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(54) Laundry washer-dryer

(57) 1. A method for operating a washing cycle (10) and a subsequent drying cycle (20) in a laundry washer-dryer (1), the washer-dryer (1) comprising: a tub (3) and a drum (4) for storing laundry rotatably arranged inside the tub (3); a water circulation line (40) to supply the tub (3) and the drum (4) with water in said washing cycle (10);an air circulation channel (50) including a blower (55) for blowing air through the tub (3) and the drum (4) in said drying cycle (20); and a heat pump system having at least one heater (32, 62) and at least one cooler (33, 63) for said water circulation line (40) and said air circulation channel (50), and a single compressor (31) for circulating a refrigeration fluid through said heater (32, 62) and cooler (33, 63), the method comprising the steps of: performing the washing cycle (10) comprising at least one washing phase (14) and at least one rinsing phase (16); and performing the drying cycle (20) including at least one drying phase (22), wherein said compressor (31) is energized during the washing phase (14) for heating up washing water, during the rinsing phase (16) for heating up rinsing water and during the drying phase (22) for heating up drying air.

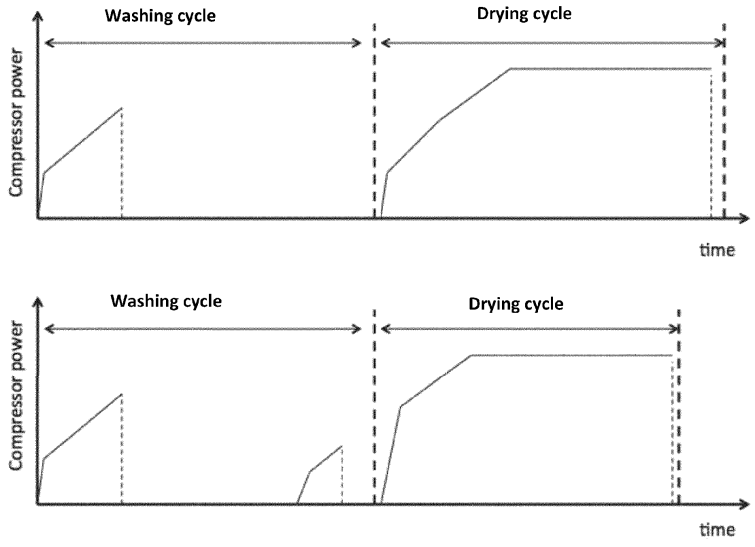

Fig. 6

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Description

[0001] The present invention relates to a method for operating a washing cycle and a subsequent drying cycle in a laundry washer-dryer with a heat pump system according to the preamble of claim 1. Further, the present invention relates to a laundry washer-dryer with a heat pump system.

[0002] The use of a heat pump system for dryers is nowadays very common. As a matter of fact a laundry washer-dryer with heat pump technology achieves an efficient way to save energy during the drying cycle. The laundry washer-dryer allows a combined washing and drying cycle. After the laundry has been filled into the laundry washer-dryer by the user, the washing cycle and the subsequent drying cycle can be performed automatically. The user can take the washed and dried laundry from the laundry washer-dryer, after the drying cycle has been finished. It is not necessary, that the user has to open the door of the laundry washer-dryer between the washing cycle and the drying cycle.

[0003] In the drying cycle, both heat pump cooling and heating powers are used as the drying air flows in a close loop and therefore it must be continuously cooled down and dehumidified, to drain water from the laundry, and then heated up .

[0004] As for the washing cycle, the same heat pump system is used to warm up the washing water instead of using a different heater, e.g. an electrical resistance.

[0005] Usually, the compressor of the heat pump system is hence switched off when the water is warmed up to the desired temperature level, and it stays off for a long time, i.e. through the washing, the rinsing and the spinning steps before being switched on again for the drying phase.

[0006] However, after the staring of the drying phase when the compressor is switched on and an air flow is circulated through the evaporator and the condenser, the heap pump system requires time to reach steady state working condition in terms of refrigerant pressure and refrigerant temperature to effectively remove moisture for the laundry. During this time interval, i.e. transitory phase, which usually lasts at least 30 minutes after the activation of the compressor, the refrigerant temperature raise to reach the steady state working condition. The transitory phase reduces the overall efficiency of the drying process and increase the duration of the drying phase.

[0007] It is an object of the present invention to provide an improved method for operating the washing cycle and the subsequent drying cycle in a laundry washer-dryer comprising: a tub and a drum for storing laundry rotatably arranged inside the tub; a water circulation line to supply the tub and the drum with water in said washing cycle; an air circulation channel including a blower for blowing air through the tub and the drum in said drying cycle; and a heat pump system having an evaporator and a condenser for the water circulation line and the air circulation channel, and a single compressor for circulating a refrigeration fluid through said evaporator and condenser.

[0008] Preferably, the heat pump system comprises a respective evaporator and a respective condenser for each of said water circulation line and said air circulation channel.

[0009] The object of the present invention is achieved by the method according to claim 1.

[0010] According to the present invention, the heat pump system is operated to heat water at the rinsing phase.

[0011] The idea underlying the present inventions relates to the management of the compressor of the washer-dryer using the heat pump system for both the washing and drying phase in order to further improve the energy performances.

[0012] In particular, a single compressor, operated for both the refrigeration circuits respectively used for the water circulation line and the air circulation channel, is started during the first part of the main washing phase to efficiently heat up the water, so as to replace the electrical heater of the known art, and then it is switched on during the last part of the washing phase, namely to heat up rinse water.

[0013] If the washing cycle ends with at least one rinse step with heated water, which means that the compressor is energized during said rinse step, at the beginning of the following drying cycle the compressor is still warm from the previous hot rinsing step, and being the refrigerant temperature relative high when the compressor is energized again at the start of the drying cycle, the heat pump transitory phase is reduced thereby providing an energy consumption saving and a drying time shortening.

[0014] Additionally, if the rinse with heated water immediately precedes the drying cycle, i.e. the last rinse is performed with heated water, the temperature of the clothes and the water contained therein are higher, then the air flowing through the clothes can trap more humidity, thus further reducing the drying time and hence the energy consumption.

[0015] Additionally, a rinse with heated water provides more benefits in connection to rising performances, since solubility of washing residuals, e.g. organic species like surfactants and soils residuals, in washing liquor is strictly related to the water temperature. Raising the water temperature increases the solubility of washing residuals and improves the removal of contaminants with respect to a traditional cold rinse. Consequently, the improved rinse performances achieves environmental advantages such as the reduction in the water used for rinsing, but also the allergenic impact of the residuals possibly kept in the clothes can be highly minimized .

[0016] Further, a higher temperature of last rinse water (to about 40°C) provides a reduced viscosity of the water itself, making easier the removal thereof by spinning. Therefore, an improved spinning efficiency can shorten the spinning phase, thus allowing an additional energy saving.

[0017] The present invention relates further to a laundry washer-dryer with a heat pump system, wherein the laundry washer-dryer is provided for a method described above. In particular, the laundry washer-dryer comprises a control unit programmed or programmable for performing the method described above.

[0018] The novel and inventive features believed to be the characteristic of the present invention are set forth in the appended claims.

[0019] The invention will be described in further detail with reference to a preferred embodiment thereof and to the attached drawings, wherein:

FIG 1 : illustrates a schematic flow chart diagram of a method for operating a washing cycle and a subsequent drying cycle in a laundry washer-dryer with a heat pump system according to a preferred embodiment of the present invention, and

FIG 2 : illustrates a schematic inner view of the laundry washer-dryer with a heat pump system according to a preferred embodiment of the present invention, depicting a washing phase thereof;

FIG 3 : illustrates a schematic inner view of a the laundry washer-dryer of FIG. 2, depicting a drying phase thereof;

FIG 4 : illustrates a block diagram of laundry washer-dryer with a heat pump system according to a preferred embodiment of the present invention, depicting a washing phase thereof;

FIG 5 : illustrates the block diagram of laundry washer-dryer with a heat pump system of FIG. 4, depicting a washing phase thereof; and

FIG. 6 : shows two diagrams comparing the compression activation time along both the washing and the drying phase in the prior art devices and in a laundry washer-dryer according to the invention.

[0020] In the following, cold water is used to designate water directly supplied from the water network or from a suitable reservoir without any kind of heating and with a certain network pressure.

[0021] Accordingly, hot or heated water is used to designate water having a temperature raised to an appropriate value, suitable for effectively performing steps of a washing cycle, i.e. washing or rinsing. Temperatures may change in view of the washing conditions and according to user's choices.

[0022] FIG 1 illustrates a schematic flow chart diagram of a method for operating a washing cycle 10 and a subsequent drying cycle 20 in a laundry washer-dryer according to a preferred embodiment of the present invention.

[0023] The first step of the method is a selection of the operation mode. By the selection 12, for example via control panel of the washer-dryer, the user can select the cycle or cycles to be activated. In the preferred embodiment of the present invention the washing cycle 10 and the subsequent drying cycle 20 are activated by the cycle selection 12 so that the machine performs a complete washing-drying cycle without any further intervention of the user. Alternatively, the washing cycle 10 without drying cycle 20 or the drying cycle 20 without washing cycle 10 may be activated.

[0024] Preferably, when a complete washing-drying cycle is selected, the amount of laundry loaded into the drum is suitable for performing an effective drying without the need for the user to remove laundry before starting the drying cycle.

[0025] The first part of the method is the washing cycle 10. The washing cycle 10 includes a washing phase 14 and at least one subsequent rinsing phase 16. During the washing phase 14, the water is heated at a selected temperature and the laundry may be handled by a cleaning agent. Hence, upon appropriate selection, such a washing phase is carried out by hot water heated through a heat pump system, which will be detailed hereinafter.

[0026] During the rinsing phase 16 the laundry is rinsed by water. After the washing phase 14, the subsequent rinsing phase 16 may be carried out only once, or it may be repeated for several times, according to a selected rinsing program.

[0027] According to the invention, the single rinse, at least one rinse or all the rinses or possibly the last rinse of the rinsing phase 16 are performed by heated water. Therefore, in the rinsing phase, water is heated to a temperature of about 40°C, preferably to a temperature in the range from 35°C to 50°C. Higher temperatures may be foreseen in special washing and rinsing condition, up to 80°C.

[0028] The last step of the washing cycle 10 is a spinning phase 18, through which the rinse water is mechanically removed from the laundry. After the spinning phase 18, the washing cycle 10 is concluded.

[0029] The second part of the method is the drying cycle 20. The drying cycle 20 includes a drying phase 22 and possibly a cooling-down phase 24. The drying phase 22 is carried out by heating and dehumidifying an air flow in a closed loop by a heat pump system, wherein the laundry is crossed by such an air flow to extract water from it, until a certain degree of dryness. A heat pump evaporator cools down and dehumidify the air flow exiting the drum and a heat pump condenser heat up the air flow before entering again into the drum At the evaporator of the heat pump system, the excess water is drained away.

[0030] Since the rinse or at least one of the rinses of the rinsing phase 16 has been performed with water heated by means of the heat pump system, when the drying cycle begins and the compressor starts to be energized again to perform the drying phase 22, the heat pump compressor is still relatively warm and the refrigerant temperature and the internal temperature of the com-

pressor component (electric motor) are relatively high (in any case higher that ambient temperature) from the previous rinsing phase 16. In this manner the transitory phase is drastically reduced. The rinse by heated water reduces the time interval for reaching the steady state of the heat pump system during the drying phase 22. This is particularly advantageous, if the drying cycle starts after the rinsing phase 16 with heated water and preferably if a complete washing-drying cycle has been selected by the user.

[0031] According to the present preferred embodiment, the heat pump system includes a single compressor, some exchangers thermally coupled with the washing water and with the drying air, and a proper valve system to force the refrigerant flowing into the desired exchangers according to the phase, i.e. washing or drying.

[0032] Said heat exchangers embody condensers, where a refrigeration fluid is condensed to heat another fluid on the other side of the exchanger, and an evaporators, where said refrigeration fluid is evaporated cooling down the other fluid and possibly to make water in a gaseous flow to condensate and precipitate.

[0033] The refrigeration line also includes an expansion device, wherein the pressure exerted by the compressor is dissipated. Said heat exchangers can be of the air-liquid or of the liquid-liquid kind.

[0034] With reference to FIG. 2, a laundry washer-dryer according to the present embodiment of the invention is indicated as 1. It comprises a boxed chassis 2 enclosing a tub, schematically indicated as 3 in which a drum 4 is rotatably engaged, connected to a motor system, not visible in the drawings, to receive a spin at an appropriate and selectable speed. A control unit governs the operation of this motor system and of further functional system of the washer-dryer, according to the options selected in the selecting mode 12 (FIG. 1). The drum 4 is provided for receiving the laundry to be washed and possibly dried.

[0035] FIGS. 2 and 4 are provided to depict the washing cycle 10. A water circulation line 40 receives water from a water supply, e.g. a water tap at a certain network pressure, and it may include a water pump 5 which would be appropriately motorized. However, the pressure network may be sufficient to ensure an appropriate water circulation through the water circulation line, thus avoiding the needing of a water pump. A supply valve (not shown) may be used to check the water supply and to control the water pressure at the water inlet.

[0036] The water line 40 possibly passes through a detergent drawer 41, to eventually collect a dosed detergent therefrom.

[0037] The water flowing in the water circulation line 40 is heated by a heat pump system as previously indicated. In this embodiment, the heat pump system includes the compressor 31, a first heater 32, a first cooler 33 which is in fluidly communication with a liquid tank 35, i.e. a water reservoir providing a certain thermal capacity, which act as a heat sink, and an expansion means 34, such as a capillary tube or an expansion valve. These components are placed along a first refrigeration line 30 forming a closing loop. The compressor may includes a cooling fan (not shown).

[0038] The water circulation line 40 passes through said first heater 32. In this way, when the heat pump system is operated, i.e. when the compressor works and suitable valves, not shown in the drawings, are opened to allow the refrigeration fluid circulation in the first refrigeration line 30, the first heater 32 heats up the water in the circulation line 40 thereof. On the other hand the first cooler 33 absorbs heat from the liquid tank 35 where the water contained tends to ice.

[0039] FIGS. 3 and 5 are in turn provided to depict the drying cycle 10. An air circulation channel 50, preferably but not exclusively forming a closed loop, is indicated by arrows, powered by an appropriately motorized blower 55. Beside, the heat pump system further includes a second refrigeration line 60 including a second heater 62, a second cooler 63 and a second expansion valve 64, such as a capillary tube or an expansion valve.

[0040] The air channel 50 and the second refrigerant line 60 are thermally coupled by the second cooler 63 and the second heater 62 which are provided as air-refrigerant heat exchangers. In this way, when the heat pump system is operated, i.e. when the compressor works and suitable valves, not shown in the drawings, are opened to allow the refrigeration fluid circulation in the second refrigeration line 60, the second heater 32 heat up the air in the channel 50 thereof. The hot air is passed through the drum 4 and the laundry contained therein, to capture water converting it into humidity. Then, the humid air is circulated through the second cooler 63, wherein the water trapped into the air is condensed and collected to a suitable reservoir possibly provided with a drain water pump (not shown), provided for removing condensed water.

[0041] Further, the above air circuit 50 also comprises a lint filter (not shown) arranged between the drum 4 and the second cooler 63.

[0042] Due to the fact that the compressor 31 has been activated during the rinse phase 16, the refrigerant temperature is still relatively high when the compressor 31 is energized again at the start of the drying phase 22 and therefore the transitory phase of the drying phase is effectively shortened

[0043] FIG. 6 shows the compressor activation time in a prior art machine (see top diagram), and according to the present invention (see bottom diagram). In a washer-dryer prior art machine, the compressor is energized a first time at the start of the washing phase of the washing cycle wherein the washing water is heated up and the compressor is de-energized when the same washing phase is concluded (for example when a predetermined temperature of the washing water has been reached). The compressor is energized again a second time at the start of the drying phase of the drying cycle, wherein the drying air flow is heated up to remove moisture from the laundry. A relatively long time interval elapses between

the deactivation of the compressor at the end of the washing phase and the second activation of the compressor at the beginning of the drying phase. During this time interval the refrigerant temperature and the internal temperature of the compressor component (electric motor) decrease to substantially ambient temperature, and a long transitory phase is needed to reach the drying phase steady state condition, which is represented by the horizontal line depicted in the drying cycle diagram.

[0044] Differently according to the present invention as it can be seen at the bottom diagram of figure 6, after the washing phase, the compressor is energized again during the rinsing phase of the washing cycle in order to perform at least one hot water rinse. in this manner the time interval between the deactivation of the compressor at the end of the rinsing phase and the activation of the compressor at the beginning of the drying phase is very short so that the refrigerant temperature and the internal temperature of the compressor component (electric motor) are higher than the ambient temperature. Therefore the transitory phase of the drying phase is heavily reduced and the steady state working condition is reached quicker, thereby reducing the overall drying cycle time and improving the energy efficiency of the heat pump system during the drying cycle.

[0045] The preferred embodiment shown in figures 2 to 5, discloses a heat pump system having a first heater 32 and a first cooler 33 for heating up the washing water and rinsing water and a second heater 62 and a second cooler 63 for heating up the drying air. However, it is to be noted that alternative embodiments can envisage the use of a single heater for heating up washing/rinsing water and drying air, for example the heater can include a single heat exchanger having fins for the heat exchange with the drying air and having a piping for water circulation in thermal connection with the refrigerant piping. In a similar manner, the heat pump system can includes a single cooler adapted to exchange heat with the drying air during the drying cycle and with ambient air during the washing/rinsing water heating up, appropriate flap can alternatively put the cooler in fluid communication with the drying air or ambient air.

[0046] The present invention can also be embedded in a computer program product which comprises all the features enabling the implementation of the method described herein. Further, when loaded in computer system, said computer program product is able to carry out these methods.

[0047] Although an illustrative embodiment of the present invention has been described herein with reference to the accompanied drawings, it is to be understood that the present invention is not limited to that precise embodiment, and that various other changes and modifications may be affected therein by one skilled in the art without departing from the scope or spirit of the invention. All such changes and modifications are intended to be included within the scope of the invention as defined by the appended claims.

List of reference numerals:

[0048]

1 :	laundry washer-dryer
2 :	boxed chassis
3 :	tub
4 :	drum
5 :	water pump
10 :	washing cycle
12 :	selecting the operation mode
14 :	washing phase
16 :	rinsing phase
18 :	spinning phase
20 :	drying cycle
22 :	drying phase
24 :	cooling-down phase
26 :	finishing the drying cycle
30 :	first refrigeration line
31 :	compressor
32 :	first heater
33 :	first cooler
34 :	first expansion valve
35 :	cold sink
40 :	water circulation line
41 :	detergent drawer
50 :	air circulation channel
55 :	blower
60 :	second refrigeration line
62 :	second heater
63 :	second cooler
64 :	second expansion valve

Claims

1. A method for operating a washing cycle (10) and a subsequent drying cycle (20) in a laundry washer-dryer (1), the washer-dryer (1) comprising:

- a tub (3) and a drum (4) for storing laundry rotatably arranged inside the tub (3);
- a water circulation line (40) to supply the tub (3) and the drum (4) with water in said washing cycle (10);
- an air circulation channel (50) including a blower (55) for blowing air through the tub (3) and the drum (4) in said drying cycle (20); and
- a heat pump system having at least one heater (32, 62) and at least one cooler (33, 63) for said water circulation line (40) and said air circulation channel (50), and a single compressor (31) for circulating a refrigeration fluid through said heater (32, 62) and cooler (33, 63),

the method comprising the steps of:

- performing the washing cycle (10) comprising

at least one washing phase (14) and at least one rinsing phase (16); and

- performing the drying cycle (20) including at least one drying phase (22),
- wherein said compressor (31) is energized during the washing phase (14) for heating up washing water, during the rinsing phase (16) for heating up rinsing water and during the drying phase (22) for heating up drying air.

2. The method according to claim 1, wherein said compressor (31) is de-energized at the end of washing phase (14) and energized again at the rinsing phase (16) to perform a rinsing with heated water, said compressor (31) is de-energized at the end of the rinsing phase (16) and energized again at the drying phase (16).

3. The method according to claim 1 or 2, wherein the washing cycle (20) comprises several rinsing phases (16), the last of them being carried out with heated water.

4. The method according to claim 1 or 2, wherein the washing cycle (10) comprises several rinsing phases (16), all carried out with heated water.

5. The method according to any of the preceding claims, wherein the water at the rinsing phase (22) is heated to a temperature in a range between 35°C and 80°C.

6. The method according to claim 5, wherein the water at the rinsing phase (22) is heated to a temperature in a range between 35°C and 50°C.

7. The method according to any one of the preceding claims, wherein at least one spinning phase (18) is provided as last step of the washing cycle (10) after said at least one rinsing phase (16).

8. A laundry washer-dryer (1) comprising:

- a tub (3) and a drum (4) for storing laundry rotatably arranged inside the tub (3);
- a water circulation line (40) to supply the tub (3) and the drum (4) with water in a washing cycle (10);
- an air circulation channel (50) including a blower (55) for blowing air through the tub (3) and the drum (4) in a drying cycle (20);
- a heat pump system having at least one heater (32, 62) and at least one cooler (33, 63) for said water circulation line (40) and said air circulation channel (50), and a single compressor (31) for circulating a refrigeration fluid through said heater (32, 62) and cooler (33, 63),

the laundry washer-dryer (1) being adapted to perform a method according to any of the preceding claims.

9. The laundry washer-dryer (1) according to claim 8, comprising a control unit programmed or programmable for performing the method according to any one of the claims 1 to 7.

10. The laundry washer-dryer (1) according to claim 8 or 9, wherein the heat pump system includes said compressor (31), a first heater (32), a first cooler 33 fluidly communicating with a liquid tank 35, and an expansion means (34) placed along a first refrigeration line (30) forming a closing loop, wherein the first heater (32) is adapted to heat up the washing water, the first cooler (33) is adapted to absorb heat from the liquid tank 35.

11. The laundry washer-dryer (1) according to claim 8 or 9, wherein the heat pump system includes a second heater (62), a second cooler (63) and a second expansion means (64) placed along a second refrigeration line (60) forming a closing loop, said air circulation channel (50) passing through said second heater (62), through the tub (3) and drum (4) and through said second cooler (63), the air channel (50) and the second refrigerant line (60) being thermally coupled by the second heater (62) and the second cooler (63), to capture water converting it into humidity inside the drum (4) and to collect the condensed water respectively.

12. The laundry washer-dryer (1) according to claim 11, wherein the air circulation channel (50) forms a closed loop.

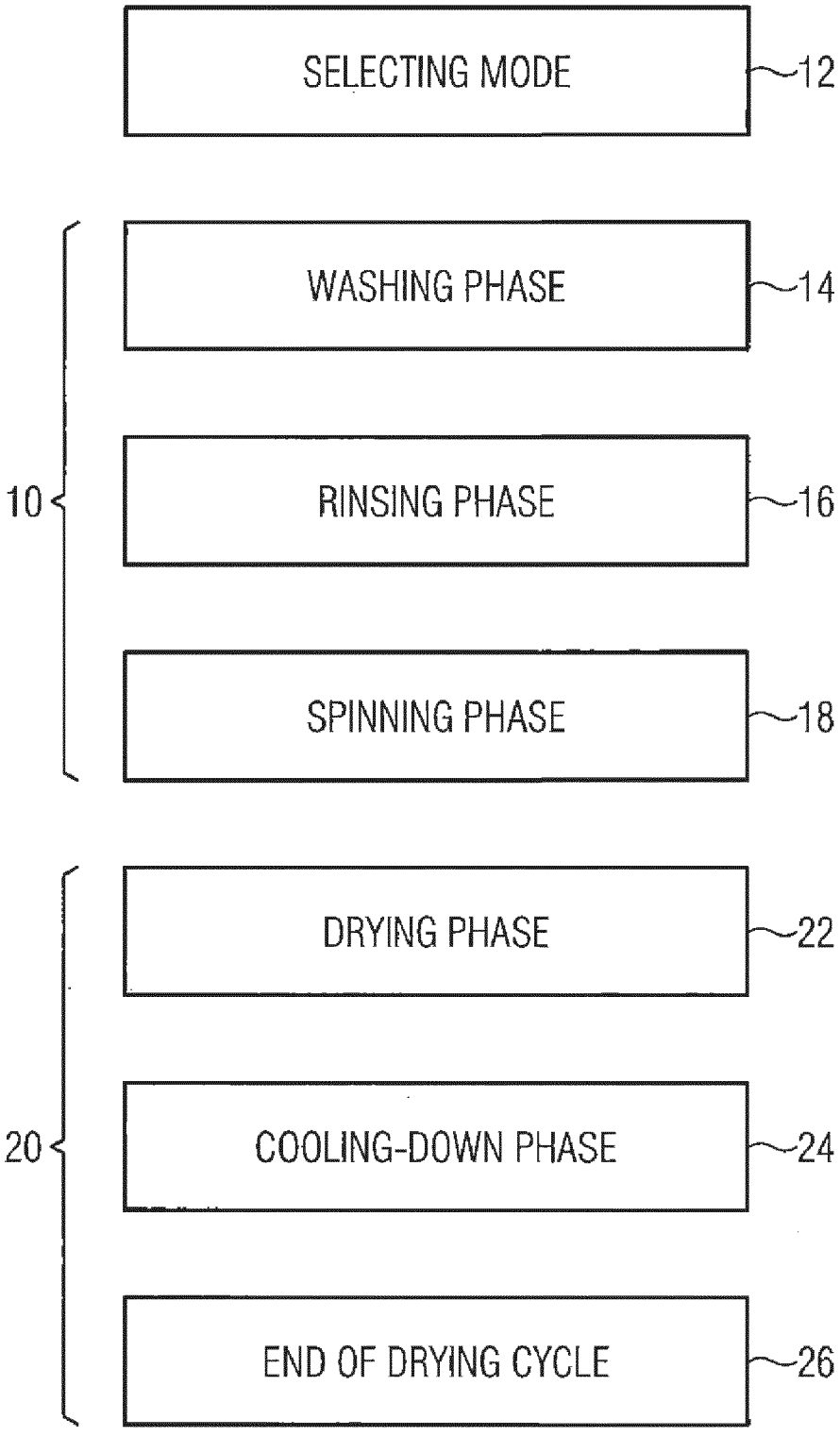
SELECTING MODE
12
WASHING PHASE
14
10
RINSING PHASE
16
SPINNING PHASE
18
DRYING PHASE
22
20
COOLING-DOWN PHASE
24
END OF DRYING CYCLE
26

Fig. 1

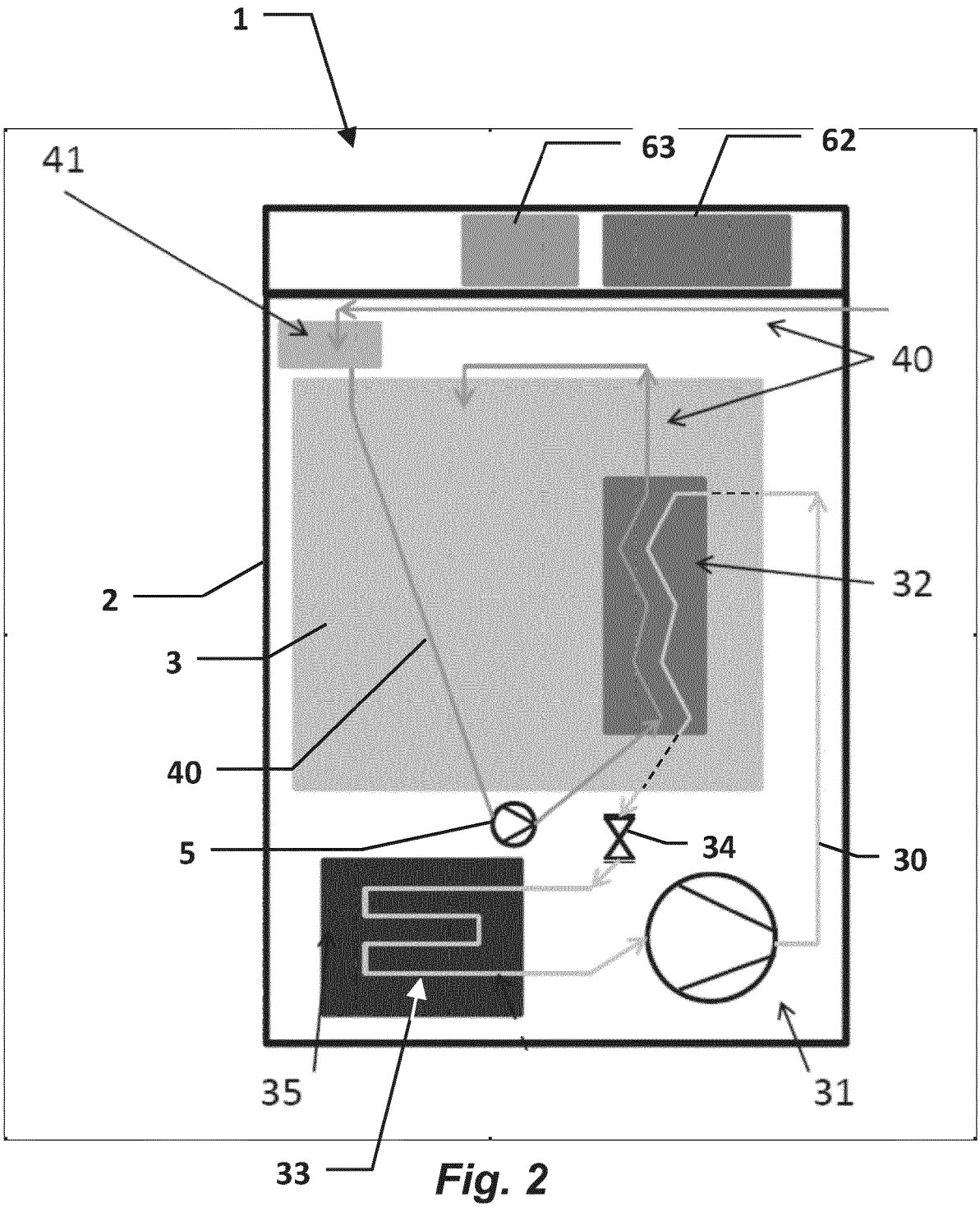

Fig. 2

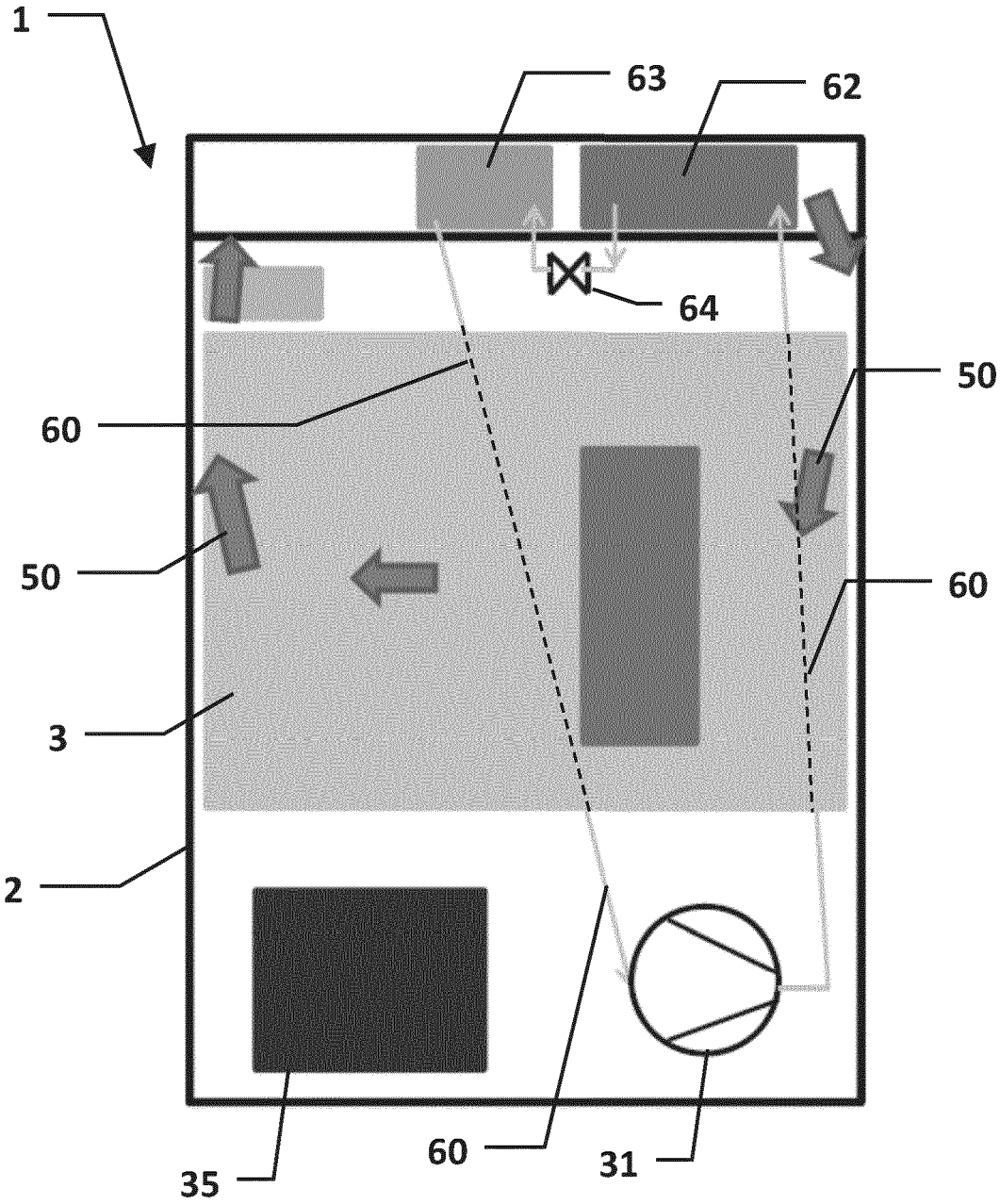

Fig. 3

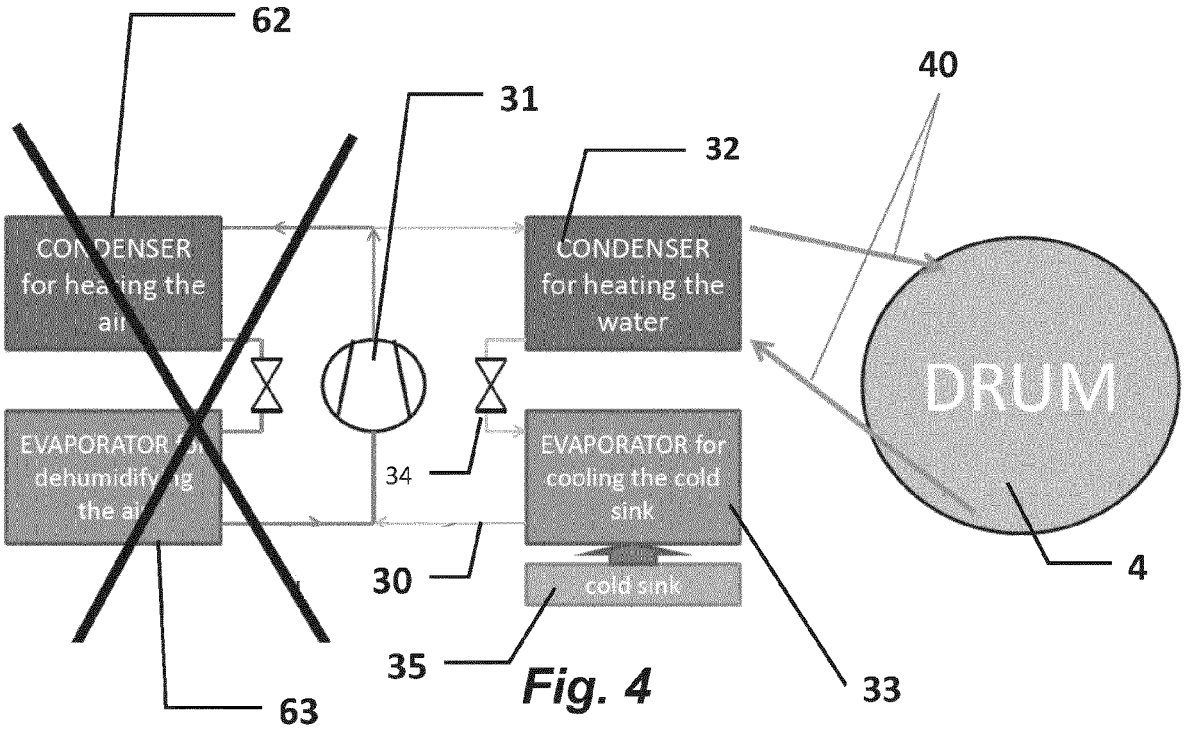
62
31
32
40
CONDENSER for heating the air
CONDENSER for heating the water
DRUM
EVAPORATOR for dehumidifying the air
34
EVAPORATOR for cooling the cold sink
4
30
cold sink
35
33
63

Fig. 4

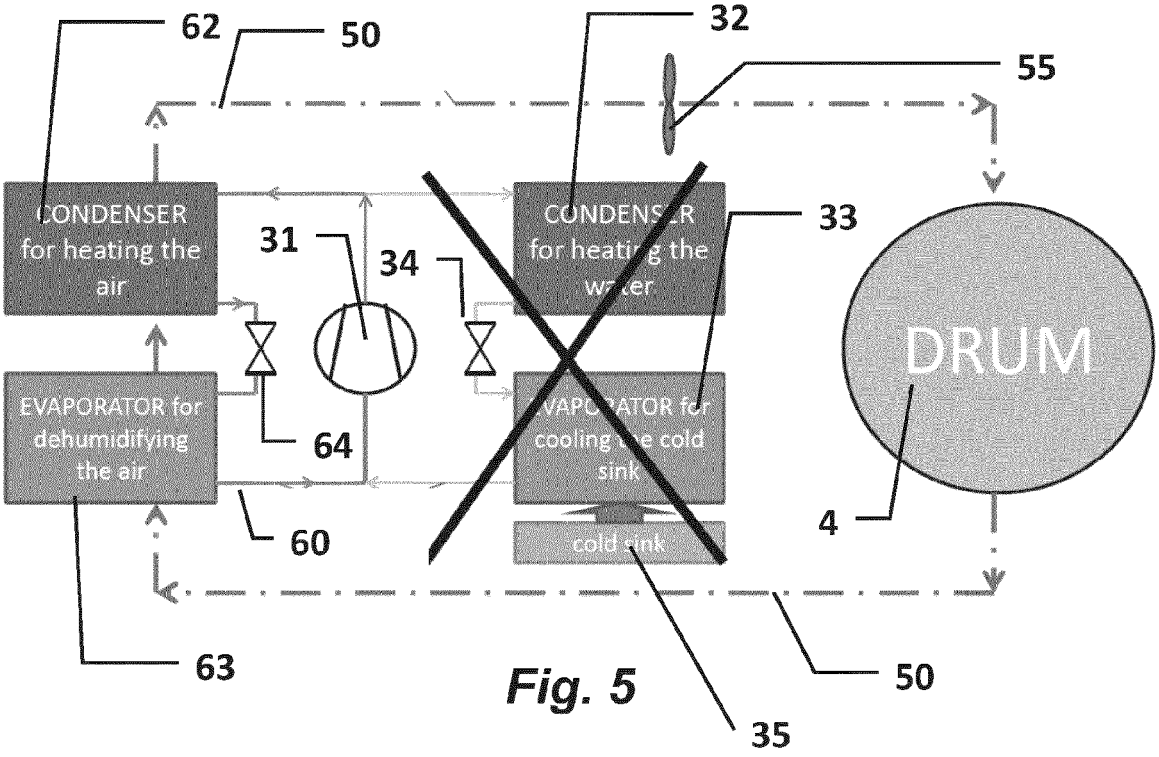
62
50
32
55
CONDENSER for heating the air
31
34
CONDENSER for heating the water
33
DRUM
EVAPORATOR for dehumidifying the air
64
EVAPORATOR for cooling the cold sink
4
cold sink
60
63
50
35

Fig. 5

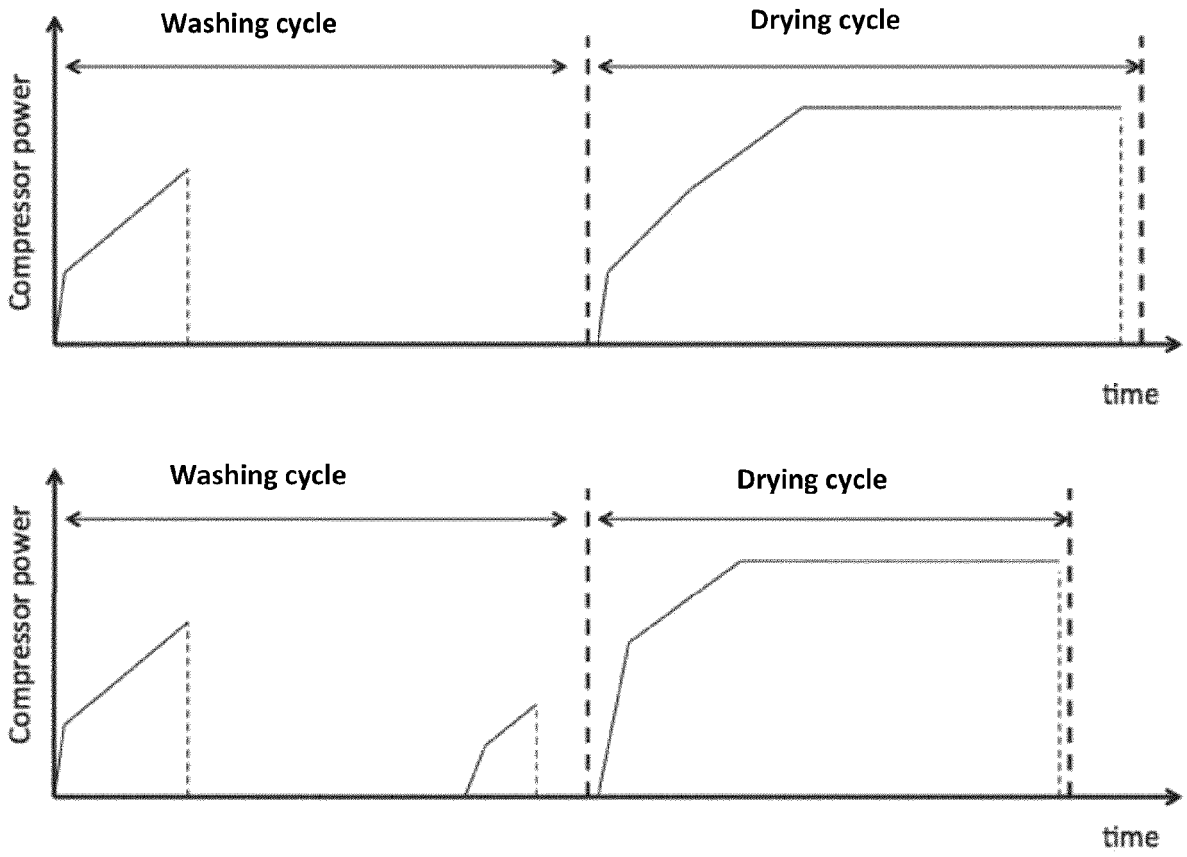
Washing cycle
Drying cycle
Compressor power
time
Washing cycle
Drying cycle
Compressor power
time

Fig. 6

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 12 19 4467

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 2 390 397 A1 (ELECTROLUX HOME PROD CORP [BE]) 30 November 2011 (2011-11-30) * paragraphs [0003], [0007], [0012], [0014], [0024], [0034] - [0037]; figures 1,2 *	1,5,8,9	INV. D06F58/20 D06F25/00
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A	JP 2008 161639 A (HITACHI APPLIANCES INC) 17 July 2008 (2008-07-17) * abstract; figures 1-4 *	1,8	
A	WO 2007/144340 A1 (ARCELIK AS [TR]; SEKER DENIZ [TR]) 21 December 2007 (2007-12-21) * paragraphs [0016] - [0019], [0022]; figure 1 *	1,8	
			TECHNICAL FIELDS SEARCHED (IPC) D06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	24 June 2013	Kising, Axel

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 19 4467

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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