(19) DANMARK

(10) **DK/EP 2215955 T3**

(12) Oversættelse af europæisk patentskrift

Patent- og Varemærkestyrelsen

(51) Int.Cl.: ***A 47 L 15/42 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2017-10-16**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2017-07-26**

(86) Europæisk ansøgning nr.: **09005448.7**

(86) Europæisk indleveringsdag: **2009-04-17**

(87) Den europæiske ansøgnings publiceringsdag: **2010-08-11**

(30) Prioritet: **2009-02-09 EP 09001756**

(84) Designerede stater: **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 SE SI SK TR**

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(54) Benævnelse: **Opvaskemaskine med varmepumpe**

(56) Fremdragne publikationer:
EP-A- 1 864 603
EP-A- 1 917 899
DE-A1- 3 048 268
JP-A- 10 080 391

The invention relates to a dishwasher as well as to a method for operating it according to the preamble of the independent claims.

In order to improve the energy efficiency of dishwashers, it has amongst others been proposed to provide a heat exchanger, which serves to retrieve heat from the vat and to supply it to the fresh water.

Additionally, EP 1 864 603 and JP 10080391 propose dishwashers with heat pumps in order to improve efficiency of the device.

It is the objective of the present invention to further improve energy efficiency of a dishwasher. This objective is reached by the independent claims. According to this, a heat pump with at least a condenser and at least an evaporator is used, by means of which heat can be extracted from and/or supplied to the process water or the vat.

Furthermore, the dishes are leaned during at least a first and a second process phase, wherein process water is guided from the vat into a drain area at the end of the first process phase and fresh water is guided into the vat at the beginning of the second process phase, wherein in the second process phase heat is extracted from the process water in the drain area with the heat pump and is supplied to the process water in the vat. In this way the efficiency of the device is improved.

Preferably, the condenser or (if multiple condensers are present) at least one of the condensers respectively and/or, if multiple evaporators are present, at least one of the evaporators respectively are arranged at a wall of the vat, particularly alongside this wall, thus making it possible in a simple way, meaning without special heat exchange devices, etc., to provide a direct heat supply or a direct heat retrieval respectively. "Wall" of the vat thereby means a sidewall of the vat, its top and its bottom.

Preferably, at least an evaporator and at least a condenser are arranged at the vat. In this case, heat is supplied to a first wall section with the heat pump in a drying phase, and heat is extracted from a second wall section in order to generate a convection flow inside the vat and extract water from the process air.

In a particularly advantageous embodiment, a condenser is provided at least at a lateral wall of the vat. It serves e.g. to heat up the vat during the drying phase. By arranging it at a lateral wall and not on the floor it is avoided that it heats up an unnecessarily high amount of condensed water. Preferably, an evaporator is provided at an opposite lateral wall, such that a convection flow for dry air is generated between the condenser and the evaporator. "Lateral wall" is understood as a vertical wall of the vat, including the rear wall (or potentially the front wall).

In a further preferred embodiment the evaporator or (if multiple evaporators are present) at least one of the evaporators, respectively, is thermally coupled to the drain area, through which water is released from the vat into the sewage after use. In this way, heat can be extracted from the discharge water.

Preferably, two condensers and two evaporators are provided. A first condenser and a first evaporator serve to extract heat from the drain area during the cleaning phase and to supply it to the vat. A second condenser and a second evaporator serve to extract humidity from the process air during the drying phase.

Further preferred embodiments of the invention result from the dependent claims as well as from the now following description by means of the figures. Thereby it is shown in:

Fig. 1 a first embodiment of a dishwasher,

Fig. 2 a second embodiment of a dishwasher with a single evaporator,

Fig. 3 a third embodiment of a dishwasher with a single evaporator,

Fig. 4 a fourth embodiment of a dishwasher with a bypass valve,

Fig. 5 a fifth embodiment of a dishwasher with an additional circulation pump,

Fig. 6 a sixth embodiment of a dishwasher with a discharge water tank,

Fig. 7 a seventh embodiment of a dishwasher with a coaxial heat exchanger,

Fig. 8 a section through the discharge water tube of a further embodiment,

Fig. 9 an eighth embodiment of the dishwasher with two condensers.

The dishwasher shown schematically in Fig. 1 has a vat 1 for receiving the items to be washed, like i.e. dishes, crockery or the like. Furthermore, the dishwasher has, as known, spraying arms (not shown), as well as a circulation pump for circulating process water from the sump 2 into the spraying arms. The items to be washed are located in one or more racks. A control controls and commands the operations of all components. A device formed in this way is known to the skilled person.

Fresh water is supplied to the device via a fresh water valve 3 and a softener 4. Used water is pumped into a discharge pipe 6 by a discharge pump 5. These components are also basically known to the skilled person.

The dishwasher further has a heat pump comprising a compressor 7 from which a heat pump medium is pumped to one or more condensers 8, where liquefaction takes place by releasing heat. From the condenser 8 the medium travels to at least an evaporator 10a, 10b via at least an expansion valve 9a, 9b, where the medium evaporates by absorbing heat. The medium goes back to the compressor 7 from the evaporator 10a, 10b.

The term "expansion valve" comprises each type of capillary, regulators or the like, which are suitable to reduce the pressure of the medium pumped into the heat pump before the evaporator.

In the embodiment shown in Fig. 1 the condenser 8 is arranged at the bottom 12 of the vat and contacts it directly, in a heat conducting manner, and/or is arranged on its inner side, such that the bottom 12 can be heated in the vicinity of the condenser 8.

Furthermore, in the embodiment shown in Fig. 1 two evaporators 10a, 10b are provided, wherein an own expansion valve 9a, 9b is attributed to each one. Furthermore, a switch 14 is provided before the expansion valves in order to supply the pumped medium optionally to the one or the other evaporator 10a or 10b respectively.

The first evaporator 10a is thermally coupled to the vat 1, preferably by being arranged at a first side wall 15 of it. In this way, the vat 1 and particularly said side wall 15 can be cooled with the first evaporator 10a.

The second evaporator 10b is thermally coupled to a drain area 16 of the device, wherein the term "drain area" denotes an area through which the water is transferred from the vat 1 to the discharge pipe 6 after use. In this way, heat can be retrieved from the drain area 16 and particularly from the water located there by means of the second evaporator 10b.

In practice the drain area 16 consists, in the embodiment according to Fig. 1, of a discharge pipe 17 alongside or inside which the tubular second evaporator 10b is guided, wherein the discharge pipe 17 and the second evaporator 10b are thermally coupled. In order to extend the interaction period between the evaporator 10b and the discharge pipe 17 and to increase the amount of water which can be stored in the drain area 16 to at least around the amount of the water required during a process phase, meaning at least around 3 liters,

the discharge pipe 17 and the evaporator 10b are installed preferably in a meander-shaped or helical way. In order to improve the heat transfer the water flows in the discharge pipe 17 preferably in the opposite direction with respect to the medium in the second evaporator 10b.

The medium of the first evaporator 10a and of the second evaporator 10b are reunited in a combination valve or a second switch 18 before the compressor 7.

The operation of the device is as follows:

1. At the beginning of a main washing cycle fresh water is supplied via the fresh water valve 3.

2. At the same time, the heat pump is started, with the aim to supply thermal energy from the water in the drain area 16 to the vat 1. For this, the switch 14 is adjusted in a way that the second evaporator 10b is in operation. The heat pump is switched off when the water temperature in the drain area goes below a threshold value, i.e. 5°C. If the temperature inside the vat or in the cleaning water respectively doesn't reach a predefined value (depending on the program i.e. between 40 and 60°C) it is possible to additionally electrically heat, either simultaneously with the heating by the heat pump or after that.

3. At the end of the main washing cycle the water is discharged from the vat into the drain area 16. There it replaces the water which was cooled down by the heat pump in step 2.

4. New fresh water is supplied for an intermediary rinsing phase via the fresh water valve 3.

5. The heat pump is actuated again in order to transfer the heat from the drain area 16 into the vat 1. In this process, the water in the drain area 16 is again cooled off at most to said threshold value of for example 5°C. At the same time the circulation pump which transports water from the sump 2 into the spraying arms is preferably operated at least temporarily with low

power in such a way that water flows out of the lower spraying arm without impinging on the items to be washed. In this way it is reached that the water can absorb the heat from the condenser 8 at the bottom 12 of the vat 1, without cooling down by the cold water the items to be washed. As soon as the heat from the drain area 16 has been exchanged the items to be washed are intermediary rinsed and thereafter the intermediary rinsing phase is ended.

6. The water from the vat 1 is again pumped out and replaces the now cold water in the drain area 16.

7. New fresh water is supplied for a gloss refining phase (clear refining phase) via the fresh water valve 3.

8. The heat pump is again operated in order to transfer the heat from the drain area 16 into the vat 1. Again, the circulation pump which transports water from the sump 2 into the spraying arms is preferably at least temporarily operated with low power in order that the water to be circulated, however without impinging on the items to be washed. As soon as the heat from the drain area 16 has been exchanged, and if necessary after an optional additional electric heating, the items to be washed are rinsed in a glossy way and thereafter the gloss rinsing phase is ended. The gloss rinsing water can be transferred to the drain area 16.

9. Now the drying phase can begin. The switch 14 is switched over such that now the first evaporator 10a lies in the circuit, however not the second evaporator 10b. The heat pump is started. Thereby the bottom 12 of the vat 1 is heated by the condenser 8 while the lateral wall 15 is cooled by the evaporator 10a. In this way, a convection stream is generated in the vat 1 insofar as air is heated via the condenser 8 and rises. This air flows between the items to be washed and dries them. The air then contacts the lateral wall 15 where it is cooled down, such that water is extracted from it. The

condensed water flows down the lateral wall 15 and gets into the sump 2.

The convection in step 9 can be intensified by arranging the condenser 8 only in a section of the bottom area 12 which is located opposite of the first lateral wall 15.

It is evident from the above process course that the heat pump serves two objectives. On the one hand it is used to transfer heat from the drain area 16 into the vat 1 or the water located there respectively. Furthermore it is used to extract water from the air in the vat 1 during the drying. For this, both evaporators 10a and 10b are alternatively used. By attributing an own expansion valve 9a or 9b respectively, to each evaporator, the expansion valves can be adapted to the parameters and desired operating temperatures of both evaporators in an optimum way. Additionally, the switch 14 can be arranged in the high pressure area in this case, where its flow resistance plays a subordinate role. It is however also conceivable to provide only a common expansion valve for both evaporators 10a, 10b.

In the above example heat is transferred in the steps 5 and 8 from the respective previous process phase in the current process phase. Depending on the number of process phases also further such steps can take place. Thereby, at the end of the respective process phase the cooled down water is replaced with used warm water in the drain area 16.

It is also conceivable to operate the second evaporator 10b at least temporarily in the drying phase, either together (parallel) or alternating with the first evaporator, in order to still supply heat from the drain area 16 to the vat 1.

Both functions mentioned above of the heat pump (drying process and heat transfer) may also be used in a standalone manner. According to this, Fig. 2 shows a simpler embodiment of a dishwasher in case of which only

the first evaporator 10a is present. The second evaporator 10b is omitted, thus simplifying the construction. In this case the heat pump is only used to support the drying.

Accordingly, an alternative embodiment is shown in Fig. 3, in case of which only the second evaporator 10b is present and the first evaporator 10a is omitted. Again, the construction is simplified. In this case the heat pump is used to transfer heat from a process phase to a later process phase.

A further embodiment is shown in Fig. 4. Here, a bypass valve 20 is provided, by means of which water can be transferred from the device from the vat 1 to the discharge pipe 6 optionally by bypassing the drain area 16. In this way it is possible to carry out a heat transfer between two process phases, even when they are separated by a third process phase. Particularly, the intermediary rinsing phase doesn't necessarily require heat, such that the process course described above can be changed with the assembly according to Fig. 4 insofar, as the heat pump is not operated in the intermediary rinsing phase, thus in step 5. At the end of the rinsing phase the water is not transferred to the drain area 16 but directly to the discharge pipe 6 by bypassing the drain area 16. Thus, the heat from the hot water of the main washing phase can be pumped into the vat in the subsequent rinsing phase. In this way, an unnecessary heat loss is avoided. Besides, the intermediary rinsing phase may be shortened because no heat transfer is necessary.

A further embodiment of the dishwasher is shown in Fig. 5. Here, an additional circulation pump 21 as well as a switching valve 22 is provided at the end of drain area 16, such that water can be circulated in the drain area 16. In this way, the heat transfer between the second evaporator 10b and the water in the drain area 16 can be accelerated.

In the embodiment according to Fig. 6 the water in the drain area is guided through a tank 22. The tank 22 takes over the storing function of the discharge pipe 17, however it has the advantage of a better space usage. However, in this case one should be cautious that the tank 22 is formed in such a way that in case of an inflow of new discharge water a mixing with the old water should be avoided as much as possible. Additionally, the tank 22 has to be formed such that as little dirt as possible can deposit. When a discharge pipe 17 is used, the danger of a mixing and of a deposit of dirt is basically smaller.

In the embodiment according to Fig. 7 the pipe of the second evaporator 10b and the discharge pipe 17 don't run side by side but the evaporator 10b is at least partly surrounded by the discharge pipe 17.

A preferred construction of this heat exchanger is shown in Fig. 8. As can be seen, the evaporator 10b is arranged in an elongate recess of the discharge pipe 17. Preferably, the discharge pipe is formed as a blow-moulded plastic part and elastically presses against the evaporator 10b.

A further embodiment is shown in Fig. 9, which illustrates some important further principles which are explained in the following.

Firstly, in this embodiment a condenser 8' is provided at a second lateral wall 15' of the vat 1, which is preferably arranged opposite of the first lateral wall 15 with the condenser 10a. It may basically replace or complement the condenser 8. In the following, the condenser 8 is called "first condenser" and the condenser 8' is called "second condenser".

The arrangement of one or of the second condenser 8' at the lateral wall has the advantage that the floor 12 of the vat doesn't have to be heated during the drying phase, as this would inevitably occur during operation of the first condenser 8. The use of a

condenser 8' at the lateral wall is more efficient during the drying phase, as during the drying phase relatively much condensed water, which in fact doesn't have to be heated up anymore, flows on the floor 12 of the vat 1.

Preferably, the second condenser 8' as well as the first evaporator 10a are arranged in series, with an interposed expansion valve 9a, such that the cooling medium can be guided through the second condenser 8' and the first evaporator 10a during the drying phase, in order to extract water from the process air.

If the first condenser 8 is also provided on the floor 12 of the vat 1 additionally to the second condenser 8', the first condenser 8 can be used to supply heat from the drain area 16 to the vat 1 during the cleaning phase, in the aforementioned way. The first evaporator 8 is better suitable for this than the second evaporator 8', because the first evaporator can heat up the process water flowing on the floor 12 in an efficient way.

The first condenser 8 on the floor 12 may however also be obsolete or it may be arranged elsewhere, if the heat shall be supplied to the process water at another location. For example, the first condenser may be thermally coupled to the pipe system or the recirculation pump for recirculating water from the sump into the spraying arms, or the heat can only be supplied to the vat via the second condenser 8'.

Preferably, the first condenser 8 and the second evaporator 10b are arranged in series, with interposed expansion valve 9b, such that the cooling medium can be guided through the first condenser 8 and the second evaporator 10b during the cleaning phase, in order to transport heat from the drain area 16 into the process water.

As can be seen in Fig. 9, a switch 14' may be arranged between the compressor 7 and the first and the second condenser 8 or 8', respectively, in order to

supply the pumped medium optionally to the first and/or the second condenser 8 or 8', respectively.

Patentkrav

1. Opvaskemaskine med et kar (1) til optagelse af emner, der skal vaskes op, hvor den omfatter en varmepumpe, og hvor varmepumpen omfatter mindst en kondensator (8) og mindst en fordamper (10a, 10b), der er anbragt på en sådan måde, at der kan udtages og/eller tilføres varme til procesvandet eller karret (1), hvor fordamperen (10b) eller mindst en af fordamperne (10a, 10b) er koblet termisk med et afløbsområde (16), hvor opvaskemaskinen er udformet til at afgive vand fra karret (1) efter anvendelse via afløbsområdet (16), og hvor den endvidere er udformet til at
rengøre servicen i mindst en første og en anden procesfase,
ved slutningen af den første procesfase at lede procesvand fra karret (1) til afløbsområdet (16),
ved begyndelsen af den anden procesfase at føre frisk vand til karret (1), og
i den anden procesfase at udtage varme fra procesvandet i afløbsområdet (16) med varmepumpen og tilføre det til procesvandet i karret (1).

2. Opvaskemaskine ifølge krav 1, hvor kondensatoren (8) eller mindst en af kondensatorerne og/eller fordamperen (10a) eller mindst en af fordamperne (10a, 10b) er anbragt på en væg af karret (1) og især strækker sig langs denne væg.

3. Opvaskemaskine ifølge krav 2, hvor mindst en kondensator (8) er anbragt på bunden (12) af karret (1).

4. Opvaskemaskine ifølge et af kravene 2 eller 3, hvor fordamperen (10a) eller mindst en af fordamperne (10a, 10b) er anbragt på en første sidevæg (15) af karret (1).

5. Opvaskemaskine ifølge kravene 3 og 4, hvor kondensatoren (8) er anbragt på et område af bunden (12), der vender væk fra den første sidevæg.

6. Opvaskemaskine ifølge et af kravene 2 til 4, hvor mindst en kondensator (8') er anbragt på en sidevæg (15') af karret.

7. Opvaskemaskine ifølge krav 6, hvor en fordamper (10a) er anbragt på en sidevæg (15) af karret, der ligger over for kondensatoren (8').

8. Opvaskemaskine ifølge krav 3 og 6, hvor en første kondensator (8) er anbragt på bunden, og en anden kondensator (8') er anbragt på sidevæggen (15'), hvor varmepumpen omfatter en kompressor (7), og hvor en kontakt (14') er anbragt mellem kompressoren (7) og den første og den anden kondensator (8, 8') for at valgfrit at tilføre et pumpet medium til den første og den anden kondensator (15, 15').

9. Opvaskemaskine ifølge et af de foregående krav, hvor opvaskemaskinen omfatter en første fordamper (10a), der er koblet termisk med karret (1), og omfatter en anden fordamper (10b), der er koblet termisk med afløbsområdet (16).

10. Opvaskemaskine ifølge krav 7, hvor den første kondensator (8) er anbragt i serie med den anden fordamper (10b), og den anden kondensator (8') er anbragt i serie med den første fordamper (10a).

11. Opvaskemaskine ifølge et af kravene 9 eller 10, hvor den til de to fordampere (10a, 10b) omfatter to separate ekspansionsventiler (9a, 9b).

12. Opvaskemaskine ifølge et af de foregående krav, hvor afløbsområdet (16) omfatter et afløbsrør (17), hvorpå eller hvori den anden fordamper (10b) er ført langs, og især hvor afløbsrøret (17) og den anden fordamper (10b) er lagt meanderformet eller spiralformet.

13. Fremgangsmåde til drift af opvaskemaskinen ifølge et af de foregående krav, hvor varme udtages fra og/eller tilføres til procesvandet eller karret (1) med varmepumpen, **kendetegnet ved, at** servicen rengøres i mindst en første og en anden procesfase, hvor procesvand ledes ud af karret (1) til et afløbsområde ved slutningen af den første procesfase, og frisk vand tilføres til karret (1) ved begyndelsen af den anden procesfase, hvor varme udtages fra procesvandet i afløbsområdet med varmepumpen i den anden procesfase og tilføres til procesvandet i karret (1).

14. Fremgangsmåde ifølge krav 13, hvor varme med varmepumpen tilføres til et første vægområde, især en sidevæg (15'), af karret (1) og udtages af et andet vægområde, især en første sidevæg (15), i en tørrefase, og der således genereres en konvektionsstrøm i karret (1).

15. Fremgangsmåde ifølge et af kravene 13 eller 14, hvor procesvandet ved slutningen af den anden procesfase føres fra karret (1) til afløbsområdet og dér erstatter procesvandet fra den første procesfase.

16. Fremgangsmåde ifølge krav 15, hvor
et medium i rengøringsfasen pumpes gennem en første kondensator (8) for at tilføre varme til procesvandet og gennem en anden fordamper (10b) for at udtage varme fra vandet i afløbsområdet, og
det samme medium i tørrefasen pumpes gennem en anden kondensator (8') på en anden sidevæg (15') af karret (1) og gennem en første fordamper (10a) på en første sidevæg (15) af karret (1).

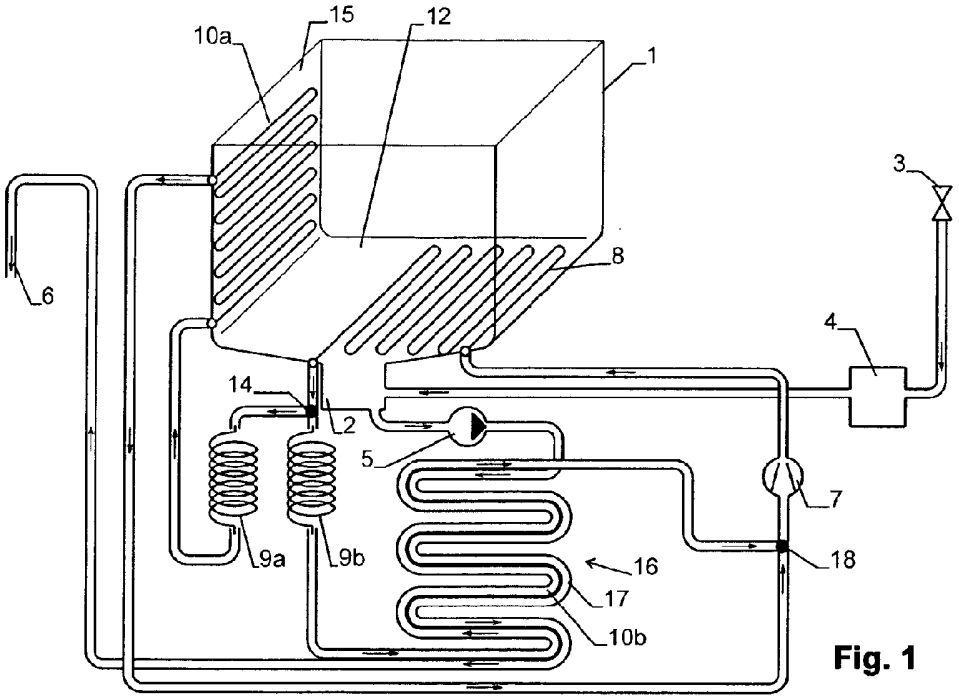
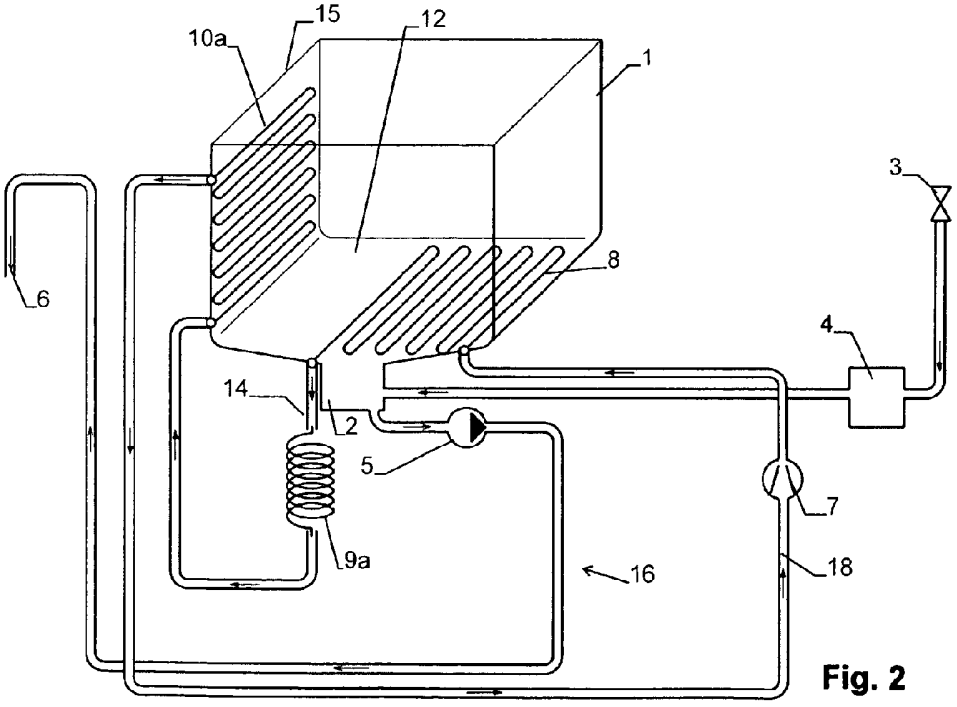

15
12
10a
1
3
8
6
4
14
2
5
7
9a
9b
16
18
17
10b

Fig. 1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10a
1
3
8
6
4
14
2
5
7
9a
16
18

Fig. 2

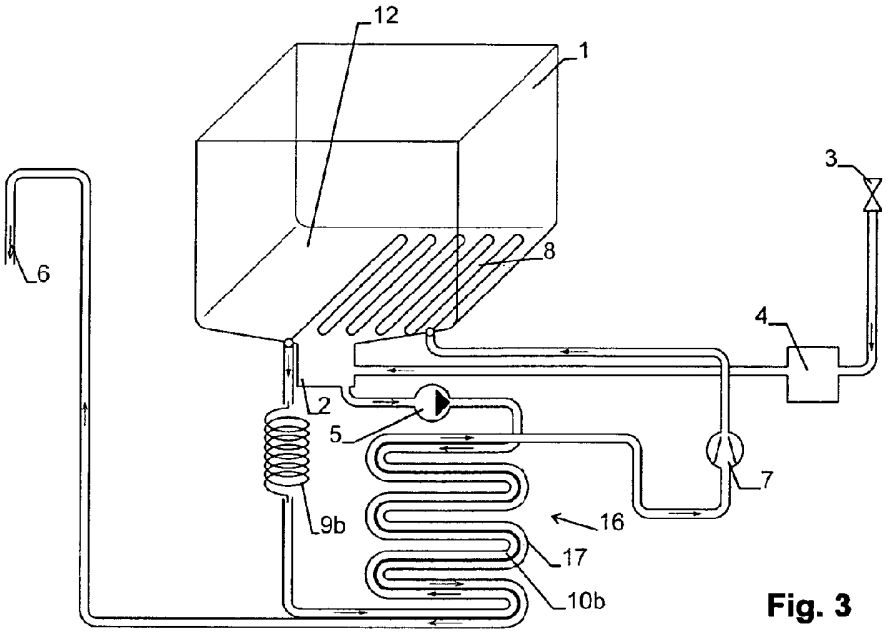
12
1
3
6
8
4
2
5
7
9b
16
17
10b

Fig. 3

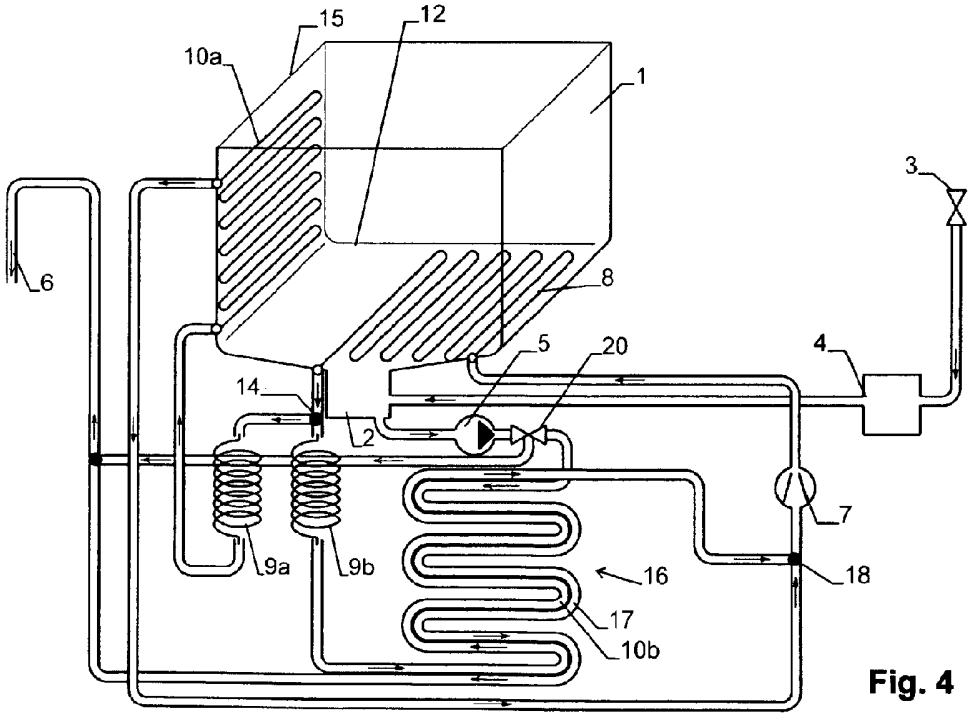
15
12
10a
1
3
6
8
5
20
4
14
2
7
9a
9b
16
18
17
10b

Fig. 4

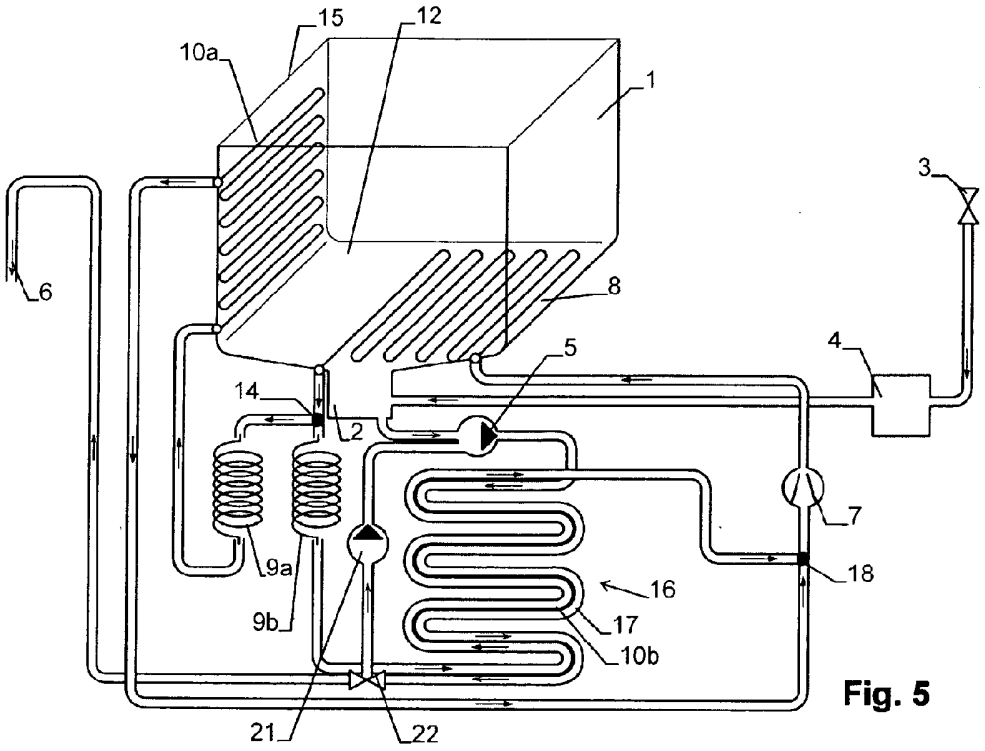
15
12
10a
1
3
6
8
5
4
14
2
7
9a
18
16
9b
17
10b
21
22

Fig. 5

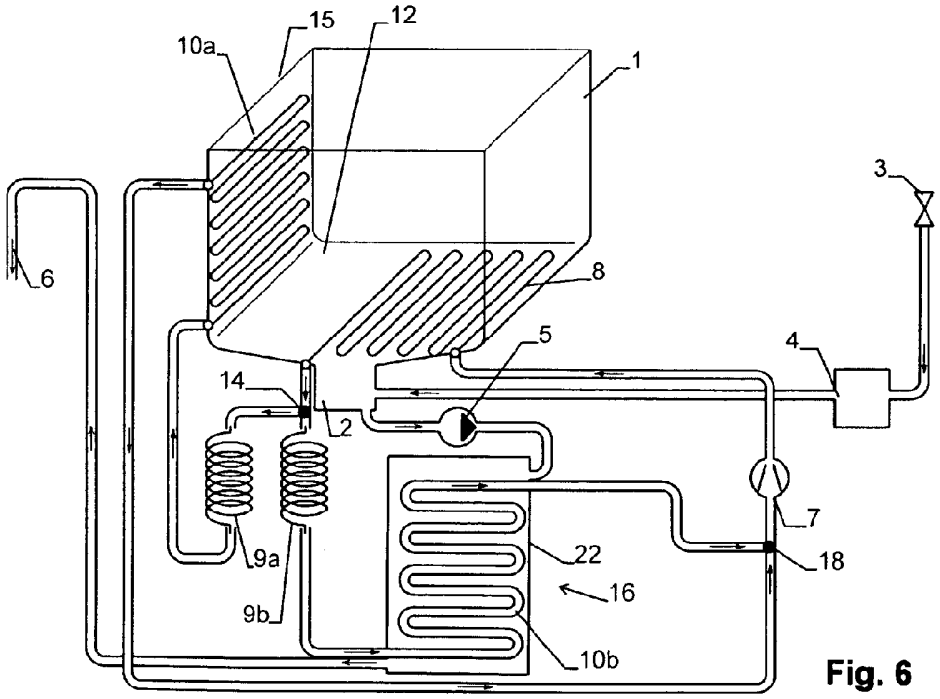
15
12
10a
1
3
6
8
5
4
14
2
7
9a
22
18
16
9b
10b

Fig. 6

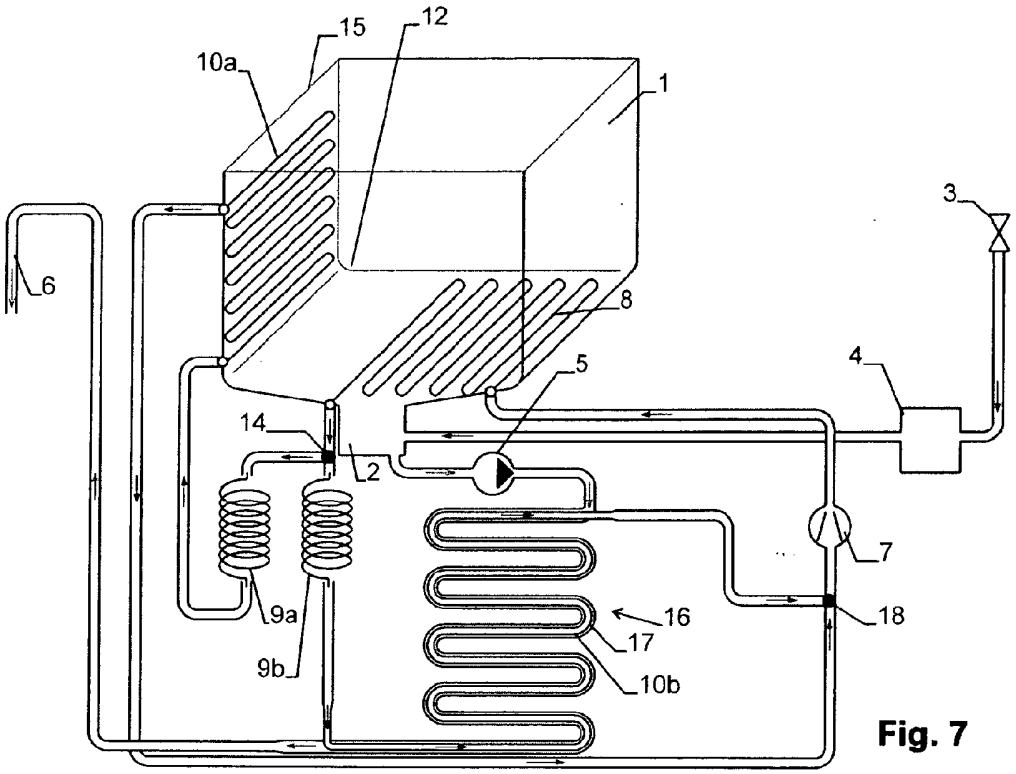

Fig. 7

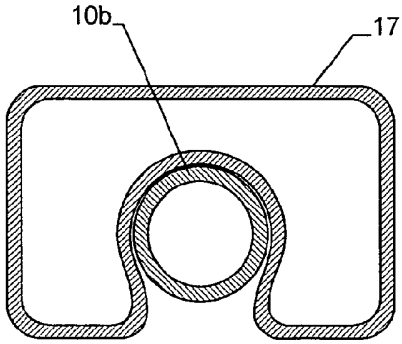

Fig. 8

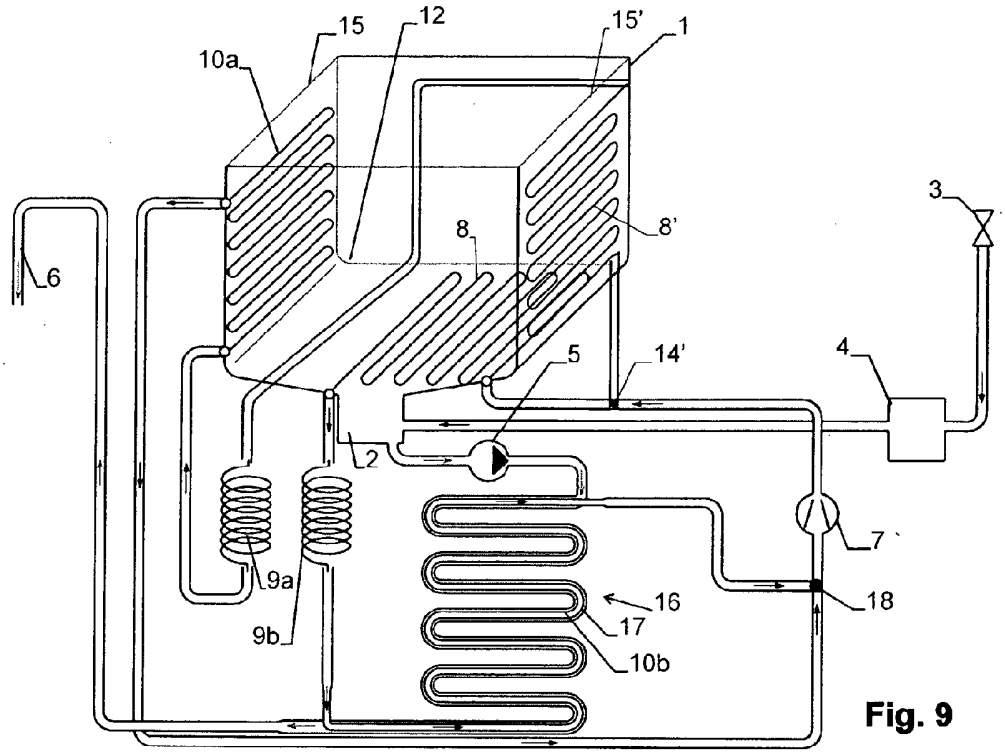

Fig. 9