



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
01.02.2017 Bulletin 2017/05

(51) Int Cl.:
D06F 58/20 (2006.01) D06F 58/28 (2006.01)

(21) Application number: **15178434.5**

(22) Date of filing: **27.07.2015**

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

(72) Inventors:
• **RAGOGNA, Roberto**
33080 Porcia (PN) (IT)
• **GARZENA, Fabio**
33080 Porcia (PN) (IT)

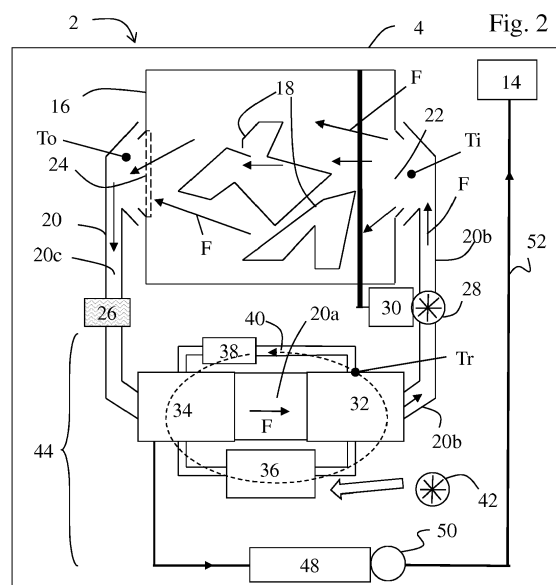
(74) Representative: **Electrolux Group Patents**
AB Electrolux
Group Patents
105 45 Stockholm (SE)

(71) Applicant: **Electrolux Appliances Aktiebolag**
105 45 Stockholm (SE)

(54) **METHOD FOR ADAPTING OPERATION PARAMETERS DURING DRYING IN A HEAT PUMP DRYER**

(57) According to the invention a method for operating a heat-pump dryer (2) during a drying program is provided. The dryer comprises: a cabinet (4), a drum (16) arranged within the cabinet and being adapted to receive laundry (18) for drying the laundry within the drum using drying air (F), an air channel (20) adapted to guide the drying air from at least one air outlet (24) at the drum (16) to at least one air inlet (22) at the drum for providing an air circulation arrangement, a drying air fan (28) adapted to convey the drying air (F) through the air circulation arrangement, a heat pump system (44) comprising a first heat exchanger (32) adapted to heat the drying air, a second heat exchanger (34) adapted to cool the drying air for humidity condensation, and a compressor (36) adapted to circulate refrigerant through the first and second heat exchangers, a temperature sensor adapted to detect a refrigerant temperature (Tr) of the heat pump system (44), and a) a fan motor (70) adapted to drive the drying air fan (28) selectively in a first rotation direction (CW) or in a second rotation direction (CCW) or to drive the drying air fan selectively at least at a first rotation speed or at a second rotation speed, and a drum motor (30) adapted to drive the drum (16) selectively in a first rotation direction (CW) or in a second rotation direction (CCW), or b) a motor (30) adapted to drive in a synchronized manner the drying air fan (28) and the drum (16) selectively in a first rotation direction (CW) or in a second rotation direction (CCW). The method comprises: starting a drying program, monitoring the refrigerant temperature (Tr) of the heat pump system (44), and in dependency of the temperature (Tr) of the heat pump system, adapting at least one of: l) the temporal ratio of rotating

the drum (16) in the first rotation direction (CW) to rotating the drum in the second rotation direction (CCW), m) the temporal ratio of rotating the drying air fan (28) in the first rotation direction (CW) to rotating the drying air fan in the second rotation direction (CCW), and n) the temporal ratio of rotating the drying air fan at the first rotation speed to rotating the drying air fan at the second rotation speed or changing rotating the drying air fan at the second rotation speed to rotating the drying air fan at the first rotation speed, wherein the first rotation speed is higher than the second rotation speed.



Description

[0001] The invention relates to a method of operating a heat-pump dryer during a drying program in a way to provide optimized drying specifically for a low amount of laundry.

[0002] EP 2 832 921 A1 suggests to operate an electrically heated dryer or a heat-pump dryer dependent on the drying air temperature. The dryer has a common motor for driving the drum and the drying air fan in the forward and backward rotation direction at the nominal rotation speed. The drying air fan is designed such that the conveyance rate is lower when the fan is rotated in the backward direction as compared to the conveyance rate when rotated in the forward direction. In the heat-up phase, when the drying air temperature is low, the ratio of the periods rotating the forward direction to the periods of rotating in the backward direction is low. If the drying air temperature is reaching a certain level, the ratio of forward/rearward drum and fan rotation is increased. In the first phase of the drying program the rotation speed of the heat pump compressor can be higher than in the second phase. By adjusting the ratio of forward/backward rotation, it is not necessary to provide a drying air fan having an adjustable speed.

[0003] It is an object of the invention to operate a heat pump dryer or a washer-dryer implementing a drying function such that the drying result of drying low loads of laundry or of drying silk laundry is improved.

[0004] The invention is defined in claim 1. Particular embodiments are set out in the dependent claims.

[0005] In dryer development it can be observed that the drum volume (specifically the drum diameter) is steadily increased. There are also improvements in drying air fan conveyance rate resulting in higher air flow and air pressure differences along the air flow path. With such improved dryers the efficiency in terms of total energy consumption is improved when using the full drying capacity provided. It was observed that, if only some laundry pieces or laundry having a low surface friction (like silk) at low laundry volume or weight is to be dried (i.e. the available drying capacity is not used), the higher drum volume and air flow rate may result in sticking of the few laundry pieces at the air outlet of the drum - which in turn may result in lowering of the drying efficiency and an increase of crease formation (specifically for the sticking laundry pieces).

[0006] According to claim 1 a method for operating a heat-pump dryer during a drying program is provided. The dryer comprises: a cabinet; a drum arranged within the cabinet and being adapted to receive laundry for drying the laundry within the drum using drying air; an air channel adapted to guide the drying air from at least one air outlet at the drum to at least one air inlet at the drum for providing an air circulation arrangement; a drying air fan adapted to convey the drying air through the air circulation arrangement; a heat pump system comprising a first heat exchanger adapted to heat the drying air, a second heat exchanger adapted to cool the drying air for humidity condensation, and a compressor adapted to circulate refrigerant through the first and second heat exchangers; and a temperature sensor adapted to detect a refrigerant temperature of the heat pump system. Further, if the dryer has separate motors for the drum and the drying air fan, the dryer comprises: a fan motor adapted to drive the drying air fan selectively in a first rotation direction or in a second rotation direction and/or to drive the drying air fan selectively at least at a first rotation speed or at a second rotation speed, and a drum motor adapted to drive the drum selectively in a first rotation direction or in a second rotation direction. Otherwise, if the dryer has a common motor for the drum and the drying air fan, the dryer further comprises: a motor adapted to drive in a synchronized manner the drying air fan and the drum selectively in a first rotation direction or in a second rotation direction.

[0007] Preferably the heat pump system further comprises an expansion device and/or a cooling air fan for cooling the compressor or an auxiliary heat exchanger of the heat pump system and/or one or more further components as described below in the detailed embodiment. The dryer may be a dryer or a washer-dryer implementing the drying function/program. The air circulation arrangement is provided by the air channel and the fluidly connected drum. E.g. in the washer-dryer the drum may be arranged in a tub and the at least one inlet and/or outlet opening is provided at the tub. The drying air guiding by the tub is providing the connection between the drum and the at least one inlet and/or outlet where applicable. The drum may be rotated by a drum motor around a horizontal axis, around an axis inclined relative to the vertical axis, or around a vertical axis. In the washer-dryer preferably one motor is provided for rotating the drum and another motor is provided for rotating the drying air fan.

[0008] The method comprises: starting a drying program; monitoring the refrigerant temperature of the heat pump system; and in dependency of the temperature of the heat pump system, adapting at least one of:

- a) the temporal ratio of rotating the drum in the first rotation direction to rotating the drum in the second rotation direction,
- b) the temporal ratio of rotating the drying air fan in the first rotation direction to rotating the drying air fan in the second rotation direction, and
- c) the temporal ratio of rotating the drying air fan at the first rotation speed to rotating the drying air fan at the second rotation speed or changing rotating the drying air fan at the second rotation speed to rotating the drying air fan at the first rotation speed, wherein the first rotation speed is higher than the second rotation speed.

[0009] An adaptation may be made for the drying air fan for example by adapting the ratio of rotating the fan in the first rotation direction / in the second rotation direction, and/or the adaption is made by adapting the ratio of the first rotation speed / the second rotation speed. Therein different fan rotation speeds result in different conveyance rates (at least in one rotation direction). In case the drum motor also drives the drying air fan, the ratios are both synchronously increased. Preferably the drum motor and/or the fan motor are variable speed motors.

[0010] The first rotation direction can also be denoted as 'forward' rotation direction or clockwise direction. The second rotation direction can be denoted as 'backward' rotation direction or counterclockwise direction. From the construction aspect a preference for the 'forward' direction is given by mechanical layout and/or energy efficiency and/or drying air flow efficiency and/or laundry movement in drum. E.g. the drying air fan is designed such that at the same rotation speed or rotation speeds the conveyance rate when rotating in the first rotation direction is higher than the conveyance rate when rotating in the second rotation direction.

[0011] In an embodiment the drying program has a first drying phase which is before the temperature reaches (the first time) at or above the first threshold value, and a second drying phase after the first drying phase. Preferably adapting the temporal ratios in dependency of the temperature of the heat pump system comprises: if the temperature of the heat pump system is at or above a first threshold value, changing the drying mode of the drying program from a first drying phase to a second drying phase by one or more of: a) increasing the temporal ratio of rotating the drum in the first rotation direction to rotating the drum in the second rotation direction, b) increasing the temporal ratio of rotating the drying air fan in the first rotation direction to rotating the drying air fan in the second rotation direction, and c) increasing the temporal ratio of rotating the drying air fan at the first rotation speed to rotating the drying air fan at the second rotation speed or changing rotating the drying air fan at the second rotation speed to rotating the drying air fan at the first rotation speed, wherein the first rotation speed is higher than the second rotation speed.

[0012] Preferably, when it is detected that the temperature of the heat pump system is at or above the first threshold value, the compressor is deactivated or is deactivated after a predetermined delay time. Additionally or alternatively a fan for cooling the compressor is activated.

[0013] Adapting in dependency of the temperature may be provided in that, when the drum is rotating in the first rotation direction, the rotation speed is higher as compared to the rotation speed when the drum is rotated in the second rotation direction. And/or, when the drum is rotating in the first rotation direction, the duration of uninterrupted rotation in the first rotation direction is longer than the duration of uninterrupted rotation of the drum in the second rotation direction.

[0014] Adapting in dependency of the temperature may be provided additionally or alternatively in that, when the drying air fan is rotating in the first rotation direction, the rotation speed is higher as compared to the rotation speed when the drying air fan is rotated in the second rotation direction. And/or, when the drying air fan is rotating in the first rotation direction, the duration of uninterrupted rotation in the first rotation direction is longer than the duration of uninterrupted rotation of the drying air fan in the second rotation direction.

[0015] In an embodiment the drum motor speed is adapted in dependency of the temperature of the heat pump system, or the rotation speed of drum rotation in the first direction is adapted in dependency of the temperature of the heat pump system while the rotation speed of rotating the drum in the second rotation direction is constant.

[0016] In an embodiment the drum motor speed is adapted in dependency of the temperature of the heat pump system by one of the following: if the temperature of the heat pump system is at or above a first threshold value, increasing the absolute value of the drum rotation speed; and if the temperature of the heat pump system is at or above a first threshold value, increasing the rotation speed of rotating the drum in the first rotation direction and maintaining the rotation speed of rotating the drum in the second rotation direction.

[0017] The fan motor may be adapted to drive the drying air fan selectively at least at a first rotation speed and at a second rotation speed, wherein the first rotation speed is higher than the second rotation speed. Then the method may further comprise: when the temperature of the heat pump system is at or above the first threshold value, increasing the temporal ratio of rotating the drying air fan at the first rotation speed to rotating the drying air fan at the second rotation speed.

[0018] In an embodiment the drying program comprises at least a first and optionally a second drying phase and subsequent to the drying phases a cooling phase, wherein in the cooling phase at least one of the following is applied:

- a) the ratio of duration of rotating the drum in the first rotation direction to the duration of rotating the drum in the second rotation direction is decreased as compared to the preceding or second drying phase, or this ratio is decreased to below 1,
- b) the ratio of duration of rotating the drying air fan in the first rotation direction to the duration of rotating the drying air fan in the second rotation direction is decreased as compared to the preceding or second drying phase, or this ratio is decreased to below 1,
- c) the rotation speed of the drum in the first rotation direction is reduced as compared to the rotation speed in the preceding or second drying phase,
- d) the rotation speed of the drum in the second rotation direction is reduced as compared to the rotation speed in

the preceding or second drying phase,

e) the rotation speed of the drying air fan in the first rotation direction is reduced as compared to the rotation speed in the preceding or second drying phase, and

f) the rotation speed of the drying air fan in the second rotation direction is reduced as compared to the rotation speed in the preceding or second drying phase.

[0019] The cooling phase preferably follows (immediately or directly with no other interlaced phase) the second drying phase. In an embodiment of a or the cooling phase of the drying program the method provides as the final drum rotation of the drying program: rotating the drum in the second or counterclockwise rotation direction for a time period.

[0020] Preferably the drying program is proceeding to the cooling phase in dependency of one or more of the following conditions:

- the laundry humidity is at or below a predetermined threshold or target humidity,
- a parameter indicating laundry humidity is lower or equal to a set value,
- the temperature of the air exhausted out of the drum is higher than a set value,
- a temperature gradient of the air exhausted out of the drum is higher than a set value, and
- a drying time as set by a user or as determined by the dryer has lapsed.

[0021] As an option, a drying phase may be provided in which the laundry at least temporally is moved in a 'cradle movement'. This drying phase may be a pre-drying phase preceding a or the first drying phase, wherein in the pre-drying phase, the method provides one or more of the following:

- one or more periods are provided in which the drum is alternately rotated in the first and second rotation direction, wherein in each rotation direction the rotation angle of the rotation is less than 360°, 270°, 200°, 180°, 150° or 100°,
- the ratio of duration of rotating the drum in the first rotation direction to the duration of rotating the drum in the second rotation direction is lower than in the following first drying phase,
- the ratio of duration of rotating the drying air fan in the first rotation direction to the duration of rotating the drying air fan in the second rotation direction is lower than in the following first drying phase,
- the duration of rotating the drum and/or the drying air fan in the first rotation direction in the pre-drying phase is shorter than in the first drying phase,
- the duration of rotating the drum and/or the drying air fan in the second rotation direction in the pre-drying phase is shorter than in the first drying phase,
- the rotation speed of the drum in the first rotation direction is lower as compared to the rotation speed in the following first drying phase,
- the rotation speed of the drum in the second rotation direction is lower as compared to the rotation speed in the following first drying phase,
- the rotation speed of the drying air fan in the first rotation direction is lower than the rotation speed in the following first drying phase, and
- the rotation speed of the drying air fan in the second rotation direction is lower than the rotation speed in the following first drying phase.

[0022] The term 'duration' may either relate to repeating sequences or periods or to the sum of all durations in this pre-drying phase. In repeating sequences the respective durations in the sequence for the active or on period is compared to the deactivated or off period. In the sum of all respective durations the sum of all active or on periods is divided by the sum of all deactivated or off periods.

[0023] In an embodiment some of the process variables used by the control unit may be adjusted or adapted for the different phases of the drying program in dependency of user selection or process parameters. For example one or more of the following applies:

- the ratio of duration of rotating the drum in the first rotation direction to the duration of rotating the drum,
 - the ratio of duration of rotating the drying air fan in the first rotation direction to the duration of rotating the drying air fan in the second rotation direction,
 - the rotation speed of the drum in the first rotation direction,
 - the rotation speed of the drum in the second rotation direction,
 - the rotation speed of the drying air fan in the first rotation direction, and
 - the rotation speed of the drying air fan in the second rotation direction;
- in one or more of the following phases:
- a or the pre-drying phase

- a or the first drying phase
 - a or the second drying phase, and
 - a or the cooling phase;
- are dependent on one or more of the following:
- a laundry treatment program or a laundry treatment option set by a user via an input device of the dryer,
 - a laundry type as set by a user or as estimated by the dryer,
 - the duration of the laundry treatment program set by a user or as estimated by the dryer,
 - in case that the drying program is part of a washing and drying program, an estimation of the water content in the laundry at the beginning of a drying cycle based on the laundry weight difference between the dry laundry weight and the laundry wet weight at the end of the washing program,
 - the amount or weight of laundry to be dried,
 - the current degree of humidity of the laundry,
 - the temperature of the drying air,
 - the ambient temperature,
 - the internal temperature of the dryer, and
 - the duration since the start of the drying.

[0024] In an embodiment the temperature sensor adapted to detect the temperature of the heat pump system is arranged at one of the following positions of the heat pump system:

- an outlet of the first heat exchanger for detecting the refrigerant temperature,
- an outlet of the compressor for detecting the refrigerant temperature,
- the compressor for detecting the compressor temperature,
- the second heat exchanger for detecting the refrigerant temperature, or
- an expansion device arranged between the second and first heat exchanger for detecting the refrigerant temperature.

[0025] The dryer may be implemented by a washer dryer providing at least one washing program. Then preferably a tub is arranged in the cabinet and the drum is arranged in the tub, and/or the at least one outlet of the drum is at least one outlet of the tub, or the at least one inlet of the drum is at least one inlet of the tub, or the at least one outlet of the drum is at least one outlet of the tub and the least one inlet of the drum is at least one inlet of the tub, and/or the fan is driven by a or the motor independent of a or the motor driving the drum. The drum and fan can be rotated/activated independent of each other. If this option is provided the speed and/or direction of rotation can be adjusted independent of each other

[0026] In an embodiment, when the drying program is started, the method provides immediately at the beginning of the drying program a phase of detecting whether laundry is loaded into the drum or not. Preferably the presence of laundry is detected by a humidity sensor (e.g. conductivity sensor) and/or the presence of load in the drum is determined by evaluating the drum and/or fan motor parameters (current and/or torque and/or power and/or phase shift).

[0027] The dryer may comprise an option selector to be activated and/or a program selector for setting a drying program by the user for drying silk laundry or for drying a laundry load of maximum or less than 3 kg, 2 kg, 1 kg, 0.8 kg or 0.5 kg. When the user has selected such option, the laundry is dried according to any of the above method and embodiments thereof.

[0028] In embodiments the method and/or the dryer implementing the method may comprise one or more features and/or elements and/or steps in any arbitrary combination or sub-combination as disclosed above and/or below in the detailed embodiment.

[0029] Reference is made in detail to a preferred embodiment of the invention, an example of which is illustrated in the accompanying figures, which show:

Fig. 1 a perspective view of a laundry dryer,

Fig. 2 a schematic overview of some components of the dryer of Fig. 1,

Fig. 3 a block diagram depicting some of the components of the dryer of Fig. 1 providing signals to a control unit and/or being controlled by the control unit,

Fig. 4 a time diagram showing the temporal behavior of the refrigerant temperature and some temperature-controlled parameters,

Fig. 5 an enlarged portion of the time diagram of Fig. 4 at the beginning of the drying program,

Fig. 6 an enlarged portion of the time diagram of Fig. 4 at the transition between a first and a second drying phase, and

Fig. 7 a flow diagram representing control steps during execution of a drying program corresponding to the one shown in Fig. 4.

5

[0030] Fig. 1 shows a perspective outer appearance of an exemplary laundry dryer 2. In this embodiment, the laundry dryer is a dryer only, but in alternative embodiments the dryer function according to the control method is implemented by a washer-dryer in which the rotatable drum is arranged in a tub and which provides a washing arrangement including (for example) a detergent dispenser, a heater for heating wash liquid and a drain pump for draining out of the liquids.

10 **[0031]** As shown in Fig. 1, the laundry dryer 2 has an outer housing 4 or cabinet including a front wall 6. At the front wall 6 a loading opening 8 is provided which is closed by a door 10. In the depicted embodiment the dryer is a front-loading dryer having a horizontal drum rotation axis, but in alternative embodiments the drum may be inclined relative to the horizontal and vertical directions, or the dryer may be a vertical rotation axis dryer in which the drum rotates around a vertical axis and where top-loading is provided. This correspondingly applies for the washer-dryer implementing the

15 **[0032]** The dryer 2 has a control panel 12 arranged at the upper region of the front wall 6 and a condensate drawer 14 in which the condensate collected from drying is stored until removal by the user.

[0033] In the schematic diagram of components shown in Fig. 2, the drum 16 is arranged inside the housing 4, in which laundry 18 is received. The flow of drying air F is indicated by the arrows, wherein the drying air F leaves the drum 16 at an outlet 24 and enters a process air channel 20 at the front channel 20c. By the front channel 20c the drying air is guided through a fluff filter element 26 towards a second heat exchanger 34 and a first heat exchanger 32. The first and second heat exchangers 32, 34 are arranged in a battery channel 20a of the process air channel 20. The first heat exchanger 32 is a condenser which heats the drying air and the second heat exchanger 34 is an evaporator which cools the drying air for humidity removal in form of condensed water.

25 **[0034]** The drying air leaving the first heat exchanger 32 is entering a rear channel 20b in which a drying air fan 28 is arranged which conveys the drying air. The fan 28 is driven by a motor 30 which at same time drives the rotation of the drum 16. In the depicted embodiment, a belt driven by the motor 30 is wound around the drum mantel for driving the fan. In the depicted embodiment, in which the single motor 30 drives the fan 28 as well as the drum 16, the drum and fan 28 are driven in a synchronous manner according to the gear ratio. Synchronous rotation includes a forward and

30 **[0035]** The first and second heat exchangers 32, 34 are part of a heat pump system 44 which further comprises an expansion device 38 and a compressor 36. In the heat pump system 44 a refrigerant loop 40 is formed, wherein the refrigerant pumped by the compressor 36 passes first the condenser 32, is forwarded to the expansion device 38 from where it expands into the second heat exchanger 34 and from where it is sucked into the compressor 36. Heat can be removed from the heat pump system (in addition to the heat deposited in the drying air and laundry for drying the laundry) by activating a cooling air fan 42 which provides a flow of cooling air from the outside of the cabinet 4 towards the outer surfaces of the compressor 36. After passing the compressor 36, the cooling air is exhausted out of the cabinet 4.

40 **[0036]** The condensate that condenses at the evaporator 34 flows down and collects in a condensate collector 48. From the condensate collector 48 the condensate is pumped by a draining pump 50 through a drain conduit 52 into the condensate drawer 14 from where it can be removed by the user as mentioned above.

45 **[0037]** At the outlet 24 of the drum 16 a temperature sensor is provided which detects the outlet temperature T_o of the drying air. At the inlet 22 of the drum 16 another temperature sensor is provided which detects the inlet temperature T_i of the drying air. At the outlet of the condenser 32 a temperature sensor is provided which detects the refrigerant temperature T_r at this position.

[0038] In case the dryer 2 is a washer-dryer as mentioned above, preferably the outlet of the drying air is arranged in a gasket which is provided between the tub surrounding the drum and the front wall 6 of the washer-dryer. The inlet 22 of the drying air is then provided at an upper and rear side position of the tub from where the drying air enters the drum 16. Such drum has a perforated back wall and/or peripheral drum mantel through which the drying air enters into the drum. Of course, the drying air flow F can also be reverted in view of the inlet/outlet of the washer-dryer as described here.

50 **[0039]** Fig. 3 is a block diagram of components of the dryer 2 that interact for enabling a control unit 60 to control the drying operation or program. The control unit 60 has a memory 62 in which program parameters and look-up tables are stored such that the control unit, by retrieving corresponding data from the memory 62, can control different basic drying programs preferably under conditions as set by the user via option selectors at the control panel 12. Such user-settable options are for example: the final drying degree, the load of the laundry loaded by the user and inputted by him/her, the type of laundry, the duration of drying, a silent- or night-mode option by which the operation noise can be reduced by corresponding input of the user under the control of the control unit, and/or an energy option.

55

[0040] The control unit 60 receives the signals from the sensors for the refrigerant temperature T_r , the inlet temperature T_i of the drying air, the outlet temperature T_o of the drying air, and a humidity signal H from the humidity sensor (e.g. conductivity electrodes). The control unit sends control signals to a drum motor inverter 64 and receives operation parameters therefrom. The drum motor inverter 64 supplies the power to the motor 30 driving the drum 16 and the drying air fan 28. The control unit 60 sends control signals to a compressor motor inverter 66 and receives operation parameters therefrom. The inverter 66 powers a compressor motor 67 for driving the compressor 36. Further, the control unit 60 controls the draining pump 50, a motor 68 for driving the cooling air fan 68 and optionally, if a separate motor 70 is provided for the drying air fan 28, the drying air fan motor 70.

[0041] In case of the dryer being a washer-dryer, normally the separate motor 70 is provided, such that the rotation speed of the drying air fan 28 can be set by the control unit 60 independent of the drum rotation speed via inverter 64 and drum motor 30. Of course, if the separate motor 70 is provided, the motor 30 does not drive the drying air fan 28.

[0042] With reference to Figs. 4 to 7, an exemplary drying program is described which is designed to efficiently dry small laundry loads, in particular valuable and/or delicate laundry pieces which the user wishes to dry separately from the other laundry types and within a reasonable drying time. The drying program is specifically convenient for drying silk laundry like silk scarfs or silk shirts.

[0043] The time diagram of Fig. 4 shows a complete run of the drying program with the phases A, B1, B2, B3 and C. The diagram shows as curve T_r the temporal development of the refrigerant temperature, where the temperature in °C is indicated at the right Y-axis. The curve D shows the absolute value of the drum rotation speed. In this case the left Y-axis indicates the motor rotation speed D in rpm, wherein the gear ratio of between motor rotation speed and drum rotation speed is 50:1 (when the motor axis turns 50 times the drum rotates a full 360° rotation).

[0044] Further, the diagram of Fig. 4 shows in the lower region the drum/motor rotation direction with the two states CW and CCW. The clockwise rotation direction or first rotation direction CW is indicated in a height of corresponding to 10°C on the right Y-axis and the counter clockwise rotation CCW or second rotation direction is shown in a height corresponding to 2°C at the right Y-axis. This means in case that the drum is rotated with a speed $D \neq 0$ in the clockwise direction, CW has the value 10 and if the drum is rotated with a speed D in the counter clockwise direction, CCW has the value 2.

[0045] With the above mentioned ratio of 50:1 of motor rotation speed/drum rotation speed, the four different absolute levels of drum rotation speeds are as follows:

- D1 = 40 rpm (corresponding to 2000 rpm motor rotation speed),
- D2 = 15 rpm (corresponding to 750 rpm motor rotation speed),
- D3 = 46 rpm (corresponding to 2300 rpm motor rotation speed),
- D4 = 55 rpm (corresponding to 2750 rpm motor rotation speed).

[0046] At the start of the drying program an initialization phase A including a load detection is performed. Phase A proceeds to a pre-drying phase B1 where the drying already has been started and during which the laundry pieces within the drum 16 are equally distributed and detangled. After a predetermined duration of phase B 1, the program proceeds to a first drying phase B2 during which the laundry drying is continued and the refrigerant temperature T_r is further increasing. When the refrigerant temperature T_r has exceeded (or is at) a first temperature threshold T_{r1} , the drying program proceeds from phase B2 to a second drying phase B3 during which the laundry is dried up to a predetermined final humidity H_{set} . When the final humidity H_{set} has been reached in the second drying phase B3, the drying program proceeds to a cooling phase C during which laundry cooling is provided for a predetermined duration.

[0047] Fig. 5 shows the phases A and B1 as well as the beginning of phase B2 in more detail. During the initialization phase A, the drum is rotated with speed $D1 = 40$ rpm in the clockwise direction CW for detecting whether wet laundry is loaded in the drum or not. For detecting the wet laundry, the conductivity sensor is provided and the control unit 60 monitors and averages the conductivity/humidity signal H . Additionally or alternatively the signal sent from the drum motor inverter 64 to the control unit 60 is evaluated, whether for example the torque signal, the current signal, the power signal, the phase signal, the voltage signal or any other signal available from the inverter 64 indicates whether laundry has been loaded or not. In case that no laundry is detected via one or both of the signals, the drying program is aborted and a respective indication is displayed on the control panel 12 to motivate the user to check whether laundry has correctly been loaded - compare S12 in Fig. 7.

[0048] With the start of the drying program at the beginning of phase A, the refrigerant temperature T_r continuously rises during the phases A, B1 and B2 until the threshold T_{r1} is exceeded. When in phase A load was detected, phase A is ended and phase B1 started. In the first drying phase B1 of the exemplary embodiment, three "cradle" movements are provided during which the drum is rotated at the rotation speed $D2 = 15$ rpm in the sequence CCW-CW-CCW. In these cradle periods the duration of CW and CCW rotation are selected such short, such that the drum does not provide a full turn. For example the drum is rotated for three seconds with 15 rpm in each rotation direction, such that the rotation angle of the drum within these periods is only 270°. By forward and backward rotation with such restricted rotation angle,

the laundry twisted before in the initialization phase A (e.g. in the form of a laundry roll) is detangled and flatly distributed within the drum. This increases the surface area of the laundry pieces and improves removal of humidity from the laundry.

[0049] After each of these "cradle" periods in phase B1, an extended period of counter clockwise rotation CCW is provided at rotation speed $D3 = 46$ rpm. The rotation directions in these extended rotation periods following to each cradle period in phase B1 are in the sequence of CCW-CW-CCW. It has been found that by operating the drum in the CCW rotation direction the small number of normally light-weight pieces of laundry is not sucked by the air flow towards the outlet 24 of the drum 16 where the inlet grill of the fluff filter element 26 is arranged. As the drying air fan 28 is designed such that at the same rotation speed in CCW rotation direction the air flow rate is much lower than in the CW rotation direction, the risk that the laundry is transported towards and fixed at the outlet 24 is much lower in CCW direction than in CW direction. It is to be noted that due to the small number of pieces (load of laundry for this drying program is restricted to low loads) there is the risk in the first section of the drying program that laundry is sucked to the outlet openings 24 and sticks there during all or essential parts of the drying program preventing efficient drying and resulting in increased crease formation at least at the laundry pieces sticking at the outlet 24. Thus in the first section of the drying program, when the laundry is wet or has the higher humidity, the average air flow rate is reduced to prevent the sticking of laundry pieces.

[0050] The phase B1 is provided for a predetermined duration and then the drying program proceeds to the first drying phase B2. During phase B1 a pre-drying of the laundry pieces was achieved and the laundry was detangled and distributed in the drum, such that in the first drying phase B2 the drying can be intensified by increasing the average air flow. During the phase B2 the drum is rotated alternately in CW and CCW rotation direction each time at the rotation speed $D3 = 46$ rpm. Each of the periods of CW rotation is longer than the respective following period of CCW rotation. In average this results in a higher air flow rate through the drum as compared to the initialization phase B 1. Due to the higher air flow, more humidity can be removed from the laundry. But still during phase B1 the highest drum rotation speed $D3$ and thus the highest fan rotation speed is lower than the maximum possible or nominal rotation speed $D4$ (corresponding to 2750 rpm motor speed and fan rotation speed).

[0051] Referring back to Fig. 4, it can be seen, that during the phase B2 the refrigerant temperature Tr increases in waves until reaching the threshold $Tr1$. The reason for the increase in waves is that during rotation of the drum in CCW direction the drying air flow rate is reduced and less heat is removed from the condenser 32 such that the refrigerant temperature detected at the outlet of the condenser 32 increases in these periods. In the periods where the drum and thus the fan 28 are rotated in CW rotation direction, the drying air flow rate is higher and more heat is removed from condenser 32. In these periods, the refrigerant temperature is decreasing. However, during phase B2 the net effect of increase and decrease is that the refrigerant temperature Tr is rising.

[0052] Fig. 6 shows in detail the transition from the first drying phase B2 to the second drying phase B3. As compared to phase B2, in phase B3 the drying efficiency is further intensified in that the duration of rotating the drum and fan 28 in forward direction CW is extended (as compared to the duration of the CCW periods) and additionally the rotation speed is increased to $D4 = 55$ rpm. Further, the duration of rotating the drum and fan in the counter clockwise rotation direction CCW is shortened whereas the rotation speed in CCW rotation direction is maintained at $D3 = 46$ rpm. Thus, in B3 as compared to B2, the ratio of the duration of CW rotation direction divided by the duration of rotation of CCW rotation direction is increased. This increase of the ratio is true for each one of the repeating periods of clockwise CW rotation period followed by a CCW rotation period, as well as for the average over the total duration in B3 (when compared with the respective ratios in phase B2).

[0053] The second drying phase B3 is continued until a predetermined laundry humidity H_{set} is reached or is below the predetermined target humidity H_{set} of the laundry. The humidity H is determined from the humidity sensor by evaluation in the control unit 60. Alternatively based on the starting humidity, the laundry load and other parameters the control unit 60 can estimate the duration of the phase B3 (or the total drying time of the drying program) such that the second drying phase B3 is terminated as soon as the estimated time is lapsed.

[0054] In the cooling phase C as shown in Fig. 4 the drum is first rotated in CW direction at the drum speed $D3 = 46$ rpm for a predetermined period and then the drum is rotated at the speed $D3$ in the CCW rotation direction. The duration of CW rotation is shorter than the duration of the CCW rotation during the cooling phase C and also cooling phase C is terminating with a CCW rotation. Thereby, it is achieved that by mechanical agitation of the drum the laundry is distributed over a wider area of the drum without excessive flow pressure onto the laundry. Thus the reduced drying air flow rate in the final CCW rotation improves spreading of the laundry such that crease formation during the time until the user removes the dry laundry is reduced.

[0055] Fig. 7 shows a flow diagram of the drying program. The drying program is started at $S0$ and an increment counter with the variable n is set to zero at $S2$. At $S4$ the initialization phase A is started during which it is detected whether wet laundry is present in the drum 16 or not. Initialization phase A is executed for a predetermined period and proceeds to $S6$ where it is checked whether load is in the drum. If no load was detected, the program proceeds to $S6$ where it is checked whether the count n is less than a predetermined count N . If count n is not less than the predetermined count N , in $S12$ the drying program aborts and the user is informed via the display at the control panel 12 that an error

EP 3 124 680 A1

occurred. For example by displaying the question "Load Correct?" Optionally it can be checked by the initialization phase A (S4 + modified S6) whether the load is above a threshold weight which would not allow to properly execute the drying program dedicated for small laundry loads.

[0056] If in S8 the count n is less than the predetermined count N, the program proceeds to S10, where the count n is incremented by one. Thereafter, the program proceeds back S4 to repeat the load detection in phase A.

[0057] If in S6 the result of the load detection is positive, the program proceeds to S14 where the pre-drying phase B1 or cradle phase is executed by distributing or spreading the laundry within the drum by the movements and reduced drying air flow rate as described above. The pre-drying phase B1 is continued in this example for 3 minutes.

[0058] Then the program proceeds to S16 for executing the first drying phase B2 which is the main drying phase. The main drying phase B2 is continued in the loop S16-S18-S20 as long as either the refrigerant temperature Tr has exceeded the refrigerant threshold Tr1 (step S18) or the laundry has already reached a humidity H lower than the predetermined final humidity Hset (step S20). When in S18 the refrigerant temperature Tr > threshold Tr1, then the program proceeds to S22 for executing the second drying phase B3. When in S20 the laundry humidity H < predetermined humidity Hset, then the program proceeds to the cooling phase C in S26. Otherwise the program proceeds back to S16.

[0059] In the second drying phase B3, also called "safe" drying phase which guaranties achieving the predetermined or target humidity Hset, the loop S22-S24 is repeatedly executed until the laundry humidity H is less than the target humidity Hset. If in S24 the laundry humidity H < Hset, then the program proceeds to S26 where the cooling phase C is executed for 150 sec in this example.

[0060] After the cooling phase C in S26 the program proceeds to S28 where the condensate pump 50 is activated for 30 seconds to remove the collected condensate from the condensate collector 48 into the condensate drawer 14. After condensate pumping in S28, the program proceeds to S30 where the drying program is successfully terminated.

[0061] In the following another example for the drum rotation sequence during the drying program (which is modified as compared to the sequence shown in Figs. 4-6) is given:

Phase	Drum Rotation Speed D + Duration (motor speed)
Phase A	off: 2 sec CW: 180 sec @ 40 rpm (2000 rpm) off: 2 sec CCW: 15 sec @ 40 rpm (2000 rpm)
Phase B1	off: 3 sec CCW: 3 sec @ 15 rpm (750 rpm) off: 3 sec CW: 3 sec @ 15 rpm (750 rpm) off: 3 sec CCW: 3 sec @ 15 rpm (750 rpm) off: 3 sec CW: 40 sec @ 46 rpm (2300 rpm) off: 3 sec CCW: 3 sec @ 15 rpm (750 rpm) off: 3 sec CW: 3 sec @ 15 rpm (750 rpm) off: 3 sec CCW: 3 sec @ 15 rpm (750 rpm) off: 3 sec CW: 40 sec @ 46 rpm (2300 rpm)
Phase B2	One Period: off: 2 sec CW: 90 sec @ 46 rpm (2300 rpm) off: 2 sec CCW: 30 sec @ 46 rpm (2300 rpm) Periods repeated until Tr > Tr1

(continued)

Phase	Drum Rotation Speed D + Duration (motor speed)
Phase B3	One Period: off: 2 sec CW: 240 sec @ 55 rpm (2750 rpm) off: 2 sec CCW: 10 sec @ 46 rpm (2300 rpm) Periods repeated until H < Hset
Phase C	off: 2 sec CW: 60 sec @ 46 rpm (2300 rpm) off: 2 sec CCW: 240 sec @ 46 rpm (2300 rpm)

[0062] The rotation speeds given here are only examples for optimized parameters applicable in one model of dryer. The absolute values of the rotation speeds and the durations in each rotation direction have to be adapted in dependency of one or more of: the drum diameter, the drum internal design, the gear ratio between the drum motor rotation speed and the drum rotation speed, possibly (if not 1:1) the gear ratio between drum or drying air fan motor rotation speed and drying air fan rotation speed, the conveyance capacity of the drying air fan, the drying air flow resistance, and the geometry of the at least one drying air outlet 24 (and the design of the entrance grill of the fluff filter element 26).

[0063] For further illustration the above is summarized:

[0064] For reducing creases in a low load of laundry, first action is to reduce the risk that the laundry is getting stuck and twisted. To obtain this, the CW drum rotation speed has been reduced from the nominal speed. For example the nominal speed is in a dryer-only (no washer dryer) or is for the standard drying program in a washer dryer 2900 rpm for cotton and 2750 rpm for other cycles. In the method according to the invention for such examples the nominal speed is reduced to 2300 rpm. This speed reduction decreases airflow enough to allow silk piece to tumble freely in the drum without getting stuck between drum and filter.

[0065] In addition it has been observed that drum movement CCW at the reduced speed (of e.g. 2300 rpm) is able to well "open" (or lay out) the clothes such that the opening effect of the cradle movement in phase B1 is more effective in crease prevention.

[0066] The main part of drying cycle is performed with drum reversing (e.g. 2 sec OFF/ 90 sec 2300 rpm CW/2 sec OFF/30 sec CCW).

[0067] A positive effect on creases prevention has been identified also on cooling phase extension. In this phase, since the compressor is OFF it is possible to maintain the drum motor in CCW rotation for more time (in CCW rotation the air flow is very limited, and with compressor on, it can create issues on the heat pump system if prolonged too much). It is also good that last drum movement before end cycle is in CCW direction, because of the "opening" effect already described.

[0068] An additional improvement has been provided for the implemented drying program resulting in higher robustness of the heat pump system 44: A reduced drying air flow in the system can result in the heat pump not operating in a proper operating range. For this reason, the usage of main silk drying drum reversing in phase B2 (e.g. 2 sec OFF; 90 sec / 2300 rpm / CW; 2 sec OFF; 30 sec / CCW) is limited to the first drying phase B2 of the drying program, until the heat pump operating temperature Tr (we read this temperature through an NTC on the condenser exit) reach a certain limit Tr1 (we set this at 55°C). Interesting range for this parameter can be 50-65°C). After the reach of NTC temperature threshold Tr1, a safer motor reversing is activated in drying phase B3. The main purpose of phase B3 is to increase average airflow: drum speed for CW direction is increased to 2750 rpm and its duration is extended to 240sec, while CCW rotation has been reduced to 10 sec but always to 2300 rpm.

Reference Numeral List

2	laundry dryer	62	memory
4	housing / cabinet	64	drum motor inverter
6	front wall	66	compressor motor inverter
8	loading opening	67	compressor motor
10	door	68	cooling air fan motor
12	control panel	70	(drying air fan motor)
14	condensate drawer		

(continued)

	16	drum	A	initialization phase
	18	laundry	B1	pre-drying phase
5	20	process air channel	B2	first drying phase
	20a	battery channel	B3	second drying phase
	20b	rear channel	C	cooling phase
	20c	front channel	CW	clockwise rotation / first rotation direction
10	22	inlet		
	24	outlet	CCW	counter clockwise rotation / second rotation speed
	26	fluff filter element		
	28	fan	D	drum (motor/drying air fan) rotation speed
	30	motor		
15	32	first heat exchanger	D1, D2, D3, D4	first, second, third, fourth drum rotation speed
	34	second heat exchanger		
	36	compressor	F	process air flow
	38	expansion device	H	laundry humidity / humidity sensor
	40	refrigerant loop	Hset	humidity threshold
20	42	cooling air fan	Ti	drying air inlet temperature / sensor
	44	heat pump system	To	drying air outlet temperature / sensor
	48	condensate collector		
	50	draining pump	Tr	refrigerant temperature /
25	52	drain conduit		temperature sensor
	60	control unit	Tr1	refrigerant temperature threshold

Claims

- 30 1. Method for operating a heat-pump dryer (2) during a drying program, the dryer comprising:
- a cabinet (4),
- a drum (16) arranged within the cabinet and being adapted to receive laundry (18) for drying the laundry within
- 35 the drum using drying air (F),
- an air channel (20) adapted to guide the drying air from at least one air outlet (24) at the drum (16) to at least one air inlet (22) at the drum for providing an air circulation arrangement,
- a drying air fan (28) adapted to convey the drying air (F) through the air circulation arrangement,
- a heat pump system (44) comprising a first heat exchanger (32) adapted to heat the drying air, a second heat
- 40 exchanger (34) adapted to cool the drying air for humidity condensation, and a compressor (36) adapted to circulate refrigerant through the first and second heat exchangers,
- a temperature sensor adapted to detect a refrigerant temperature (Tr) of the heat pump system (44), and
- a) a fan motor (70) adapted to drive the drying air fan (28) selectively in a first rotation direction (CW) or in
- 45 a second rotation direction (CCW) or to drive the drying air fan selectively at least at a first rotation speed or at a second rotation speed, and a drum motor (30) adapted to drive the drum (16) selectively in a first rotation direction (CW) or in a second rotation direction (CCW), or
- b) a motor (30) adapted to drive in a synchronized manner the drying air fan (28) and the drum (16) selectively in a first rotation direction (CW) or in a second rotation direction (CCW),
- 50 wherein the method comprises:
- starting a drying program,
- monitoring the refrigerant temperature (Tr) of the heat pump system (44), and
- in dependency of the temperature (Tr) of the heat pump system, adapting at least one of:
- 55 - the temporal ratio of rotating the drum (16) in the first rotation direction (CW) to rotating the drum in the second rotation direction (CCW),
- the temporal ratio of rotating the drying air fan (28) in the first rotation direction (CW) to rotating the drying

air fan in the second rotation direction (CCW), and

- the temporal ratio of rotating the drying air fan at the first rotation speed to rotating the drying air fan at the second rotation speed or changing rotating the drying air fan at the second rotation speed to rotating the drying air fan at the first rotation speed, wherein the first rotation speed is higher than the second rotation speed.

2. Method according to claim 1, wherein adapting the temporal ratios in dependency of the temperature (Tr) of the heat pump system (44) comprises: if the temperature of the heat pump system is at or above a first threshold value (Tr1), changing the drying mode of the drying program from a first drying phase (B2) to a second drying phase (B3) by one or more of:

- increasing the temporal ratio of rotating the drum (16) in the first rotation direction (CW) to rotating the drum in the second rotation direction (CCW),

- increasing the temporal ratio of rotating the drying air fan (28) in the first rotation direction (CW) to rotating the drying air fan in the second rotation direction (CCW), and

- increasing the temporal ratio of rotating the drying air fan at the first rotation speed to rotating the drying air fan at the second rotation speed or changing rotating the drying air fan at the second rotation speed to rotating the drying air fan at the first rotation speed, wherein the first rotation speed is higher than the second rotation speed.

3. Method according to claim 1 or 2, wherein the drying air fan (28) is designed such that at the same rotation speed or rotation speeds the conveyance rate when rotating in the first rotation direction (CW) is higher than the conveyance rate when rotating in the second rotation direction (CCW).

4. Method according to claim 1, 2 or 3, wherein when rotating the drum (16) in the first rotation direction (CW) the rotation speed is higher as compared to the rotation speed when the drum is rotated in the second rotation direction (CCW), or when rotating the drum in the first rotation direction the duration of uninterrupted rotation in the first rotation direction is longer than the duration of uninterrupted rotation of the drum in the second rotation direction.

5. Method according to any of the previous claims, wherein when rotating the drying air fan (28) in the first rotation direction (CW) the rotation speed is higher as compared to the rotation speed when the drying air fan is rotated in the second rotation direction (CCW), or when rotating the drying air fan in the first rotation direction the duration of uninterrupted rotation in the first rotation direction is longer than the duration of uninterrupted rotation of the drying air fan in the second rotation direction.

6. Method according to any of the previous claims, wherein the drum motor speed or the drum rotation speed (D) is adapted in dependency of the temperature (Tr) of the heat pump system (44), or wherein the drum rotation speed (D) in the first rotation direction (CW) is adapted in dependency of the temperature (Tr) of the heat pump system while the rotation speed of rotating the drum in the second rotation direction (CCW) is constant.

7. Method according to claim 6, wherein the drum rotation speed (D) is adapted in dependency of the temperature (Tr) of the heat pump system (44) by one of the following:

- if the temperature of the heat pump system is at or above a first threshold value (Tr1), increasing the absolute value of the drum rotation speed (D), and

- if the temperature of the heat pump system is at or above a first threshold value (Tr1), increasing the drum rotation speed (D) in the first rotation direction (CW) and maintaining the drum rotation speed in the second rotation direction (CCW).

8. Method according to any of the previous claims, wherein the drying air fan (28) is driven by the motor (70) independent of the motor (30) driving the drum (16).

9. Method according to any of the previous claims, wherein the drying program comprises at least a first and second drying phase (B2, B3) and subsequent to the drying phases a cooling phase (C), wherein in the cooling phase at least one of the following is applied:

- the ratio of duration of rotating the drum (16) in the first rotation direction (CW) to the duration of rotating the drum in the second rotation direction (CCW) is decreased as compared to the preceding or second drying phase (B3), or this ratio is decreased to below 1,
- the ratio of duration of rotating the drying air fan (28) in the first rotation direction (CW) to the duration of rotating the drying air fan in the second rotation direction (CCW) is decreased as compared to the preceding or second drying phase (B3), or this ratio is decreased to below 1,
- the rotation speed (D) of the drum in the first rotation direction (CW) is reduced as compared to the rotation speed in the preceding or second drying phase (B3),
- the rotation speed (D) of the drum in the second rotation direction (CCW) is reduced as compared to the rotation speed in the preceding or second drying phase (B3),
- the rotation speed of the drying air fan (28) in the first rotation direction (CW) is reduced as compared to the rotation speed in the preceding or second drying phase (B3), and
- the rotation speed of the drying air fan (28) in the second rotation direction (CCW) is reduced as compared to the rotation speed in the preceding or second drying phase (B3).

10. Method according to claim 9, wherein the drying program is proceeding to the cooling phase (C) in dependency of one or more of the following conditions:

- the laundry humidity (H) is at or below a predetermined threshold or target humidity (Hset),
- a parameter indicating laundry humidity is lower or equal to a set value,
- the temperature (To) of the air exhausted out of the drum (16) is higher than a set value,
- a temperature gradient of the air exhausted (ΔT_o) out of the drum is higher than a set value, and
- a drying time as set by a user or as determined by the dryer (2) has lapsed.

11. Method according to any of the previous claims, wherein a pre-drying phase (B1) is preceding a or the first drying phase (B2), wherein in the pre-drying phase, the method provides one or more of the following:

- one or more periods are provided in which the drum (16) is alternately rotated in the first and second rotation direction (CW, CCW), wherein in each rotation direction the rotation angle of the rotation is less than 360°, 270°, 200°, 180°, 150° or 100°,
- the ratio of duration of rotating the drum (16) in the first rotation direction (CW) to the duration of rotating the drum in the second rotation direction (CCW) is lower than in the following first drying phase (B2),
- the ratio of duration of rotating the drying air fan (28) in the first rotation direction (CW) to the duration of rotating the drying air fan in the second rotation direction (CCW) is lower than in the following first drying phase (B2),
- the duration of rotating the drum (16) or the drying air fan (28) in the first rotation direction (CW) in the pre-drying phase (B1) is shorter than in the first drying phase (B2),
- the duration of rotating the drum or the drying air fan in the second rotation direction (CCW) in the pre-drying phase (B1) is shorter than in the first drying phase (B2),
- the rotation speed of the drum (16) in the first rotation direction is lower as compared to the rotation speed (D) in the following first drying phase,
- the rotation speed (D) of the drum (16) in the second rotation direction is lower as compared to the rotation speed in the following first drying phase,
- the rotation speed of the drying air fan (28) in the first rotation direction is lower than the rotation speed in the following first drying phase, and
- the rotation speed of the drying air fan (28) in the second rotation direction is lower than the rotation speed in the following first drying phase.

12. Method according to any of the previous claims, wherein one or more of the following:

- the ratio of duration of rotating the drum (16) in the first rotation direction (CW) to the duration of rotating the drum in the second rotation direction (CCW),
- the ratio of duration of rotating the drying air fan (28) in the first rotation direction to the duration of rotating the drying air fan in the second rotation direction,
- the rotation speed (D) of the drum (16) in the first rotation direction,
- the rotation speed (D) of the drum (16) in the second rotation direction,
- the rotation speed of the drying air fan (28) in the first rotation direction, and
- the rotation speed of the drying air fan (28) in the second rotation direction;

in one or more of the following phases:

- a or the pre-drying phase (B1),
- a or the first drying phase (B2),
- a or the second drying phase (B3), and
- a or the cooling phase (C);

are dependent on one or more of the following:

- a laundry treatment program or laundry treatment options set by a user via an input device (12) of the dryer (2),
- a laundry type as set by a user or as estimated by the dryer,
- the duration of the laundry treatment program set by a user or as estimated by the dryer,
- in case that the drying program is part of a washing and drying program, an estimation of the water content in the laundry (18) at the beginning of a drying program based on the laundry weight difference between the dry laundry weight and the laundry wet weight at the end of the washing program,
- the amount or weight of laundry (18) to be dried,
- the current degree of humidity (H) of the laundry,
- the temperature (Ti, To) of the drying air (F),
- the ambient temperature,
- the internal temperature of the dryer, and
- the duration since the start of the drying.

13. Method according to any of the previous claims, wherein the temperature sensor adapted to detect the refrigerant temperature (Tr) of the heat pump system (44) is arranged at one of the following positions of the heat pump system:

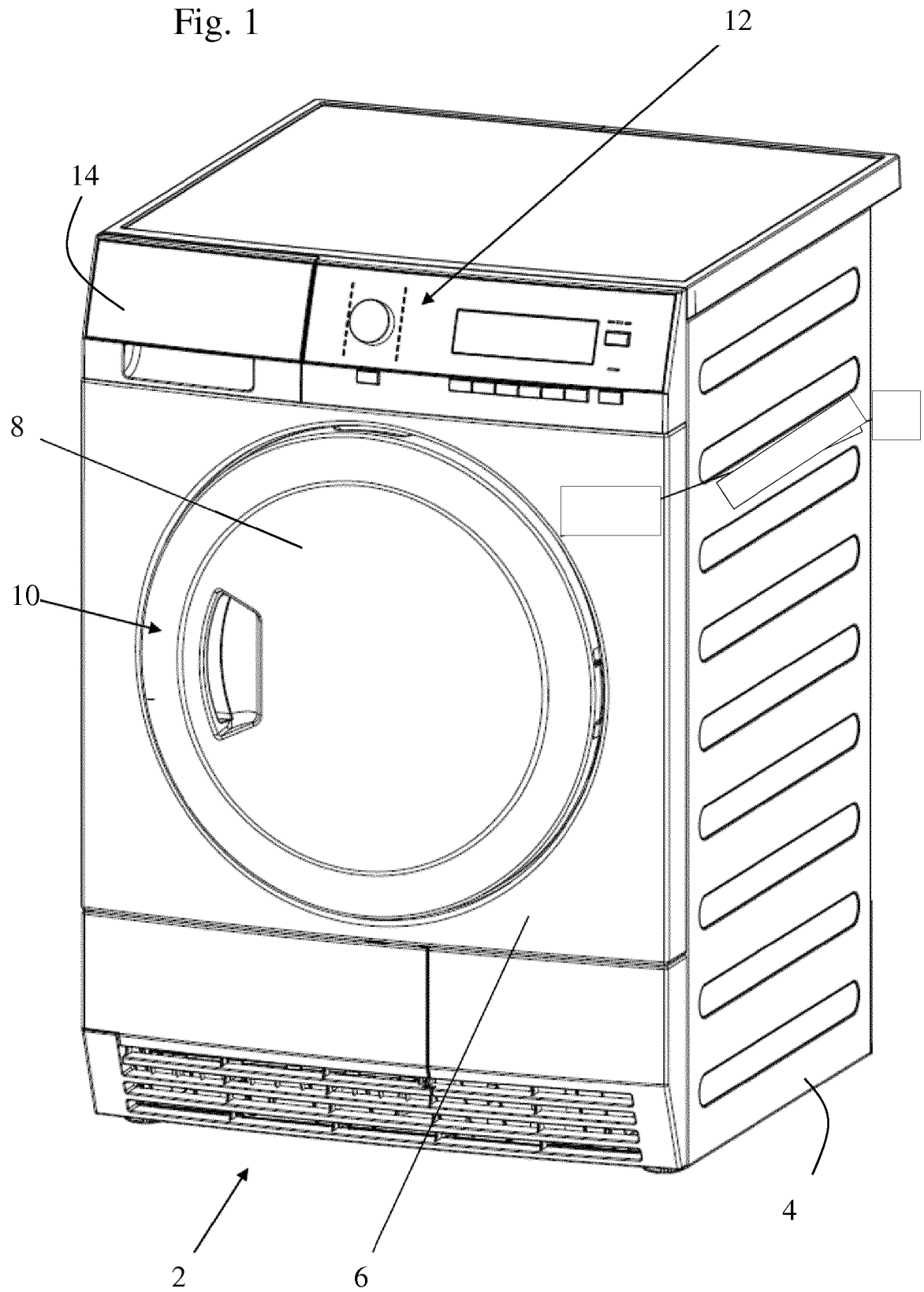
- an outlet of the first heat exchanger (32) for detecting the refrigerant temperature (Tr),
- an outlet of the compressor (36) for detecting the refrigerant temperature,
- the compressor (36) for detecting the compressor temperature,
- the second heat exchanger (34) for detecting the refrigerant temperature, or
- an expansion device (38) arranged between the second and first heat exchanger for detecting the refrigerant temperature.

14. Method according to any of the previous claims, wherein the dryer (2) is implemented by a washer dryer providing at least one washing program, wherein a tub is arranged in the cabinet (4) and the drum (16) is arranged in the tub, wherein the at least one outlet (24) of the drum is at least one outlet of the tub, or the at least one inlet (22) of the drum is at least one inlet of the tub, or the at least one outlet of the drum is at least one outlet of the tub and the least one inlet of the drum is at least one inlet of the tub, and wherein the drying air fan (28) is driven by a or the motor (70) independent of a or the motor (30) driving the drum (16).

15. Method according to any of the previous claims, wherein, when the drying program is started, the method provides immediately at the beginning of the drying program a phase (A) of detecting whether laundry (18) is loaded into the drum (16) or not.

16. Method according to any of the previous claims, wherein the dryer (2) comprises an option selector to be activated by the user or comprises a program selector (12) for selecting a drying program for drying silk laundry or for drying a laundry load of maximum or less than 2 kg or 1 kg, wherein, when the user has selected such option or such program, the laundry is dried according to any of the previous claims.

Fig. 1



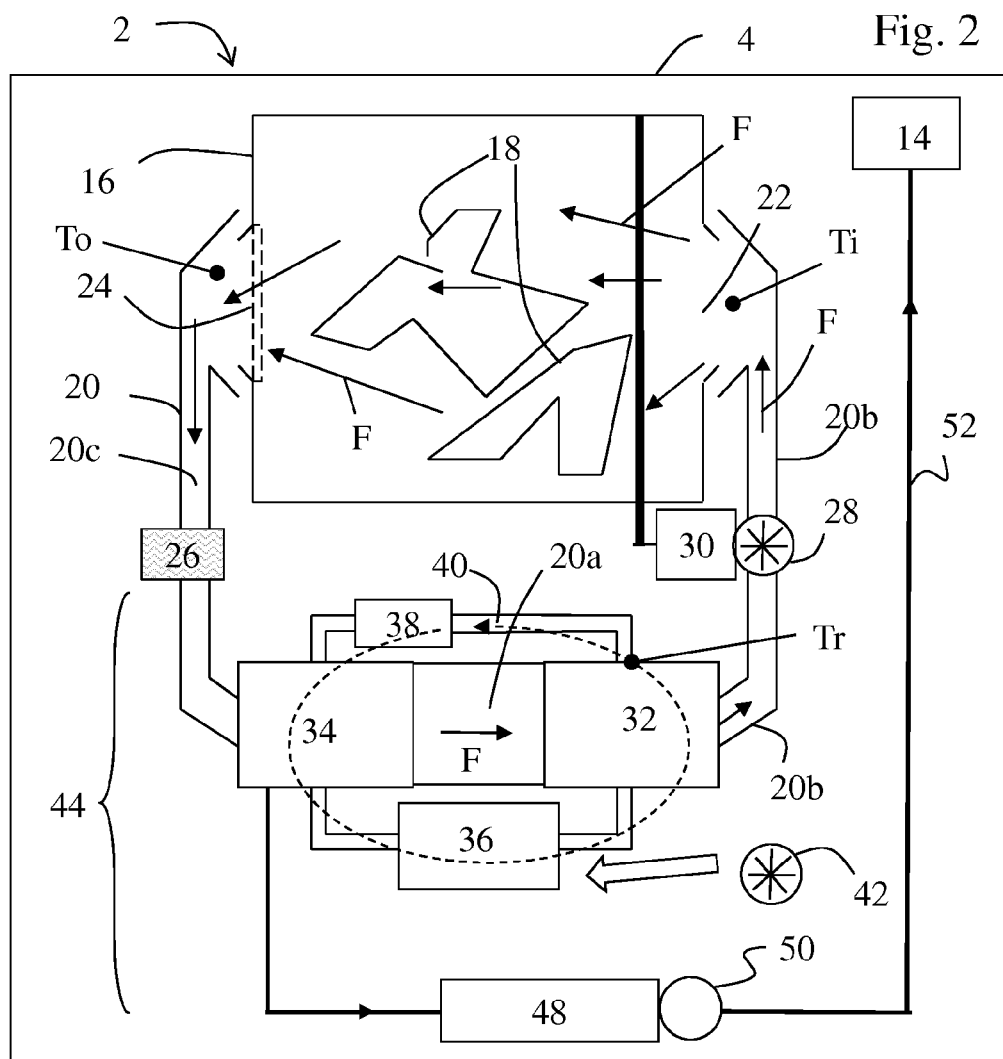
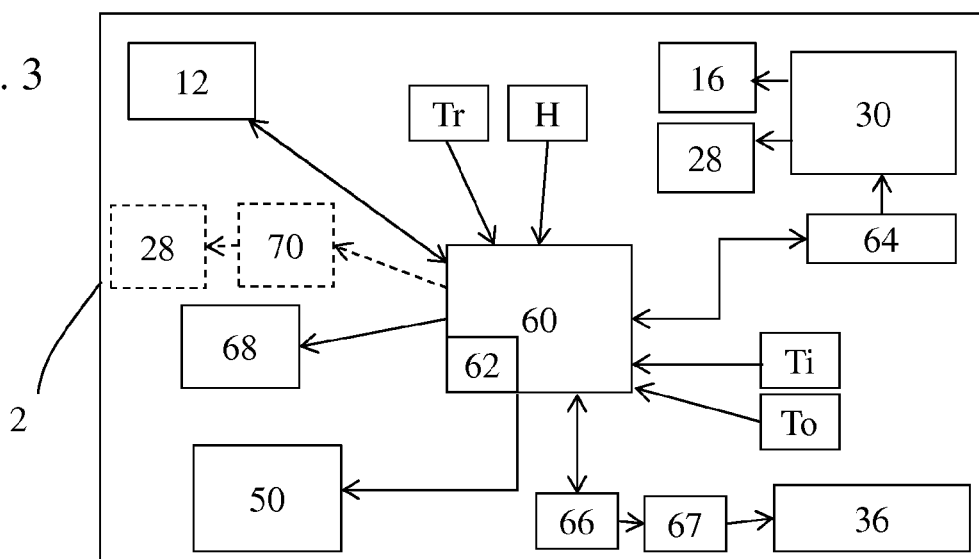


Fig. 3



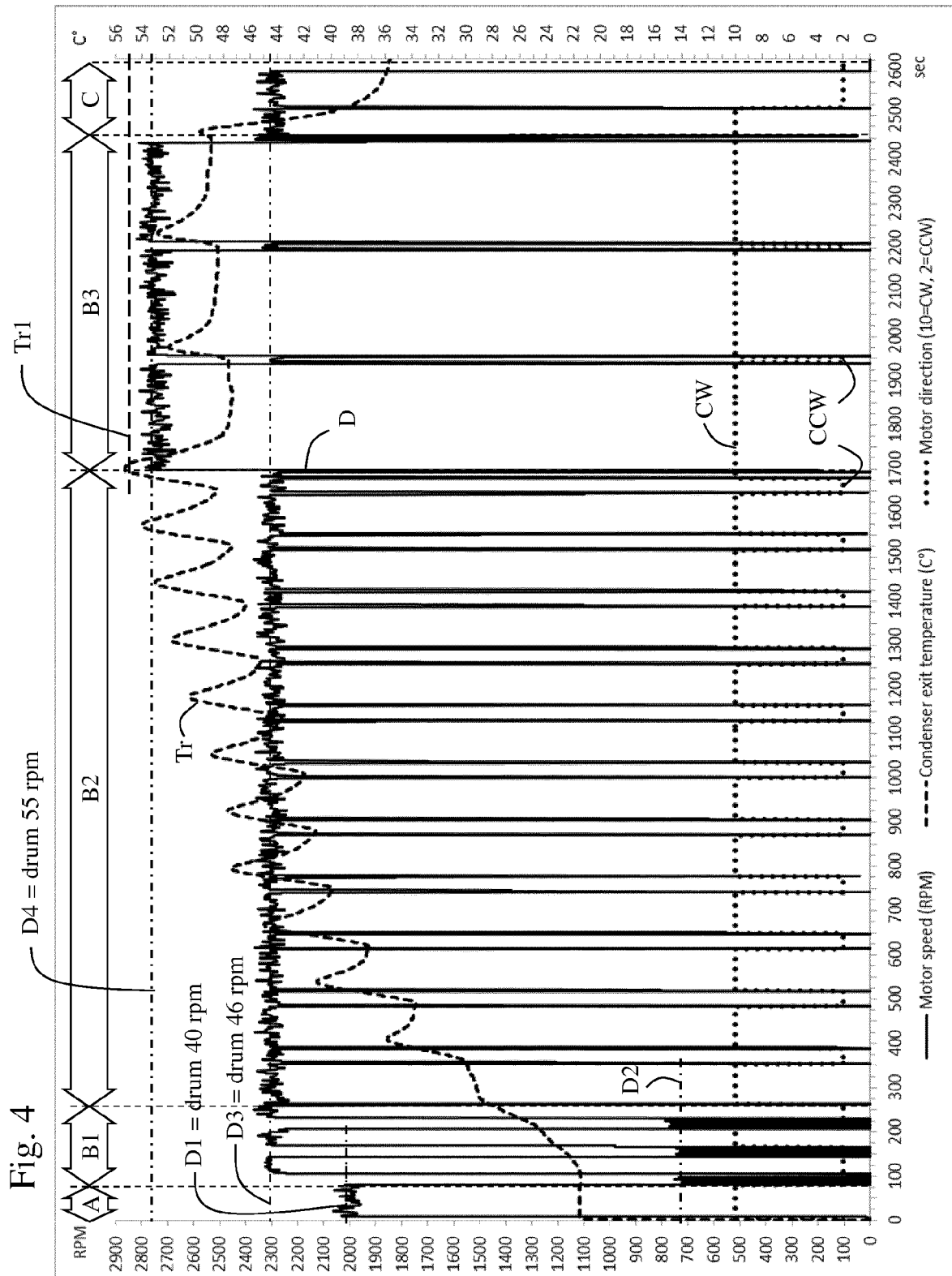


Fig. 5

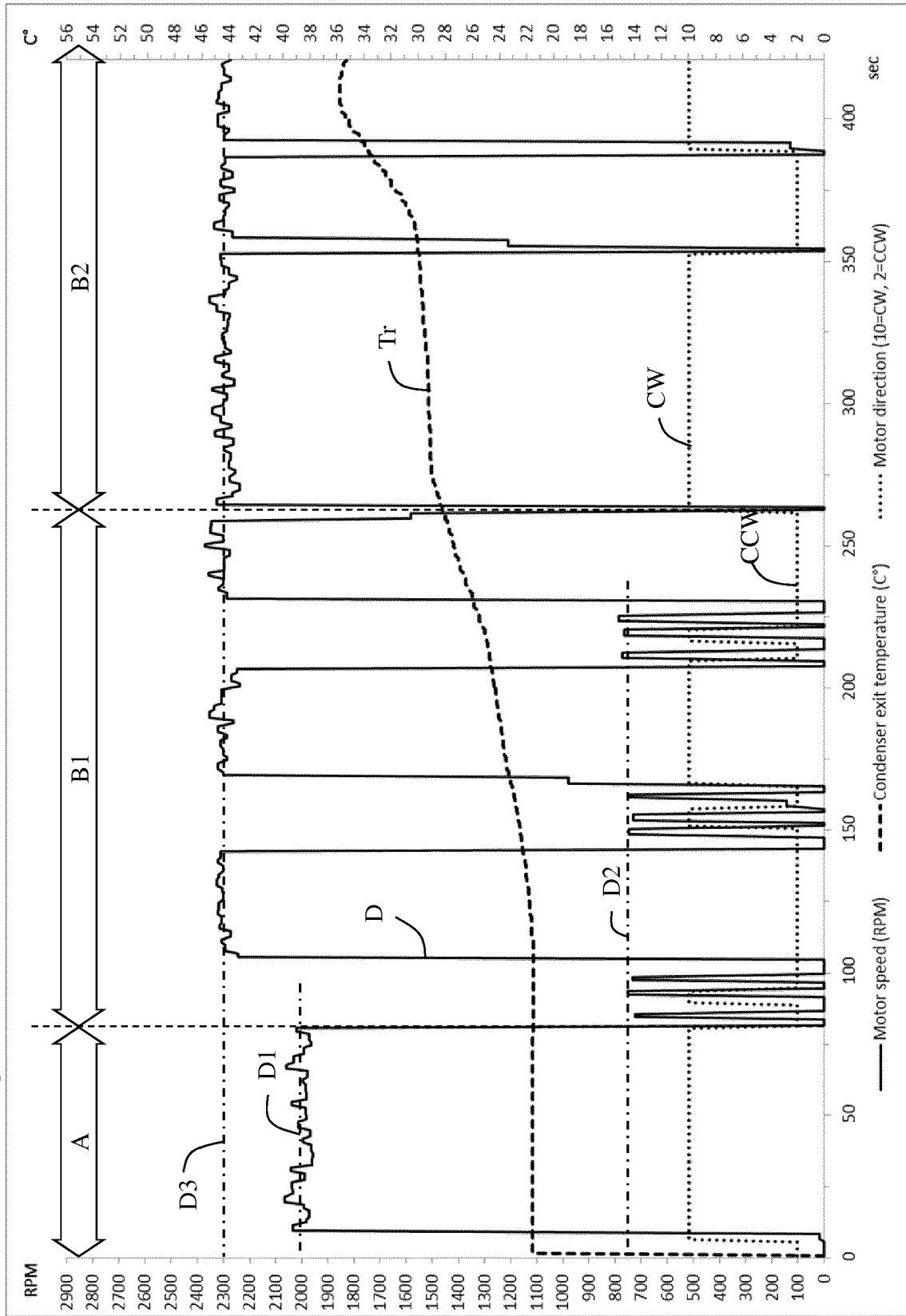


Fig. 6

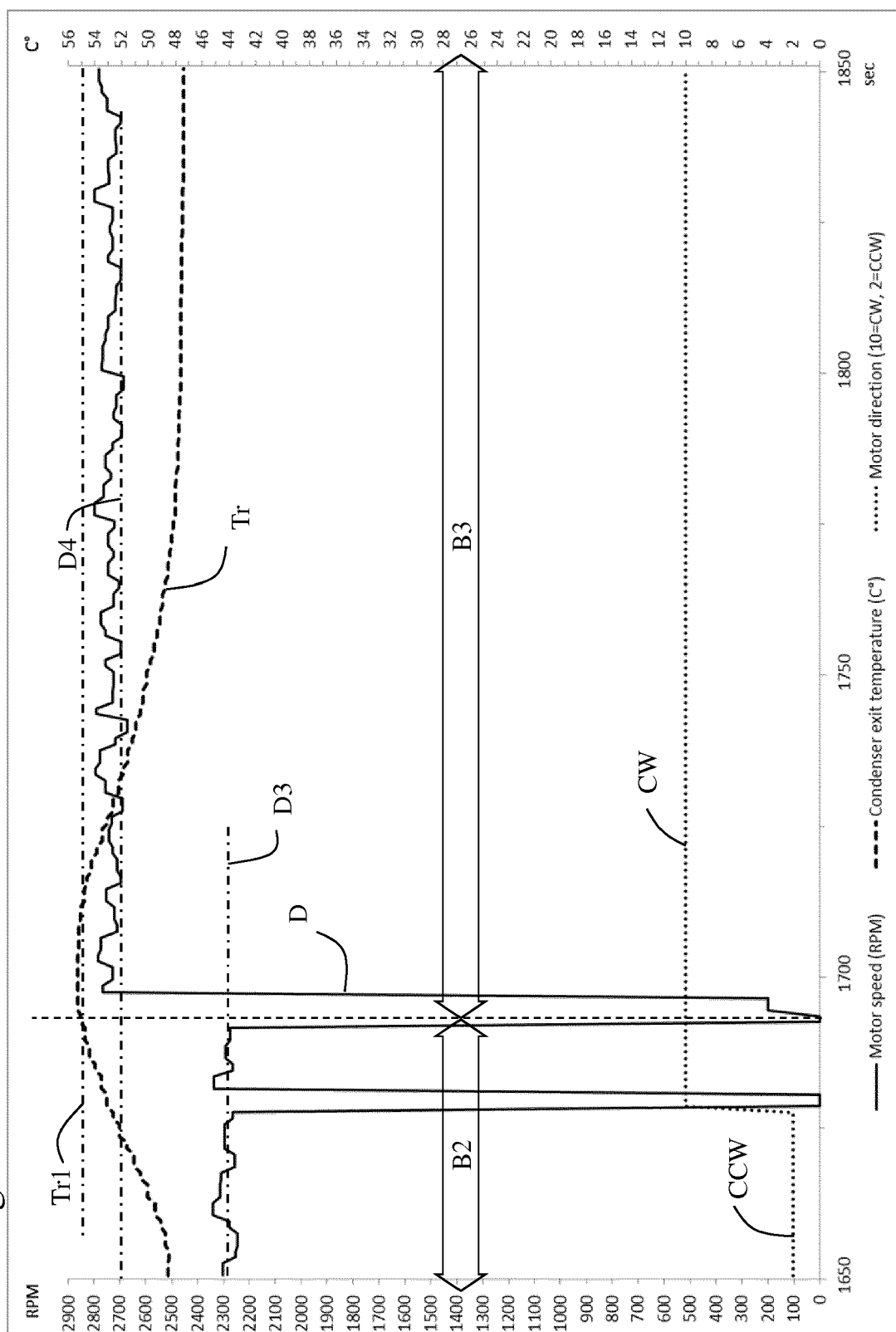
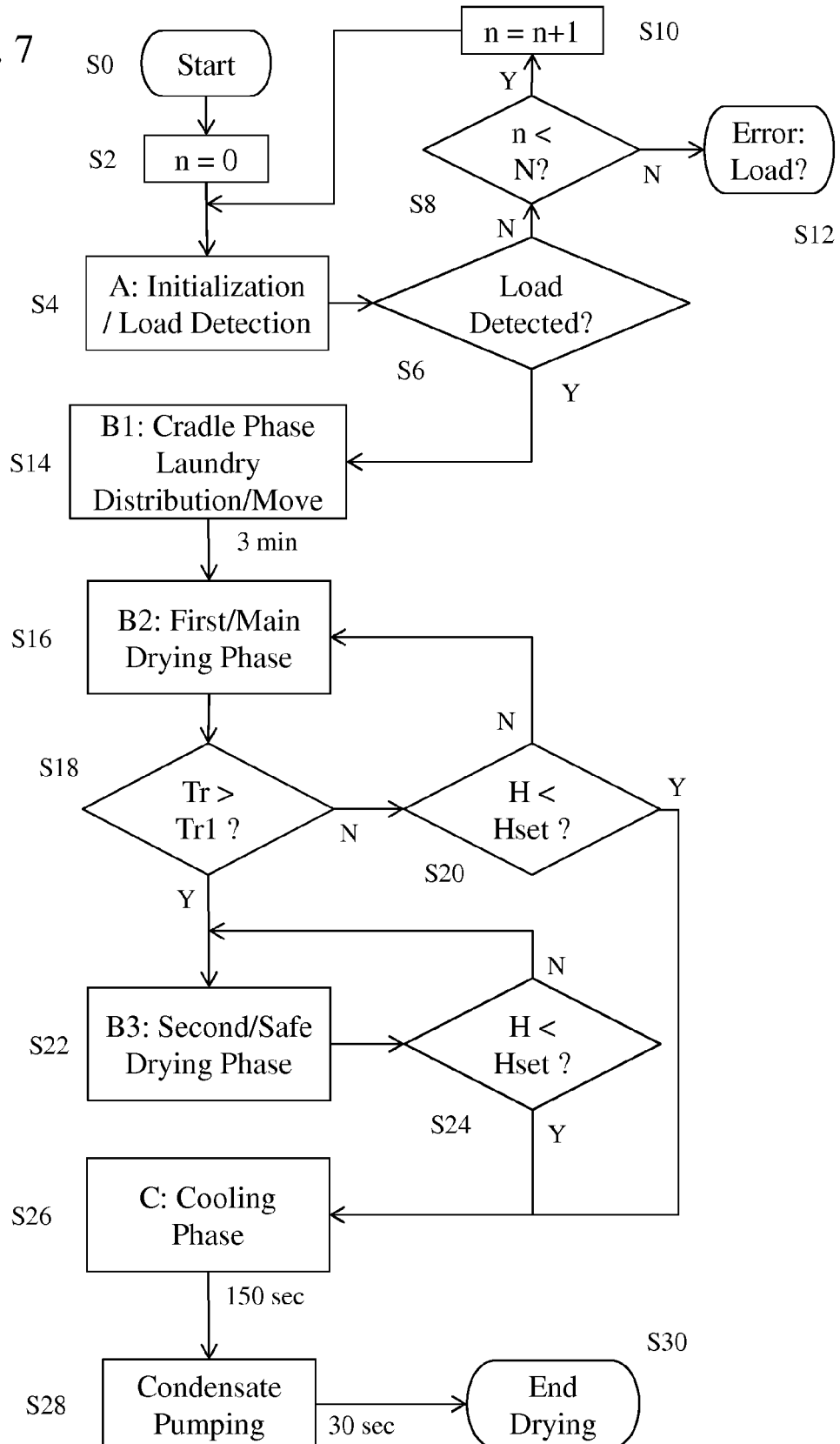


Fig. 7





EUROPEAN SEARCH REPORT

 Application Number
 EP 15 17 8434

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 2 679 718 A1 (ELECTROLUX HOME PROD CORP [BE]) 1 January 2014 (2014-01-01) * paragraphs [0015], [0016], [0040], [0041]; claim 15; figures 1-3 *	1,3-6,8,13,14	INV. D06F58/20 D06F58/28
A	DE 40 32 079 A1 (LICENTIA GMBH [DE]) 16 April 1992 (1992-04-16) * column 2, line 60 - column 314 *	1-3,9,12,14	
A	EP 1 852 541 A1 (ELECTROLUX HOME PROD CORP [BE]) 7 November 2007 (2007-11-07) * paragraphs [0012] - [0014], [0027]; figure 1 *	1,3,12-15	
A	US 5 555 645 A (JOSLIN DAN F [US]) 17 September 1996 (1996-09-17) * column 1, line 60 - column 2, line 50; figures 1,2 *	1,9,12,14	
A,D	EP 2 832 921 A1 (MIELE & CIE [DE]) 4 February 2015 (2015-02-04) * paragraph [0018]; figure 1 *	1,2	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 14 January 2016	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	

 1
 EPO FORM 1503 03.82 (P04C01)

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

EP 15 17 8434

5

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

14-01-2016

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2679718 A1	01-01-2014	AU 2013283593 A1	15-01-2015
		CN 104583483 A	29-04-2015
		EP 2679718 A1	01-01-2014
		EP 2867400 A1	06-05-2015
		WO 2014001114 A1	03-01-2014

DE 4032079 A1	16-04-1992	NONE	

EP 1852541 A1	07-11-2007	AT 544899 T	15-02-2012
		BR PI0711161 A2	23-08-2011
		CN 102212957 A	12-10-2011
		CN 102260989 A	30-11-2011
		EP 1852541 A1	07-11-2007
		EP 2163678 A1	17-03-2010
		EP 2163679 A1	17-03-2010
		ES 2371505 T3	03-01-2012
		KR 20090008417 A	21-01-2009
		US 2009282695 A1	19-11-2009
		WO 2007128439 A1	15-11-2007

US 5555645 A	17-09-1996	NONE	

EP 2832921 A1	04-02-2015	DE 102013108061 A1	29-01-2015
		EP 2832921 A1	04-02-2015

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 2832921 A1 [0002]