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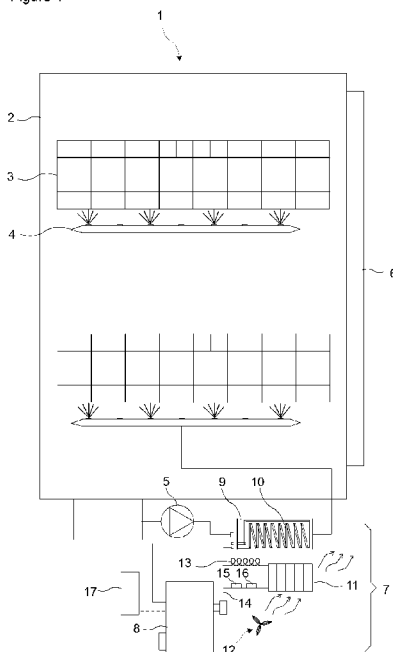
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(54) Title: A HEAT PUMP DISHWASHER AND METHOD FOR PREVENTING REFRIGERANT FLOODING

Figure 1



(57) Abstract: The present invention relates to a dishwasher (1) comprising a tub (2) wherein the processes of washing, rinsing and drying are performed; at least one rack (3) wherein the items to be washed are placed; at least one spray arm (4) and a circulation pump (5) that provide the delivery of the washing water onto the items to be washed; a drying duct (6) that takes the humid air in the tub (2) out of the tub (2) after the washing process and thus that enables the items washed to be dried, and a heat pump system (7) that is disposed at the lower part of the tub (2) and that provides the heating of the washing water, the present invention further relating to a method for preventing refrigerant flooding.

Description**A HEAT PUMP DISHWASHER AND METHOD FOR PREVENTING
REFRIGERANT FLOODING**

- [0001] The present invention relates to a heat pump dishwasher providing the heating of the wash water and to a method for preventing refrigerant flooding.
- [0002] The heat pump system in the heat pump dishwashers is composed of a compressor that pressurizes the refrigerant and provides the circulation thereof, flow tubes wherein the refrigerant circulates, a condenser, an evaporator, and an expansion element. Like in the conventional dishwashers, the washing program in the heat pump dishwashers is generally composed of the steps of main washing, cold rinsing, hot rinsing and drying. In these steps, the water is heated by the heater in the conventional dishwashers, and is heated by the condenser, that is the "hot" component of the heat pump system, in the heat pump dishwashers. In the heat pump dishwashers, with the compressor compressing and pressurizing the refrigerant, the refrigerant gains high pressure and high temperature. The refrigerant reaching the condenser after leaving the compressor gives off heat to the outer environment, thus the temperature thereof starts decreasing and the refrigerant condenses. The gas at low temperature and high pressure is passed through the throttle valve and the pressure thereof is decreased, and the gas liquefies. Afterwards, the refrigerant at low temperature and low pressure draws heat from the environment while passing through evaporator and changes from the liquid phase into gas phase and vaporizes. Then, the refrigerant reaches the compressor and this cycle is repeated. In the dishwashers, the water is heated with the heat emitted by the condenser. The amount of refrigerant used in the heat pump heating cycle is one of the important parameters that affect the cost/performance of the system. The difference between the temperature of evaporation and condensation depending on the changing ambient conditions affects the temperature and dryness level of the refrigerant at the outlet of the evaporator. Since the refrigerant that reaches the compressor in two phases (liquid + gas), the performance and

lifespan of the compressor is affected. In long periods of operation, irreversible damages may occur. The refrigerant leaving the evaporator in the liquid + gas phase without completely evaporating (without completely shifting to the gas phase) is called refrigerant (liquid) flooding. In case the refrigerant is sucked by the compressor in the liquid phase, the cylinder head in the compressor and the gasket acting as the sealing element in the cylinder may be damaged and break to pieces. Therefore, it is critical for the refrigerant to enter the compressor in the gas phase. Moreover, when the refrigerant entering the compressor in the liquid phase mixes with the oil, the viscosity of the oil perceptibly decreases, thus increasing the risk of the wearing down of the compressor bearings. The reason of the refrigerant flooding is that the refrigerant in the cycle does not sufficiently evaporate in the evaporator due to changes in the pressure-temperature relation of the refrigerant, and remains in the liquid phase. Therefore, the refrigerant must completely evaporate before reaching the compressor.

- [0003] In the state of the art Patent Application No. US2015354879 (A1), a method for preventing refrigerant flooding in a cooling unit is disclosed.
- [0004] In the state of the art Patent Application No. US2016076542 (A1), a start-up method applied in a compressor wherein refrigerant migration is detected is disclosed.
- [0005] In the state of the art Patent Application No. WO2006088717 (A2), a method for preventing refrigerant flooding that may occur in the compressor in a heat pump used in cooling systems is disclosed.
- [0006] In the state of the art Patent No. EP2921098 (B1), a dishwasher is disclosed, wherein the heat pump system is used in the drying process.
- [0007] The aim of the present invention is the realization of a heat pump dishwasher wherein the problem of refrigerant flooding is eliminated.
- [0008] The dishwasher realized in order to attain the aim of the present invention comprises a heat pump system that is composed of a compressor, a condenser, an evaporator, refrigerant flow tubes and an expansion element that together perform the refrigerant cycle. The condenser acts as a heater, and the washing water is heated by the condenser placed into a

sump.

- [0009] In the dishwasher of the present invention, if the temperature or pressure of the compressor return tube in the heat pump system is higher than the predetermined threshold values according to the data received from a temperature sensor and a pressure sensor, the control unit decides that the refrigerant coming from the evaporator to the compressor has not completely changed from the liquid phase into vapor phase and increases the compressor speed and/or the evaporator fan speed. Thus, the problem of refrigerant flooding described as the entry of refrigerant in liquid phase into the compressor is eliminated.
- [0010] In an embodiment of the present invention, if the outer environment temperature falls below a predetermined limit value, for example 21°C, an electric heater disposed in front of the evaporator fan is activated.
- [0011] In another embodiment of the present invention, if the problem of refrigerant flooding is detected, the control unit decreases the speed of the circulation pump so as to decrease the flow rate of the water heated by the condenser, thus enabling both the condenser and the evaporator to be operated at low capacity.
- [0012] The heat pump dishwasher realized in order to attain the aim of the present invention is illustrated in the attached figures, where:
- [0013] Figure 1 - is the schematic view of a heat pump dishwasher.
- [0014] Figure 2 - is the schematic view of a heat pump system in an embodiment of the present invention.
- [0015] The elements illustrated in the figures are numbered as follows:
1. Dishwasher
 2. Tub
 3. Rack
 4. Spray arm
 5. Circulation pump
 6. Drying duct
 7. Heat pump system
 8. Compressor
 9. Sump

10. Condenser
11. Evaporator
12. Evaporator fan
13. Expansion element
14. Return tube
15. Temperature sensor
16. Pressure sensor
17. Control unit
18. Heater

[0016] The dishwasher (1) comprises a tub (2) wherein the processes of washing, rinsing and drying are performed; at least one rack (3) wherein the items to be washed are placed; at least one spray arm (4) and a circulation pump (5) that provide the delivery of the washing water onto the items to be washed; a drying duct (6) that takes the humid air in the tub (2) out of the tub (2) after the washing process and thus that enables the items washed to be dried, and a heat pump system (7) that is disposed at the lower part of the tub (2) and that provides the heating of the washing water.

[0017] The heat pump system (7) comprises a compressor (8); a condenser (10) that emanates heat by condensing the refrigerant pressurized by the compressor (8) and that is used for heating the washing water by being disposed in a sump (9) wherein the washing water is collected; an evaporator (11) that evaporates the refrigerant so as to draw heat from the outer environment and to transfer the same to the condenser (10); at least one evaporator fan (12) that provides the heat transfer by blowing the outer environment air onto the evaporator (11); an expansion element (13), for example a capillary tube or an expansion valve, that provides the expansion of the refrigerant flowing from the condenser (10) to the evaporator (11), and a return tube (14) that forms the part of the refrigerant flow tubes between the evaporator (11) and the compressor (8); the compressor (8), the condenser (10) the evaporator (11), the evaporator fan (12), the expansion element (13) and the return tube (14) all performing the refrigerant cycle.

[0018] Contrary to state of the art embodiments, the condenser (10) of the heat

pump system (7) is used for heating the washing water collected in the sump (9), and the evaporator (11) performs the task of completing the refrigerant cycle so as to carry out the function of the condenser (10). The heat transfer required for the refrigerant passing through the evaporator (11) to reach the evaporation temperature is realized by the evaporator fans (12). The heat pump system (7) is used only for the condenser (10) to heat the washing water, and the evaporator (11) is not required to dry (cool and condense) the washing environment in the tub (2). Since the heat pump system (7) is positioned outside the drying duct (6), the heat pump system (7) has only the "water heating" function, not the function of drying the air in the tub (2).

- [0019] The dishwasher (1) of the present invention comprises
- [0020] - a temperature sensor (15) and a pressure sensor (16) that are disposed into the heat pump system (7), and
- [0021] - a control unit (17) that enables the compressor (9) (the electric motor of the compressor (9)) and the evaporator fan (12) (the electric motor of the evaporator fan (12)) to be operated at variable rotational speed (variable speed, variable capacity, ...), and
- [0022] - that decides that the refrigerant coming from the evaporator (11) to the compressor (8) has not completely changed from the liquid phase into vapor phase if the temperature or pressure values detected in the heat pump system (7) are higher than the predetermined threshold values according to the data received from the temperature sensor (15) and the pressure sensor (16), and that increases the compressor (8) speed and/or the evaporator fan speed (12) (Figure 1, 2).
- [0023] In an embodiment of the present invention, the temperature sensor (15) measures the temperature of the return tube (14) between the evaporator (11) and the compressor (8) while the pressure sensor (16) measures the pressure created by the refrigerant in the return tube (14) (the return tube (14) pressure).
- [0024] When the compressor (8) speed is increased by the control unit (17), the capacity of the compressor (8) also increases, and on the other hand, the capacity of the condenser (10) and hence of the evaporator (11) is

decreased to balance the heat pump system (7). In the evaporator (11) with decreased capacity and hence decreased load, the refrigerant is enabled to quickly change into the vapor phase. The refrigerant is enabled to enter from the return tube (14) into the compressor (8) completely in the vapor phase, thus preventing the problem of refrigerant flooding.

- [0025] When the control unit (17) increases the evaporator fan (12) speed, the evaporator (11) is enabled to draw more heat from the outer environment and to operate at low capacity, thus decreasing the load of the evaporator (11). Consequently, in the evaporator (11), the refrigerant changes to the vapor phase more easily and the problem of refrigerant flooding is prevented.
- [0026] In an embodiment of the present invention, the dishwasher (1) comprises a heater (18) that is disposed in front of the evaporator fan (12), that is activated when the temperature of the outer environment falls below a predetermined limit value, for example 21°C, so as to increase the temperature of the air blown from the evaporator fan (12) towards the evaporator (11) and hence the amount of heat drawn by the evaporator (11) from the outer environment, and that enables the refrigerant circulating in the evaporator (11) to more quickly change to the vapor phase so as to prevent the problem of refrigerant flooding (Figure 2).
- [0027] In an embodiment of the present invention, the dishwasher (1) comprises a variable-speed circulation pump (5), and if the problem of refrigerant flooding is detected according to the data received from the temperature sensor (15) and the pressure sensor (16), the control unit (17) decreases the speed of the circulation pump (5) so as to decrease the flow rate of the water heated by the condenser (10), thus enabling the condenser (10) to be operated at low capacity. Depending on the decreasing of the condenser (10) capacity, the evaporator (11) is also enabled to be operated at low capacity. Thus, the refrigerant passing through the evaporator (11) quickly change to the vapor phase and the problem of refrigerant flooding is prevented.
- [0028] In an embodiment of the present invention, the method for preventing refrigerant flooding executed by the control unit (17) comprises the steps

of

- [0029] - operating the compressor (8),
- [0030] - measuring the temperature of the return tube (14) by means of the temperature sensor (15),
- [0031] - measuring the pressure of the return tube (14) by means of the pressure sensor (16), and
- [0032] - gradually increasing the compressor (8) speed if the temperature or pressure of the return tube (14) is higher than the threshold values.
- [0033] In an embodiment of the present invention, the method for preventing refrigerant flooding executed by the control unit (17) comprises the steps of
 - [0034] - operating the compressor (8),
 - [0035] - measuring the temperature of the return tube (14) by means of the temperature sensor (15),
 - [0036] - measuring the pressure of the return tube (14) by means of the pressure sensor (16), and
 - [0037] - gradually increasing the evaporator fan (12) speed if the temperature or pressure of the return tube (14) is higher than the threshold values.
- [0038] In an embodiment of the present invention, the method for preventing refrigerant flooding executed by the control unit (17) comprises the steps of
 - [0039] - operating the compressor (8),
 - [0040] - measuring the temperature of the return tube (14) by means of the temperature sensor (15),
 - [0041] - measuring the pressure of the return tube (14) by means of the pressure sensor (16), and
 - [0042] - gradually increasing both the compressor (8) speed and the evaporator fan (12) speed if the temperature or pressure of the return tube (14) is higher than the threshold values.
- [0043] In the heat pump dishwasher (1) of the present invention, the refrigerant is enabled to enter the compressor (8) always in the vapor (gas) phase, and the problem of refrigerant flooding, known as the entry of refrigerant in the liquid phase into the compressor (8), is prevented. The mixing of the

refrigerant with the oil in the compressor (8) is prevented, the viscosity of the oil is maintained, and thus, the movable components in the compressor (8) that are required to be lubricated are prevented from wearing down and being damaged. The compressor (8) provides the desired performance in different operating conditions.

Claims

1. A dishwasher (1) **comprising** a tub (2), a drying duct (6) that enables the washed items to be dried, and a heat pump system (7) that is disposed at the lower part of the tub (2) and that has a compressor (8), a condenser (10), an evaporator (11), at least one evaporator fan (12), an expansion element (13) and a return tube (14) forming the part of the refrigerant flow tubes between the evaporator (11) and the compressor (8), **characterized by**
 - a temperature sensor (15) and a pressure sensor (16) that are disposed into the heat pump system (7), and
 - that enables the compressor (8) and the evaporator (12) to be operated at variable speeds, and that increases the compressor (8) speed and/or the evaporator fan speed (12) if the temperature or pressure values detected in the heat pump system (7) are higher than the predetermined threshold values according to the data received from the temperature sensor (15) and the pressure sensor (16).
2. A dishwasher (1) as in Claim 1, **characterized by** a temperature sensor (15) that measures the temperature of the return tube (14) between the evaporator (11) and the compressor (8) and a pressure sensor (16) that measures the return tube (14) pressure.
3. A dishwasher (1) as in Claim 1 or 2, **characterized by** a heater (18) that is disposed in front of the evaporator fan (12) and that is activated when the temperature of the outer environment falls below a predetermined limit value so as to increase the amount of heat drawn by the evaporator (11) from the outer environment.
4. A dishwasher (1) as in Claim 1 or 2, **characterized by** a variable-speed circulation pump (5), and the control unit (17) that, if the problem of refrigerant flooding is detected according to the data received from the temperature sensor (15) and the pressure sensor (16), decreases the speed of the circulation pump (5) so as to enable the evaporator (11) to be operated at low capacity.
5. A method for preventing refrigerant flooding executed by the control unit (17) for a dishwasher (1) as in Claim 1, comprising the steps of:
 - operating the compressor (8),

- measuring the temperature of the return tube (14) by means of the temperature sensor (15),
 - measuring the pressure of the return tube (14) by means of the pressure sensor (16), and
 - gradually increasing the compressor (8) speed if the temperature or pressure of the return tube (14) is higher than the threshold values.
6. A method for preventing refrigerant flooding executed by the control unit (17) for a dishwasher (1) as in Claim 1, comprising the steps of:
- operating the compressor (8),
 - measuring the temperature of the return tube (14) by means of the temperature sensor (15),
 - measuring the pressure of the return tube (14) by means of the pressure sensor (16), and
 - gradually increasing the evaporator fan (12) speed if the temperature or pressure of the return tube (14) is higher than the threshold values.
7. A method for preventing refrigerant flooding executed by the control unit (17) for a dishwasher (1) as in Claim 1, comprising the steps of:
- operating the compressor (8),
 - measuring the temperature of the return tube (14) by means of the temperature sensor (15),
 - measuring the pressure of the return tube (14) by means of the pressure sensor (16), and
 - gradually increasing both the compressor (8) speed and the evaporator fan (12) speed if the temperature or pressure of the return tube (14) is higher than the threshold values.

Figure 1

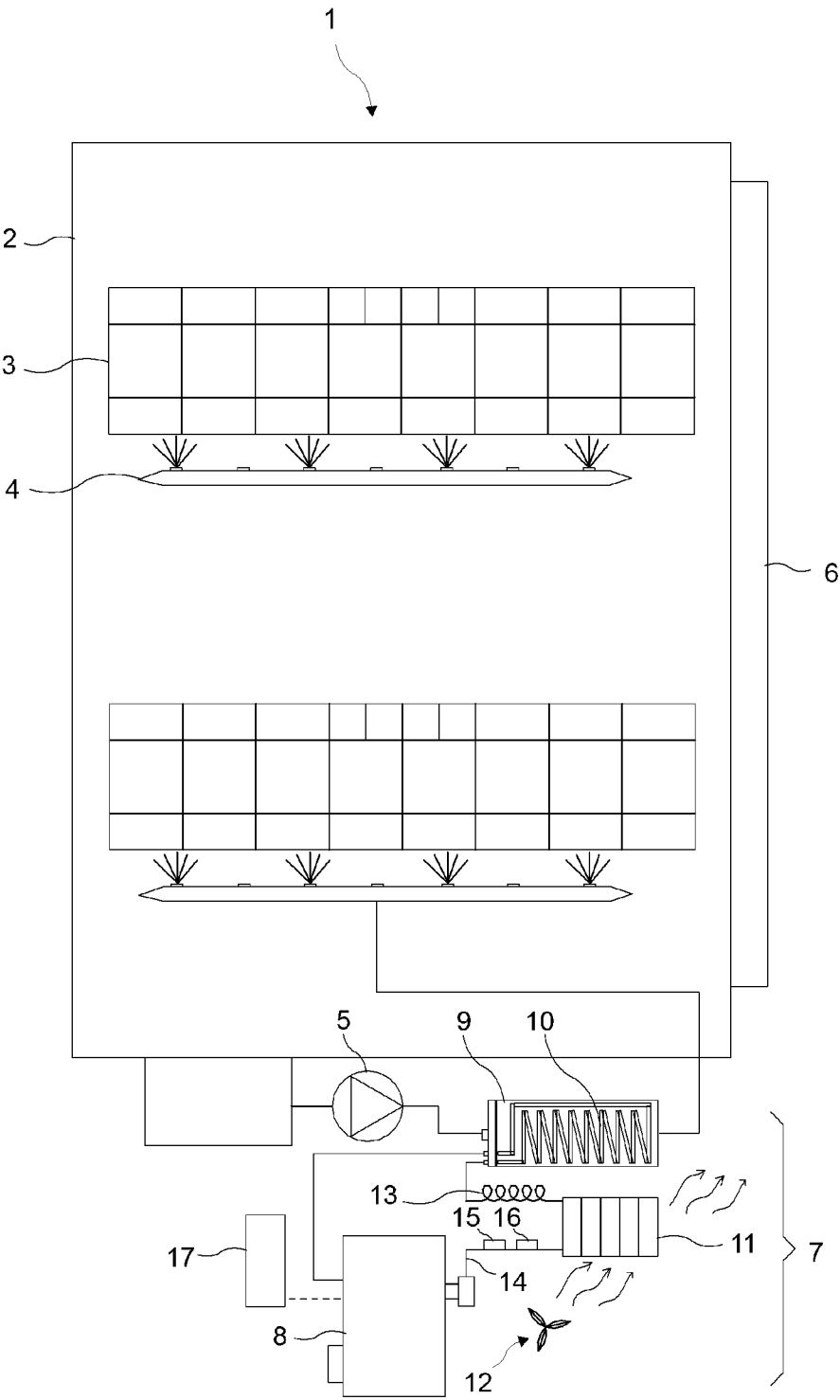
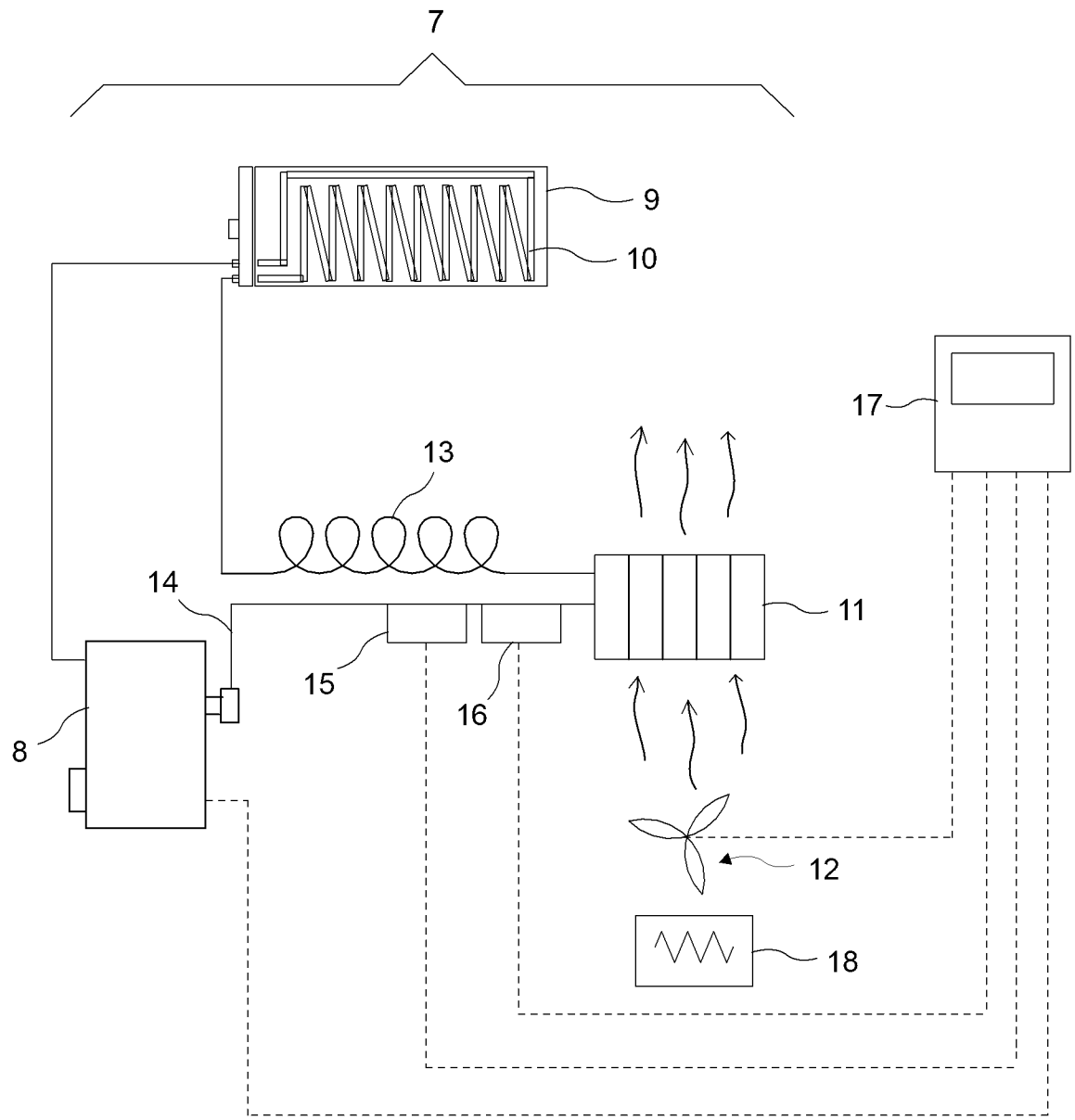


Figure 2



INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
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ADD.

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Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 527 520 A1 (ELECTROLUX HOME PROD CORP [BE]) 28 November 2012 (2012-11-28)	1-5,7
Y	column 1, paragraph 0006 - column 7, paragraph 0024 column 9, paragraph 0034 - column 10, paragraph 0035 column 16, paragraph 0060 - column 20, paragraph 0068 column 22, paragraph 0078 - column 23, paragraph 0079 column 32, paragraph 0116 - column 33, paragraph 0119 column 33, paragraph 0123 - column 35, paragraph 0131; figures 2,5 ----- -/--	6



Further documents are listed in the continuation of Box C.



See patent family annex.

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2015/185086 A1 (ELECTROLUX APPLIANCES AB [SE]) 10 December 2015 (2015-12-10)	1-5,7
Y	page 3, line 18 - line 31 page 5, line 4 - line 31 page 7, line 32 - page 10, line 23; figure 1	6
A	----- WO 2015/090409 A1 (ELECTROLUX APPLIANCES AB [SE]) 25 June 2015 (2015-06-25) figure 3	1-7
A	----- CN 106 852 673 A (HANGZHOU SANHUA HOME APPLIANCE THERMAL MAN SYSTEM CO LTD) 16 June 2017 (2017-06-16) figure 1	1-7
A	----- FR 2 304 314 A1 (STIERLEN MAQUET AG [DE]) 15 October 1976 (1976-10-15) claim 19; figures 6,7	1-7
A	----- WO 2014/094854 A1 (ELECTROLUX HOME PROD CORP [BE]) 26 June 2014 (2014-06-26) page 5, last paragraph; figure 1	1-7
A	----- WO 2015/101864 A1 (INDESIT CO SPA [IT]) 9 July 2015 (2015-07-09) page 4, line 2 - line 27; figure 1	3
A	----- WO 2016/091329 A1 (ELECTROLUX APPLIANCES AB [SE]) 16 June 2016 (2016-06-16) the whole document	1-7

INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2527520	A1	28-11-2012	NONE
WO 2015185086	A1	10-12-2015	BR 112016025236 A2 15-08-2017 CN 106455899 A 22-02-2017 EP 3148392 A1 05-04-2017 PL 3148392 T3 31-08-2018 US 2017051953 A1 23-02-2017 WO 2015185086 A1 10-12-2015
WO 2015090409	A1	25-06-2015	AU 2013407868 A1 28-04-2016 EP 3082554 A1 26-10-2016 PL 3082554 T3 30-05-2018 WO 2015090409 A1 25-06-2015
CN 106852673	A	16-06-2017	NONE
FR 2304314	A1	15-10-1976	NONE
WO 2014094854	A1	26-06-2014	EP 2934272 A1 28-10-2015 PL 2934272 T3 29-09-2017 US 2015308699 A1 29-10-2015 WO 2014094854 A1 26-06-2014
WO 2015101864	A1	09-07-2015	EP 3090092 A1 09-11-2016 WO 2015101864 A1 09-07-2015
WO 2016091329	A1	16-06-2016	EP 3230516 A1 18-10-2017 WO 2016091329 A1 16-06-2016