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(54) Laundry washing and drying machine

(57) Laundry washing and drying machine (1) comprising a casing (2) and, inside the casing, a laundry container (3, 6) for housing the laundry to be washed and dried, and a heat-pump-type, hot-air generator (10) able to circulate a stream of hot air inside said laundry container (3, 6), and to heat up the washing water supplied to said laundry container (3, 6); the hot-air generator (10) comprising a heat-pump assembly (21) which is provided with a first air/refrigerant heat exchanger (23) which is located along the air recirculating conduit (19) for heating us the airflow (f) directed to the laundry container (3, 6); with a second water/refrigerant heat exchanger (24) which is located out of the air recirculating conduit (19), and heats up or cools down the water arriving from the laundry container (3, 6); with a third air/water heat exchanger (25) which is located along the air recirculating conduit (19), upstream of the first air/refrigerant heat exchanger (23), for cooling the airflow (f) arriving from the laundry container (3, 6); with a water circulation circuit (26) for circulating the water stored into the laundry container (3, 6) through the second water/refrigerant heat exchanger (24) and the third air/water heat exchanger (25); and with a hydraulic distributor (28) for reversing, on command, the flow of the refrigerant along the first air/refrigerant heat exchanger (23), the refrigerant expansion device (27) and the second water/refrigerant heat exchanger (24).

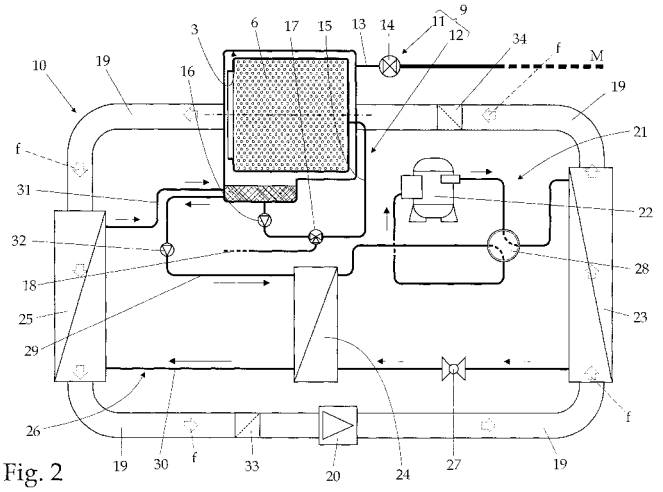

Fig. 2

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Description

[0001] The present invention relates to a laundry washing and drying machine.

[0002] More specifically, the present invention relates to a front-loading home laundry washing and drying machine, to which the following description refers purely by way of example.

[0003] As is known, front-loading laundry washing and drying machines generally comprise a substantially parallelepiped-shaped outer box casing resting on the floor; a substantially bell-shaped washing tub which is suspended in floating manner inside the casing by means of a number of coil springs and shock-absorber, directly facing a laundry loading and unloading opening formed in the front face of the casing; a door hinged to the front face of the casing to rotate to and from a closing position in which the door closes the opening in the front face of the casing to seal the washing tub; a substantially bell-shaped cylindrical revolving drum for housing the laundry to be washed and dried, and which is housed substantially horizontally inside the washing tub to rotate about its longitudinal axis; and an electric motor for rotating the revolving drum about its longitudinal axis inside the washing tub.

[0004] Front-loading laundry washing and drying machines of the above type also have a water supply and recirculating circuit for supplying a given amount of tap water into the washing tub, and for circulating said water into the washing tub during washing and rinsing phases of the washing cycle; and a closed-circuit, hot-air generator designed to circulate inside the washing tub a stream of hot air with a low moisture content, and which flows through the revolving drum and over the laundry inside the drum to rapidly dry the laundry.

[0005] In some laundry washing and drying machines, the closed-circuit, hot-air generator comprises an air recirculating conduit having its two ends connected to the washing tub, on opposite sides of the latter; an electric centrifugal fan located along the recirculating conduit to produce, inside the latter, an airflow which flows through the washing tub and the revolving drum; and finally a heat-pump assembly having its two heat exchangers located one after the other, along the air recirculating conduit. The first air/refrigerant heat exchanger of the heat-pump assembly provides for rapidly cooling the airflow arriving from the washing tub to condense the surplus moisture in the airflow; whereas the second air/refrigerant heat exchanger of the heat-pump assembly provides for rapidly heating the airflow arriving from the first heat exchanger and directed back to the washing tub, so that the airflow re-entering into the washing tub is heated rapidly to a temperature higher than or equal to that of the air flowing out of the washing tub.

[0006] More specifically, the heat-pump assembly of the hot-air generator comprises:

- a refrigerant reciprocating compressor which subjects a refrigerant in the gaseous state to compression, so that refrigerant pressure and temperature are much higher at the outlet than at the inlet of the reciprocating compressor;
- a first air/refrigerant heat exchanger through which the refrigerant coming out from the compressor and the airflow entering into the washing tub flow simultaneously, and which is designed so that the refrigerant releases heat to the airflow entering into the washing tub, while at the same time condensing in the liquid state;
- a second air/refrigerant heat exchanger through which the refrigerant flowing to the compressor and the airflow coming out from the washing tub flow simultaneously, and which is designed so that the refrigerant absorbs heat from the airflow arriving from washing tub to cause condensation of the surplus moisture in the airflow, while at the same time completely turning back into the gaseous state; and
- a refrigerant expansion device which subjects the refrigerant flowing from the first to the second air/refrigerant heat exchanger to a rapid expansion, so that pressure and temperature of the refrigerant entering in the second air/refrigerant heat exchanger are much lower than pressure and temperature of the refrigerant coming out from the first air/refrigerant heat exchanger, thus turning the refrigerant back into the gaseous state and completing the closed thermodynamic cycle in opposition to the reciprocating compressor, which provides for rapidly compressing the refrigerant.

[0007] Obviously, first and second air/refrigerant heat exchangers of the heat-pump assembly are located along the air recirculating conduit, so as that the second air/refrigerant heat exchanger provides for rapidly cooling the airflow arriving from the washing tub to condense the surplus moisture in the airflow, and the first air/refrigerant heat exchanger provides for rapidly heating the airflow arriving from the second air/refrigerant heat exchanger and directed back to the washing tub, so that the airflow entering into the tub is heated rapidly to a temperature higher than or equal to that of the same air flowing out of the tub.

[0008] In addition to the above, in a few laundry washing and drying machines, the first air/refrigerant heat exchanger of the heat-pump assembly (i.e. the heat exchanger which heats up the airflow directed back to the washing tub) is also used for heating up the tap water necessary for performing the washing and rinsing phases of the washing cycle.

[0009] Unluckily, this way of heating up the washing water is not highly efficient because of the structure of the first heat exchanger of the heat-pump-type, hot-air generator. This heat exchanger, in fact, is structured for performing an optimal heat exchange between two fluids in gaseous state (i.e. the dehumidified air directed back to the washing tub and the refrigerant in the gaseous

state), and therefore it is unable to allow an optimal heat exchange between a fluid in liquid state and a fluid in gaseous state.

[0010] In other words, the first heat exchanger of the heat-pump-type, hot-air generator is unable to speedy heat up the washing water stored in the washing tub.

[0011] It is the aim of the present invention to improve energy efficiency of the heat-pump-type, hot-air generator of the above cited home laundry washing and drying machines.

[0012] According to the present invention, there is provided a laundry washing and drying machine as claimed in Claim 1 and preferably, though not necessarily, in any one of the Claims depending directly or indirectly on Claim 1.

[0013] A non-limiting embodiment of the present invention will be described by way of example with reference to the accompanying drawings, in which:

- Figure 1 shows a perspective view, with parts in section and parts removed for clarity, of a front-loading laundry washing and drying machine in accordance with the teachings of the present invention;
- Figure 2 shows a schematic view of the Figure 1 laundry washing and drying machine in a first working configuration;
- Figure 3 shows a schematic view of the Figure 1 laundry washing and drying machine in a second working configuration;
- Figure 4 shows a schematic view of a second embodiment of the Figures 1-3 laundry washing and drying machine; and
- Figure 5 shows a schematic view of a third embodiment of the Figures 1-3 laundry washing and drying machine.

[0014] With reference to Figure 1, number 1 indicates as a whole a laundry washing and drying machine comprising a preferably, though not necessarily, parallelepiped-shaped outer box casing 2 resting on the floor; a substantially bell-shaped washing tub 3 suspended in floating manner inside casing 2 via a suspension system comprising a number of coil springs 4 (only one shown in Figure 1) preferably, though not necessarily, combined with one or more vibration dampers 5 (only one shown in Figure 1); a substantially bell-shaped cylindrical revolving drum 6 for housing the laundry to be washed and/or dried, and which is fixed in axially rotating manner inside washing tub 3 for rotating about its longitudinal axis L; and an electric motor assembly 7 for rotating, on command, revolving drum 6 about its longitudinal axis L inside washing tub 3.

[0015] In particular, in the example shown, laundry washing and drying machine 1 is a front-loading home washing and drying machine, therefore washing tub 3 is suspended substantially horizontally inside casing 2, with the front opening of washing tub 3 directly faced to a laundry loading and unloading opening formed in a front face 2a of casing 2. Revolving drum 6, in turn, is housed into washing tub 3 so that its longitudinal axis L is oriented substantially horizontally, and coincides with the longitudinal axis of washing tub 3.

[0016] With reference to Figure 1, laundry washing and drying machine 1 is also provided with a cylindrical elastic-deformable bellows 8 connecting the front opening of washing tub 3 to the laundry loading and unloading opening formed in front face 2a of casing 2, and with a door (not shown) hinged to front face 2a of casing 2 to rotate to and from a closing position in which the door closes the laundry loading and unloading opening in front face 2a to seal washing tub 3.

[0017] Casing 2, washing tub 3, the suspension system, revolving drum 6, electric motor assembly 7 and bellows 8 are commonly know parts in the washing machine technical field, and therefore not described in detail.

[0018] With reference to Figures 2 and 3, laundry washing and drying machine 1 is also provided with a water supply and recirculating system 9 for supplying a given amount of tap water into washing tub 3, and for circulating said water into washing tub 3 during washing and rinsing phases of the washing cycle; and with a closed-circuit, hot-air generator 10 designed to circulate inside washing tub 3 a stream of hot air with a low moisture content, and which flows through revolving drum 6 and over the laundry inside the drum to rapidly dry the laundry.

[0019] More specifically, closed-circuit, hot-air generator 10 provides for gradually drawing air from washing tub 3; extracting surplus moisture from the air drawn from washing tub 3; heating the dehumidified air to a predetermined temperature, normally higher than the temperature of the air from washing tub 3; and feeding the heated, dehumidified air back into washing tub 3, where it flows over, to rapidly dry, the laundry inside the revolving drum 6.

[0020] With reference to Figures 2 and 3, in the example shown laundry washing and drying machine 1 is preferably, though not necessarily, provided with a detergent drawer (not shown) which is removably housed inside a seat on front face 2a of casing 2, and which has at least one compartment for a given amount of detergent and/or softener for use in the washing cycle. The seat communicates directly with washing tub 3, and the water supply and recirculating system 9 consists of a drawer flush circuit 11 which, on command, feeds a given amount of tap water into the compartments of the detergent drawer to flush the detergent and/or softener out of the compartments and down into washing tub 3; and of a washing water recirculating and draining circuit 12 which, on command, sucks the washing water from the bottom of washing tub 3 and feeds said water back into the revolving drum 6, or alternatively drains the water accumulated into the washing tub 3 into a waste-water exhaust duct (not shown) located out of the laundry washing and drying machine 1.

[0021] With reference to Figures 2 and 3, the drawer

flush circuit 11 comprises at least one water supply pipe 13, which is connected to the external water supply main M of the building in which the washing machine is installed, and terminates directly over the detergent drawer; and at least one electrically controlled on-off valve 14 interposed between water supply pipe 13 and the water supply main M to regulate the pressurized-water flow to the end of water supply pipe 13, so as to sprinkle, on command, the compartment/s of the detergent drawer.

[0022] In the example shown, electrically controlled on-off valve 14 is a conventional controlled-open-close solenoid valve 14.

[0023] As regards the washing water recirculating and draining circuit 12, it comprises a water recirculating pipe 15 having a first end in communication with the bottom of washing tub 3, and a second end faced to, or connected in known manner to, the revolving drum 6; an electrically operated water circulating pump 16 located along water recirculating pipe 15 for sucking the washing water from the bottom of washing tub 3 and pumping said water towards revolving drum 6; water filtering means (not shown) located along water recirculating pipe 15, preferably, though not necessarily, upstream of pump 16; and an electrically controlled tree-way valve 17 which is located along water recirculating pipe 15, immediately downstream of pump 16, for channeling, on command, the water flowing along recirculating pipe 15 into a water draining pipe 18 which is in communication with the waste-water exhaust duct (not shown) located out of the laundry washing and drying machine 1.

[0024] With reference to Figure 2 and 3, hot-air generator 10 is a heat-pump-type, hot-air generator and substantially comprises:

- an air recirculating conduit 19, the two ends of which are connected to washing tub 3 preferably, though not necessarily, on opposite sides of the latter;
- an electrically operated centrifugal fan 20, or other type of air circulating pump, located along recirculating conduit 19 to produce, inside recirculating conduit 19, an airflow f which flows into washing tub 3 and over the laundry inside the revolving drum 6; and
- a heat-pump assembly 21 which is able to rapidly cool the airflow f coming out from washing tub 3 for condensing the surplus moisture in the airflow f, and then to rapidly heat the airflow f returning back into washing tub 3, so that the airflow entering into washing tub 3 is heated rapidly to a temperature higher than or equal to that of the same air flowing out of the washing tub 3.

[0025] Heat-pump assembly 21 operates in the same way as a traditional heat-pump - which is capable of transferring heat from one fluid to another using an intermediate gaseous refrigerant subjected to a closed thermodynamic cycle, the thermodynamic principles of which are widely known and therefore not described in detail - but, differently from known laundry washing and drying machines, heat-pump assembly 21 is a bi-directional device and it comprises:

- two refrigerant heat exchangers 23 and 24 designed so that the refrigerant flowing through them can alternatively release or absorb heat from other fluids simultaneously flowing through the corresponding heat exchangers 23 and 24; and
- bi-directional closed-circuit refrigerant circulating means able to circulate a gaseous refrigerant in succession through the two refrigerant heat exchangers 23 and 24, while subjecting the gaseous refrigerant in succession to a compression and an expansion in the passing from a heat exchanger 23, 24 to the other, so that alternatively one of the two refrigerant heat exchangers 24 and 24 can receive a high-pressure and high-temperature refrigerant while the other refrigerant heat exchanger receives a low-pressure and low-temperature refrigerant.

[0026] More specifically, refrigerant heat exchanger 23 is located along air recirculating conduit 19, upstream of washing tub 3 - and preferably, thought not necessarily, downstream of centrifugal fan 20 -, and is designed so that the refrigerant arriving from the bi-directional closed-circuit refrigerant circulating means and the airflow f directed to washing tub 3 flow through it simultaneously, allowing the refrigerant to release or absorb heat to/from said airflow f, thus rapidly heating or cooling the airflow f.

[0027] Instead, differently from known laundry washing and drying machines, refrigerant heat exchanger 24 is located out of air recirculating conduit 19, and is designed so that the washing water arriving from revolving drum 3 and the refrigerant arriving from the bi-directional closed-circuit refrigerant circulating means flow through it simultaneously, allowing the refrigerant to release or absorb heat to/from said washing water, thus rapidly heating or cooling the washing water arriving from revolving drum 3; and hot-air generator 10 is also provided with:

- an air/water heat exchanger 25 which is located along air recirculating conduit 19, upstream of heat exchanger 23, and is designed so that the airflow f arriving from washing tub 3 and the water arriving from washing tub 3 or refrigerant heat exchanger 24 flow through it simultaneously, allowing the water having a temperature lower than that of the airflow f, to absorb heat from the airflow f thus causing condensation of the surplus moisture in the airflow f; and
- a water circulation circuit 26 which, on command, circulates the washing water stored into washing tub 3 through, in sequence, the refrigerant heat exchanger 24 and the air/water heat exchanger 25.

[0028] More specifically, with reference to Figure 2 and 3, heat-pump assembly 21 comprises:

- an electrically powered refrigerant compressing device 22 which subjects a gaseous refrigerant to compression (e.g. adiabatic compression) so that refrigerant pressure and temperature are much higher at the outlet than at the inlet of compressing device 22;
- a first air/refrigerant heat exchanger 23 which is located along air recirculating conduit 19, upstream of washing tub 3 - and preferably, thought not necessarily, downstream of centrifugal fan 20 -, and is designed so that the refrigerant coming out from compressing device 22 and the airflow f entering into washing tub 3 flow through it simultaneously, allowing the refrigerant having a temperature greater than that of the airflow f to release heat to the airflow f, thus rapidly heating the airflow f to a temperature preferably, thought not necessarily, higher or equal to the temperature of the airflow f coming out of washing tub 3;
- a second water/refrigerant heat exchanger 24 which is located out of air recirculating conduit 19, and is designed so that the water arriving from revolving drum 3 and the refrigerant flowing to the inlet of compressing device 22 flow through it simultaneously, allowing the refrigerant having a temperature lower than that of the water, to absorb heat from the water thus causing the cooling of the water to a temperature preferably, thought not necessarily, lower or equal to the temperature of the airflow f coming out of washing tub 3; and
- a throttling valve or similar refrigerant expansion device 27 which subjects the refrigerant flowing from the air/refrigerant heat exchanger 23 to the water/ refrigerant heat exchanger 24, or vice versa, to a rapid expansion so that pressure and temperature of the refrigerant entering in the water/refrigerant heat exchanger 24 (or the air/refrigerant heat exchanger 23) are much lower than pressure and temperature of the refrigerant coming out from the air/ refrigerant heat exchanger 23 (or the water/refrigerant heat exchanger 24), thus completing the closed thermodynamic cycle in opposition to the compressing device 22, which provides for rapidly compressing the refrigerant.

[0029] Heat-pump assembly 21 also comprises a number of suitable connecting pipes which connect refrigerant compressing device 22, air/refrigerant heat exchanger 23, water/refrigerant heat exchanger 24 and refrigerant expansion device 27 one to the other, so as to form a closed circuit allowing the refrigerant coming out from the outlet of compressing device 22 to flow through, in sequence, air/refrigerant heat exchanger 23, refrigerant expansion device 27 and water/refrigerant heat exchanger 24, before returning to the inlet of compressing device 22; and an electrically controlled four-way hydraulic distributor 28 which connects compressing device 22 to both the air/refrigerant heat exchanger 23 and the water/refrigerant heat exchanger 24.

[0030] The four-way hydraulic distributor 28 is structured for selectively putting the outlet of compressing device 22 in direct communication with the air/refrigerant heat exchanger 23 or, alternatively, the water/refrigerant heat exchanger 24, and the inlet of compressing device 22 in direct communication with the other refrigerant heat exchanger 23 or 24, so as to select, on command, the flowing direction of the refrigerant through the air/refrigerant heat exchanger 23, the water/ refrigerant heat exchanger 24 and the refrigerant expansion device 27.

[0031] In other words, hydraulic distributor 28 is able to reverse, on command, the normal flowing direction of the refrigerant along, in sequence, the air/refrigerant heat exchanger 23, the refrigerant expansion device 27 and the water/refrigerant heat exchanger 24. Thus, when the outlet of compressing device 22 is directly connected to water/refrigerant heat exchanger 24, the refrigerant releases heat to the water arriving from washing tub 3 when flowing through water/refrigerant heat exchanger 24, and absorbs heat from the air circulating into the air recirculating conduit 19 when flowing through air/refrigerant heat exchanger 23.

[0032] Refrigerant compressing device 22, refrigerant expansion device 27, the electrically controlled four-way hydraulic distributor 28, and the connecting pipes which connect compressing device 22, heat exchanger 23, heat exchanger 24 and expansion device 27 one to the other, define the bi-directional closed-circuit refrigerant circulating means of heat-pump assembly 21.

[0033] The water/refrigerant heat exchanger 24 and the electrically controlled four-way hydraulic distributor 28 are commonly know parts in the heat-pump technical field, and therefore not described in detail.

[0034] Similarly the air/water heat exchanger 25 is a commonly know part in the washing machine technical field, and therefore not described in detail.

[0035] As regards the water circulation circuit 26, in the example shown it comprises a first pipe 29 connecting the bottom of washing tub 3 to the inlet of water/refrigerant heat exchanger 24; a second pipe 30 connecting the outlet of water/refrigerant heat exchanger 24 to the inlet of the air/water heat exchanger 25; a third pipe 31 connecting the outlet of air/water heat exchanger 25 to the bottom of washing tub 3; and an electrically powered water circulating pump 32 which is located along pipe 29 (or alternatively along pipe 30 or pipe 31) for sucking, on command, the washing water from the bottom of washing tub 3 and circulating said water through, in sequence, the water/refrigerant heat exchanger 24 and the air/water heat exchanger 25, or vice versa, before feeding said water back into washing tub 3.

[0036] With reference to Figures 2 and 3, in the example shown the electrically operated centrifugal fan 20 is preferably, though not necessarily, located between air/ refrigerant heat exchanger 23 and air/water heat exchanger 25; and hot-air generator 10 also comprises electrically controlled air valves, air baffles or similar airflow control means, which are able to put, on command,

the air recirculating conduit 19 in direct communication with the outside, for allowing external air to circulate through air/refrigerant heat exchanger 23. In addition to the above, said airflow control means are preferably, though not necessarily, also able to prevent, at the same time, the external air from circulating through the air/water heat exchanger 25.

[0037] More specifically, in the example shown, hot-air generator 10 is provided with two three-way valves 33 and 34, which are located along air recirculating conduit 19, on both sides of air/refrigerant heat exchanger 23, so to divide air recirculating conduit 19 into two consecutive segments, each of which crosses a respective heat exchanger 23, 25. Both three-way valves 33 and 34 are designed to put the first segment of air recirculating conduit 19 that crosses air/refrigerant heat exchanger 23, in direct communication with the outside or, alternatively, in direct communication with the other segment of the air recirculating conduit 19, so to allow external air to circulate through air/refrigerant heat exchanger 23 while, at the same time, preventing said external air from circulating through the air/water heat exchanger 25.

[0038] In particular, in the example shown, three-way valve 33 is preferably, though not necessarily, located between air/water heat exchanger 25 and centrifugal fan 20, whereas three-way valve 34 is preferably, though not necessarily, located between air/refrigerant heat exchanger 23 and washing tub 3. This arrangement of valves 33 and 34 allows the use of centrifugal fan 20 for generating the airflow f along the whole air recirculating conduit 19, or the airflow f' along the segment of air recirculating conduit 19 that crosses the air/refrigerant heat exchanger 23.

[0039] Operation of the laundry washing and drying machine 1 will now be described assuming that the bottom of washing tub 3 is empty of water; that hydraulic distributor 28 is configured to put the outlet of compressing device 22 in direct communication with the air/refrigerant heat exchanger 23, and the inlet of compressing device 22 in direct communication with the water/refrigerant heat exchanger 24; and that both three-way valves 33 and 34 are in their firs operative configuration in which they keep the air recirculating conduit 19 isolated from the outside (i.e they connect the two segments of the air recirculating conduit 19 one another), and let the airflow f flow along the whole air recirculating conduit 19.

[0040] At this point, when the user requests a combined washing and drying cycle to be performed, the electronic central control unit 35 of the laundry washing and drying machine 1 opens the on-off valve 14 of drawer flush circuit 11 to fill up the bottom of washing tub 3 with an appropriate quantity of tap water.

[0041] With reference to Figure 3, when tap water reaches the predetermined level within washing tub 3, central control unit 35

- closes valve 14;
- switches the hydraulic distributor 28 so as to put the outlet of compressing device 22 in direct communication with the water/refrigerant heat exchanger 24, and the inlet of compressing device 22 in direct communication with the air/refrigerant heat exchanger 23; and finally
- switches three-way valves 33 and 34 in their second operative configuration so as to put the first segment of air recirculating conduit 19 that crosses air/refrigerant heat exchanger 23, into communication with the outside of the household appliance while, at the same time, preventing free air circulation along the second segment of the air recirculating conduit 19 that crosses air/water heat exchanger 25.

[0042] When hot-air generator 10 is configured for heating up the water stored in washing tub 3, central control unit 35 switches on, respectively, centrifugal fan 20, compressing device 22, and pump 32 of the water circulation circuit 26, to enable heat-pump assembly 21 to transfer heat from the airflow f' circulating through air/refrigerant heat exchanger 23 and arriving from the outside of the household appliance, to the water circulating into water circulation circuit 26 and directed back to washing tub 3.

[0043] Since at this moment no air flows through air/water heat exchanger 25, all heat absorbed from the airflow f' arriving from the outside is used for quickly heating up the tap water in washing tub 3.

[0044] More specifically, the high-temperature and high-pressure refrigerant coming out from compressing device 22 passes through hydraulic distributor 28 and reaches the water/refrigerant heat exchanger 24, inside which the refrigerant releases heat to the tap water arriving from the bottom of washing tub 3 and directed back to washing tub 3. Within heat exchanger 24, therefore, the high-temperature and high-pressure refrigerant arriving from compressing device 22 heats up the water circulating into water circulation circuit 26.

[0045] After leaving the water/refrigerant heat exchanger 24, the high-pressure refrigerant coming out from compressing device 22 then passes through the refrigerant expansion device 27, wherein the refrigerant is rapidly expanded so that pressure and temperature of the refrigerant entering in the air/refrigerant heat exchanger 23 are much lower than pressure and temperature of the refrigerant coming out from the water/refrigerant heat exchanger 24.

[0046] Finally, when passing through the air/refrigerant heat exchanger 23, the low-pressure and low-temperature refrigerant arriving from expansion device 27 and flowing back to compressing device 22 absorbs heat from the airflow f' circulating through air/refrigerant heat exchanger 23, thus rapidly cooling the airflow f' flowing along the segment of air recirculating conduit 19 that crosses the air/refrigerant heat exchanger 23.

[0047] Since no air flows through the air/water heat exchanger 25, the air/water heat exchanger 25 operates like a traditional water conduit, and the temperature of

the water arriving from the water/refrigerant heat exchanger 24 and directed back to washing tub 3 remains unchanged. In other words, all heat absorbed from the airflow f' arriving from the outside is transferred to the tap water circulating into water circulation circuit 26.

[0048] When the water inside washing tub 3 reaches the requested temperature, central control unit 35 may either switch off the hot-air generator 10 (i.e. centrifugal fan 20, compressing device 22 and pump 32) and start washing the laundry placed inside revolving drum 6 with the heated up tap water, or may open again on-off valve 14 to pour some more tap water into washing tub 3 and continue heating the water within the tub.

[0049] With reference to Figure 2, when the rising phase of the combined washing and drying cycle is completed, central control unit 35 switches again the hydraulic distributor 28 to put the outlet of compressing device 22 in direct communication with the air/refrigerant heat exchanger 23 and the inlet of compressing device 22 in direct communication with the water/refrigerant heat exchanger 24; and switches the three-way valves 33 and 34 back in their first operative configuration to isolate the air recirculating conduit 19 from the outside, and to let the airflow f flow along the whole air recirculating conduit 19.

[0050] When hot-air generator 10 is configured for drying the laundry inside revolving drum 6, central control unit 35 switches on centrifugal fan 20, compressing device 22, and pump 32 of the water circulation circuit 26, to enable heat-pump assembly 21 to rapidly cool the airflow f coming out from washing tub 3 for condensing the surplus moisture in the airflow f, and then to rapidly heat the airflow f returning back into washing tub 3, so that the airflow f entering into washing tub 3 is heated rapidly to a temperature higher than or equal to that of the same air flowing out of the washing tub 3.

[0051] In which case, the cold water flowing in the water circulation circuit 26 is used for transferring heat from the airflow f coming out from washing tub 3 to the refrigerant flowing through the water/refrigerant heat exchanger 24.

[0052] More specifically, the high temperature and pressure refrigerant coming out from compressing device 22 passes through hydraulic distributor 28 and reaches the air/refrigerant heat exchanger 23 inside which the refrigerant releases heat to the airflow f flowing into the air recirculating conduit 19, back to washing tub 3. Within heat exchanger 23, therefore, the high-temperature and high-pressure refrigerant arriving from compressing device 22 heats up the airflow f directed back into washing tub 3.

[0053] After leaving the air/refrigerant heat exchanger 23, the high-pressure refrigerant coming out from compressing device 22 then passes through the refrigerant expansion device 27, wherein the refrigerant is rapidly expanded so that pressure and temperature of the refrigerant entering in the water/refrigerant heat exchanger 24 are much lower than pressure and temperature of the refrigerant coming out from the air/refrigerant heat exchanger 23.

[0054] Finally, when passing through the water/refrigerant heat exchanger 24, the low-pressure and low-temperature refrigerant arriving from expansion device 27 and flowing back to compressing device 22 absorbs heat from the water arriving from the bottom of washing tub 3 and directed back to washing tub 3, thus rapidly cooling the water circulating into the water circulation circuit 26 and directed to the air/water heat exchanger 25.

[0055] The cold water circulating into the water circulation circuit 26 may consist in a given quantity of the rinsing water previously used in the rinsing phase of the washing and drying cycle, or may consist in a given quantity of fresh water provided by the water supply and recirculating system 9 (namely the drawer flush circuit 11).

[0056] Obviously, if the laundry washing and drying machine 1 is requested to perform a sole drying cycle, the cold water circulating into the water circulation circuit 26 consists preferably, though not necessarily, in a given quantity of fresh water provided by the water supply and recirculating system 9.

[0057] Since now the airflow f arriving from washing tub 3 flows through the air/water heat exchanger 25, the cold water circulating into the water circulation circuit 26 absorbs heat from the airflow f arriving from washing tub 3, thus rapidly cooling the airflow f to condense the surplus moisture in the airflow.

[0058] Obviously, the temperature of the washing water leaving the air/water heat exchanger 25 and directed back to the water/refrigerant heat exchanger 24 is slightly higher than the temperature of the washing water arriving from the water/refrigerant heat exchanger 24, and the increase in the water temperature is due to the heat amount absorbed from the airflow f arriving from washing tub 3. This heat amount is immediately transferred to the refrigerant flowing back to compressing device 22 within the water/refrigerant heat exchanger 24.

[0059] In other words, during the drying cycle, the water flowing into the water circulation circuit 26 only transfers heat from the airflow f arriving from washing tub 3 to the low-pressure and low-temperature refrigerant flowing back to compressing device 22.

[0060] In addition to the above, it is finally evident that the bottom of washing tub 3 is structured to contain a sufficient quantity of fresh or rinsing water to be used in the drying cycle, and, at the same time, to prevent said fresh or rinsing water to reach the revolving drum 6 and the laundry stored inside the drum.

[0061] The particular structure of heat-pump assembly 21 has lots of advantages. Firstly the heat exchange taking place in heat exchanger 24 of heat-pump assembly 21 always involves a fluid in gaseous state (i.e. the refrigerant) and a fluid in liquid state (i.e. the washing water stored in washing tub 3), thus heat exchanger 24 assures optimal heat-exchange performances both when laundry is dried, and when washing water is heated up.

[0062] In addition to the above, if the air/water heat

exchanger 25 is a water spray condenser 25, the washing water circulating in water circulation circuit 26 can be used for capturing fluff or lint particles in the airflow f arriving from washing tub 3.

[0063] Clearly, changes may be made to laundry washing and drying machine 1 as described herein without, however, departing from the scope of the present invention.

[0064] For example, with reference to Figure 4, the water circulation circuit 26 may be integrated in the water recirculating and draining circuit 12, so as to reduce the number of water pumps.

[0065] More specifically, instead of selectively channeling into water draining pipe 18 the water flowing along recirculating pipe 15, the tree-way valve 17 channels, on command, the water flowing along recirculating pipe 15 directly into water pipe 29; and the water recirculating and draining circuit 12 is provided with a second electrically controlled tree-way valve 17' which is located along water pipe 29 for channeling, on command, the water flowing along pipe 29 into water draining pipe 18. In which case, therefore, pump 16 can suck the washing water from the bottom of washing tub 3 and feed said either towards revolving drum 6, or towards water/refrigerant heat exchanger 24.

[0066] With reference to Figure 5, in a further different embodiment, the bi-directional closed-circuit refrigerant circulating means of heat-pump assembly 21 may lack the electrically controlled four-way hydraulic distributor 28, and may comprise instead two refrigerant compressing devices 22 which are connected to heat exchanger 23 and heat exchanger 24 via two electrically controlled three-way valves 36. The two refrigerant compressing devices 22 are in anti-parallel one to the other, so that each three-way valves 36 communicates with the inlet of a first refrigerant compressing device 22, and with the outlet of a second refrigerant compressing device 22.

[0067] In this embodiment, the electronic central control unit 35 of the laundry washing and drying machine 1 controls both three-way valves 36 so to selectively connect only one of the two refrigerant compressing devices 22 to heat exchanger 23 and heat exchanger 24, while keeping the other refrigerant compressing device 22 isolated.

Claims

1. A laundry washing and drying machine (1) comprising a casing (2) and, inside the casing, a laundry container (3, 6) for housing the laundry to be washed and dried, and a hot-air generator (10) able to circulate a stream of hot air inside said laundry container (3, 6), and to heat up the washing water stored into the laundry container (3, 6); said hot-air generator (10) comprising

- an air recirculating conduit (19) connected at both ends to said laundry container (3, 6);
- ventilating means (20) able to produce, along the recirculating conduit (8), an airflow (f) which flows through the laundry container (3, 6); and
- a heat-pump assembly (21) which is able to rapidly cool the airflow (f) coming out from the laundry container (3, 6) for condensing the surplus moisture in said airflow (f), and then to rapidly heat the airflow (f) returning back into said laundry container (3, 6);

said laundry washing and drying machine (1) being **characterized in that** said heat-pump assembly (21) is a bi-directional device and it comprises:

- a first (23) and a second refrigerant heat exchanger (24) designed so that the refrigerant flowing through them can alternatively release or absorb heat from other fluids simultaneously flowing through said first (23) and second heat exchanger (24); and
- bi-directional refrigerant circulating means (22, 27, 28, 36) able to circulate a refrigerant in succession through said first (23) and second heat exchanger (24) while subjecting said refrigerant in succession to a compression and an expansion in the passing from a refrigerant heat exchanger (23, 24) to the other, so that alternatively the first (23) or the second refrigerant heat exchanger (24) can receive a high-pressure and high-temperature refrigerant while the other refrigerant heat exchanger receives a low-pressure and low-temperature refrigerant;

said first refrigerant heat exchanger (23) being located along the air recirculating conduit (19), and being designed so that the refrigerant arriving from the bi-directional refrigerant circulating means (22, 27, 28, 36) and the airflow (f, f') directed to the laundry container (3, 6) flow through it simultaneously, allowing the refrigerant to release or absorb heat to/from said airflow (f, f'); said second refrigerant heat exchanger (24) being instead located out of the air recirculating conduit (19), and being designed so that the washing water arriving from the laundry container (3, 6) and the refrigerant arriving from the bi-directional closed-circuit refrigerant circulating means (22, 27, 28, 36) flow through it simultaneously, allowing the refrigerant to release or absorb heat to/from said washing water; the hot-air generator (10) being also provided with:

- an air/water heat exchanger (25) which is located along the air recirculating conduit (19), upstream of the first refrigerant heat exchanger (23), and is designed so that the airflow (f) arriving from the laundry container (3, 6) and the water arriving from said second refrigerant heat

exchanger (24) flow through it simultaneously, allowing the water to absorb heat from the airflow (f); and

- with a water circulation circuit (26) for circulating the water stored into the laundry container (3, 6) through the second refrigerant heat exchanger (24) and the air/water heat exchanger (25).

2. A laundry washing and drying machine as claimed in Claim 1, wherein the hot-air generator (10) is also provided with airflow control means (33, 34) which are located along the air recirculating conduit (19) for putting, on command, said air recirculating conduit (19) in communication with the outside, for allowing the external air (f') to circulate through the first refrigerant heat exchanger (23).

3. A laundry washing and drying machine as claimed in Claim 2, wherein said airflow control means (33, 34) are also able to prevent air circulation through the air/water heat exchanger (25), when the air recirculating conduit (19) is in communication with the outside.

4. A laundry washing and drying machine as claimed in anyone of the foregoing Claims, wherein said ventilating means (20) are located along the air recirculating conduit (19), between the air/water heat exchanger (25) and the first refrigerant heat exchanger (23).

5. A laundry washing and drying machine as claimed in Claim 4, wherein said airflow control means (33, 34) comprise two three-way valves (33, 34) or similar, which are located along the air recirculating conduit (19), on both sides of the first refrigerant heat exchanger (23), so to divide the air recirculating conduit (19) into two consecutive segments each of which crosses a respective heat exchanger (23, 24); both three-way valves (33, 34) or similar being designed to put the segment of the air recirculating conduit (19) that crosses the first refrigerant heat exchanger (23), in direct communication, alternatively, with the outside or with the other segment of the air recirculating conduit (19).

6. A laundry washing and drying machine as claimed in Claim 5, wherein a first three-way valve (33) or similar is located between the air/water heat exchanger (25) and the ventilating means (20), and a second three-way valve (34) or similar is located between the first refrigerant heat exchanger (23) and the laundry container (3, 6).

7. A laundry washing and drying machine as claimed in anyone of the foregoing Claims, wherein said water circulation circuit (26) comprises a first pipe (15; 29) connecting the bottom of the laundry container (3, 6) to the inlet of the second refrigerant heat exchanger (24); a second pipe (30) connecting the outlet of the second refrigerant heat exchanger (24) to the inlet of the air/water heat exchanger (25); a third pipe (31) connecting the outlet of the air/water heat exchanger (25) to the laundry container (3, 6); and a water circulating pump (16; 32) which is located along said first (15; 29), said second (30) or said third pipe (31) for sucking, on command, the washing water from the bottom of the laundry container (3, 6) and circulating said water through the second refrigerant heat exchanger (24) and the air/water heat exchanger (25), before feeding said water back into the laundry container (3, 6).

8. A laundry washing and drying machine as claimed in anyone of the foregoing Claims, wherein said laundry container (3, 6) comprises a washing tub (3) suspended in floating manner inside the casing (2), and a revolving drum (6) for housing the laundry to be washed and/or dried, and which is fixed in axially rotating manner inside the washing tub (3).

9. A laundry washing and drying machine as claimed in Claim 7 and 8, wherein said laundry washing and drying machine (1) also comprises a washing-water recirculating and draining circuit (12) for sucking the washing water from the bottom of the washing tub (3) and feeding said water back into the revolving drum (6), or alternatively feeding said water into an external waste-water exhaust duct; said water circulation circuit (26) being integrated into said washing-water recirculating and draining circuit (12).

10. A laundry washing and drying machine as claimed in anyone of the foregoing Claims, wherein said bi-directional refrigerant circulating means (22, 27, 28) comprise:

- refrigerant compressing means (22) form compressing a gaseous refrigerant so that refrigerant pressure and temperature are much higher at the outlet than at the inlet of the refrigerant compressing means (22);
- a refrigerant expansion device (27) which subjects the refrigerant flowing from the first refrigerant heat exchanger (23) to the second refrigerant heat exchanger (24) or vice versa, to a rapid expansion for reducing pressure and temperature of said refrigerant; and
- an hydraulic distributor (28) which connects the refrigerant compressing means (22) to both the first (23) and the second refrigerant heat exchanger (24), and is structured for selectively putting the outlet of the refrigerant compressing means (22) in communication with the first (23) or, alternatively, the second refrigerant heat ex-

changer (24), and the inlet of the refrigerant compressing means (22) in communication with the other refrigerant heat exchanger (23, 24), for selecting, on command, the flow of the refrigerant along the first refrigerant heat exchanger (23), the refrigerant expansion device (27) and the second refrigerant heat exchanger (24).

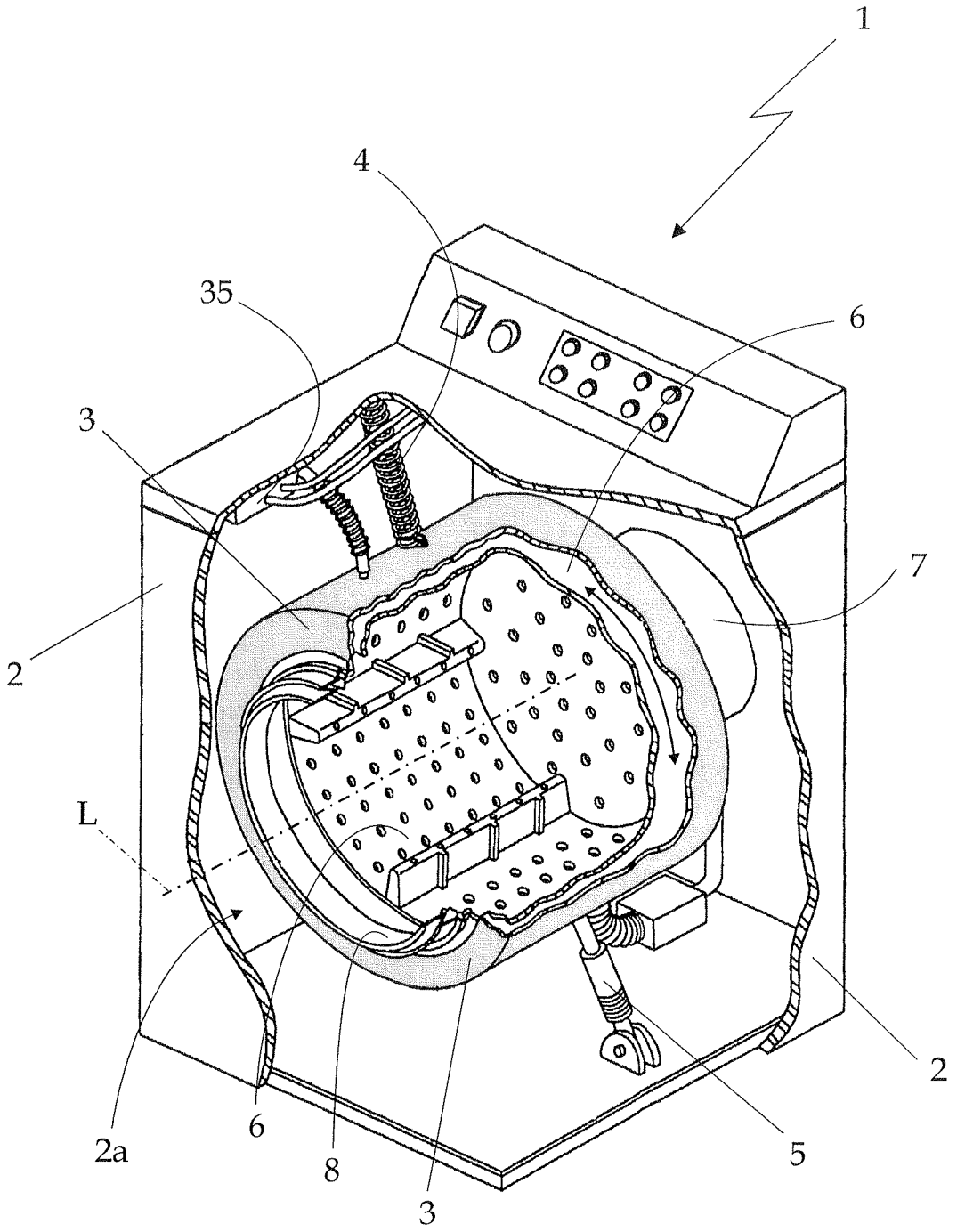

Fig. 1

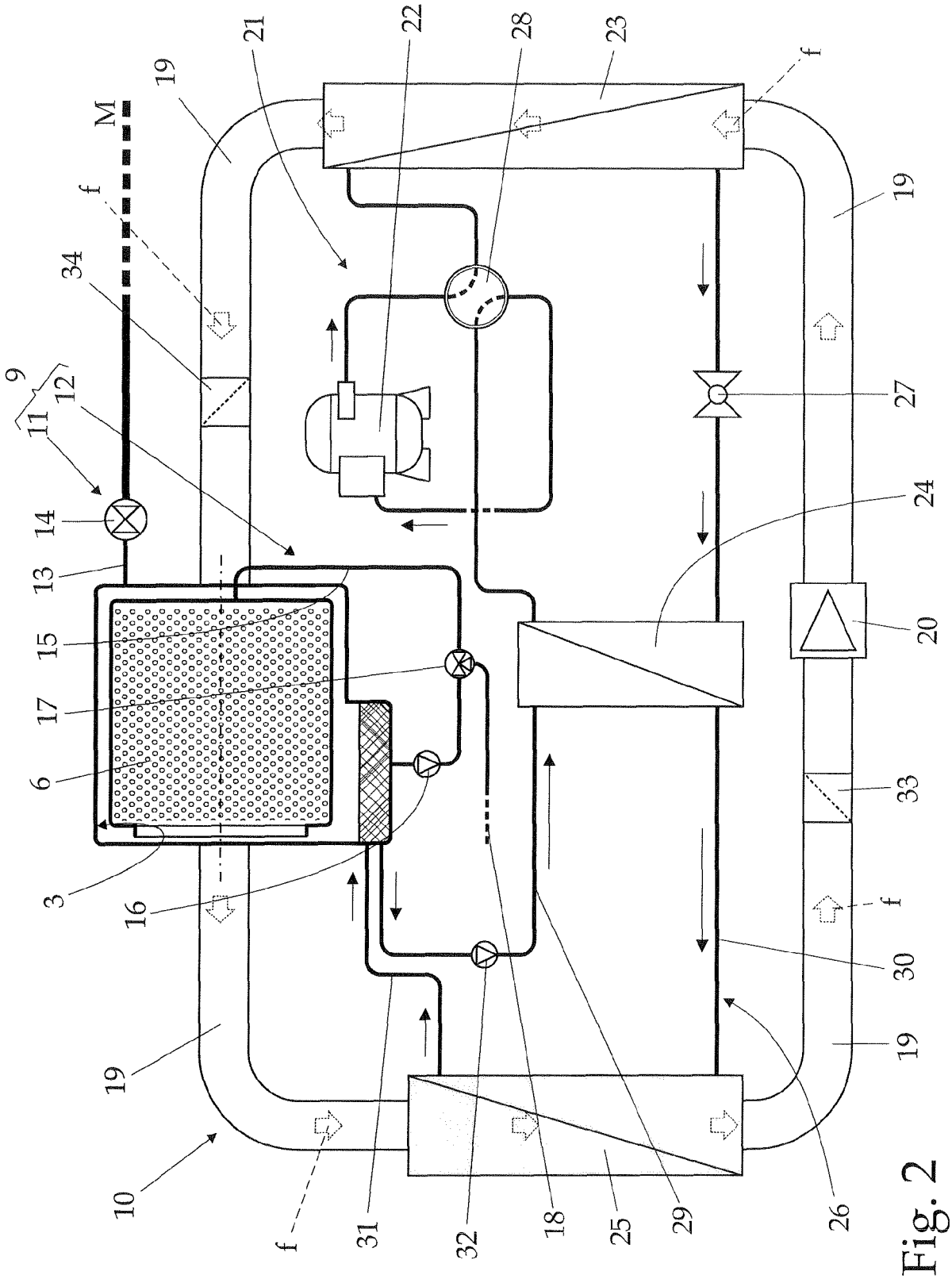
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Fig. 2

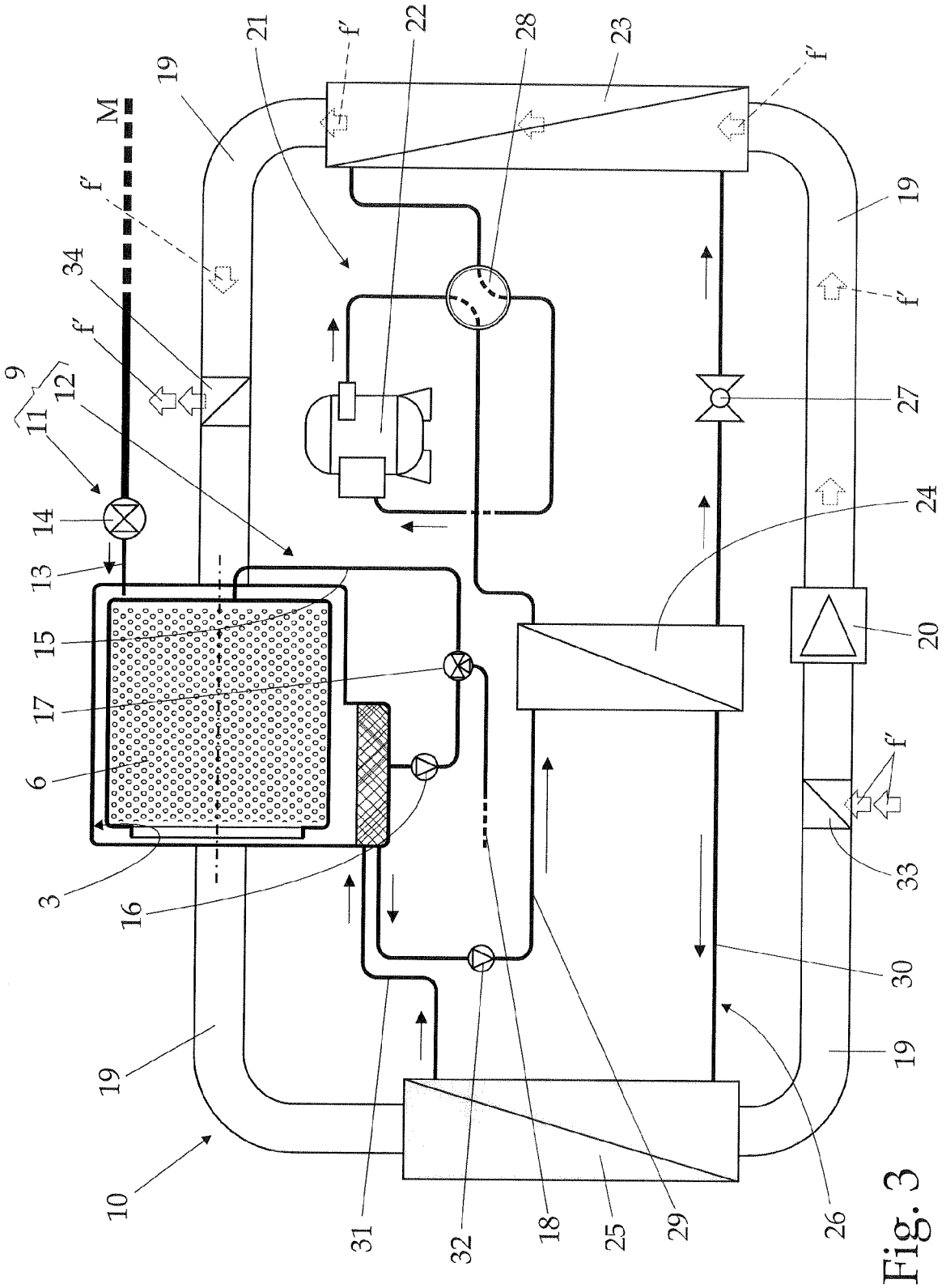
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Fig. 3

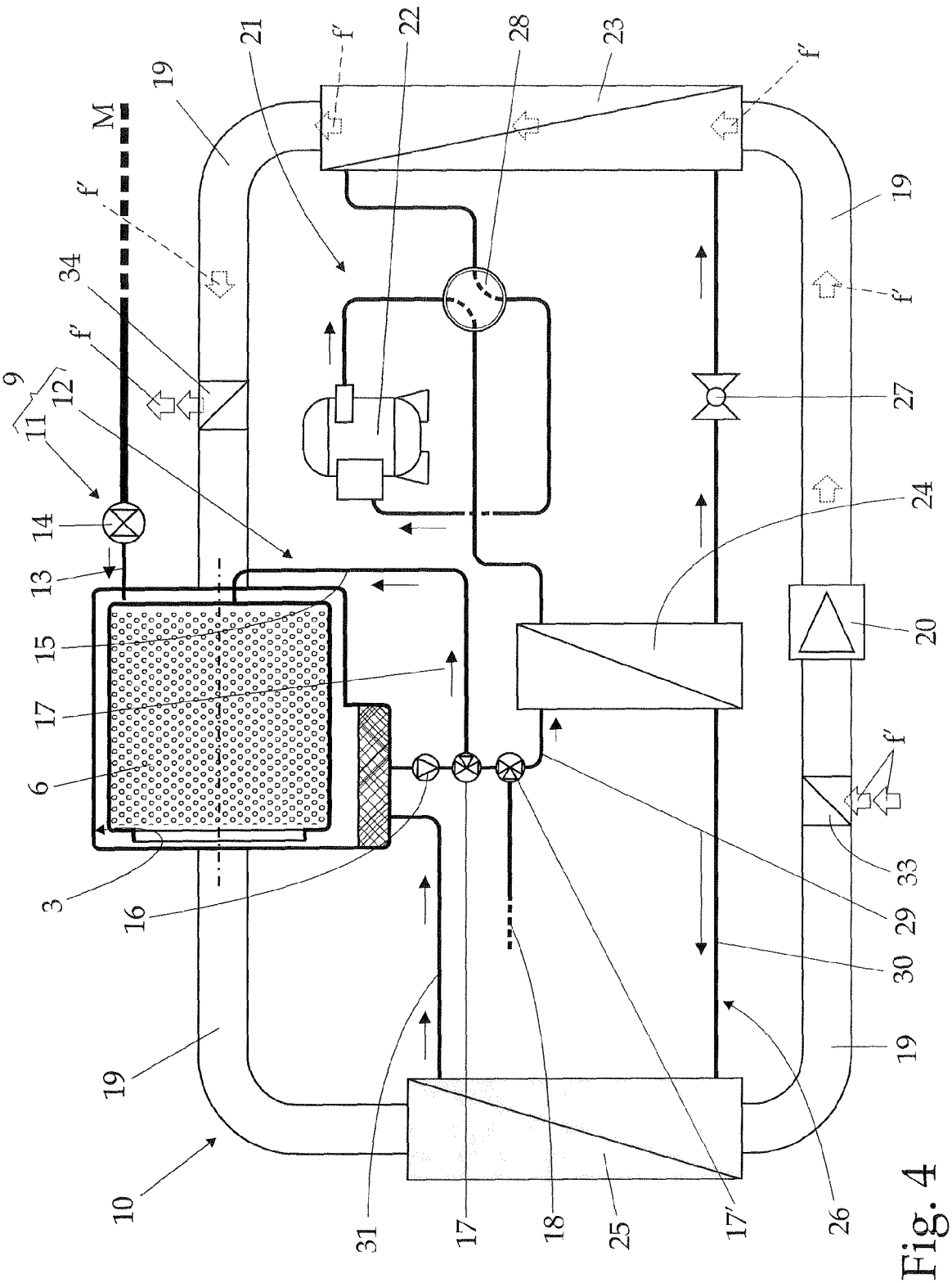
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Fig. 4

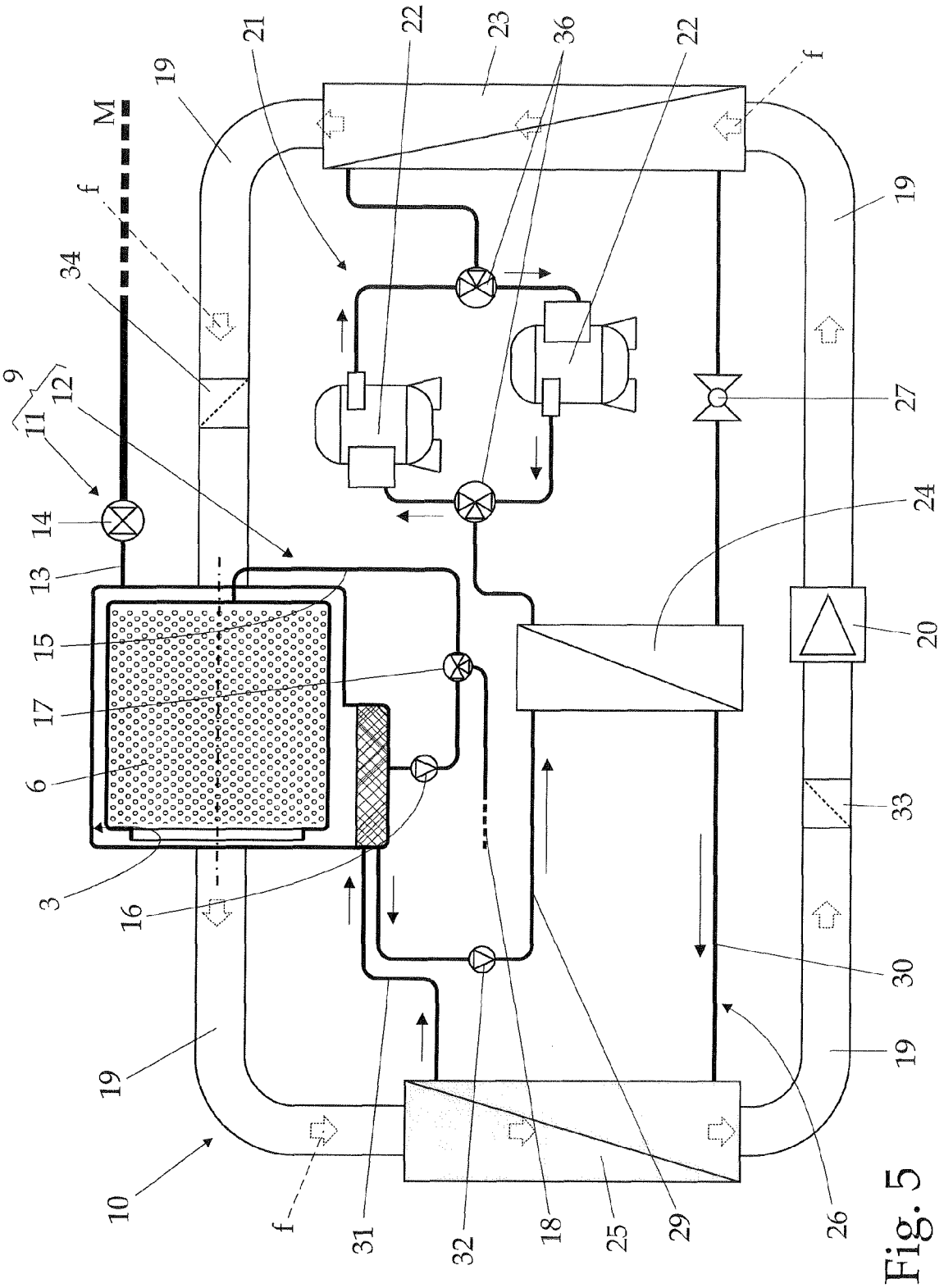
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Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 08 16 9589

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	US 2005/086824 A1 (ONO KOJI [JP] ET AL) 28 April 2005 (2005-04-28) * paragraph [0008] * * paragraph [0025] * * paragraph [0033] - paragraph [0039] * * paragraph [0048] - paragraph [0055]; figure 1 *	1	INV. D06F58/20 D06F39/04
A	US 4 665 628 A (CLAWSON LAWRENCE G [US]) 19 May 1987 (1987-05-19) * column 6, line 24 - column 7, line 24; figure 6 *	1	
A	DE 32 16 315 A1 (POMPLUN DIETER) 3 November 1983 (1983-11-03) * the whole document *	1	
A	DE 102 55 575 C1 (MIELE & CIE [DE]) 11 December 2003 (2003-12-11) * the whole document *	1	
			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	22 April 2009	Fachin, Fabiano

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22-04-2009

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005086824 A1	28-04-2005	CN 1576439 A	09-02-2005
		CN 1974915 A	06-06-2007
		CN 1952251 A	25-04-2007
		EP 1493860 A2	05-01-2005
		JP 2005024113 A	27-01-2005
US 4665628 A	19-05-1987	DE 3710592 A1	01-10-1987
		FR 2602525 A1	12-02-1988
		GB 2189876 A	04-11-1987
		JP 62295695 A	23-12-1987
DE 3216315 A1	03-11-1983	NONE	
DE 10255575 C1	11-12-2003	NONE	

EPO FORM P0459

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