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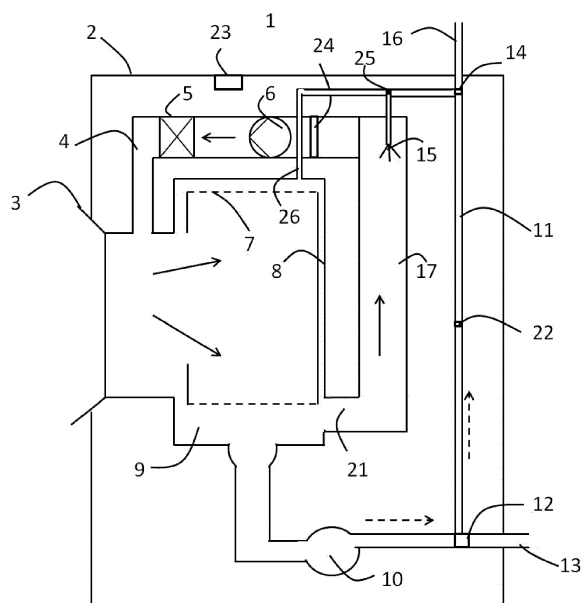
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(54) **WASHER-DRYER WITH A COOLING WATER CIRCUIT**

(57) The invention relates to a washer-dryer 1 comprising a tub 8 and a drum 7 rotatably mounted inside the tub 8, a process air circuit 4, adapted to circulate process air through the drum 7 for drying laundry, comprising a fan 6 and a heater 5, a cooling water circuit 11,28 in contact with the process air circuit 4, a pump 10,

a condenser 17, and a control unit 23, wherein the cooling water circuit 11,28 is in heat exchanging contact with at least one cooling means 16,18 which is adapted to cool the cooling water. The invention is also directed to a process for operating the washer-dryer 1.

Fig. 1



Description

[0001] The present invention relates to a washer-dryer for washing and drying laundry comprising a tub and a drum rotatably mounted inside the tub, a process air circuit, adapted to circulate process air through the drum for drying laundry, comprising a fan and a heater, a cooling water circuit in contact with the process air circuit, a pump, a condenser, and a control unit. Furthermore, the present invention also relates to a process for operating said washer-dryer.

[0002] In recent years, washer-dryers, i.e. drum washing machines with a drying function, have become popular among consumers because they are very convenient and compact household appliances as they incorporate both washing and drying functions. Moreover, commercially available washer-dryers are already provided with a water supply access, such that water is available not only for the washing of laundry, but also for other treatment steps. In a washer-dryer process air is circulated with the aid of a fan and heated with an air heater. The heated air enters the tub and the inside of the drum where it takes up moisture contained in the laundry. In order to lead the air in a closed circuit, washer-dryers are almost exclusively realized as condensation dryers. The hot and humid air leaving the drum is carried away and moisture is condensed in a so-called condenser, where heat is removed from the process air via cooling. The condensed water is usually collected and discharged in the same manner as the washing liquid.

[0003] Commercially available washer-dryers generally use fresh tap water as refrigerant to cool down the hot and humid process air. As a result of the condensation of the humidity, the process air is dried and introduced again into the tub. A problem associated with such commercially available washer-dryers is the enormous consumption of fresh tap water during each drying program. Namely, when the fresh tap water passes through the condenser it is heated up. The hot water can no longer be used for cooling purposes and is thus discarded. A washer-dryer providing a more eco-friendly way of drying is thus desired.

[0004] Washer-dryers using tap water cooling are known.

[0005] EP 2 749 682 A1 discloses a washer-dryer comprising a chamber for receiving goods to be washed and dried, a tank adapted to contain a fluid, a washer heat pump comprising a refrigerant. The washer heat pump of the washer-dryer is adapted to cool said refrigerant during a washing phase and to heat water to be used in the chamber, and to heat said refrigerant and to cool the fluid contained in the tank. The washer-dryer further comprises an air cooling/dehumidifier element that is adapted during a drying phase of the washer-dryer to cool/dehumidify process air downstream of the chamber. Said tank or a heat exchanger thermally connected with said tank is arranged downstream of said chamber and upstream of said air cooling/dehumidifier element, so as to pre-

cool/pre-dehumidify process air which exits from the chamber before the pre-cooled/pre-dehumidified process air is introduced into said air cooling/dehumidifier element.

[0006] EP 2 216 436 A1 discloses a washer-dryer comprising a washing tub, a tank for storing used water, a drying air duct disposed outside the washing tub and having opposite ends connected to the washing tub for use in a drying program, and air blowing/heating means provided in the drying air duct for sucking air out of the washing tub through one of the opposite ends of the drying air duct, heating the sucked air and feeding the heated air back into the washing tub through the other end of the drying air duct in the drying program. The washer-dryer comprises also a tank water circulation passage including a supply passage having opposite ends, one of which is connected to the tank and the other of which is connected to a first position of the drying air duct, and a recovery passage having opposite ends, one of which is connected to a second position of the drying air duct or the washing tub and the other of which is connected to the tank. A pump is provided in the tank water circulation passage for pumping up water from the tank through the supply passage to supply water into the drying air duct from the first position and causing the water to fall through the drying air duct to feed the water back into the tank through the recovery passage from the second position or the washing tub to circulate the water. The washer-dryer further comprises control means which control the pump so as to circulate a smaller amount of water through the tank water circulation passage in a first half of the drying program and circulate a greater amount of water through the tank water circulation passage in a second half of the drying program.

[0007] In view of this situation, an object underlying the present invention is to provide a washer-dryer with improved process air cooling that allows reducing tap water consumption, as well as a process for operating said washer-dryer.

[0008] In accordance with the present invention, this object is achieved by a washer-dryer and a process for operating a washer-dryer with the features of the respective independent claim. Preferred and facultative embodiments of the invention are detailed in the respective dependent claims. Preferred and facultative embodiments of the washer-dryer correspond to preferred and facultative embodiments of the process, even if they are not referred to herein in detail.

[0009] The invention thus relates to a washer-dryer comprising a tub and a drum rotatably mounted inside the tub, a process air circuit, adapted to circulate process air through the drum for drying laundry, comprising a fan and a heater, a cooling water circuit in contact with the process air circuit, a pump, a condenser, and a control unit, whereby the cooling water circuit is in heat exchanging contact with at least one cooling means which is adapted to cool the cooling water.

[0010] In a washer-dryer, a condenser generally

serves to cool and dehumidify the hot and humid process air during a drying program. Therefore, a condenser is usually disposed in the process air circuit downstream the tub, where the process air reaching the condenser has already taken up moisture from the laundry to be dried. In order to circulate the hot and dry process air back into the tub, the moisture has to be removed first. In a condenser this is generally achieved by applying a refrigerant to induce condensation, whereby condensation is triggered by bringing the refrigerant in heat exchanging contact, direct or indirect, with the process air. In the present invention the refrigerant is an aqueous liquid, in particular water. As a consequence of removing heat from the process air, the cooling water is heated up. In order to ensure a good and sufficient cooling efficiency, the cooling water thus has to be cooled itself before it is circulated into the condenser again. The cooling of the cooling water might in principle be achieved by a simple heat exchange (natural cooling) with the surrounding through natural convection, conduction or radiation. However, in the present invention cooling means are used. The kind of cooling which may thus be achieved might also be termed "active cooling" versus "natural cooling".

[0011] The cooling water circuit therefore comprises at least one cooling means. The cooling means are not limited according to the present invention as long as an active cooling can be achieved. Cooling can be actively induced or naturally take place. In a preferred embodiment of the present invention, however, the at least one cooling means in the cooling water circuit is preferably selected from a group comprising at least one heat exchanger, a cooling air fan and a water supply access. The heat exchanger is preferably an air-air heat exchanger. In this case the cooling air can be circulated in the heat exchanger also with the help of a cooling air fan.

[0012] Preferably, the at least one cooling means is selected from a group consisting of a heat exchanger, a cooling air fan and a tap water supply.

[0013] In a preferred embodiment the cooling water circuit comprises a heat exchanger. Technically, the type of heat exchanger used is not limited as long as it serves to cool the cooling water in the cooling water circuit. However, preferably the heat exchanger is an air/water heat exchanger, wherein the cooling air is provided by a cooling air fan. The control unit is then adapted to steer the cooling air fan. Preferably, specific points, durations and speeds for the cooling air fan to operate during a drying program are stored in the control unit.

[0014] When the cooling water passes through the air/water heat exchanger, the flow of cooling air comes into contact with the cooling water circuit removing heat from the cooling water. Preferably, the air/water heat exchanger is therefore disposed downstream the condenser outlet in the cooling water circuit. More preferably, the heat exchanger is also disposed close to the outer wall of the washer-dryer housing. In this way, natural cooling may additionally occur. Even more preferably, the cooling

water circuit may comprise two or more heat exchangers.

[0015] In another preferred embodiment, the cooling water circuit comprises a tap water supply. One way to realize the tap water supply may be the connection of the cooling water circuit to a tap water supply via a valve that can be operated by the control unit. Preferably, in order to cool the cooling water inside the cooling water circuit, the control unit is adapted to mix fresh tap water via a respective water supply access into the cooling water. More preferably, specific points and durations for mixing fresh water into the cooling water during a drying operation can be stored in the control unit. For this purpose, the cooling water circuit may additionally be connected to a drain to prevent overflow.

[0016] In an even more preferred embodiment, the washer-dryer comprises two cooling means, preferably a heat exchanger and a tap water supply access. Preferably, if the amount of cooling provided by one cooling means is not sufficient to let the temperature of the cooling water fall below the threshold value $T_{W,max}$, the control unit is adapted to operate the second cooling means in addition.

[0017] In a preferred embodiment of the washer-dryer, the cooling water circuit comprises a tank. The term "tank" means here especially a container with a larger internal cross-section than the tubing that is usually used within the cooling water circuit. Preferably, the cross-section in a tank used is at least five times larger than the cross-section of any tubing used within the cooling air circuit. The tank serves the purpose to increase the volume of the cooling water in the cooling water circuit and therefore to slow down its temperature increase in cases with insufficient cooling. The dimensions of the tank are not limited in the present invention. Accordingly, the tank may be small, e.g. even just a part of the cooling water circuit that is enlarged in its diameter. The tank may also be of a medium or large size. However, the size of the tank is usually determined by the design and desired technical abilities of the washer-dryer. If the tank is arranged close to an outer wall of the housing of the washer-dryer, natural cooling of the water inside may occur. This heat exchange may increase the time needed for the cooling water to heat up during a drying program and thus serves to enhance the cooling efficiency of the cooling water circuit.

[0018] If a tank is used, the tank preferably comprises cooling fins on an outer surface thereof. In this manner the heat exchange with the surrounding is improved such that a more effective cooling of the cooling water in the cooling water circuit can be achieved. Preferably, the cooling fins are then provided on a part of the surface that is closest to the outer wall of the washer-dryer housing. Cooling fins in general serve to increase the efficiency of natural convection cooling by providing a larger surface area and by inducing a flow direction of air. Hence, the amount of natural cooling of the water inside the tank may be increased even further by the provision of cooling fins.

[0019] If a tank is used, the circulation of the cooling water might be driven or at least assisted by natural convection in that a cold aqueous liquid has usually a higher density than a comparably warm aqueous liquid. In such an embodiment the warmed up cooling water is usually introduced in an upper part of the tank. The more the cooling water is then cooled, the more it flows downward in the direction of the condenser. This process might be assisted by a suitable internal structure in the tank. Namely, the tank might comprise inside a plurality of plane parts. These plane parts may be fixed to the walls of the tank as such that a horizontal layer structure is created along which the cooling water is forced to flow.

[0020] In a preferred embodiment of the washer-dryer, the tank thus comprises at the top an inlet for warmed up cooling water, such that natural convection cooling can drive or assist the circulation of the cooling water along the flow direction from the inlet of the tank.

[0021] Even more preferably, a cooling means is positioned at the cooling water inlet of the tank, i.e. where the temperature of the cooling water is often the highest. In any way, the cooling water circuit might perhaps be run in this embodiment without having to operate a pump therein. At least the power consumption of the pump could be reduced.

[0022] In a preferred embodiment, the washer-dryer comprises a washing liquor recirculation system and the pump is connected to both the cooling water circuit and the washing liquor recirculation system such that the pump can be operated by the control unit to circulate an aqueous liquid either in the cooling water circuit or in the washing liquor recirculation system. To this end, a suitable three-way valve may be placed in the recirculation system.

[0023] The control unit may then additionally be adapted to operate the pump and fill the cooling water circuit with washing liquor, or more suitably cleaner rinsing liquid from a last rinsing step, prior to the start of a drying program. Accordingly, the rinsing liquid which is usually water containing only minor amounts of detergent might serve in this embodiment as cooling water. In this way, water used for washing and/or rinsing the laundry can be reused. This allows reducing the overall water consumption of the washer-dryer even further.

[0024] In a further preferred embodiment, the cooling water circuit further comprises a water supply valve which can connect the cooling water circuit and the tap water supply and which is controlled by the control unit. This embodiment is especially useful if the temperature of the cooling water becomes too high despite the use of other cooling means, such that the use of other cooling means is insufficient.

[0025] In order to allow a more efficient operation of the washer-dryer, the washer-dryer comprises preferably a first temperature sensor in the cooling water circuit for measuring the temperature T_W of the cooling water. Preferably, a relationship between the temperature T_W of the cooling water and a flow rate of the pump and/or a cooling

power of the cooling means is in this case stored in the control unit and the control unit is adapted to control the flow rate of the pump and/or the cooling power of the cooling means based on this relationship. Most preferably, the optional first temperature sensor is positioned at the cooling water inlet of the condenser, but other positions are also possible.

[0026] It is moreover preferred that a maximum threshold value $T_{W,max}$ for the cooling water in the cooling water circuit is stored in the control unit and the control unit is adapted to operate the pump and/or the at least one cooling means, in general by increasing their power, until the temperature T_W of the cooling water falls below $T_{W,max}$. The type of temperature sensor used is not limited. However, the first temperature sensor is most preferably a NTC temperature sensor.

[0027] In another preferred embodiment, the washer-dryer comprises a second temperature sensor in the process air circuit to measure the temperature T_P of the process air and the control unit is adapted to operate the pump in the cooling water circuit and/or the cooling means when the temperature T_P has reached a set minimum threshold value $T_{P,min}$. The type of this temperature sensor is also not limited. However, the second temperature sensor is most preferably also a NTC sensor. It is usually disadvantageous to cool the process air during the heating up phase, as this would prolong this phase and hence the whole drying program. Preferably, a minimum threshold value $T_{P,min}$ is thus stored in the control unit. Once the second temperature sensor detects that the temperature of the process air has reached the threshold value $T_{P,min}$, the control unit is adapted to for example operate the pump in the cooling water circuit to pump cooling water through the cooling water circuit and to cool the process air inside the condenser. It is furthermore preferable, that a maximum threshold value $T_{P,max}$ is stored in the control unit. Once the second temperature sensor detects that the temperature T_P of the process air has risen above $T_{P,max}$, the control unit is adapted to increase the pump speed and consequently the flow rate of the cooling water in the cooling water circuit and/or to operate the at least one cooling means.

[0028] In a further embodiment of the washer-dryer, the cooling water circuit is a closed cooling circuit wherein the cooling water does not come into direct contact with the process air in the condenser in the process air circuit. In this embodiment, a cooling circuit pump is provided preferably in the closed cooling water circuit. To this end, the washer-dryer can be provided with a second pump. It is however also possible to use only one pump, namely the pump that is used in general for pumping the washing and rinsing liquids.

[0029] In this embodiment, preferably the cooling water circuit forms inside the condenser at least one coil serving as cooling coil for process air flowing through the condenser. In an even more preferred embodiment, the cooling water circuit forms several cooling coils inside the condenser. This increases the surface area, across

which the process air flows and is cooled down. Hence the cooling of the process air can be faster and more effective.

[0030] In an alternative embodiment, the cooling water circuit is an open cooling water circuit, wherein the cooling water comes into direct contact with the process air in the condenser. It is then preferred for an efficient heat exchange that the open cooling water circuit comprises a nozzle which is positioned inside the condenser and which allows a direct contact between the cooling water and the process air in the condenser in the process air circuit. Namely, the cooling water, which is lead through the cooling water circuit, can then be sprayed directly into the process air. As a consequence, the process air is directly exposed to the cooling water forming droplets. This way of making contact between the process air and the cooling water circuit is therefore herein denoted as direct contact. Preferably, at the outlet of the condenser the cooling water is collected and redirected into the cooling water circuit. The collecting vessel can be a separate vessel. But more preferably, the cooling water is collected in the tub of the washer-dryer with the tub being a part of the open cooling water circuit.

[0031] The washer-dryer of the present invention can thus be operated in essentially two different ways, in that the cooling water circuit is operated as a closed cooling circuit or as an open cooling circuit. Both principles can however also be combined. Such a combination can be realized in that a part of the tubing of an essentially open cooling water circuit is placed in a manner in the washer-dryer such that a heat transfer between this tubing and the process air circuit is possible.

[0032] The type of condenser used is not limited according to the invention. It can be a separate component or an integrated part of a component of the washer-dryer depending in particular on the type of the cooling water circuit. For example, if the cooling water circuit is an open cooling water circuit, the condenser may be a space behind the tub in which the hot humid process air comes into direct contact with the cooling water, preferably in that the water is sprayed via a nozzle against the flow direction of the hot humid process air. In contrast, in a closed cooling water circuit, the condenser might be a separate unit which might be in close contact with a wall of the tub or which might have a suitably formed surface within the process air circuit to allow an efficient heat exchange between the cooling water and the hot humid process air through the walls of the condenser.

[0033] Generally, a drying operation comprises three phases, a heating up phase, a main drying phase and a cool down phase. During the heating up phase, the temperature T_P of the process air usually increases constantly with time. Once the process air has reached a certain temperature depending on the drying program chosen, the temperature T_P of the process air stays constant and the main drying phase is reached. During the main drying phase most of the moisture is removed from the laundry inside the drum. The main drying phase is followed by a

cool down phase. During the cool down phase only residual moisture has to be removed from the laundry. During the cool down phase the temperature T_P of the process air usually decreases again until the drying program is finished.

[0034] The invention is moreover directed to a process for operating a washer-dryer comprising a tub and a drum rotatably mounted inside the tub, a process air circuit, adapted to circulate process air through the drum for drying laundry, comprising a fan and a heater, a cooling water circuit in contact with the process air circuit, a pump, a condenser, and a control unit, wherein the cooling water circuit is in heat exchanging contact with at least one cooling means which is adapted to cool the cooling water, whereby the process comprises the following steps:

- (b) starting a drying program;
- (d) pumping cooling water through the cooling water circuit, so as to cool and dehumidify the process air inside the condenser;
- (e) cooling of the cooling water inside the cooling water circuit by the at least one cooling means.

[0035] In a preferred embodiment, the washer-dryer comprises a washing liquor recirculation system, wherein the pump is connected to both the cooling water circuit and the washing liquor recirculation system. In a then preferred process, in a step (a) before step (b), aqueous liquid from a rinsing step in the drum is transferred by the pump into the cooling water circuit. In this manner it is possible to use less or no extra water for the cooling water circuit.

[0036] In another preferred embodiment, the washer-dryer further comprises a second temperature sensor, whereby the first temperature sensor is positioned in the process air circuit. Preferably the process then further comprises a step (c) measuring the temperature T_P of the process air, so as to start pumping cooling water through the cooling water circuit upon reaching a minimum threshold value $T_{P,min}$.

[0037] It is also preferred that the process then further comprises a step (f) measuring the temperature T_P of the process air, so as to increase the pump speed and/or to increase the cooling of the cooling water by operating the at least one cooling means upon reaching a maximum threshold value $T_{P,max}$.

[0038] In another preferred embodiment, the washer-dryer further comprises a first temperature sensor, whereby the first temperature sensor is positioned in the cooling water circuit. Preferably, step (d) of the process is then modified by measuring the temperature T_W of the cooling water in the cooling water circuit, so as to operate and/or increase the cooling of the cooling water in the cooling water circuit by operating the at least one cooling means upon reaching a maximum threshold value $T_{W,max}$ until the temperature T_W falls below $T_{W,max}$.

[0039] In general, how the increase in the operation of

the at least one cooling means is realized, will depend on the type of cooling means applied in the cooling water circuit.

[0040] In a preferred embodiment, the at least one cooling means in the cooling water circuit is an air/water heat exchanger, wherein the cooling air is provided by a cooling air fan. Accordingly, an increase in the operation of the heat exchanger would be to increase the speed of the cooling fan.

[0041] In another preferred embodiment, the at least one cooling means in the cooling water circuit is a tap water supply, wherein an operation corresponds to a mixing of water from the tap water supply with the cooling water in the cooling water circuit. Accordingly, an increase in the operation of the tap water supply would mean to increase the amount of water from the tap supply to be mixed with the cooling water.

[0042] The invention has numerous advantages. Compared to commercially available water-cooled washer-dryers, the fresh water consumption is significantly reduced in the present invention due to the implementation of a cooling water circuit. Heated up cooling water is not discarded at the outlet of the condenser. Nevertheless, an efficient cooling of the process air can be achieved through the use of cooling means for the cooling water circuit. These advantages can be achieved in embodiments in an easy manner. For example, if the washer-dryer according to embodiments of the invention comprises an aqueous liquor recirculation system, fresh water consumption can even be lower while at the same time a part of the recirculation system can be used for the cooling water circuit. If the washer-dryer according to further embodiments of the invention comprises a first temperature sensor measuring the temperature of the cooling water, the operation of the at least one cooling means can be adapted such that a drying program can be carried out efficiently with a reduced overall energy consumption. If the washer-dryer according to even further embodiments of the invention comprises a second temperature sensor measuring the temperature of the process air, the cooling of the process air can additionally be tailored to each drying phase, which allows streamlining the drying program further in terms of drying speed, water and energy consumption.

[0043] The invention will be described below by referring to Figures 1 to 4 of the attached drawing. The Figures show washer-dryers according to four specific embodiments of the present invention. Other embodiments are conceivable.

Fig. 1 shows a cross-section of a washer-dryer according to a first embodiment which contains an open cooling water circuit and a washing liquor recirculation system between which the operation may be switched, and a tap water supply as cooling means.

Fig. 2 shows a cross-section of a washer-dryer ac-

cording to a second embodiment which contains an open cooling water circuit and as cooling means therein a heat exchanger and a tap water supply.

Fig. 3 shows a cross-section of a washer-dryer according to a third embodiment which contains an open cooling water circuit and as cooling means for the cooling water a heat exchanger, a tap water supply and a tank provided with fins on an outer surface.

Fig. 4 shows a cross-section of a washer-dryer according to a fourth embodiment which contains a closed cooling water circuit and as cooling means for the cooling water a heat exchanger and a tap water supply.

[0044] Fig. 1 shows a cross-section of a washer-dryer 1 according to a first embodiment which contains an open cooling water circuit 11 and a washing liquor recirculation system 26 between which the operation may be switched by means of a three-way valve 25, and a tap water supply 16 as cooling means. The washer-dryer 1 depicts a housing 2, a tub 8 and a drum 7, which is mounted inside the tub 8 such that it can be rotated around a horizontal axis. Laundry items to be treated (not shown in Fig. 1) can be placed in the drum 7 via the door 3. The operation of washer-dryer 1 is controlled by means of a control unit 23.

[0045] The tub 8 is connected to a pump 10, which allows discharging an aqueous liquid 9, e.g. lye, out of the tub 8. The pump 10 is connected via a three-way valve 12 to the cooling water circuit 11 and to a drain 13, so as to pump the aqueous liquid 9 from the tub 8 via the valve 12 either into the cooling water circuit 11 or into the drain 13 and out of the washer-dryer 1.

[0046] The tub 8 is furthermore connected to a process air circuit 4, which allows process air to flow into the tub 8 and through the drum 7. A fan (process air fan) 6 is positioned in the process air circuit 4 to generate the air flow. A heater 5 is positioned in the process air circuit 4 before the entry of the process air into the tub 8 to heat the process air. Having passed through tub 8 and drum 7, the process air circuit 4 directs the process air into a condenser 17 which is here a space in the process air circuit 4 behind the tub 8.

[0047] The process air leaving the drum 7 is hot and humid. Inside the condenser 17 condensation is triggered via cooling. In this not limiting embodiment a nozzle 15 is arranged inside the condenser 17. The nozzle 15 is part of the cooling water circuit 11. Cooling water is pumped via the pump 10 through the cooling water circuit 11 and sprayed into the condenser 17 via the nozzle 15. Inside the condenser 17 the cooling water droplets induce condensation of the moisture taken up by the process air when in contact with the wet laundry inside the drum 7. The process air is hence dehumidified and cooled. In this not limiting embodiment the cooling water

circuit 11 is thus an open circuit wherein the cooling water is brought into direct contact with the process air inside the condenser 17.

[0048] At the condenser 21 outlet the cooling water is collected in the tub 8 from where it can be circulated again within the cooling water circuit 11 via pump 10. The flow direction of the cooling water in Figure 1 is indicated by the dashed arrows while the flow of the process air is indicated by simple arrows.

[0049] The cooling water circuit 11 comprises an access to a tap water supply 16 as cooling means. Tap water can be mixed into the cooling water circuit 11 via valve 14, wherein valve 14 is controlled by the control unit 23 of the washer-dryer 1 and opened and closed on demand. Preferably, specific points and durations for the valve 14 to be opened during a drying program are stored in the control unit 23.

[0050] In the embodiment shown in Fig. 1 a first temperature sensor 22 is located in the cooling water circuit 11 and a second temperature sensor 24 is located in the process air circuit 4. In this embodiment it is thus possible to have the control unit 23 open valve 14, if the temperature T_W of the cooling water exceeds a stored maximum threshold value $T_{W,max}$ for the cooling water. Likewise the operation of the pump 10 and the valve 14 can be controlled by the control unit 23 in response to temperature signals of the second temperature sensor 24. I.e., if the temperature T_T is too low, pump 10 and valve 14 are not operated. In embodiments, their operation can be adapted to the temperature T_P of the process air and thus to different stages in a drying program.

[0051] In conformity with the above description, the aqueous liquid 9 can be either a washing liquor (lye), rinse water or cooling water.

[0052] The washer-dryers 1 according to the second to fourth embodiments presented in Figures 2 to 4 depict to some extent the same components as the washer-dryer 1 of the first embodiment presented in Figure 1. These components will therefore not be explained again in the following. Instead, the differences between these not limiting embodiments and the first embodiment will be described in particular in the following.

[0053] Fig. 2 shows a cross-section of a washer-dryer 1 according to a second embodiment which contains an open cooling water circuit 11 and as cooling means therein a heat exchanger 18 and a tap water supply 16.

[0054] The cooling water circuit 11 of the washer-dryer 1 presented in Figure 2 comprises additionally a heat exchanger 18 as cooling means. In this non-limiting embodiment the heat exchanger 18 is positioned downstream the condenser outlet 21. The heat exchanger 18 is here an air/water heat exchanger comprising a cooling air fan (not shown here) that can be operated by the control unit 23 of the washer-dryer 1. The type of the heat exchanger can however be different. Cooling water that passes through the heat exchanger 18 is cooled by cooling air provided by the cooling air fan. The flow rate of the cooling air determines the amount of cooling and can

be steered via the rotational speed of the cooling air fan. Preferably, specific points, durations and speeds for the cooling air fan to operate during a drying program are stored in the control unit 23.

[0055] Similar to the first embodiment shown in Fig. 1, the washer-dryer of the second embodiment contains a first temperature sensor 22 which is located in the cooling water circuit 11 and a second temperature sensor 24 which is located in the process air circuit 4. Also in this embodiment it is thus possible for the control unit 23 to control valve 14 and to open it especially, if the temperature T_W of the cooling water exceeds a stored maximum threshold value $T_{W,max}$ for the cooling water. Likewise the operation of the pump 10 and the valve 14 can be controlled by the control unit 23 in response to temperature signals of the second temperature sensor 24. I.e., if the temperature T_P is too low, pump 10 and valve 14 are not operated. In embodiments, their operation can be adapted to the temperature T_P of the process air and thus to different stages in a drying program. Also here, the aqueous liquid 9 can be either a washing liquor (lye), rinse water or cooling water.

[0056] Fig. 3 shows a cross-section of a washer-dryer 1 according to a third embodiment which contains an open cooling water circuit 11 and as cooling means for the cooling water a heat exchanger 18, a tap water supply 16 and a tank 19 provided with cooling fins 20 on an outer surface thereof.

[0057] The cooling water circuit 11 of the washer-dryer 1 presented in Figure 3 thus comprises additionally a tank 19, which is positioned downstream the heat exchanger 18. To improve natural cooling of the cooling water through the walls of the tank 19, the surface of the tank 19 that is close to the outer wall of the housing 2 of the washer-dryer 1 comprises cooling fins 20. These cooling fins 20 serve to increase the surface area of the tank 19 and to induce a flow direction of air on the surface of the tank 19, thus enhancing the cooling effect.

[0058] Tank 19 serves in particular as cooling water reservoir in the cooling water circuit 11 increasing the overall volume of the cooling water circuit 11. In doing so, the cooling water is naturally cooled already in tank 19 slowing down the rate of heating up when the cooling water passes through the condenser 17. This may aid to reduce the overall energy consumption of a drying program as the other cooling means 16, 18 can be applied at a later stage.

[0059] Fig. 4 shows a cross-section of a washer-dryer 1 according to a fourth embodiment which contains a closed cooling water circuit 28 and as cooling means for the cooling water a heat exchanger 18 and a tap water supply 16.

[0060] In the fourth embodiment the cooling water thus does not come into direct contact with the process air in process air circuit 4. Accordingly, the cooling water is not collected in the condenser outlet 21 and circulated by the first pump 10. Instead, a cooling water circuit pump 27 is located as a second pump in the cooling water circuit

28.

[0061] In Fig. 4 a recirculation system 26 for washing liquor is only shown partially. It is shown here especially that the tap water supply 16 can be connected to both the recirculation system 26 and the closed cooling water circuit 28. Accordingly, Fig. 4 illustrates as to how tap water may be introduced into the tub 8.

Reference Numerals

[0062]

- | | | |
|----|---|--|
| 1 | washer-dryer | |
| 2 | housing | |
| 3 | door | |
| 4 | process air circuit | |
| 5 | heater | |
| 6 | fan | |
| 7 | drum | |
| 8 | tub | |
| 9 | aqueous liquid; for example washing liquid or cooling water | |
| 10 | pump, first pump | |
| 11 | open cooling water circuit (dashed arrows indicate direction of flow) | |
| 12 | valve in drain | |
| 13 | drain (for washing liquid, condensed water) | |
| 14 | valve to water supply | |
| 15 | nozzle | |
| 16 | tap water supply | |
| 17 | condenser | |
| 18 | heat exchanger in the cooling water circuit | |
| 19 | tank | |
| 20 | cooling fins | |
| 21 | condenser outlet | |
| 22 | cooling circuit temperature sensor; first temperature sensor | |
| 23 | control unit | |
| 24 | process air circuit temperature sensor; second temperature sensor | |
| 25 | three-way-valve (for switching between recirculation circuit and cooling water circuit) | |
| 26 | (washing liquor, aqueous liquid) recirculation circuit | |
| 27 | pump in cooling water circuit, second pump, cooling circuit pump | |
| 28 | closed cooling water circuit | |

Claims

1. Washer-dryer (1) comprising a tub (8) and a drum (7) rotatably mounted inside the tub (8), a process air circuit (4), adapted to circulate process air through the drum (7) for drying laundry, comprising a fan (6) and a heater (5), a cooling water circuit (11,28) in contact with the process air circuit (4), a pump (10), a condenser (17), and a control unit (23), **characterized in that**

the cooling water circuit (11,28) is in heat exchanging contact with at least one cooling means (16,18) which is adapted to cool the cooling water.

2. Washer-dryer (1) according to claim 1, **characterized in that** said at least one cooling means (16,18) is selected from a group consisting of a heat exchanger (18), a cooling air fan and a tap water supply (16).
3. Washer-dryer (1) according to any of the aforementioned claims, **characterized in that** the cooling water circuit (11,28) comprises a tank (19).
4. Washer-dryer (1) according to claim 3, **characterized in that** the tank (19) comprises cooling fins (20) on an outer surface thereof.
5. Washer-dryer (1) according to claim 3 or 4, **characterized in that** the tank (19) comprises at the top an inlet for warmed up cooling water, such that natural convection cooling can drive or assist the circulation of the cooling water along the flow direction from the inlet of the tank (19).
6. Washer-dryer (1) according to any of the aforementioned claims, **characterized in that** the washer-dryer (1) comprises a washing liquor recirculation system (26) and the pump (10) is connected to both the cooling water circuit (11) and the washing liquor recirculation system (26) such that the pump (10) can be operated by the control unit (23) to circulate an aqueous liquid either in the cooling water circuit (11) or in the washing liquor recirculation system (26).
7. Washer-dryer (1) according to any of the aforementioned claims, **characterized in that** the cooling water circuit (11,28) further comprises a water supply valve (14) which can connect the cooling water circuit (11,28) and the tap water supply (16) and which is controlled by the control unit (23).
8. Washer-dryer (1) according to any of the aforementioned claims, **characterized in that** the washer-dryer (1) comprises a first temperature sensor (22) in the cooling water circuit (11) for measuring the temperature T_W of the cooling water.

9. Washer-dryer (1) according to claim 8, **characterized in that** a relationship between the temperature T_W of the cooling water and a flow rate of the pump (10,27) and/or a cooling power of the cooling means (16,18) is stored in the control unit (23) and the control unit (23) is adapted to control the flow rate of the pump (10,27) and/or the cooling power of the cooling means (16,18) based on this relationship.

10. Washer-dryer (1) according to claim 8 or 9, **characterized in that** a maximum threshold value $T_{W,max}$ for the cooling water in the cooling water circuit (11,18) is stored in the control unit (23) and wherein the control unit (23) is adapted to operate the pump (16,18) and/or the at least one cooling means (16, 18) until the temperature T_W of the cooling water falls below $T_{W,max}$.
11. Washer-dryer (1) according to any of the aforementioned claims, **characterized in that** the washer-dryer (1) comprises a second temperature sensor (24) in the process air circuit (4) to measure the temperature T_P of the process air and the control unit (23) is adapted to operate the pump (10,27) in the cooling water circuit (11,28) and/or the cooling means (16,18) when the temperature T_P has reached a set minimum threshold value $T_{P,min}$.
12. Washer-dryer (1) according to any of the aforementioned claims, **characterized in that** the cooling water circuit (11,28) is a closed cooling circuit (28) wherein the cooling water does not come into direct contact with the process air in the condenser (17) in the process air circuit (4).
13. Washer-dryer (1) according to claim 11, wherein a cooling circuit pump (27) is provided in the closed cooling water circuit (28).
14. Washer-dryer (1) according to any of claims 1 to 11, **characterized in that** the cooling water circuit (11) is an open cooling water circuit (18), wherein the cooling water circuit (11) comprises a nozzle (15) which is positioned inside the condenser (17) and which allows a direct contact between the cooling water and the process air in the condenser (17) in the process air circuit (4).
15. A process for operating a washer-dryer (1) comprising a tub (8) and a drum (7) rotatably mounted inside the tub (8), a process air circuit (4), adapted to circulate process air through the drum (7) for drying laundry, comprising a fan (6) and a heater (5), a cooling water circuit (11,28) in contact with the process air circuit (4), a pump (10,27), a condenser (17), and a control unit (23), wherein the cooling water circuit (11,28) is in heat exchanging contact with at least one cooling means (16,18) which is adapted to cool the cooling water,
- characterized in that** the process comprises the following steps:
- (b) starting a drying program;
 - (c) pumping cooling water through the cooling water circuit (11,28), so as to cool and dehumidify the process air inside the condenser (17); and
 - (d) cooling of the cooling water inside the cooling
- water circuit (11) by at least one cooling means (16, 18).
16. Process according to claim 15, **characterized in that** in a step (a) before step (b) aqueous liquid from a rinsing step in the drum (7) is transferred by the pump (10) into the cooling water circuit (11).

Fig. 1

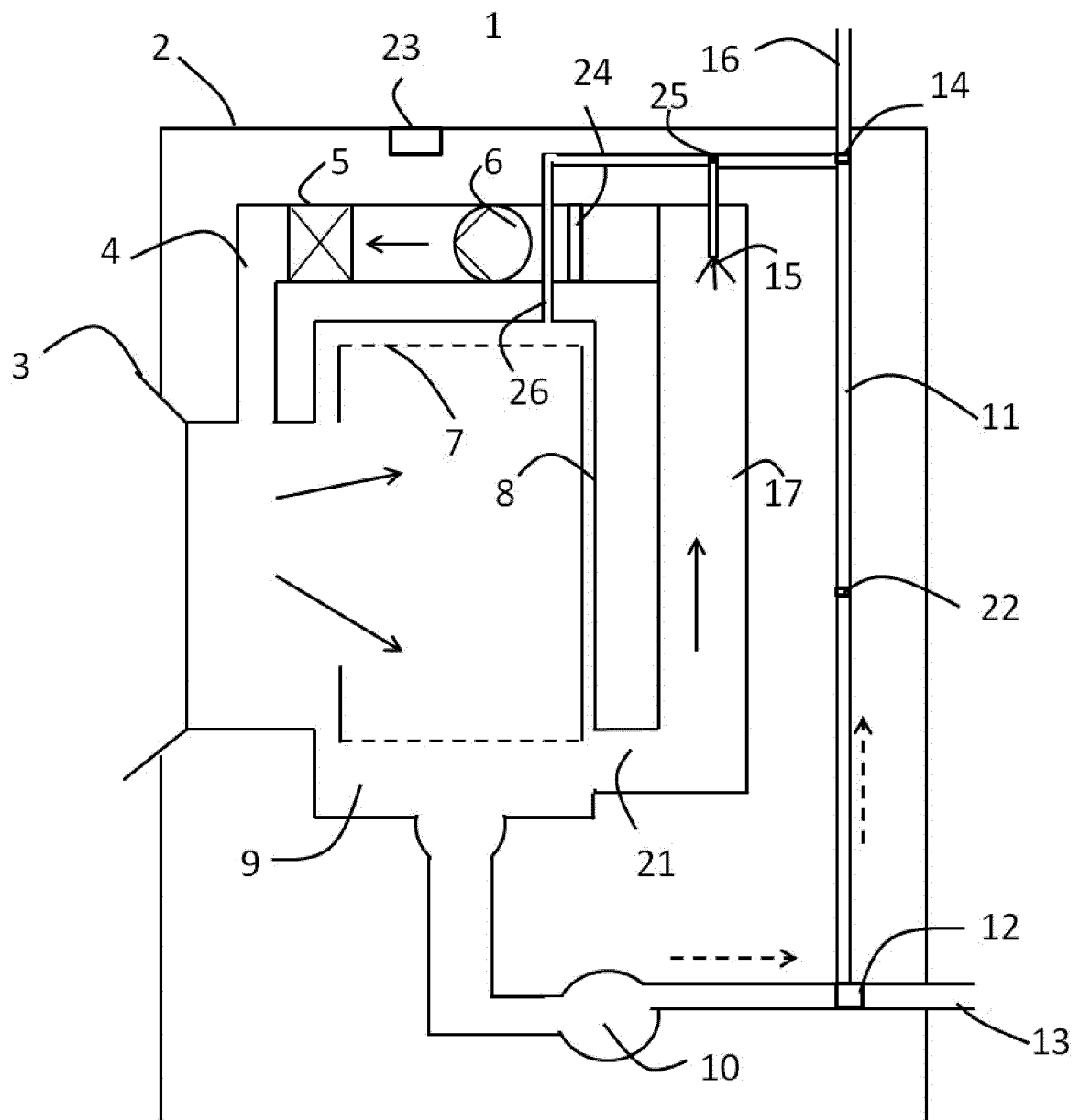


Fig. 2

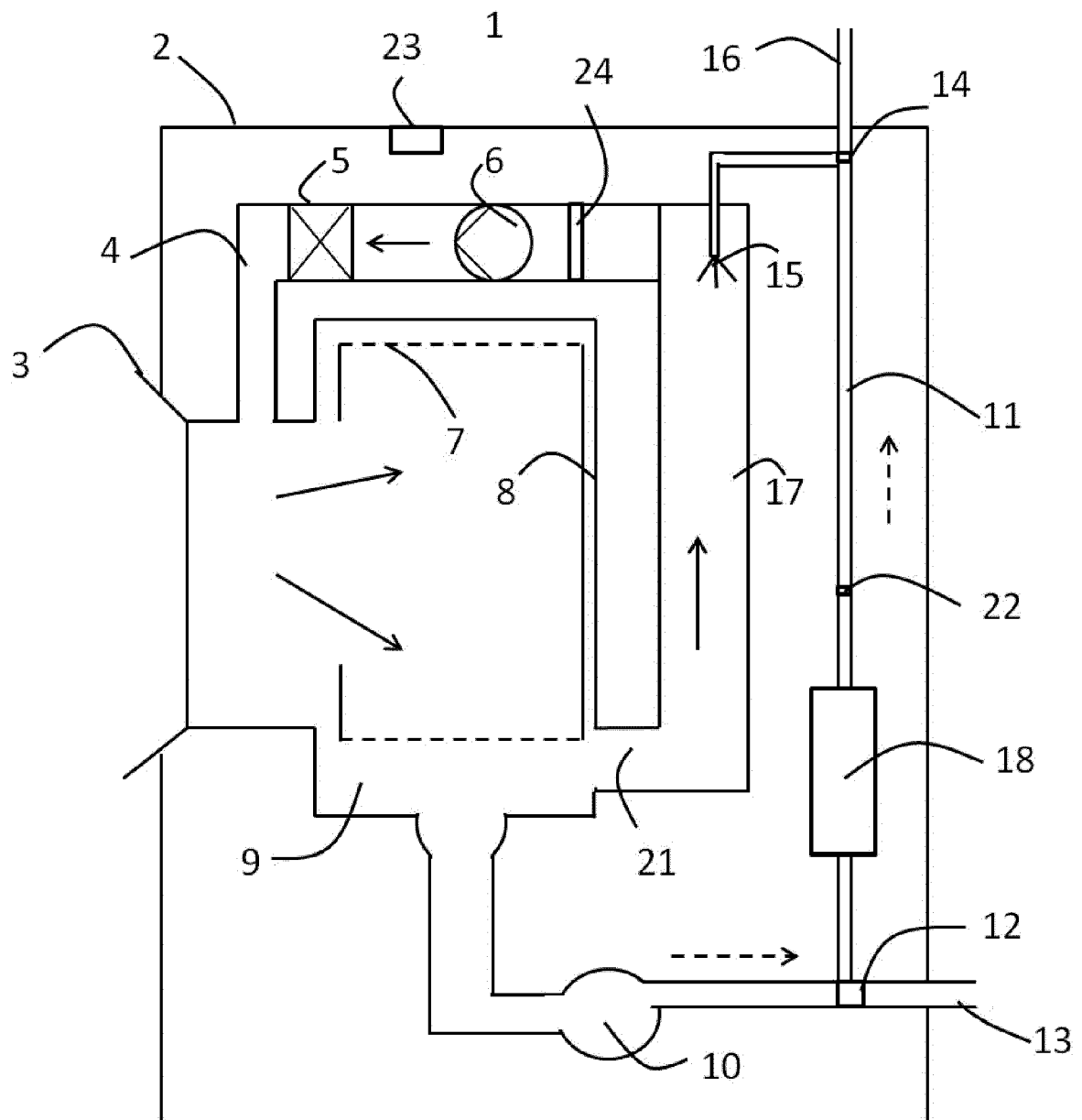


Fig. 3

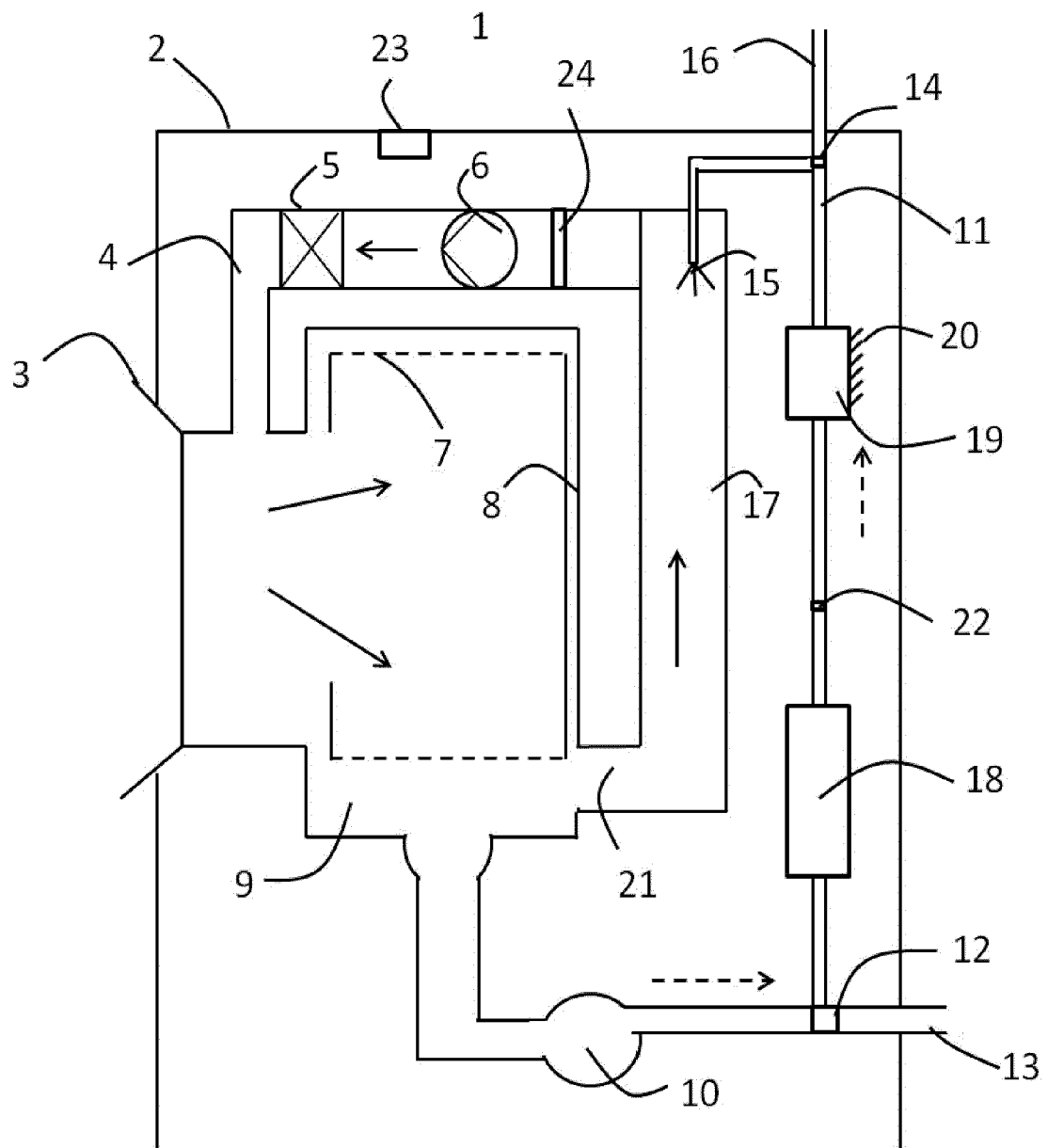
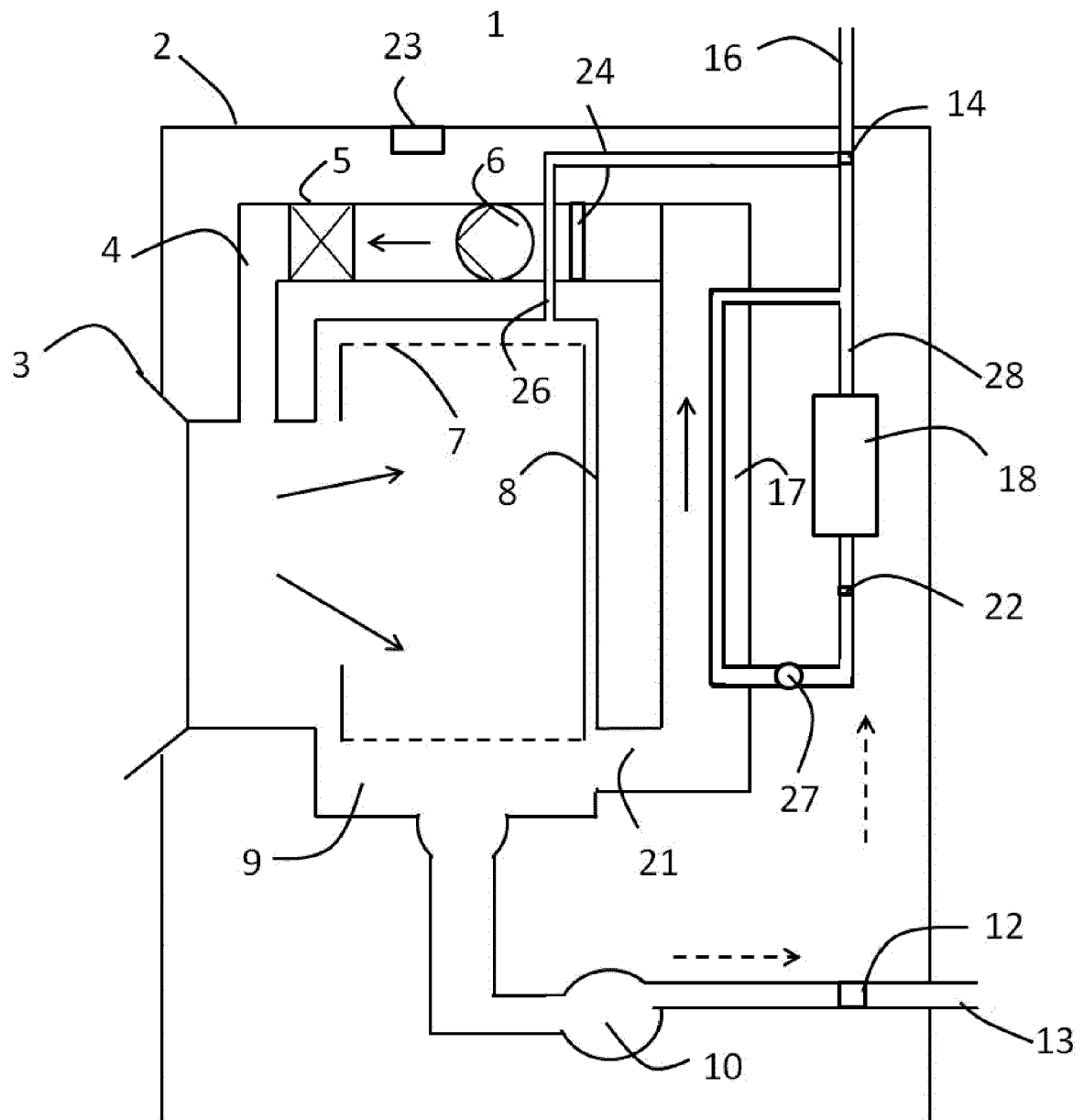


Fig. 4





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Place of search Munich		Date of completion of the search 31 March 2016	Examiner Kirner, Katharina
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