



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.10.2017 Bulletin 2017/40

(51) Int Cl.:
F25B 47/02 (2006.01) F25B 41/04 (2006.01)

(21) Application number: **16163359.9**

(22) Date of filing: **31.03.2016**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(72) Inventors:
• **Nguyen, Minh**
Livingston, EH54 5DJ (GB)
• **Mcllwain, Stuart**
Livingston, EH54 5DJ (GB)

(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
Theresienhöhe 11a
80339 München (DE)

(71) Applicants:
• **Mitsubishi Electric Corporation**
Chiyoda-ku
Tokyo 100-8310 (JP)
Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
• **Mitsubishi Electric R&D Centre Europe B.V.**
Livingston EH54 5DJ (GB)
Designated Contracting States:
GB

(54) **HEAT PUMP SYSTEM WITH RAPID DEFROSTING MODE**

(57) The invention relates to a heat pump system comprising a refrigerant circuit, the refrigerant circuit comprising an evaporator and a heat exchanger which is adapted to exchange heat between the refrigerant circuit and an entity to be heated, wherein

the refrigerant circuit further comprises a bypass line by-passing the heat exchanger and the refrigerant circuit in addition to the heat exchanger and the evaporator comprises a heat source which is adapted to heat refrigerant which is routed through the bypass line.

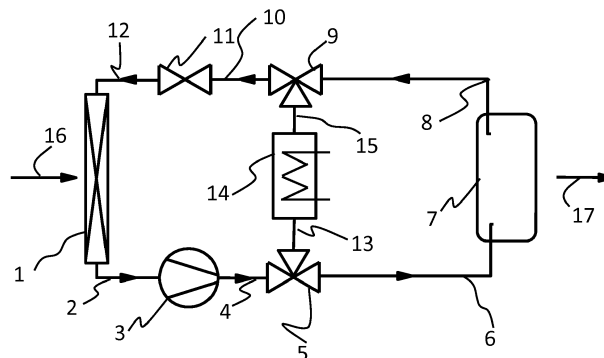


FIGURE 2

Description

[0001] The invention regards a heat pump system including a refrigerant circuit with a heat exchanger and/or condenser, wherein the refrigerant circuit comprises a bypass line bypassing the heat exchanger or condenser, respectively. Refrigerant which is routed through the bypass line can be heated with an additional heater.

[0002] In particular Air Source Heat Pumps (ASHP) take heat from the air and use it to vapourise refrigerants. The component that collects this heat is the evaporator. In cold and damp conditions frost can develop on the evaporator surface that will ultimately block the air passages between the fins and tubes of the evaporators and leave them unable to effectively absorb any useful heat. This has the result that the ASHP cannot function properly and requires the frost to be melted before normal operation can resume.

[0003] This means that for example in Air To Water (ATW) ASHP systems a water loop, which can be the heat transport means into a building, will not deliver heating and hot water.

[0004] Thus, efficient performance requires the removal of frosting and icing on the evaporator's surface. This operation method is called defrosting and it requires energy input to keep it running such as electric heater-based defrosting, hot-gas-bypass-based defrosting and/or reverse cycle-based defrosting and also by a sub-cooling heat transport process.

[0005] A problem in prior art defrosting systems is that heat which is required for defrosting is obtained from the entity which in normal mode is to be heated. If this entity is for example the inside of a building, the temperature inside the building will drop.

[0006] It is therefore the object of the present invention to provide a system which allows defrosting without temperature drop at the entity which is to be heated in normal mode.

[0007] The object is solved by the heat pump system according to claim 1 and the method for defrosting the evaporator of a heat pump system according to claim 10. The respective dependent claims describe advantageous embodiments of the heat pump system according to claim 1 and the method for defrosting according to claim 10.

[0008] The present invention relates to a heat pump system comprising a refrigerant circuit, wherein the refrigerant circuit comprises an evaporator and a heat exchanger which is adapted to exchange heat between the refrigerant circuit and an entity to be heated. The heat exchanger may comprise a condenser. To build up a refrigerant circuit one port of the evaporator can be connected to one port of the heat exchanger and another port of the evaporator can be connected to another port of the heat exchanger. In a normal mode, where the entity to be heated is heated, refrigerant can therefore circulate between the evaporator and the heat exchanger.

[0009] In the present invention the refrigerant circuit

comprises a bypass line which bypasses the heat exchanger. The bypass line can therefore connect a pipe that connects one port of the evaporator with one port of the heat exchanger with a pipe connecting the other port of the evaporator with the other port of the heat exchanger.

[0010] According to the present invention, the refrigerant circuit further comprises a heat source which is adapted to heat refrigerant which is routed through the bypass line. This heater according to the invention is in addition to the heat exchanger and the evaporator, thus it is not identical to the heat exchanger, if present, not identical to the condenser and not identical to the evaporator.

[0011] In a method for defrosting the evaporator of the heat pump system the refrigerant can be routed through the bypass line and heated by the heater. In this case, the heater can provide the heat which is required for defrosting the evaporator to the refrigerant. As the refrigerant does preferably not pass through the heat exchanger during this defrosting operation, a cooling of the entity to be heated can be avoided.

[0012] In a preferred embodiment of the invention the heater may be located within the bypass line, that is between the pipes connecting the ports of the evaporator and the heat exchanger.

[0013] Preferably the refrigerant circuit of the present invention may comprise an expansion valve located in a line connecting a first port of the heat exchanger with a first port of the evaporator.

[0014] Preferably the refrigerant circuit may comprise a compressor located in the line connecting the second port of the evaporator with a second port of the heat exchanger, wherein each first port is different from each second port. Thus, the expansion valve and the compressor may be located on opposite sides of the heat exchanger and the evaporator.

[0015] In a preferred embodiment of the present invention the bypass line may branch off a line connecting a first port of the evaporator with the first port of the heat exchanger in a first three-way valve and an opposite end of the bypass line may branch off a line connecting the second port, different from the first port, of the evaporator with a second port, different from the first port of the heat exchanger, in a second three-way valve. Thus, the bypass line may be connected to the main refrigerant circuit via a three-way valve. The three-way valves are preferably designed such that they allow to build up a fluid conduit between the evaporator and the bypass line while at the same time shutting off a conduit for the refrigerant from the evaporator to the heat exchanger and from the heat exchanger to the evaporator, respectively.

[0016] Above mentioned expansion valve may be preferably located between the bypass line and the evaporator, that is, if the bypass line is connected to the line connecting the evaporator and the heat exchanger via three-way valves, the expansion valve may be located between the evaporator and one of these three-way valves.

[0017] Above mentioned compressor may preferably be located between the evaporator and the bypass line. If the bypass line is connected to the other line connecting the heat exchanger and the evaporator via a three-way valve, the compressor may preferably be located between the evaporator and the three-way valve.

[0018] The expansion valve and the compressor are preferably located on opposite sides of the evaporator. The expansion valve and the compressor are preferably located on opposite sides of the bypass line.

[0019] It is also possible and advantageous if the expansion valve is located between the bypass line and the heat exchanger and/or the compressor is located between the heat exchanger and the bypass line.

[0020] In this case, the bypass line may in an advantageous embodiment comprise in series the heater as well as an auxiliary expansion valve, being adapted to expand refrigerant flowing in the bypass line before entering the heater, and/or an auxiliary compressor, being adapted to compress refrigerant flowing through the bypass line after leaving the heater and before entering the evaporator. The auxiliary expansion valve, the heater and the auxiliary compressor may be connected in series, which means that refrigerant flowing into the bypass line in defrost mode first flows through the expansion valve, after flowing out of the expansion valve flows into the heater and after flowing out of the heater flows into the auxiliary compressor.

[0021] In the embodiment comprising the auxiliary expansion valve and the auxiliary compressor, the bypass line would be the line comprising the auxiliary expansion valve, the heater and the auxiliary compressor.

[0022] Preferably the auxiliary compressor is arranged such that it compresses refrigerant flowing out of the heater and outputs compressed refrigerant in the direction of the evaporator.

[0023] In a preferred embodiment of the invention the bypass line may comprise a liquid pump, which is adapted to pump refrigerant flowing in the bypass line. Preferably the liquid pump is connected in series with the heater and it is particularly preferred if the liquid pump is located between a point where the bypass line branches off the line connecting the evaporator with the heat exchanger or the main expansion valve on the one-hand side and the heater on the other hand side. Preferably the liquid pump is located upstream of the heater in defrost mode. Thus, preferably the liquid pump is arranged such that it pumps refrigerant in the direction of the heater.

[0024] The invention also relates to above mentioned method for defrosting the evaporator of a heat pump system wherein the heat pump system is constituted as described before. In the defrosting method the refrigerant is routed through the bypass line and heated by the heater.

[0025] Preferably the refrigerant is routed from the evaporator to the main expansion valve, from the main expansion valve to the bypass line, from the bypass line to the main compressor and from the main compressor

back to the evaporator for defrosting.

[0026] If the bypass line branches off between the evaporator and the main expansion valve on one hand side and between the main compressor and the evaporator on the other hand side, the refrigerant in defrost mode may be conducted from the evaporator through the bypass line and back to the evaporator. If in this case the bypass line comprises above mentioned auxiliary expansion valve and above mentioned auxiliary compressor, the refrigerant may be conducted from the evaporator to the auxiliary expansion valve, from the auxiliary expansion valve to the heater, from the heater to the auxiliary compressor and from the auxiliary compressor back to the evaporator.

[0027] Preferably the direction in which the compressor compresses refrigerant is reversed in defrost mode compared to normal mode. That is, while in normal mode the compressor preferably compresses the refrigerant flowing out of the evaporator in the direction of the heat exchanger it may in defrost mode compress refrigerant flowing in direction of the evaporator. In the present invention this refrigerant may flow into the compressor out of the bypass line.

[0028] In a preferred operation mode of the defrosting method according to the invention it will be decided in a first step whether frosting has occurred at the evaporator. If frosting is present at a evaporator, above mentioned valves are operated such that the heat exchanger is closed off and refrigerant is guided through the bypass line, for example via above mentioned three-way valves. Furthermore, the heater is activated and the compressor is reversed. This operation state is maintained until it is determined that frosting has ended. The method can then proceed with normal operation and can continuously or at specific times monitor whether frosting occurs at the evaporator.

[0029] Advantageously, the heat exchanger may comprise a condenser between the first port and the second port by which ports the heat exchanger is connected to the refrigerant circuit.

[0030] Advantageously, the heater may for example be an electrical resistance heater. Such a heater may for example wrap around the refrigerant pipe, so that if the heater is power off it does not change the pipe configuration.

[0031] In the following the invention shall be described by way of examples with reference to figures. Same reference signs denote same or corresponding features. The features in the examples can be combined among the examples and can be realized independently from this specific example.

Brief description of the figures

[0032]

Fig. 1 an air source heat pump according to the prior art,

- Fig. 2 a refrigerant circuit of a heat pump system according to the invention,
- Fig. 3 the system shown in Fig. 2 in defrost mode,
- Fig. 4 an operation method of the heat pump system shown in Fig. 2 and 3,
- Fig. 5 a further embodiment of a refrigerant circuit of a heat pump system according to the present invention,
- Fig. 6 the system shown in Fig. 5 in defrost mode,
- Fig. 7 an operation of the system shown in Figs. 5 and 6,
- Fig. 8 a further embodiment of a refrigerant circuit in a heat pump system according to the present invention,
- Fig. 9 the system of Fig. 8 in defrost mode, and
- Fig. 10 an operation of the system shown in Figs. 8 and 9.

[0033] The present invention may be realized as an air source heat pump (ASHP) as an example.

[0034] Fig. 1 shows an air source heat pump system according to the prior art. The system in Fig. 1 comprises on the left hand side a refrigerant circuit comprising an evaporator 1, a compressor 3, a heat exchanger 7, which may comprise a condenser, and an expansion valve 11. On the right hand side the system of Fig. 1 comprises a heat transport medium circuit, comprising a pump 91, a water tank 92 and the heat exchanger 7. Heat can be transferred between the refrigerant circuit and the heat transport medium circuit in the heat exchanger 7. The heat exchanger 7 is port of both, the refrigerant circuit and the heat transport medium circuit.

[0035] In the heat transport medium circuit the pump 91 is connected with the secondary side port of the heat exchanger 7 via a pipe 96. The pump 91 is connected to the water tank 92 via a pipe 97. The water tank on an upper side is connected with an opposite port of the secondary side of the heat exchanger 7 via pipe 98. The water tank 92 can be used to store water which is conducted into the water tank 92 via an inlet pipe 93 and out of the water tank via an outlet pipe 94. The water in the water tank 92 can be heated by the heat transport medium flowing in the heat transport medium circuit.

[0036] In the refrigerant circuit on the left hand side of Fig. 1, left of the heat exchanger 7, a refrigerant is pumped by compressor 3. Compressor 3 is connected with a first port of a primary side of the heat exchanger 7 via a pipe 4. A second port of the primary side of the exchanger 7 is connected to the expansion valve 11 via a further pipe 6. Expansion valve 11 is connected with a

first port of evaporator 1 via pipe 12. Furthermore, a second port of evaporator 1 is connected to the compressor 3 via a pipe 2. In the normal mode where heat is pumped towards the water tank 92, the refrigerant flows in the refrigerant circuit as indicated by the arrows on the pipes 2, 4, 6 and 12. The heat transport medium and the heat transport medium cycle flows in the direction indicated by the arrows on the pipes 96, 97 and 98.

[0037] In normal mode, the compressor 3 receives refrigerant from the evaporator 1 and outputs compressed refrigerant to pipe 4 towards the heat exchanger 7.

[0038] In a defrost mode the compressor 3 reverses its operation direction. Refrigerant therefore flows in the refrigerant cycle as indicated by the dashed arrows. The compressor in defrost mode receives refrigerant through pipe 4 from heat exchanger 7 and outputs compressed refrigerant to pipe 2 towards the evaporator 1. By this, heat is received in the heat exchanger 7 from the heat transport medium cycle and pumped to the evaporator 1 which is heated and therefore defrosted. However, the heat is obtained from water tank 92 which is therefore cooled in defrost mode.

[0039] Fig. 2 shows a first example of a refrigerant circuit which can be employed in a heat pump system according to the present invention. The refrigerant circuit corresponds to the left side of Fig. 1. On the right hand side an element 7 is shown which could for example be a heat exchanger and which could for example comprise a condenser. If element 7 is a heat exchanger, heat can for example be exchanged with an optional heat transport medium circuit as shown on the right hand side in Fig. 1. Alternatively the element 7 as a condenser could exchange heat with outside air or could provide heat to any other entity to be heated. In the following only the refrigerant cycle will be regarded while the entity to be heated can for example be a heat transport medium cycle as shown in Fig. 1 or a different entity to be heated.

[0040] The refrigerant cycle in Fig. 2 comprises the heat exchanger or condenser 7. A first port of the condenser or heat exchanger 7 is connected via a pipe 8 to a three-way valve 9. Three-way valve 9 is connected to a main expansion valve 11 via a pipe 10. Main expansion valve 11 is connected to a first port of an evaporator 1 via a pipe 12. A second port, different from the first port, of the evaporator 1 is connected to a compressor 3 via a pipe 2. Compressor 3 is connected with a second three-way valve 5 via a pipe 4. One port of the second three-way valve 5 is connected to the heat exchanger 7 or condenser 7 via a pipe 6. Another port of the second three-way valve 5 is connected to a heater 14 via a pipe 13. The heater 14 is connected with another port of the first three-way valve 9 via a pipe 15.

[0041] The pipes 13 and 15 together with the heater 14 constitute a bypass line which bypasses the heat exchanger 7 or condenser 7. The heater 14 may advantageously be an electrical heater 14 in all embodiments of the present invention.

[0042] In Fig. 2 arrows on the pipes indicate a flow

direction of refrigerant in normal mode where heat is transported from the evaporator 1 to the condenser 7 or heat exchanger 7. In normal mode the first three-way valve 9 is set such that line 8 is connected to line 10 in refrigerant conducting manner and the second three-way valve 5 is set such that line 4 is connected with pipe 6 in a refrigerant conducting manner. On the other hand, the three-way valves 5 and 9 are set such that refrigerant is not guided into the bypass line.

[0043] In normal mode, the compressor 3 is operated such that it receives refrigerant coming from the evaporator 1 through pipe 2 and outputs compressed refrigerant into pipe 4 towards the second three-way valve 5.

[0044] Fig. 3 shows the refrigerant circuit shown in Fig. 2 in defrost mode, in which evaporator 1 is defrosted. The ports and the relative connection of the ports is the same as in Fig. 2. Reference is made to above description of Fig. 2.

[0045] Differently from Fig. 2 the refrigerant in the defrost mode shown in Fig. 3 flows as indicated by the arrows on the lines. In defrost mode the first three-way valve 9 is set such that refrigerant coming from the main expansion valve 11 through line 10 is guided into pipe 15 of the bypass circuit. Pipe 8 connected with the heat exchanger 7 or condenser 7 is shut off. Furthermore, the second three-way valve 5 is set such that refrigerant flowing into the three-way valve 5 from line 13, the refrigerant coming from the heater 14, is guided towards the compressor 3 via pipe 4. Compressor 3 operates in reverse direction as compared to normal mode shown in Fig. 2. That is, the compressor 3 receives refrigerant from pipe 4 and outputs compressed refrigerant into line 2 towards the evaporator 1. In defrost mode the heater 14 is operated so that refrigerant flowing through the heater 14 is heated. The heated refrigerant is conducted to the evaporator 1 and defrosts evaporator 1.

[0046] Fig. 4 shows a flow diagram of an operation of the system shown in Figs. 2 and 3. The system monitors S1 whether frosting occurs at the evaporator. The monitoring can happen continuously or at predetermined or regular times. If it is determined in S1 that frosting has occurred the three-way valves 5 and 9 are actuated in S2 to close off the condenser 7. Refrigerant is allowed to flow through bypass line 15, 14 and 13 via the three-way valves 9 and 5 in S3. In S4 the heater 14 is activated and in S5 the compressor 3 is reverted. The system is run in this state for a period of time in S6 and is monitored in S7 whether frosting has ended. If frosting has not ended, the system is further run in defrost mode in S6. On the other hand, if frosting has ended, the system returns to normal mode, which is not explicitly shown in Fig. 4. The return to normal mode reverses the actions S2, S3, S4 and S5. It should be noted that the actions S2, S3, S4 and S5 can happen at the same time or in any other order than shown in Fig. 4.

[0047] Fig. 5 shows a further example of a refrigerant circuit and a heat pump system according to the present invention.

[0048] A heat exchanger 7 or condenser 7 is connected with a main expansion valve 11 via pipe 8. Main expansion valve 11 is connected to a first three-way valve 9 via pipe 10. First three-way valve 9 is connected to an evaporator 1 via a pipe 12. The evaporator 1 is connected to a second three-way valve 5 via a pipe 2. The second three-way valve 5 is connected to a compressor 3 via a pipe 4. The compressor 3 is connected to the opposite port of the heat exchanger 7 or condenser 7 via pipe 6. A third port of the three-way valve 9, which is not connected to the pipes 10 and 12 is connected with an auxiliary expansion valve 52 via a pipe 51. The auxiliary expansion valve 52 is connected to a heater 14 via pipe 53.

[0049] A third port of the second three-way valve 5, which is not connected with pipes 2 and 4, is connected with an auxiliary compressor 56 via a pipe 55. The auxiliary compressor 56 is connected to the heater 14 via a pipe 57.

[0050] In this example the line comprising pipe 51, auxiliary expansion valve 52, pipe 53, heater 14, pipe 57, auxiliary compressor 56 and pipe 55 can be regarded as the bypass line.

[0051] Fig. 5 shows the system in normal mode. The flow of the refrigerant is indicated by arrows on the lines. It is indicated that the refrigerant only flows in the main refrigerant circuit through main expansion valve 11, three-way valve 9, evaporator 1, three-way valve 5, compressor 3, condenser 7 or heat exchanger 7 and back to the main expansion valve 11. As in the other figures compressor 3 receives refrigerant from the evaporator 1 and outputs compressed refrigerant to the condenser or heat exchanger 7. The bypass line is shut off by the three-way valves 5 and 9 in normal mode.

[0052] Fig. 6 shows the same setup as Fig. 5, however, being switched to defrost mode. Again the arrows on the lines indicate the flow of the refrigerant. It can be seen that the three-way valves 9 and 5 are set such that refrigerant flows in the bypass line. The refrigerant flows out of the evaporator 1 through the first three-way valve 9 into the auxiliary expansion valve 52 and from the auxiliary expansion valve 52 through the heater 14 into the auxiliary compressor 56. The refrigerant is received by the auxiliary compressor 56 from the heater 14 and is compressed and the compressed refrigerant is output to the evaporator 1 via the second three-way valve 5. The main refrigerant circuit comprising the main expansion valve 11, the condenser 7 and the main compressor 3 is shut off in defrost mode by the three-way valves 5 and 9.

[0053] Via the bypass circuit heat is transported to the evaporator 1 and heat 16 is set free at the evaporator 1 to defrost the evaporator 1.

[0054] Fig. 7 shows an operation of the system shown in Figs. 5 and 6. The operation is very similar to the operation shown in Fig. 4. Reference is therefore made to the description of Fig. 4. However, different from Fig. 4 it is not necessary in S5 to reverse the compressor. Instead, the auxiliary compressor 56 is activated in S5. It should also be noted that differently from Fig. 2 and 3

the refrigerant does not flow through the main expansion valve 11 in defrost mode but rather through the auxiliary expansion valve 52.

[0055] Fig. 8 shows another advantageous embodiment of the present invention.

[0056] The main refrigerant circuit in Fig. 8 is of the same structure as in Figs. 5 and 6. That is, the main expansion valve 11 is connected to the first three-way valve 9 via pipe 10 and the first three-way valve 9 is connected to the evaporator 1 via pipe 12. The evaporator 1 is connected to a second three-way valve 5 via pipe 2 and the second three-way valve 5 is connected to the compressor 3 via pipe 4. The compressor 3 is connected to the condenser 7 via pipe 6 and the condenser 7 is connected to the main expansion valve 11 via pipe 8.

[0057] Differently from Figs. 5 and 6 a third port of the first three-way valve 9, which port is not connected to lines 10 or 12, is connected to a liquid pump 82 via a pipe 81. Liquid pump 82 is connected to a heater 14 via a pipe 83. The heater 14 is connected to a third port of the second three-way valve 5, which third port is not connected to pipe 2 or 4 via pipe 84. In this example the circuit comprising the liquid pump 82, the heater 14 and the pipe 84 can be regarded as the bypass circuit.

[0058] Fig. 8 shows the system in normal mode. The normal mode of this circuit is identical to the normal mode shown in Fig. 5 as the bypass circuit is shut off equally in Figs. 5 and 8. Reference to the description above is therefore made here.

[0059] Fig. 9 shows the system of Fig. 8 operating in defrost mode. Again, the black arrows indicate the flow of the refrigerant. It can be seen that the first three-way valve 9 and the second three-way valve 5 are set such that refrigerant flowing out of the evaporator 1 is conducted to the liquid pump 82. The liquid pump 82 pumps the refrigerant into the heater 14 and out of the heater 14 through pipe 84 and the second three-way valve 5 back into the evaporator 1. The main refrigerant circuit comprising the main expansion valve 11, the condenser 7 and the compressor 3 is shut off in defrost mode in this embodiment.

[0060] Fig. 10 shows an operation of the system shown in Figs. 8 and 9. As in the other embodiments it is monitored in S1 whether frosting occurs at the evaporator. As above, the monitoring can be done continuously or at certain times. In case that frosting is detected at the evaporator, the steps S2, S3, S4 and S5 are carried out. Although they are shown subsequently in Fig. 10, they may be carried out at the same time or in different order. Thus, if defrosting is detected the first three-way valve 9 and the second three-way valve 5 are actuated to close off the condenser 7 to allow refrigerant to flow through the bypass line via the three-way valves 9 and 5 (S3). Furthermore, the heater 14 is activated in S4 and the bypass liquid pump 82 is run. While the system is running, it is monitored whether the defrosting has ended or is still present. As long as the defrosting is still present, the system is run in the configuration shown in Fig. 9. If it is

detected in S7 that the frosting has ended, the steps S2, S3, S4 and S5 are reverted that is the three-way valves 9 and 5 are activated to shut off the bypass circuit, the heater 14 is shut down and the liquid pump 82 is shut down.

Claims

1. Heat pump system comprising a refrigerant circuit, the refrigerant circuit comprising an evaporator and a heat exchanger which is adapted to exchange heat between the refrigerant circuit and an entity to be heated, wherein the refrigerant circuit further comprises a bypass line bypassing the heat exchanger and the refrigerant circuit in addition to the heat exchanger and the evaporator comprises a heat source which is adapted to heat refrigerant which is routed through the bypass line.
2. Heat pump system according to the preceding claim, wherein the refrigerant circuit comprises a main expansion valve located between a first port of the heat exchanger and the evaporator and the refrigerant circuit further comprises a main compressor located between the evaporator and a second port, different from the first port, of the heat exchanger.
3. Heat pump system according to one of the preceding claims, wherein the heater is located between the main expansion valve and the main compressor on the side of the bypass line and/or is located within the bypass line.
4. Heat pump system according to one of the preceding claims, wherein one end of the bypass line branches off a line connecting a first port of the evaporator with a first port of the heat exchanger in a first three way valve and an opposite end of the bypass line branches off a line connecting a second port, different from the first port, of the evaporator with a second port, different from the first port, of the heat exchanger, in a second three way valve.
5. Heat pump system according to the preceding claim, wherein the main expansion valve is located between the bypass line and the evaporator and/or the main compressor is located between the evaporator and the bypass line.
6. Heat pump system according to claim 2 or 4,

wherein the main expansion valve is located between the bypass line and the heat exchanger and/or the main compressor is located between the heat exchanger and the bypass line.

5

7. Heat pump system according to the preceding claim, wherein the bypass line comprises in series the heater as well as an auxiliary expansion valve, being adapted to expand refrigerant flowing in the bypass line before entering the heater, and/or an auxiliary compressor, being adapted to compress refrigerant flowing through the bypass line after leaving the heater and before entering the evaporator. 10
8. Heat pump system according to claim 6, wherein the bypass line comprises a liquid pump, being adapted to pump refrigerant flowing in the bypass line, the liquid pump being preferably connected in series with the heater between a point where the bypass line branches off the line connecting the evaporator with the main expansion valve and the heater. 15 20
9. Heat pump system according to one of the preceding claims, wherein the entity to be heated is a heat transport medium circuit, preferably a water circuit. 25
10. Method for defrosting the evaporator of a heat pump system according to one of the preceding claims, wherein the refrigerant is routed through the bypass line and heated by the heater. 30
11. Method according to the preceding claim wherein the refrigerant is routed from the evaporator to the main expansion valve, from the main expansion valve to the bypass line, from the bypass line to the main compressor and from the main compressor back to the evaporator for defrosting. 35 40

40

45

50

55

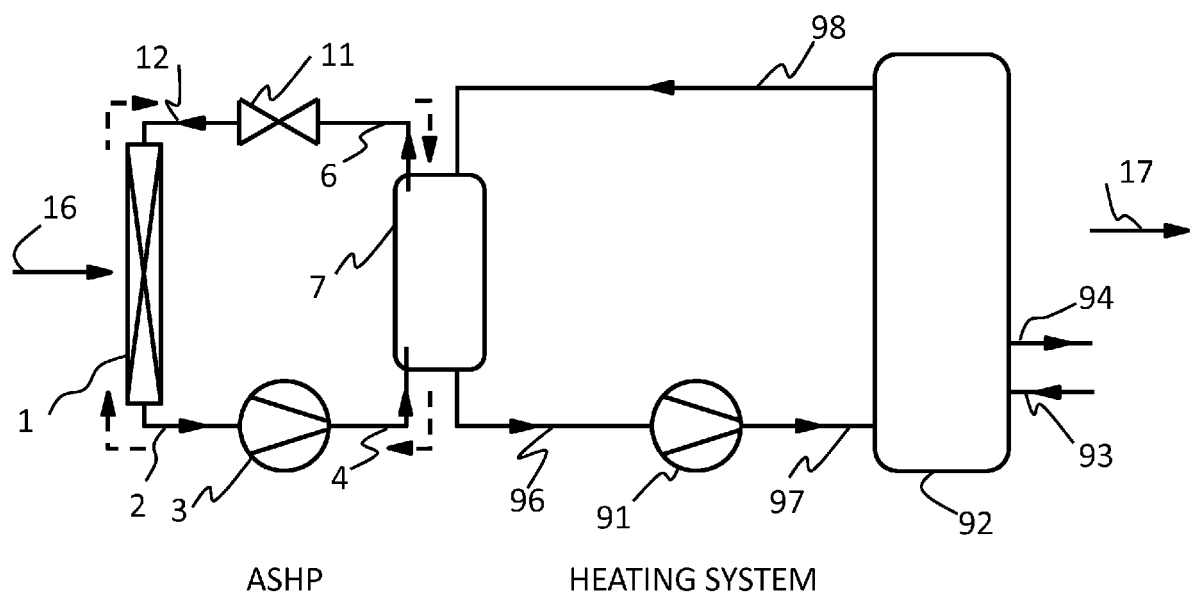


FIGURE 1

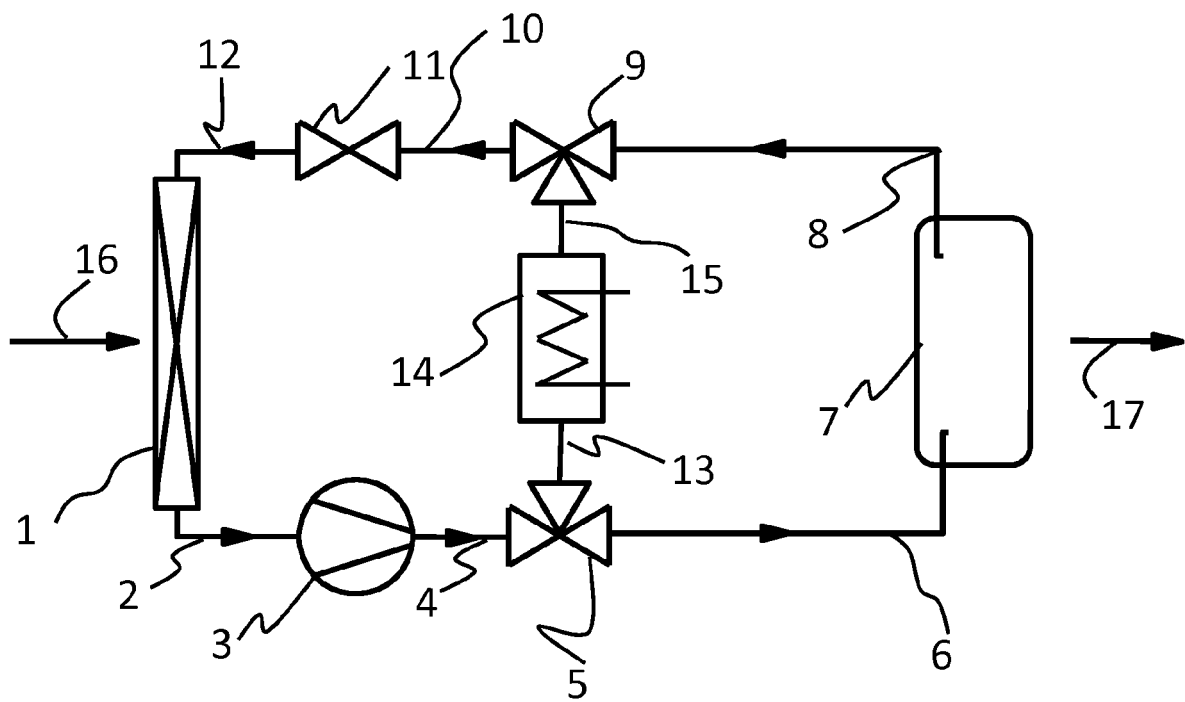


FIGURE 2

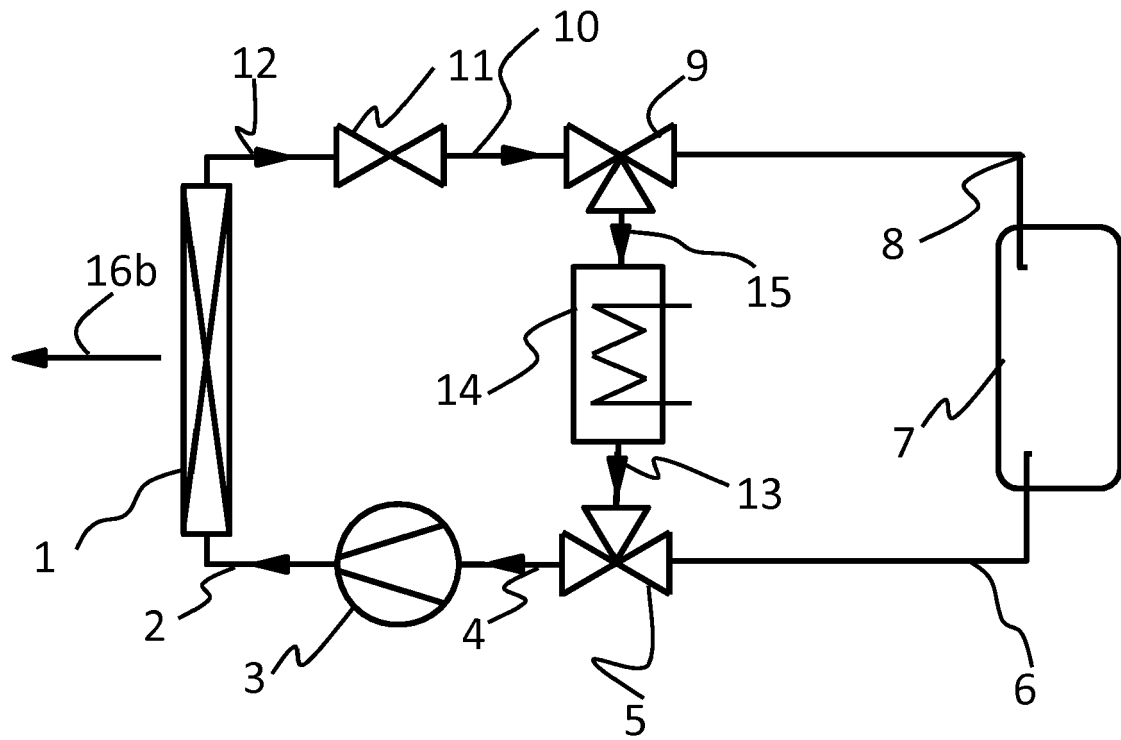


FIGURE 3

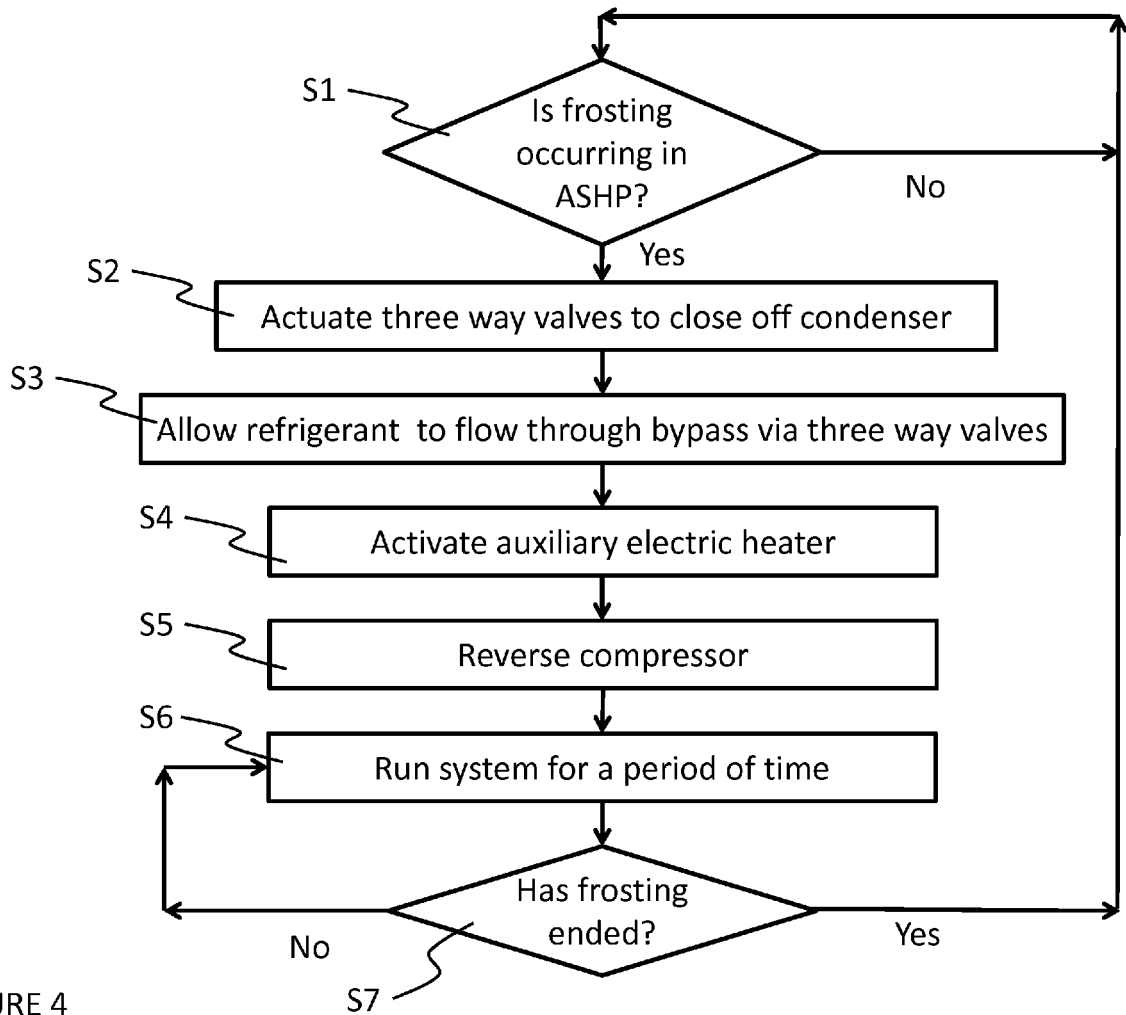


FIGURE 4

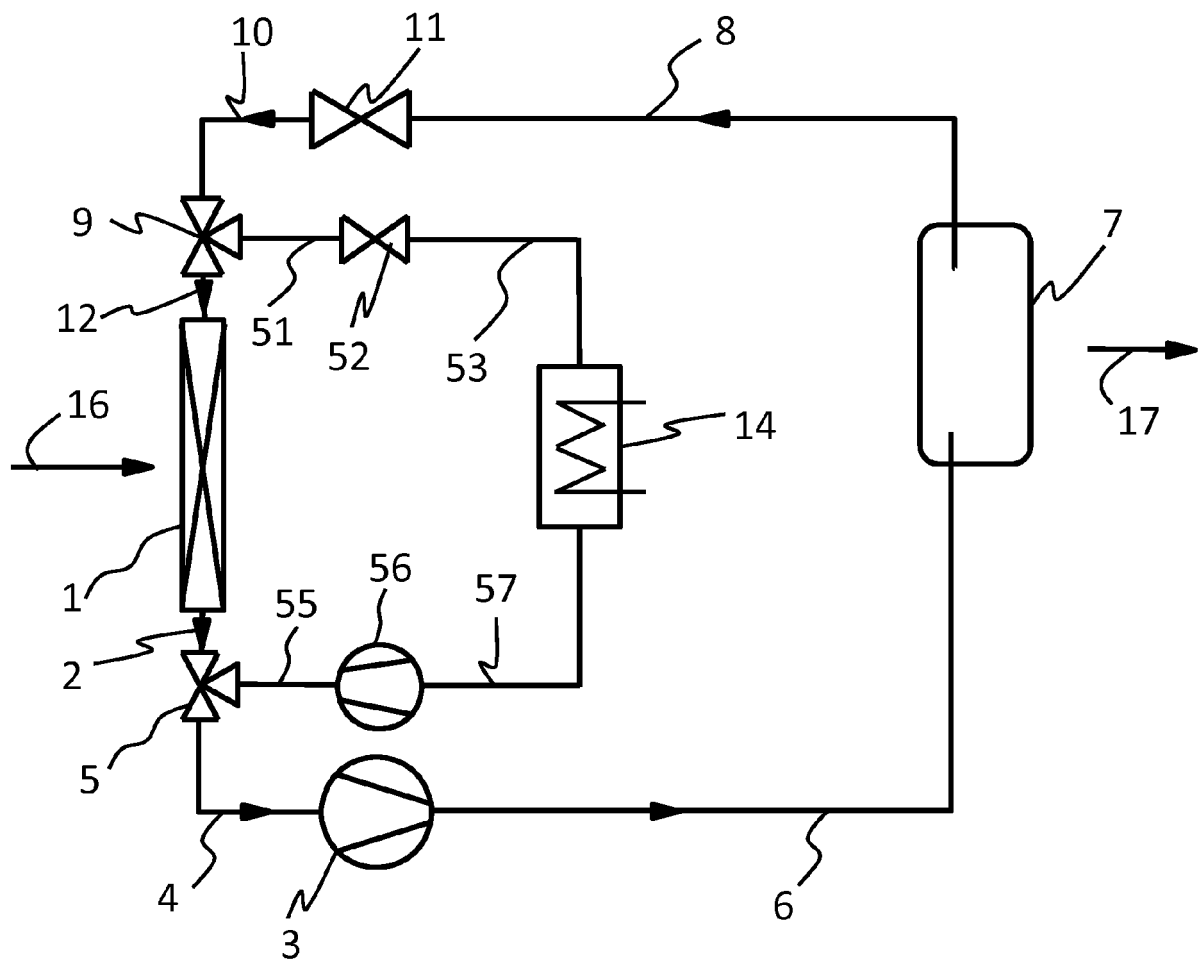


FIGURE 5

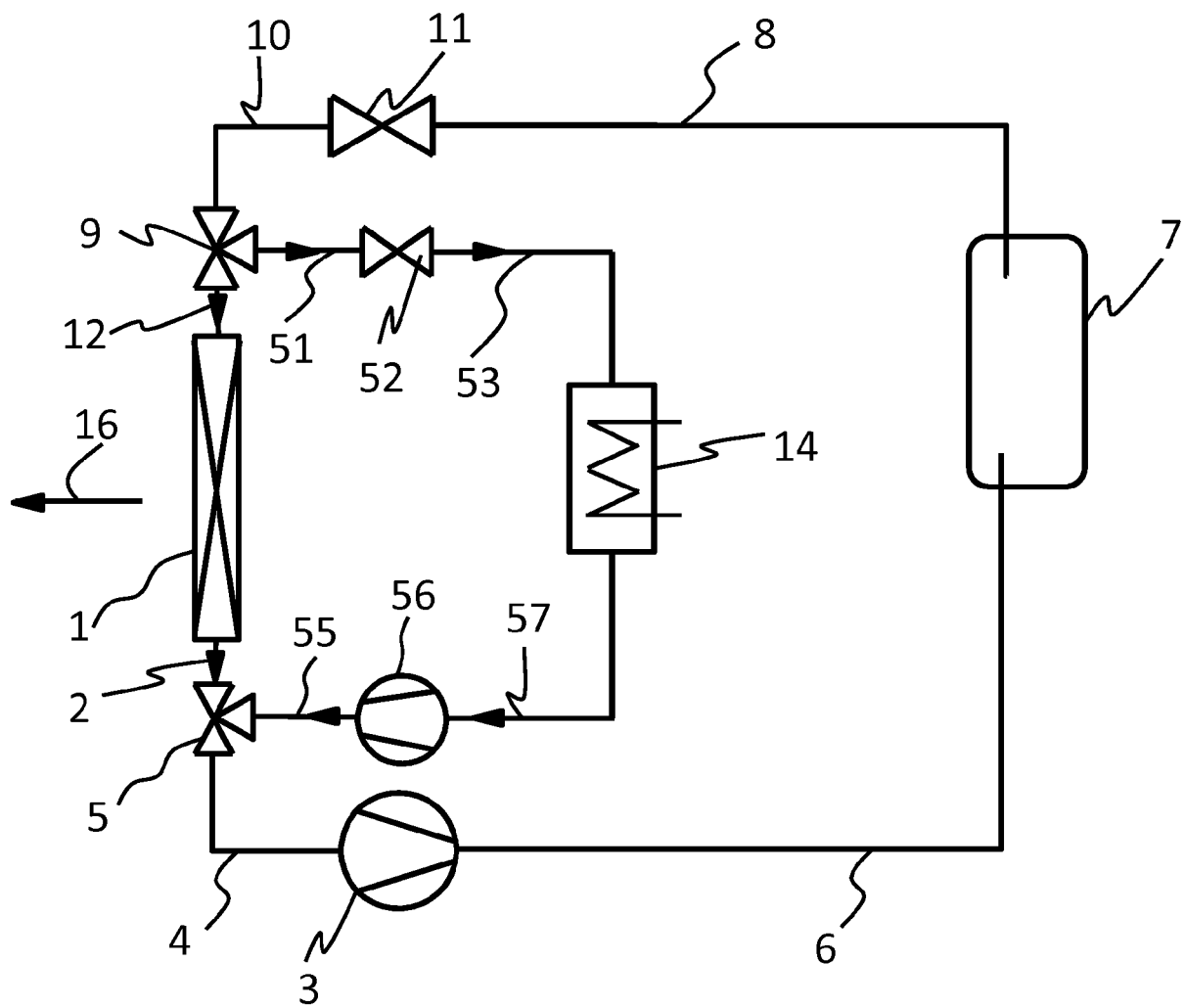


FIGURE 6

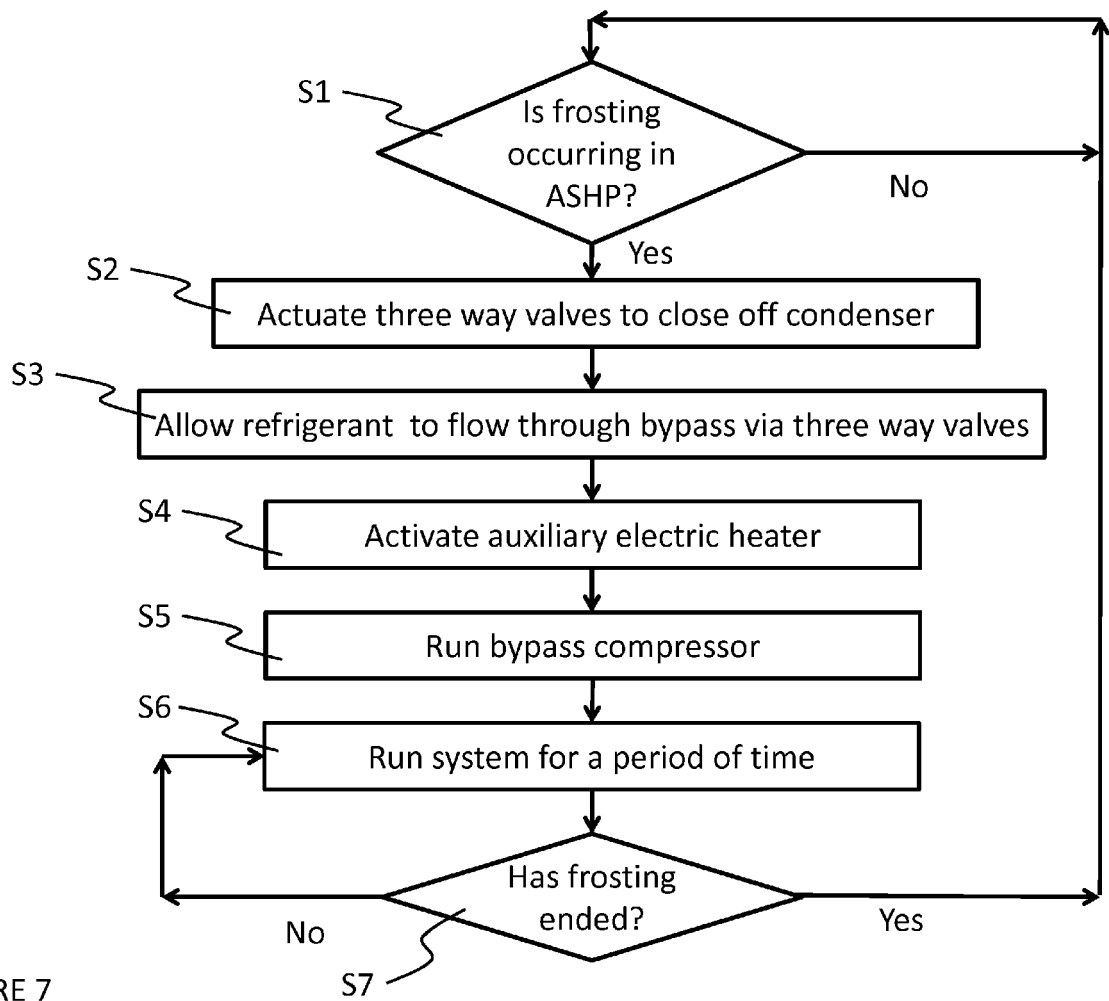


FIGURE 7

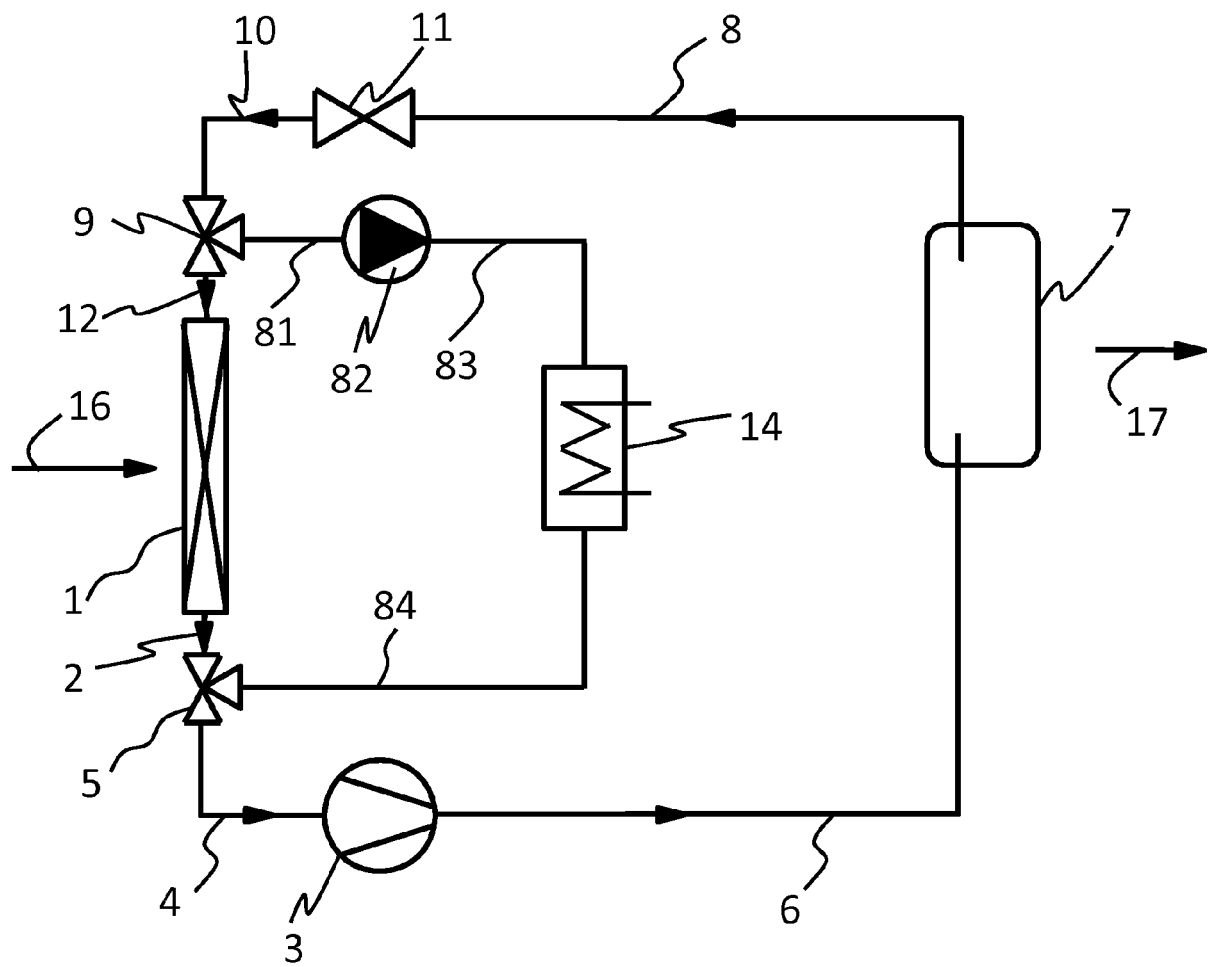


FIGURE 8

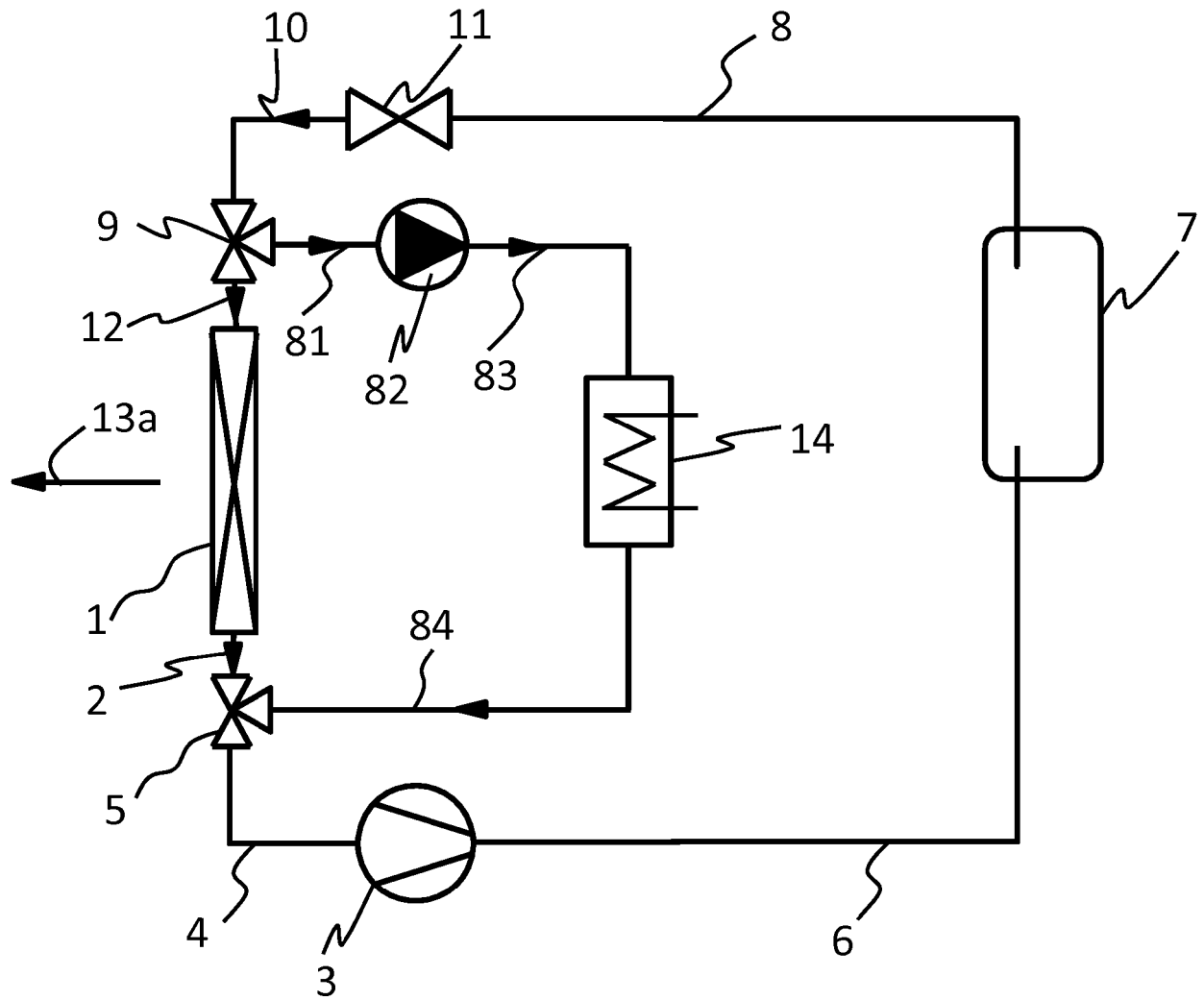


FIGURE 9

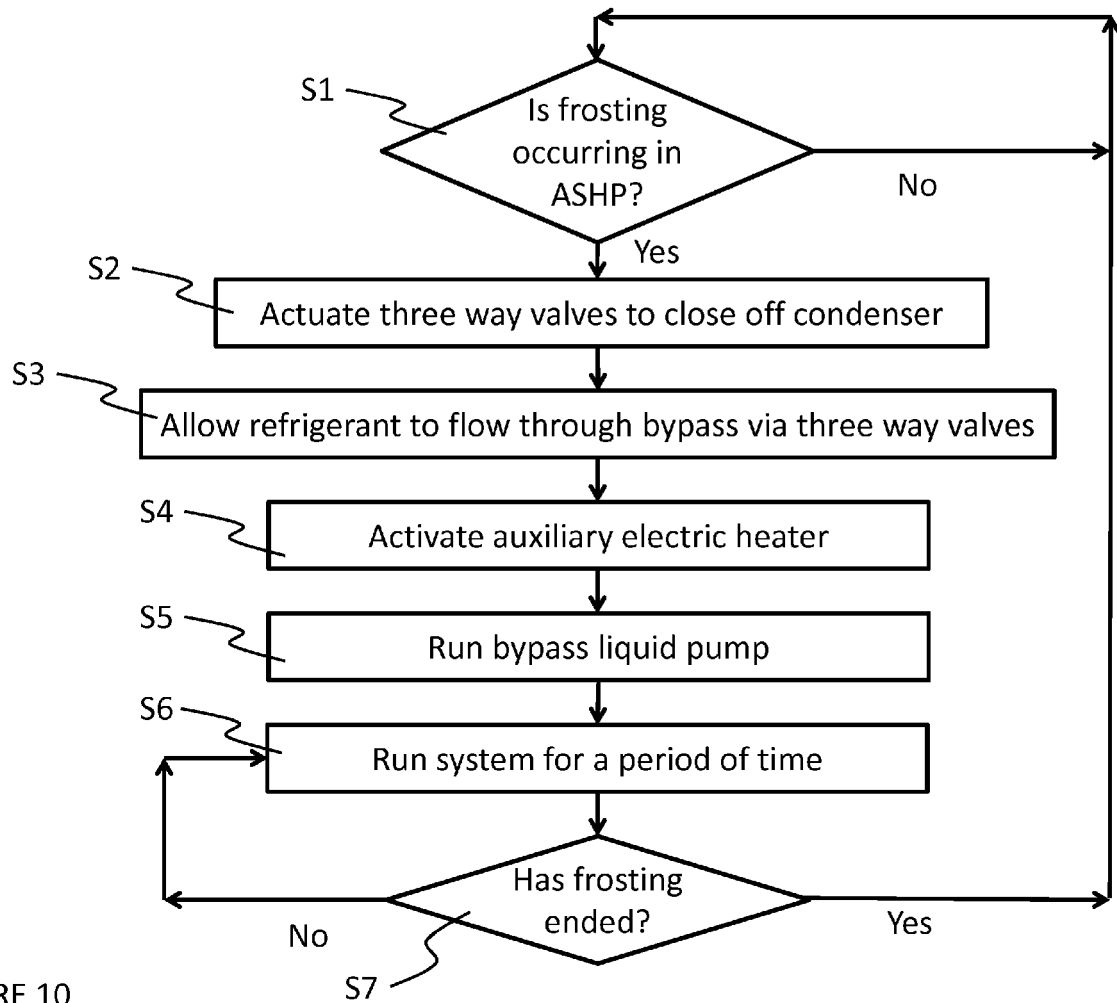


FIGURE 10



EUROPEAN SEARCH REPORT

 Application Number
 EP 16 16 3359

5

10

15

20

25

30

35

40

45

50

55

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	EP 2 677 252 A1 (LG ELECTRONICS INC [KR]) 25 December 2013 (2013-12-25) * the whole document *	1-11	INV. F25B47/02 F25B41/04
X	WO 97/24565 A1 (STORE HEAT & PRODUCE ENERGY IN [US]; RAFALOVICH ALEXANDER P [US]; EMME) 10 July 1997 (1997-07-10) * & corresponding description; figures 1-6,11-15 *	1-11	
X	US 2011/067427 A1 (HALLER REGINE [FR] ET AL) 24 March 2011 (2011-03-24) * the whole document *	1-7,9-11	
X	WO 94/21976 A1 (SHAPE INC [US]) 29 September 1994 (1994-09-29) * the whole document *	1-11	
X	EP 2 554 410 A1 (VALEO KLIMASYSTEME GMBH [DE]) 6 February 2013 (2013-02-06) * & corresponding description; figures 1,2 *	1-3,5,6	TECHNICAL FIELDS SEARCHED (IPC)
X	US 2013/098092 A1 (WAKAMOTO SHINICHI [JP] ET AL) 25 April 2013 (2013-04-25) * the whole document *	1-11	F25B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 2 September 2016	Examiner Gaspar, Ralf
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 16 16 3359

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

02-09-2016

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2677252 A1	25-12-2013	EP 2677252 A1	25-12-2013
		KR 20140000368 A	03-01-2014
		US 2013340469 A1	26-12-2013
WO 9724565 A1	10-07-1997	AU 1568697 A	28-07-1997
		US 5755104 A	26-05-1998
		WO 9724565 A1	10-07-1997
US 2011067427 A1	24-03-2011	EP 2299205 A1	23-03-2011
		FR 2950423 A1	25-03-2011
		US 2011067427 A1	24-03-2011
WO 9421976 A1	29-09-1994	AU 6363594 A	11-10-1994
		US 5355688 A	18-10-1994
		US 5507337 A	16-04-1996
		WO 9421976 A1	29-09-1994
EP 2554410 A1	06-02-2013	DE 102011109321 A1	07-02-2013
		EP 2554410 A1	06-02-2013
US 2013098092 A1	25-04-2013	EP 2600082 A1	05-06-2013
		JP 5611353 B2	22-10-2014
		US 2013098092 A1	25-04-2013
		WO 2012014345 A1	02-02-2012