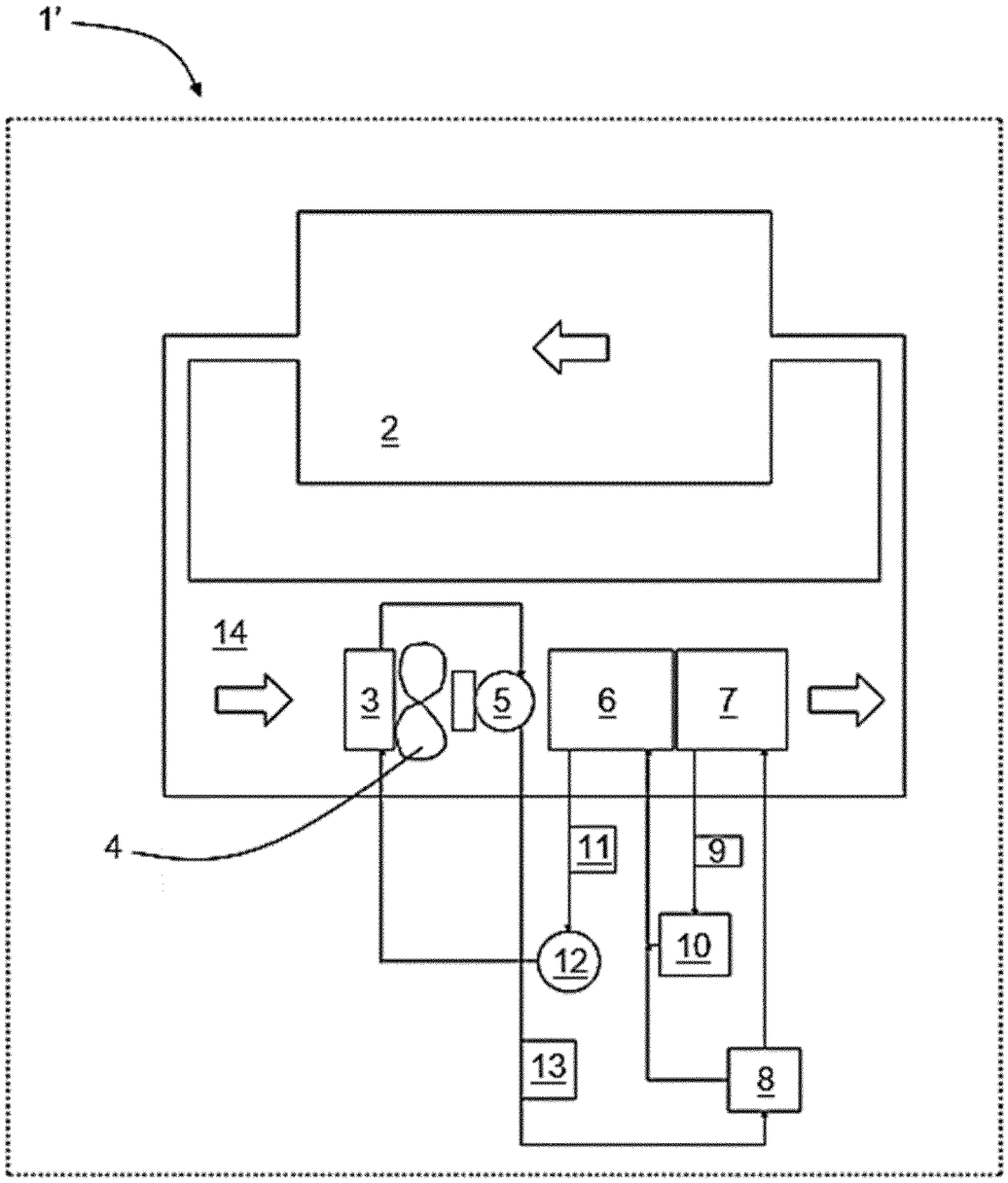

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 22 38 2865

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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TECHNICAL FIELDS SEARCHED (IPC)

D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 February 2023	Diaz y Diaz-Caneja

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 38 2865

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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