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(54) **Washer-dryer machine**

(57) Washer-dryer machine (1) comprising a chamber (10) for receiving goods, an air circuit (90) configured to circulate air through the chamber (10), and a heat pump system (20) comprising:

- a first heat exchanger (22), a second heat exchanger (24) and a compressor (26) that form a first refrigerant circuit (27) configured to circulate a refrigerant, the first heat exchanger (22) being configured to cool said refrigerant and to heat the air in said air circuit (90), the second heat exchanger (24) being configured to heat said refrigerant and to dehumidify the air in said circuit,
- a third heat exchanger (25) arranged outside the air circuit (90), the third heat exchanger (25) forming with the first heat exchanger (22) and the compressor (26) a second refrigerant circuit (28) configured to circulate said refrigerant bypassing said second heat exchanger (24), the third heat exchanger (25) being configured to heat said refrigerant, and
- a switching element (23) configured to selectively circulate said refrigerant into the first refrigerant circuit (27), during a drying cycle of the washer-dryer machine (1), and into the second refrigerant circuit (28), during a washing cycle of the washer-dryer machine (1) wherein air in said air circuit (90) is heated by the first heat exchanger (22).

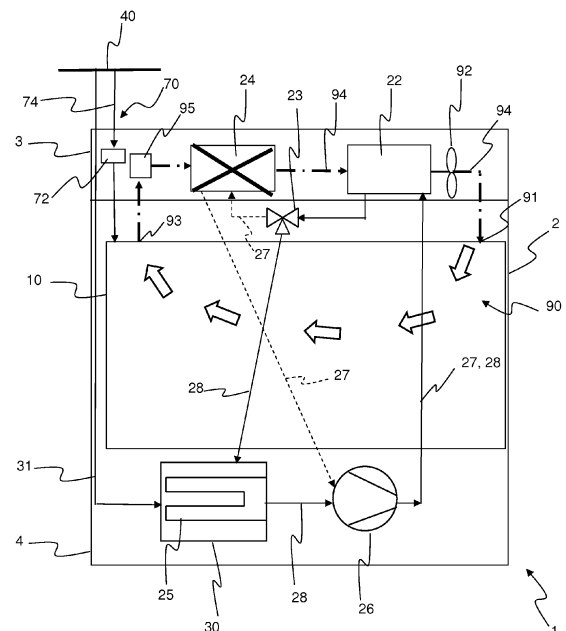


Fig. 5

Description

[0001] The present invention relates to a washer-dryer machine for washing and drying goods.

[0002] In a washer-dryer machine, washing cycles are performed, wherein goods are washed and rinsed in a chamber, and drying cycles are performed wherein the goods in the chamber are dried.

[0003] During a drying cycle, it is known to re-circulate heated air through the chamber along an air circuit wherein the heated air is conveyed into the chamber, moisture-laden air from the chamber is cooled and dehumidified and then heated again before being conveyed back into the chamber.

[0004] US 2010/0107703 discloses a drum-type washer-dryer provided with a heat pump for drying laundry. The washer-dryer comprises a water tub with a warm air inlet and a warm air outlet and an airflow duct communicating the warm air inlet and the warm air outlet. The heat pump comprises an evaporator and a condenser and a compressor. The air is re-circulated inside the water tub through the airflow duct by means of a blower. The vapour contained in the air supplied to the airflow duct from the water tub is cooled and dehumidified by the evaporator. The dehumidified air is heated by the condenser and subsequently supplied into the water tub as warm air.

[0005] The Applicant observes that this document does not provide any detail about the washing cycles of the washer-dryer.

[0006] It is an object of the invention to provide an alternative washer-dryer machine with a heat pump system.

[0007] It is another object of the invention to provide a washing-dryer machine with a heat pump system, which has enhanced performance.

[0008] It is a further object of the invention to provide a washer-dryer machine with a heat pump system wherein the washing cycles and the drying cycles are efficiently performed with reduced power consumption.

[0009] It is another object of the invention to provide a washer-dryer machine with a heat pump system, which has an improved design and construction.

[0010] The Applicant found that the above objects are achieved by a washer-dryer machine comprising a chamber for receiving goods, an air circuit for circulating air inside the chamber and a heat pump system comprising: a compressor, a first heat exchanger for heating the air that flows into the chamber and a second heat exchanger for dehumidifying and cooling the air that comes from the chamber, during a drying cycle of the machine. The heat pump system further comprises a third heat exchanger placed outside said air circuit and configured to be used in cooperation with said compressor and said first heat exchanger, bypassing the second heat exchanger, for heating the air that flows into the chamber during a washing cycle of the machine.

[0011] Indeed, the Applicant found that executing the washing cycles of the machine by exploiting the air cir-

ulation circuit and part of the heat pump elements used for executing the drying cycles (that is the first heat exchanger and the compressor) enables the washer-dryer machine to perform the washing and drying cycles with reduced power consumption, limited size and simplified structure. This is advantageous in terms of costs, design and construction of the machine.

[0012] Furthermore, the use -during a washing cycle of the machine- of a third heat exchanger, which is placed outside the air circuit and within a second refrigerant circuit that bypasses the second heat exchanger, prevents the air flowing towards the chamber from being cooled and dehumidified either by the second heat exchanger or by the third heat exchanger during washing cycles of the machine wherein goods have to be wetted and not dried.

[0013] In fact, as in the second refrigerant circuit the refrigerant bypasses the second heat exchanger, the second heat exchanger is inactive during the washing cycle. Therefore, even if it is thermally coupled with the air circuit, it is inert on (that is, it does not exchange heat with) the air re-circulating in the air circuit. On the other hand, the third heat exchanger, even if active during the washing cycle, it is outside the air circuit so that it is inert too on the air re-circulating in the air circuit.

[0014] This advantageously avoids that during a washing cycle - wherein wet goods in the chamber have to be heated - the heating efficiency is reduced by a cooling/dehumidifying action performed by the second heat exchanger and/or the third heat exchanger on the air injected into the chamber.

[0015] Enhanced performances of the washer-dryer machine both in washing cycles and drying cycles are thus guaranteed.

[0016] Accordingly, in a first aspect the present invention relates to a washer-dryer machine comprising:

- a chamber for receiving goods,
- an air circuit configured to circulate air through the chamber,
- a heat pump system comprising a first heat exchanger, a second heat exchanger and a compressor that form a first refrigerant circuit configured to circulate a refrigerant, the first heat exchanger being configured to cool said refrigerant and to heat the air in said air circuit, the second heat exchanger being configured to heat said refrigerant and to dehumidify the air in said circuit, **characterized in that** the heat pump system also comprises:
 - a third heat exchanger arranged outside the air circuit, the third heat exchanger forming with the first heat exchanger and the compressor a second refrigerant circuit configured to circulate said refrigerant so as to bypass said second heat exchanger, the third heat exchanger being configured to heat said

refrigerant, and

- a switching element configured to selectively circulate said refrigerant into the first refrigerant circuit, during a drying cycle of the washer-dryer machine, and into the second refrigerant circuit, during a washing cycle of the washer-dryer machine wherein air in said air circuit is heated by the first heat exchanger.

[0017] In the present disclosure, the term "washing cycle" is used to indicate a cycle of a washing program of the washer-dryer machine, including a washing cycle, a pre-washing cycle and a rinsing cycle. In a washing cycle, heated air circulating through the chamber increases the temperature inside the chamber. In this way, the goods in the chamber, preferably wetted by water optionally mixed with washing/rinsing products, are suitably heated up.

[0018] In the present disclosure, the term "drying cycle" is used to indicate a cycle of a drying program of the washer-dryer machine. In a drying cycle, good in the chamber are suitably dried by means of dehumidified and heated air injection into the chamber.

[0019] Preferably, the washer-dryer machine comprises a control unit configured to operate the switching element so that said refrigerant is circulated within the first refrigerant circuit, during the drying cycle of the washer-dryer machine, and within the second refrigerant circuit, during the washing cycle of the washer-dryer machine.

[0020] Suitably, the switching element is arranged downstream of the first heat exchanger and upstream of the second heat exchanger and the third heat exchanger. In the present disclosure, the terms "upstream" and "downstream" are used in relation to the direction of the refrigerant flow inside the first refrigerant circuit and the second refrigerant circuit.

[0021] In an embodiment, the switching element comprises a three-ways valve.

[0022] Preferably, the heat pump system comprises a pressure lowering device upstream of the second heat exchanger and the third heat exchanger. Preferably, the pressure lowering device is downstream of the first heat exchanger.

[0023] The pressure lowering device can comprise an expansion valve or another expansion element, such as a capillary tube.

[0024] In an embodiment, the switching element itself is configured to provide said pressure lowering device.

[0025] When the pressure lowering device is arranged upstream of the switching element or at the switching element, the pressure lowering device can be shared between the first refrigerant circuit and the second refrigerant circuit.

[0026] When the pressure lowering device is arranged downstream of the switching element, the machine preferably comprises two pressure lowering devices respectively arranged in the first refrigerant circuit upstream of the second heat exchanger and in the second refrigerant

circuit upstream of the third heat exchanger.

[0027] The first heat exchanger is thermally coupled with the air circuit. In an embodiment, the first heat exchanger is placed within the air circuit.

[0028] The second heat exchanger is thermally coupled with the air circuit. In an embodiment, the second heat exchanger is placed within the air circuit.

[0029] Preferably, the chamber is positioned downstream of the first heat exchanger and upstream of the second heat exchanger, in relation to the direction of the air flow inside the air circuit.

[0030] The third heat exchanger is arranged outside the air circuit so as to avoid heat exchange with the air circulating along the air circuit towards the chamber.

[0031] In an embodiment, the chamber comprises an air inlet for air supply into the chamber and an air outlet for air exit from the chamber.

[0032] In an embodiment, the air circuit comprises at least one duct fluidly connecting the air inlet and the air outlet of the chamber.

[0033] In an embodiment, the first heat exchanger and the second heat exchanger are placed within said at least one duct.

[0034] In an embodiment, the air circuit comprises a fan operable for propelling the air through said air circuit. Preferably, the fan is configured to propel air into the chamber, from the chamber towards the second heat exchanger, from the second heat exchanger towards the first heat exchanger and from the first heat exchanger back again into the chamber.

[0035] Suitably, the washer-dryer machine comprises a cabinet having a top.

[0036] In an embodiment, the first heat exchanger and the second heat exchanger are arranged in an upper part of the cabinet, between the chamber and a top wall of the top.

[0037] Preferably, the top of the cabinet is configured to match and close from above the cabinet. The top is preferably formed as a ready-to-mount part ready to be mounted onto the cabinet.

[0038] In a preferred embodiment, the top of the cabinet comprises, integrally formed therein, at least part of the air circuit, and seats configured to house the first heat exchanger and the second heat exchanger. As also explained in more detail below, this embodiment advantageously enables to improve the machine assembly.

[0039] Preferably, the air circuit comprises at least one duct integrally formed in the top.

[0040] According to an embodiment, the top of the cabinet also comprises, integrally formed therein, a seat configured to house the switching element.

[0041] Preferably, the third heat exchanger is arranged within the bottom of the cabinet.

[0042] Preferably, the compressor is arranged within the bottom of the cabinet.

[0043] In an embodiment, the machine comprises a tank adapted to contain a fluid.

[0044] The third heat exchanger is preferably config-

ured to cool the fluid contained in the tank.

[0045] The third heat exchanger is advantageously thermally coupled to the tank. In an embodiment, the third heat exchanger can be arranged within the tank.

[0046] Preferably, said tank is arranged within the bottom of the cabinet.

[0047] In an embodiment, the tank is a closed tank. According to another embodiment, the tank is fluidly connected to the chamber and/or to water mains.

[0048] According to a preferred embodiment, the tank is fluidly connected to water mains by means of a conduit configured to supply tap water from the water mains to the tank bypassing the chamber.

[0049] In an embodiment, the first heat exchanger is a tubes and fins heat exchanger. In an embodiment, the second heat exchanger is a tubes and fins heat exchanger.

[0050] In an embodiment, the third heat exchanger is a tube-in-tube heat exchanger or a plate heat exchanger or similar.

[0051] In an embodiment, the refrigerant is adapted to condense inside the first heat exchanger and to evaporate inside the second heat exchanger. In this embodiment, the first heat exchanger is a condenser and the second heat exchanger is an evaporator.

[0052] In an embodiment, the refrigerant is adapted to evaporate inside the third heat exchanger. In this embodiment, the third heat exchanger is an evaporator.

[0053] In another embodiment, the refrigerant can operate nonconventional cycles, as for instance in the case of carbon dioxide, that do not undergo a phase change (i.e., condensation and evaporation).

[0054] Suitably, said first refrigerant circuit and said second refrigerant circuit are closed recirculation circuits.

[0055] Suitably, the washer-dryer machine comprises a water inlet circuit adapted to supply water, that can be optionally mixed with washing/rinsing products (i.e. detergents, softeners, etc.), into the chamber. The water inlet circuit can comprise a detergent drawer and water inlet pipes.

[0056] According to a preferred embodiment, the top of the cabinet comprises, integrally formed therein, at least part of the water inlet pipes.

[0057] According to a preferred embodiment, the top of the cabinet comprises, integrally formed therein, a seat configured to house the detergent drawer.

[0058] Suitably, the washer-dryer machine comprises a water outlet circuit for discharging waste water (i.e. used water) from the chamber. The water outlet circuit is advantageously fluidly connected to the bottom of the chamber.

[0059] The water outlet circuit can comprise a draining pump and draining pipes, adapted for discharging waste water from the chamber after process cycles (e.g. washing, rinsing cycles).

[0060] It is observed that, during operation of the heat pump system in a washing cycle, the fluid in the tank, thermally coupled with the third heat exchanger, is cooled

down with respect to a starting temperature and, optionally, at least partially iced. The cooled/iced fluid needs to be regenerated, that is warmed up again towards the starting temperature, in order to be used again for a next, optionally immediately subsequent, washing cycle.

[0061] According to an embodiment, the tank is thermally coupled to the water outlet circuit (e.g. to said draining pump and/or to said draining pipes). This enables to transfer heat from the waste water flowing through the water outlet circuit to the fluid contained in the tank thereby improving regeneration of the cooled/iced fluid in the tank. The thermal coupling between the tank and the water outlet circuit can be achieved, for example, by means of a heat exchanger, as for example by placing the draining pipes in contact with the tank.

[0062] In an embodiment, the tank is configured to drain away at least part of cooled fluid from the tank.

[0063] According to an embodiment, the control unit is configured to manage fluid regeneration in the tank by managing entry of tap water from the water mains and/or from the chamber and exit of at least part of the fluid cooled by the third heat exchanger.

[0064] Advantageously, the tank is fluidly connected to the water outlet circuit in order to drain away at least part of cooled fluid from the tank via the water outlet circuit.

[0065] According to another embodiment, the tank is fluidly connected to a dedicated fluid outlet circuit (that is to a fluid outlet circuit free of fluid connection with the water outlet circuit).

[0066] In a preferred embodiment, the control unit is configured to operate the heat pump system so that the fluid in the tank is at least partially frozen. In this way, the latent heat of the phase transition from liquid to solid is advantageously used and the heat pump system efficiency is improved.

[0067] The washer-dryer machine can be a dish washer with drying functionality or a laundry washer-dryer machine.

[0068] In a further aspect the present invention relates to a method of operating a washer-dryer machine comprising a chamber for receiving goods, an air circuit, a heat pump system comprising: a first heat exchanger, a second heat exchanger and a compressor, which form a first refrigerant circuit with a refrigerant, and a third heat exchanger, arranged outside the air circuit, forming with the first heat exchanger and the compressor a second refrigerant circuit for said refrigerant, the method comprising:

during a drying cycle:

- circulating air through the chamber along said air circuit;
- switching said refrigerant into the first refrigerant circuit and operating the compressor so that: the refrigerant is circulated through the first refrigerant

erant circuit, the first heat exchanger cools said refrigerant and heats the air in said air circuit that flows into the chamber, and the second heat exchanger heats said refrigerant and dehumidifies the air in said air circuit that comes from the chamber;

during a washing cycle:

- circulating air through the chamber along said air circuit;
- switching said refrigerant into the second refrigerant circuit bypassing said second heat exchanger and operating the compressor so that: the refrigerant is circulated through the second refrigerant circuit, the first heat exchanger cools said refrigerant and heats the air that flows into the chamber, and the third heat exchanger heats said refrigerant.

[0069] Preferably, during the washing cycle and during operation of the compressor, the third heat exchanger cools a fluid in a tank. Suitably, the tank is thermally coupled to the third heat exchanger.

[0070] Suitably, during the washing cycle, the method further comprises supplying water into the chamber.

[0071] During the washing cycle, the air circulating through the chamber, heated by the first heat exchanger, increases the temperature inside the chamber. In this way, the goods (e.g. the laundry), preferably wetted by the water supplied into the chamber, are heated up.

[0072] Preferably, the method further comprises regenerating the fluid contained in the tank, cooled by the third heat exchanger during the washing cycle.

[0073] Regeneration of the fluid contained in the tank can be performed by supplying to the tank tap water from water mains, preferably bypassing the chamber, and/or by supplying to the tank process water from the chamber.

[0074] In an embodiment, regenerating the fluid contained in the tank comprises draining away at least part of the cooled fluid from the tank.

[0075] Preferably, the air is re-circulated in said air circuit in sequence through the chamber, the second heat exchanger, the first heat exchanger and back through the chamber.

[0076] Preferably, during the drying cycle, the refrigerant is caused to circulate along the first refrigerant circuit in sequence through the first heat exchanger, through the switching element, through the second heat exchanger and through the compressor.

[0077] Preferably, during the washing cycle, the refrigerant is caused to circulate along the second refrigerant circuit in sequence through the first heat exchanger, through the switching element, through the third heat exchanger and through the compressor.

[0078] Preferably, during the drying cycle, the air is circulated and the compressor is operated till the goods in

the chamber are suitably dried or till the temperature in the chamber reaches a predetermined value or for a predetermined operation time. Thereafter, the air circulation is stopped (e.g., the fan is switched off) and the compressor is switched off.

[0079] Preferably, during the washing cycle, the air is circulated and the compressor is operated till the temperature in the chamber reaches a predetermined value, or till the fluid in the tank reaches a predetermined condition (for example a predetermined degree of ice formation in the tank), or for a predetermined operation time. Thereafter, the air circulation is stopped (e.g., the fan is switched off) and the compressor is switched off.

[0080] Suitably, the air is circulated again along said air circuit (e.g., the fan is switched on again) and the compressor is operated (that is, switched-on) again when another washing cycle or drying cycle has to be performed.

[0081] Preferably, in case of a laundry washer-dryer machine, the method further comprises performing at least one laundry spinning cycle.

[0082] Features and advantages of the present invention will be more readily understood from the following detailed description of some preferred embodiments thereof, which is given below by way of non-limiting example with reference to the accompanying drawings, in which:

- figure 1 schematically shows a washer-dryer machine according to an embodiment of the invention;
- figure 2 schematically shows operation of the washer-dryer machine of figure 1, during a washing cycle;
- figure 3 schematically shows operation of the washer-dryer machine of figure 1, during a drying cycle;
- figure 4 schematically shows a washer-dryer machine according to another embodiment of the invention, during a drying cycle;
- figure 5 schematically shows the embodiment of figure 4, during a washing cycle;
- figure 6 schematically shows in perspective an exemplary washer-dryer laundry machine according to the embodiment of figures 4 and 5, with parts of the cabinet removed;
- figure 7 schematically shows in perspective, from another point of observation, the exemplary washer-dryer laundry machine of figure 6, with additional parts of the cabinet removed.

[0083] Like elements are denoted by like reference signs throughout the figures.

[0084] Figure 1 shows a washer-dryer machine 1 according to an embodiment of the invention.

[0085] The washer-dryer machine 1 is configured to wash goods in a washing phase and to dry goods in a drying phase. The drying phase can be executed after a washing phase or alone.

[0086] The washing/drying phases are suitably performed according to washing/drying programs, selectable by a user, wherein the goods are pre-washed/washed/rinsed with water and possible washing/rinsing products, according to one or more washing cycles, and at least in part dried, according to one or more drying cycles.

[0087] The washer-dryer machine 1 comprises a chamber 10 for treating goods.

[0088] The washer-dryer machine 1 can be a dish washer with drying functionality or a laundry washer-dryer.

[0089] In case of laundry washer-dryer the chamber 10 can be a drum, optionally perforated, which is rotatably contained in a tub 11 (shown only in figures 6 and 7).

[0090] The washer-dryer machine 1 comprises a control unit 60 configured to control operation of the same.

[0091] The washer-dryer machine 1 comprises a water outlet circuit 50 for discharging waste water (i.e. used water optionally mixed with washing/rinsing products) from the chamber 10 after washing (e.g., pre-washing, washing, rinsing) cycles.

[0092] The water outlet circuit 50 can comprise a draining pump 51 and draining pipes 52.

[0093] The water outlet circuit 50 is advantageously fluidly connected to the bottom of the chamber 10.

[0094] The washer-dryer machine 1 also comprises a water inlet circuit 70 adapted to supply water, that can be optionally mixed with washing/rinsing products, into the chamber 10. The water inlet circuit 70 advantageously comprises a detergent drawer 72 and water inlet pipes 74.

[0095] The water inlet pipes 74 fluidly connect water mains 40 to the chamber 10 via the detergent drawer 72.

[0096] The detergent drawer 72 is adapted to be filled with washing/rinsing products, for example detergents, softener, bleaching, sparkling/rinse aid substances, etc. The detergent drawer 72 can comprise one or more compartments (not shown) for one or more products from which a certain amount of these products, depending on the washing program, is delivered into the chamber 10.

[0097] The washer-dryer machine 1 also comprises a heat pump system 20, a tank 30 adapted to contain a fluid and an air circuit 90.

[0098] The air circuit 90 comprises a fan 92, a fan motor 96 (shown only in figure 7), air ducts 94 connecting an air inlet 91 and an air outlet 93 of the chamber 10 and an air filter 95.

[0099] As shown in figures 2-7, the heat pump system 20 comprises a first heat exchanger 22, a switching element 23, a second heat exchanger 24, a third heat exchanger 25 and a compressor 26.

[0100] In the embodiments shown, the first heat exchanger 22 and the second heat exchanger 24 are ar-

ranged within the air circuit 90.

[0101] The third heat exchanger 25 is arranged outside the air circuit 90. In this way, it does not exchange heat with the air circulating in the air circuit 90.

[0102] The air filter 95 is positioned downstream of the chamber 10 and upstream of the second heat exchanger 24, in relation to the direction of the air flow inside the air circuit 90.

[0103] The third heat exchanger 25 is suitably thermally coupled to the tank 30. In the embodiments shown in figures 2-5, the third heat exchanger 25 comprises a pipe (or a series of pipes) properly shaped and immersed in the fluid contained in the tank 30.

[0104] The fluid contained in the tank 30 preferably comprises water.

[0105] The fan 92 is configured to re-circulate air along the air circuit 90, in sequence through the chamber 10, the second heat exchanger 24, the first heat exchanger 22, the fan 92 itself and back into the chamber 10.

[0106] The first heat exchanger 22 and the second heat exchanger 24 are air-refrigerant heat exchangers for example of the type tubes and fins.

[0107] The third heat exchanger 25 is a fluid-refrigerant heat exchanger and can be a tube-in-tube heat exchanger, a plate heat exchanger or similar.

[0108] The first heat exchanger 22, the switching element 23, the second heat exchanger 24 and the compressor 26 form a first closed refrigerant circuit 27 configured to circulate a refrigerant therein.

[0109] The first heat exchanger 22, the switching element 23, the third heat exchanger 25 and the compressor 26 form a second closed refrigerant circuit 28 configured to circulate said refrigerant therein and to bypass the second heat exchanger 24.

[0110] The switching element 23 is configured to selectively switch the flow of the refrigerant into the first refrigerant circuit 27 or into the second refrigerant circuit 28.

[0111] The first heat exchanger 22 is configured to cool the refrigerant by releasing heat to the air circulating in the air circuit 90, which is flowing towards the chamber 10.

[0112] The second heat exchanger is configured to heat the refrigerant by absorbing heat from (that is, cooling and dehumidifying) the air circulating in the air circuit 90, which is coming from the chamber 10 and flowing towards the first heat exchanger 22.

[0113] The third heat exchanger 25 is configured to heat the refrigerant by absorbing heat from (that is, cooling) the fluid contained in the tank 30.

[0114] In an embodiment, the refrigerant is adapted to condense inside the first heat exchanger 22 and to evaporate inside the second heat exchanger 24 and the third heat exchanger 25. In this embodiment, the first heat exchanger 22 is a condenser and the second heat exchanger 24 and the third heat exchanger 25 are evaporators. During operation of the heat pump system 20 (that is, when the compressor 26 is switched-on), liquefaction

of the refrigerant takes place at the condenser (first heat exchanger 22) accompanied by release of heat that is used to heat the air flowing towards the chamber 10. On the other side, evaporation of the refrigerant takes place at the evaporator (second heat exchanger 24 or third heat exchanger 25) accompanied by absorption of heat that is used to dehumidify and cool the air coming from the chamber 10 (in case of the second heat exchanger 24) or to cool the fluid in the tank 30 (in case of the third heat exchanger 25).

[0115] Even if not shown in the figures, the heat pump system 20 can comprise a pressure lowering device (e.g. an expansion valve or other expansion element) downstream of the first heat exchanger 22 and upstream of the second heat exchanger 24 and the third heat exchanger 25.

[0116] When the pressure lowering device is arranged upstream of the switching element 23 or at the switching element 23, a single pressure lowering device can be used for both the first refrigerant circuit 27 and the second refrigerant circuit 28.

[0117] When the pressure lowering device is arranged downstream of the switching element 23, two pressure lowering devices are preferably used, one arranged in the first refrigerant circuit 27 upstream of the second heat exchanger 24 and the other one arranged in the second refrigerant circuit 28 upstream of the third heat exchanger 25.

[0118] Depending on the washing program, heat pump power and desired washing temperature, the heat pump system 20 alone might be insufficient to heat up the wet goods to the desired process temperature in the available time. Therefore, a conventional electrical heater (not shown) may be comprised in the washer-dryer machine 1 as well. The conventional electrical heater can be suitably positioned on the bottom of the chamber 10.

[0119] Similarly, the heat pump system 20 alone might be insufficient to properly dry the goods in the available time. Therefore, a conventional electrical heater (not shown), different from the one optionally present for the washing cycles, may be comprised in the washer-dryer machine 1. The conventional electrical heater for the drying cycles can be suitably positioned on the air circuit 90 downstream of the first heat exchanger 22 and upstream of the chamber 10, in relation to the direction of the air flow inside the air circuit.

[0120] In the preferred embodiment shown in the figures, the tank 30 is fluidly connected by means of a tap water conduit 31 to public water mains 40 in order to be able to directly receive tap water from it. Preferably, said tap water conduit 31 is configured to supply tap water from the water mains 40 to the tank 30 bypassing the chamber 10 (that is without making the tap water to pass through the chamber 10). In this way, cooled/iced fluid regeneration in the tank 30 can be performed with clean tap water, avoiding the risk of contamination with deposits and/or bacteria from waste water from the chamber 10.

[0121] In an embodiment (not shown), the tank 30 can

be thermally coupled to the water outlet circuit 50 in order to transfer heat from waste water flowing through the pipes 52 into the fluid contained in the tank 30. For example, thermal coupling can be achieved by placing the draining pipes 52 in contact with the tank 30.

[0122] In addition or in alternative, the tank 30 can be thermally coupled to electronic components and heated elements inside the machine (not shown, as for example compressor, motor, inside air). The thermal energy released by these components can be transferred to the fluid in the tank 30 for example by natural convection, forced convection or conduction.

[0123] In the embodiment shown in figure 1, the tank 30 has an output fluidly connected to the water outlet circuit 50 in order to drain away cooled fluid from the tank 30 via the water outlet circuit 50. The tank output and the water outlet circuit 50 are suitably connected through pipe(s) 34.

[0124] During operation of the heat pump system 20, the fluid in the tank 30 can be moved by a pump or impeller (not shown) in order to increase the heat transfer coefficient.

[0125] The control unit 60 is advantageously configured to operate the heat pump system 20 and the fan 92 of the air circuit 90 any time the washer-dryer machine 1 is turned on in order to perform a predetermined washing and/or drying program.

[0126] Figure 2 schematically shows the washer-dryer machine 1 during a washing cycle (e.g., pre-washing, washing, rinsing, and similar cycle) of a predetermined washing program.

[0127] During the washing cycle, water, optionally mixed with washing/rinsing products, is suitably supplied into the chamber 10 by means of the water inlet circuit 70.

[0128] The control unit 60 pilots the switching element 23 so that the flow of the refrigerant is switched into the second refrigerant circuit 28, bypassing the second heat exchanger 24. This situation is schematically represented in figure 2 by using a cross on the second heat exchanger 24 and by using dotted lines for representing the part of the first refrigerant circuit 27 which is bypassed.

[0129] Then the control unit 60 switches the fan 92 and the heat pump system 20 (that is the compressor 26) on.

[0130] In this way, the fan 92 re-circulates air along the air circuit 90, in sequence through the chamber 10, the air filter 95, the second heat exchanger 24, the first heat exchanger 22, the fan 92 itself and back into the chamber 10.

[0131] In addition, as shown in figure 2, the refrigerant is re-circulated along the second refrigerant circuit 28, in sequence through the first heat exchanger 22, the switching element 23, the third heat exchanger 25 and the compressor 26, bypassing the second heat exchanger 24.

[0132] The air circulating along the air circuit 90 is heated by the first heat exchanger 22 so that warm air is injected into the wet goods contained in the chamber 10, preferably wetted by the water supplied by the water inlet

circuit 70. In this way the temperature inside the chamber increases and the wet goods are heated up.

[0133] Suitably, the fan 92 and the heat pump system 20 are switched off by the control unit 60 when the temperature in the chamber 10 reaches a desired value, when the fluid in the tank 30 reaches a predetermined condition (for example, when it is in large part iced) or after a predetermined operation time.

[0134] It is observed that the fluid in the tank 30 exchanges with the third heat exchanger 25 sensible heat during a cooling phase of the fluid and latent heat during an icing phase (if any). The exploitation of the latent heat allows reducing the amount of fluid required and therefore the overall dimensions of the tank 30. Accordingly, the control unit 60 can be advantageously configured to operate the heat pump system 20 so that the fluid in the tank 30 is at least partially frozen.

[0135] Preferably, at the end of the washing cycle or at a predetermined time during the washing cycle, the fluid contained in the tank 30, cooled by the third heat exchanger 25, is regenerated.

[0136] In the embodiment shown in the figures, regeneration of the fluid contained in the tank 30 is performed by supplying to the tank 30 tap water from water mains 40, bypassing the chamber 10.

[0137] Suitably, regenerating the fluid contained in the tank 30 also comprises draining away from the tank 30 at least part of the cooled fluid through pipes 34 and 52.

[0138] It is observed that, as in the second refrigerant circuit 28 the refrigerant bypasses the second heat exchanger 24, the second heat exchanger 24 is inactive during the washing cycle. Therefore, even if it is placed within the air circuit 90, it is inert on (that is, it does not exchange heat with) the air re-circulating in the air circuit 90. On the other hand, the third heat exchanger 25, even if active during the washing cycle, it is outside the air circuit 90 so that it is inert too on (that is, it does not exchange heat with) the air re-circulating in the air circuit 90.

[0139] This advantageously avoids that during a washing cycle - wherein wet goods in the chamber 10 have to be heated - the heating efficiency is reduced by a cooling/dehumidifying action performed by the second heat exchanger 24 and/or the third heat exchanger 25 on the air injected into the chamber 10. In this way, enhanced performances of the washer-dryer machine 1 are guaranteed, both in washing cycles and drying cycles.

[0140] Figure 3 schematically shows the washer-dryer machine 1 during a drying cycle of a predetermined drying program.

[0141] The control unit 60 pilots the switching element 23 so that the flow of the refrigerant is switched into the first refrigerant circuit 27, bypassing the third heat exchanger 25. This situation is schematically represented in figure 3 by using a cross on the third heat exchanger 25 and by using dotted lines for representing the part of the second refrigerant circuit 28 which is bypassed.

[0142] Then, the control unit 60 switches the fan 92

and the heat pump system 20 (that is the compressor 26) on.

[0143] In this way, the fan 92 causes the air to re-circulate along the air circuit 90, in sequence through the chamber 10, the air filter 95, the second heat exchanger 24, the first heat exchanger 22, the fan 92 itself and back into the chamber 10.

[0144] In addition, as shown in figure 3, the refrigerant is re-circulated along the first refrigerant circuit 27, in sequence through the first heat exchanger 22, the switching element 23, the second heat exchanger 24 and the compressor 26.

[0145] The air circulating along the air circuit 90 is heated by the first heat exchanger 22 so that warm air is injected into wet goods contained in the chamber 10. In addition, as in the first refrigerant circuit 27 the refrigerant passes through the second heat exchanger 24, the second heat exchanger 24 is active on the air circulating in the air circuit 90 so that moisture-laden air coming from the chamber 10 is cooled and dehumidified by the second heat exchanger 24. The wet goods in the chamber 10 are thus efficiently dried by means of warm dried air injected into the chamber 10.

[0146] The fan 92 and the heat pump system 20 are operated till the goods in the chamber 10 are sufficiently dried or when the temperature in the chamber 10 reaches a desired value or according to a predetermined operation time. Then, the fan 92 and the heat pump system 20 are suitably switched off by the control unit 60.

[0147] In the washer-dryer machine 1 of the present disclosure, the washing cycles and the drying cycles are performed by sharing the air circuit 90 and part of the components (that is, the compressor 26 and the first heat exchanger 22) of the heat pump system 20. This advantageously enables to bound, in the machine, the space taken by the components necessary for performing the washing and drying functions and to limit the machine encumbrance.

[0148] In addition, with respect to an already existing design of a dryer machine (already equipped with air circuit 90 and heat pump with first heat exchanger 22 and second heat exchanger 24), the sharing of the air circuit 90, the compressor 26 and the first heat exchanger 22 between the washing cycles and the drying cycles, enables to limit the changes required to adapt the already existing design of the dryer machine in order to house the additional components (that is, the tank 30, the switching element 23 and the third heat exchanger 25), which are necessary for performing also the washing function.

[0149] This advantageously enables to reduce the impact on the already existing design of the dryer machine and it might be interesting for household appliance manufacturers to exploit the already existing design of a dryer machine for producing and offering to the customers a washer-dryer machine.

[0150] Figures 4 and 5 schematically show an arrangement of the components of the heat pump system 20, air

circuit 90 and water inlet circuit 70 inside a cabinet 2 of the washer-drier machine 1, according to an embodiment of the invention. For the sake of simplicity, other components of the washer-dryer machine 1 are not depicted in figures 4 and 5.

[0151] In figure 4, operation of the machine during a drying cycle (wherein the third heat exchanger 25 is bypassed and the second heat exchanger 24 is active) is exemplarily shown.

[0152] On the other hand, in figure 5 operation of the machine during a washing cycle (wherein the second heat exchanger 24 is bypassed and the third heat exchanger 25 is active) is exemplarily shown.

[0153] Figures 6 and 7 show two different perspective views of an exemplary washer-dryer laundry machine according to the embodiment of figures 4 and 5.

[0154] According to this embodiment, the cabinet 2 comprises a top 3 and a bottom 4.

[0155] The top 3 is configured to match and close from the above the cabinet 2.

[0156] The top 3 is formed as a ready-to-mount part ready to be mounted to the cabinet 2.

[0157] In the embodiment shown, the top 3 comprises at least part of the components of the machine that perform the drying and washing functions. Such components comprise at least part of the air circuit 90 (that is, the fan 92, the fan motor 96, the air filter 95 and part of the air ducts 94), the first heat exchanger 22 and the second heat exchanger 24.

[0158] Preferably, part of the air ducts 94 are integrally formed in the top 3. The air filter 95, the first heat exchanger 22 and the second heat exchanger 24 are preferably housed in seats integrally formed in the top 3.

[0159] In addition, the top 3 can also comprise, integrally formed therein, at least part of the water inlet pipes 74 and a seat configured to house the detergent drawer 72.

[0160] In figures 4-5, the switching element 23 is shown outside the top 3. However, according to a variant, it can be housed in a seat integrally formed in the top 3.

[0161] In the embodiment of figures 4-7, other components of the machine 1 that perform the drying and washing functions, as the compressor 26, the tank 30 and the third heat exchanger 25, are housed into the bottom 4 of the machine 1.

[0162] The embodiment of figures 4-7 enables to house at least part of the components of the heat pump system 20, air circuit 90 and air inlet circuit 70 by optimizing the machine design and improving the machine assembly.

[0163] For example, with respect to an already existing design of a dryer machine (already equipped with a top 3 comprising an air circuit 90 and heat pump with first heat exchanger 22 and second heat exchanger 24), this embodiment enables to adapt the already existing design of the dryer machine by housing the additional components (that is, the tank 30 and the third heat exchanger 25, which are necessary for performing also the washing

function) in the bottom 4 of the cabinet 2. In addition, as part of the components of the machine are integrally formed into the top 3, such components can be simply assembled by matching and closing the top 3 onto the cabinet 2.

Claims

1. Washer-dryer machine (1) comprising

- a chamber (10) for receiving goods,
 - an air circuit (90) configured to circulate air through the chamber (10),
 - a heat pump system (20) comprising a first heat exchanger (22), a second heat exchanger (24) and a compressor (26) that form a first refrigerant circuit (27) configured to circulate a refrigerant, the first heat exchanger (22) being configured to cool said refrigerant and to heat the air in said air circuit (90), the second heat exchanger (24) being configured to heat said refrigerant and to dehumidify the air in said circuit,
- characterized in that** the heat pump system (20) also comprises:

- a third heat exchanger (25) arranged outside the air circuit (90), the third heat exchanger (25) forming with the first heat exchanger (22) and the compressor (26) a second refrigerant circuit (28) configured to circulate said refrigerant so as to bypass said second heat exchanger (24), the third heat exchanger (25) being configured to heat said refrigerant, and
- a switching element (23) configured to selectively circulate said refrigerant into the first refrigerant circuit (27), during a drying cycle of the washer-dryer machine (1), and into the second refrigerant circuit (28), during a washing cycle of the washer-dryer machine (1) wherein the air in said air circuit (90) is heated by the first heat exchanger (22).

2. Washer-dryer machine (1) according to claim 1, further comprising a tank (30) adapted to contain a fluid, the third heat exchanger (25) being configured to cool the fluid contained in the tank (30).

3. Washer-dryer machine (1) according to claim 2, wherein the tank (30) is fluidly connected to water mains (40) by means of a conduit (31) configured to supply tap water from the water mains (40) to the tank (30) bypassing the chamber (10).

4. Washer-dryer machine (1) according to claim 3, comprising a control unit (60) configured to manage fluid regeneration in the tank (30) by managing entry of tap water from the water mains (40) and exit of at least part of the fluid cooled by the third heat ex-

changer (25).

5. Washer-dryer machine (1) according to claim 1, wherein the heat pump system (20) comprises a pressure lowering device upstream of the second heat exchanger (24) and the third heat exchanger (25). 5
6. Washer-dryer machine (1) according to claim 5, wherein the pressure lowering device is downstream of the first heat exchanger (22). 10
7. Washer-dryer machine (1) according to claim 1, further comprising a cabinet (2) having a top (3) with a top wall, the first heat exchanger (22) and the second heat exchanger (24) being arranged within the cabinet (2) between the chamber (10) and the top wall. 15
8. Washer-dryer machine (1) according to claim 1, further comprising a cabinet (2) and a top (3), the top (3) being configured to match and close from above the cabinet (2) and being formed as a ready-to-mount part ready to be mounted to the cabinet (2), wherein the top (3) comprises, integrally formed therein, at least part of the air circuit (90) and seats configured to house the first heat exchanger (22) and the second heat exchanger (24). 20 25
9. Washer-dryer machine (1) according to claim 8, wherein the air circuit (90) comprises at least one duct (94) integrally formed in the top (3). 30
10. Washer-dryer machine (1) according to claim 1, wherein the air circuit (90) comprises at least one duct (94) fluidly connecting an air inlet (91) and an air outlet (93) of the chamber (10). 35
11. Washer-dryer machine (1) according to claim 1, wherein the air circuit (90) comprises a fan (92) operable for propelling the air through said air circuit (90). 40
12. Washer-dryer machine (1) according to claim 11, wherein the fan (92) is configured to propel air into the chamber (10), from the chamber (10) towards the second heat exchanger (24), from the second heat exchanger (24) towards the first heat exchanger (22) and from the first heat exchanger (22) back into the chamber (10). 45 50
13. Method of operating a washer-dryer machine (1) comprising a chamber (10) for receiving goods; an air circuit (90); a heat pump system (20) comprising: a first heat exchanger (22), a second heat exchanger (24) and a compressor (26), which form a first refrigerant circuit (27) with a refrigerant, and a third heat exchanger (25), arranged outside the air circuit (90), forming with the first heat exchanger (22) and the 55

compressor (26) a second refrigerant circuit (28) for said refrigerant; the method comprising:

during a drying cycle:

- circulating air through the chamber (10) along said air circuit (90);
- switching said refrigerant into the first refrigerant circuit (27) and operating the compressor (26) so that: the refrigerant is circulated through the first refrigerant circuit (27), the first heat exchanger (22) cools said refrigerant and heats the air in said air circuit (90) that flows into the chamber (10), and the second heat exchanger (24) heats said refrigerant and dehumidifies the air in said air circuit (90) that comes from the chamber (10);

during a washing cycle:

- circulating air through the chamber (10) along said air circuit (90);
- switching said refrigerant into the second refrigerant circuit (28) bypassing said second heat exchanger (24) and operating the compressor (26) so that the refrigerant is circulated through the second refrigerant circuit (28), and the first heat exchanger (22) cools said refrigerant and heats the air in said air circuit (90) that flows into the chamber (10) and the third heat exchanger (25) heats said refrigerant.

14. Method according to claim 13, wherein, during the washing cycle and during operation of the compressor (26), the third heat exchanger (25) cools a fluid contained in a tank (30). 35

15. Method according to claim 14, comprising regenerating the fluid contained in the tank (30), cooled by the third heat exchanger (25), by supplying to the tank (30) tap water from water mains (40) bypassing the chamber (10). 40 45 50

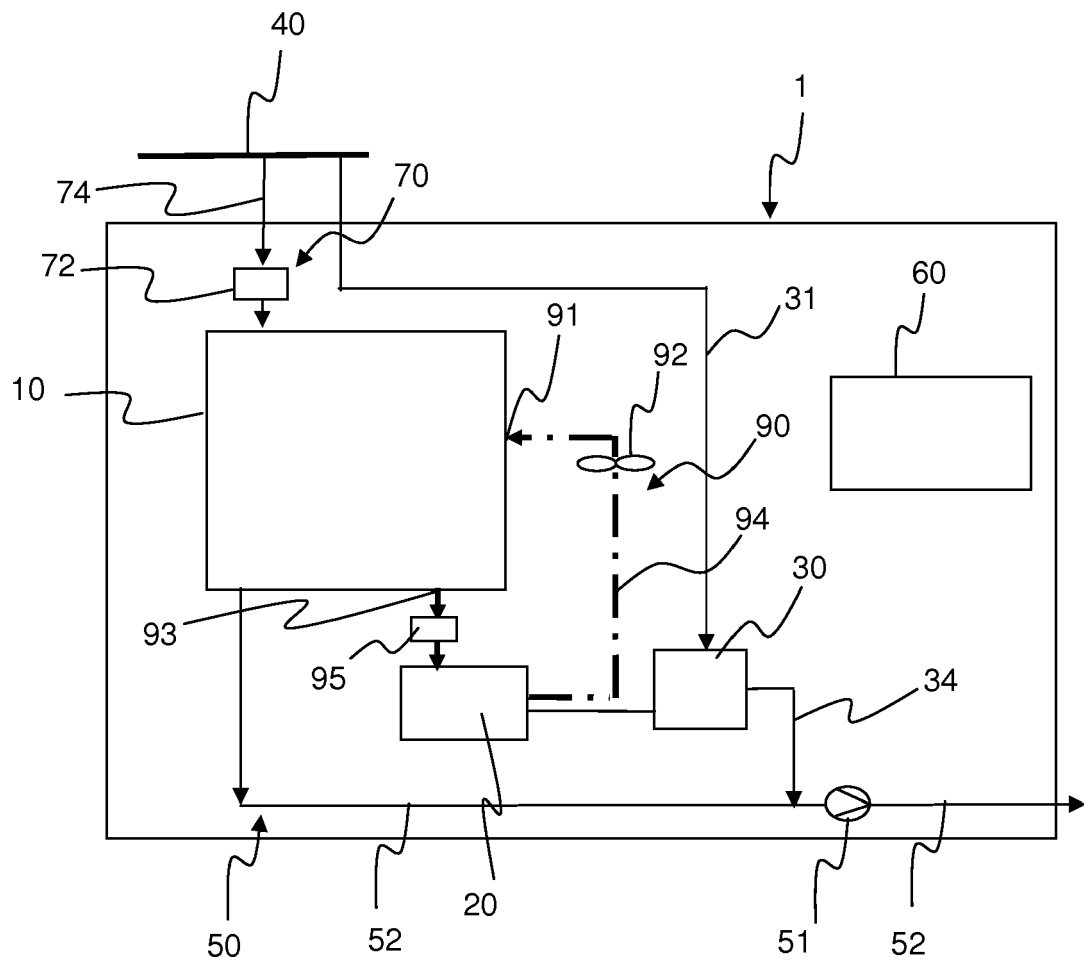
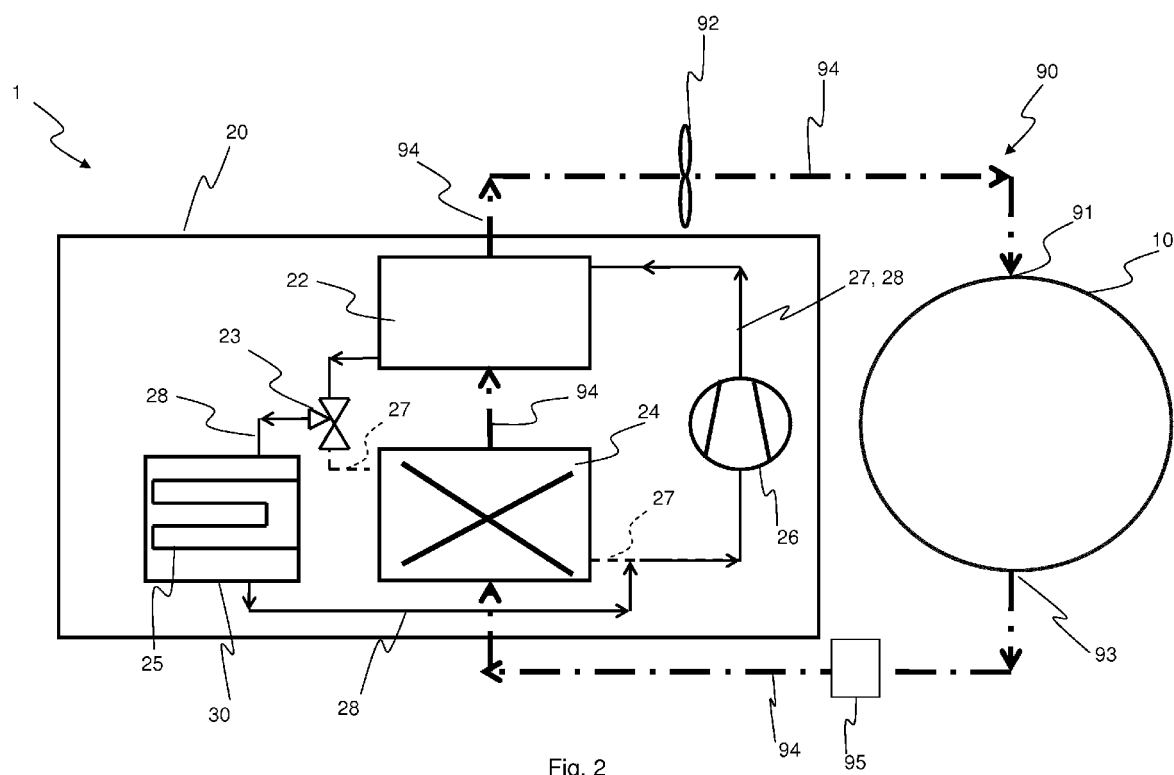
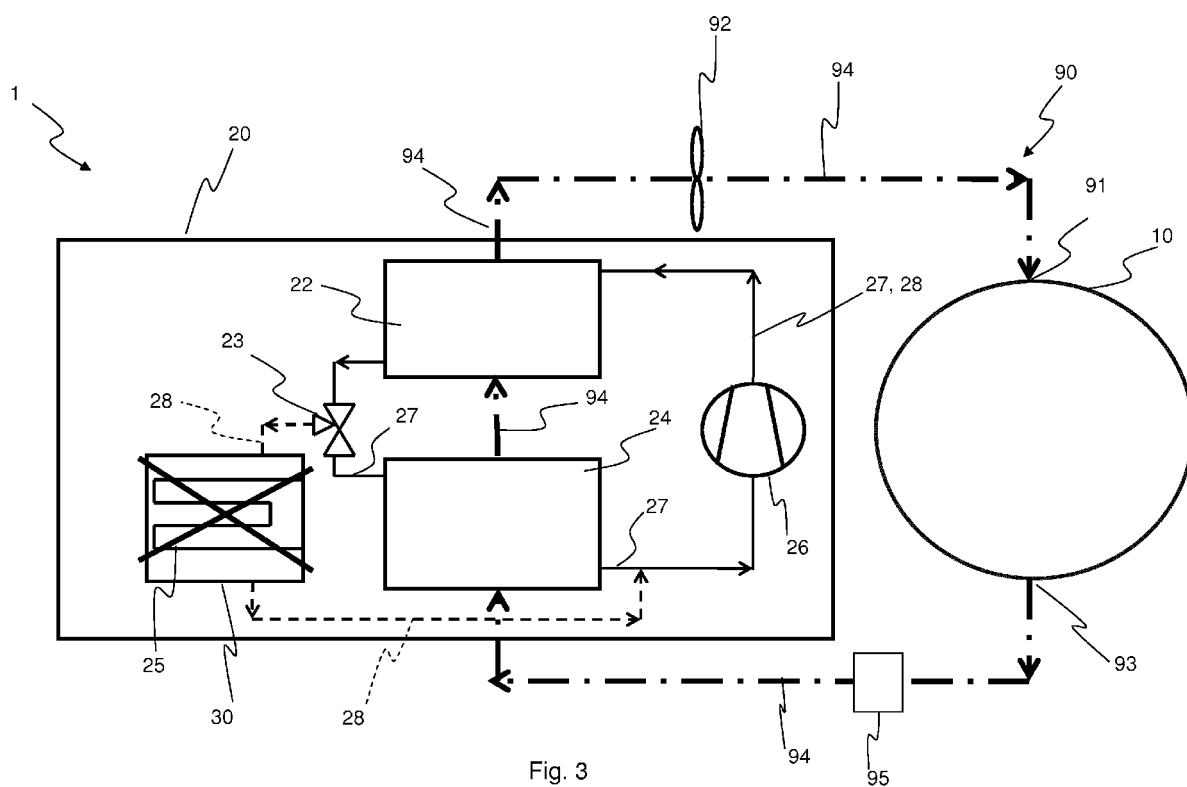


Fig. 1





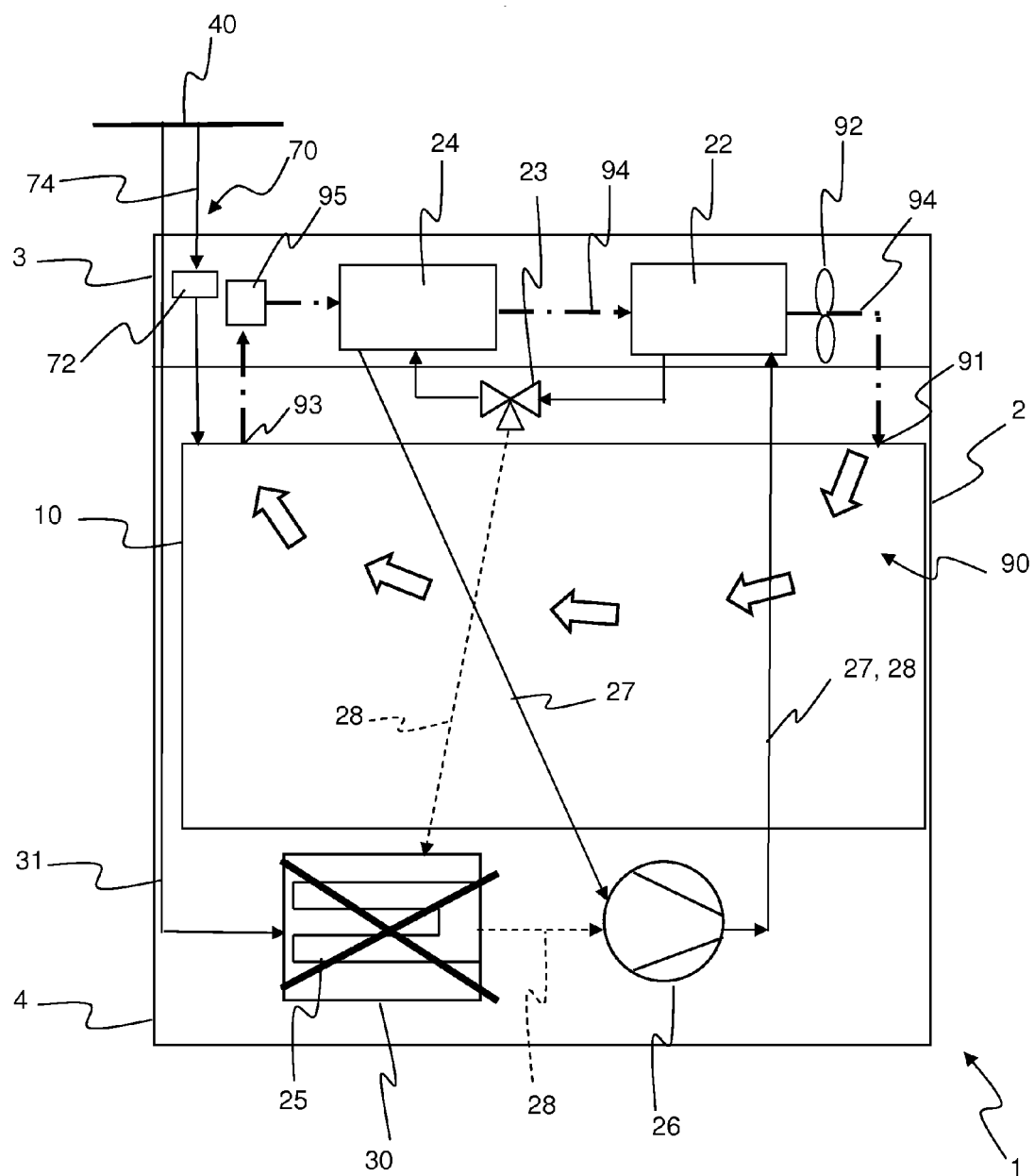


Fig. 4

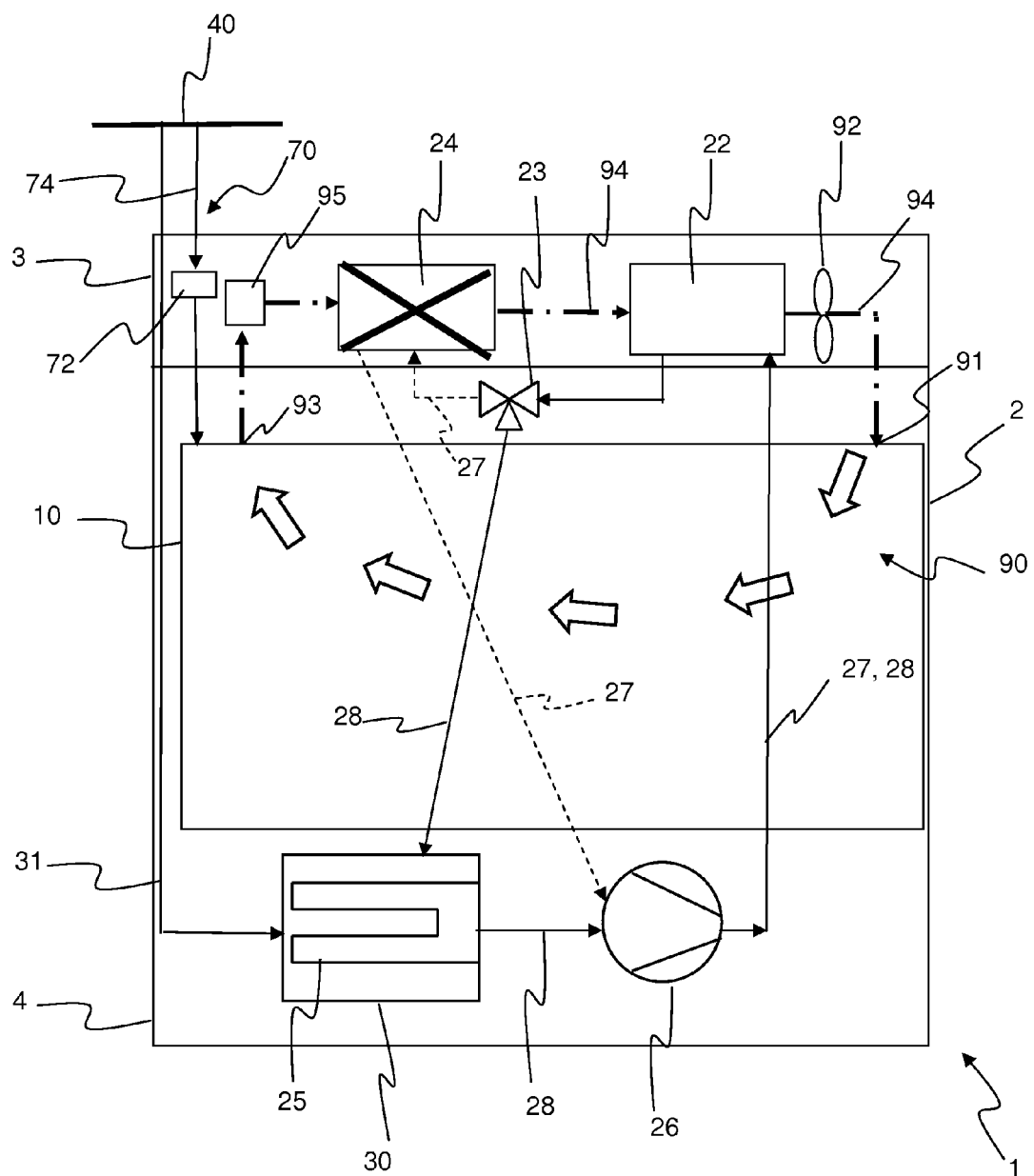


Fig. 5

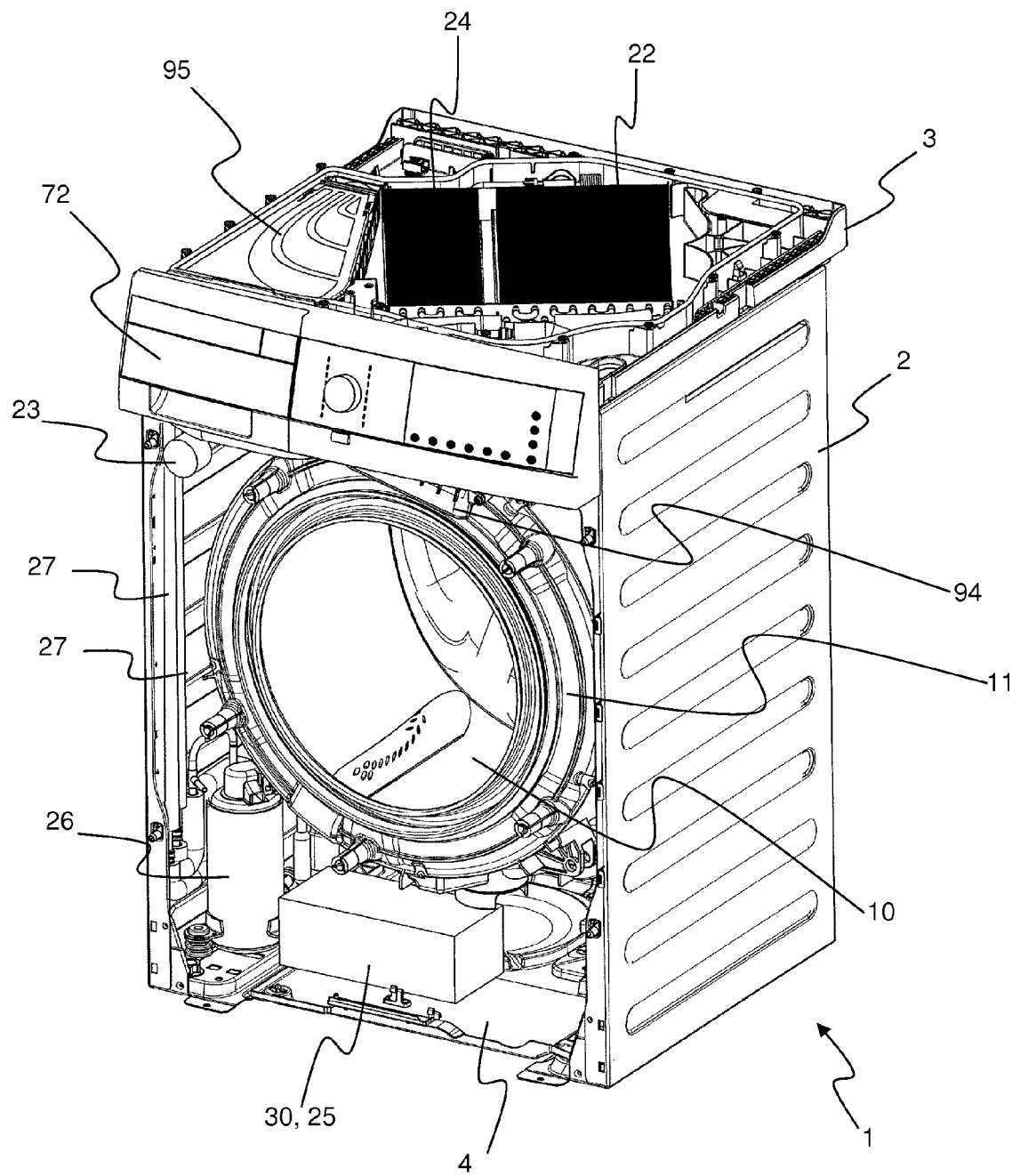


Fig. 6

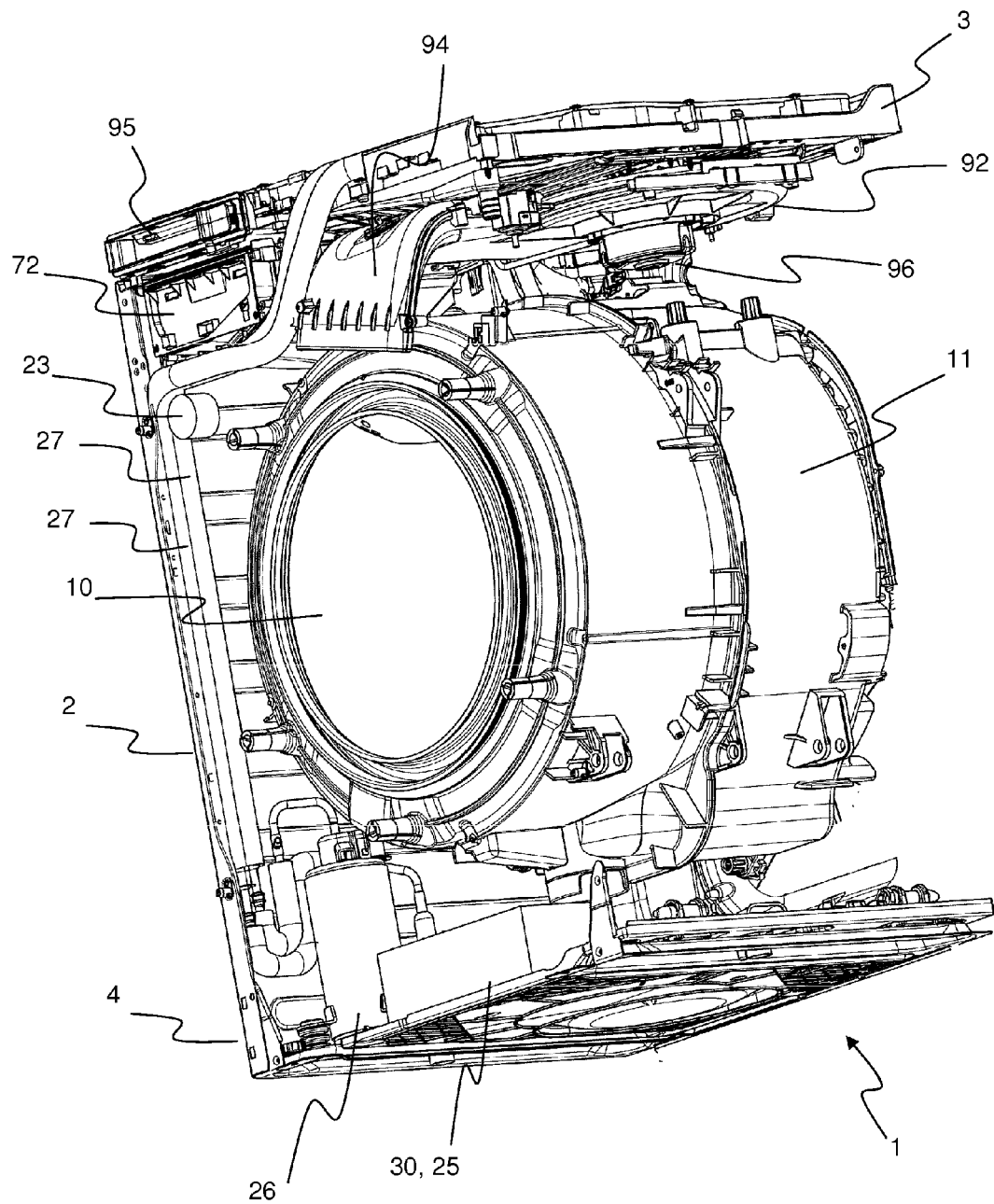


Fig. 7



EUROPEAN SEARCH REPORT

Application Number
EP 12 19 7887

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 983 094 A1 (SANYO ELECTRIC CO [JP]) 22 October 2008 (2008-10-22) * paragraphs [0071] - [0073]; figure 5 *	1,2,13,14	INV. D06F58/20 D06F25/00
A	JP 2010 069194 A (PANASONIC CORP) 2 April 2010 (2010-04-02) * abstract; figure 1 *	1,13	
A	EP 2 390 397 A1 (ELECTROLUX HOME PROD CORP [BE]) 30 November 2011 (2011-11-30) * abstract; figure 1 *	1,10-13	
A	EP 2 436 818 A1 (PANASONIC CORP [JP]) 4 April 2012 (2012-04-04) * abstract; figure 3 *	1,7	
			TECHNICAL FIELDS SEARCHED (IPC)
			D06F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 5 August 2013	Examiner Kising, Axel
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (F04C01)

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

EP 12 19 7887

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1983094 A1	22-10-2008	CN 101275357 A	01-10-2008
		EP 1983094 A1	22-10-2008
		JP 4889545 B2	07-03-2012
		JP 2008245927 A	16-10-2008
		KR 20080089232 A	06-10-2008
		US 2008235977 A1	02-10-2008

JP 2010069194 A	02-04-2010	NONE	

EP 2390397 A1	30-11-2011	CN 102260980 A	30-11-2011
		EP 2390397 A1	30-11-2011
		US 2011289696 A1	01-12-2011

EP 2436818 A1	04-04-2012	CN 102444003 A	09-05-2012
		CN 202247384 U	30-05-2012
		EP 2436818 A1	04-04-2012
		JP 2012075601 A	19-04-2012
		TW 201217598 A	01-05-2012

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 20100107703 A [0004]