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(54) A laundry or tableware treating machine

(57) A laundry or tableware treating machine including a treating chamber where the items can be introduced to be treated with a treating medium, a control unit (UC1), a heat pump system including a compressor (C), a first heat exchanger for heating a refrigerant, a second heat exchanger for cooling the refrigerant and heating the treating medium and expansion means, at least an active switching device (RL), controllable by the control unit (UC1), for selectively switching ON/OFF the compressor (C), wherein the machine comprises at least a passive switching device, not controllable by control unit (UC1), and including a thermo protector circuit (P) adapted to cut the power supply to the compressor (C) when predetermined temperature or voltage load thresholds are exceeded, monitoring means to detect the opening of the thermo protector circuit (P) to cut the power supply to the compressor (C), wherein the monitoring means includes at least one of the following: a system for monitoring the temperature of the refrigerant; a sensing circuit to detect a change of potential and/or current at an assembly comprising the compressor (C) and the thermo protector circuit (P).

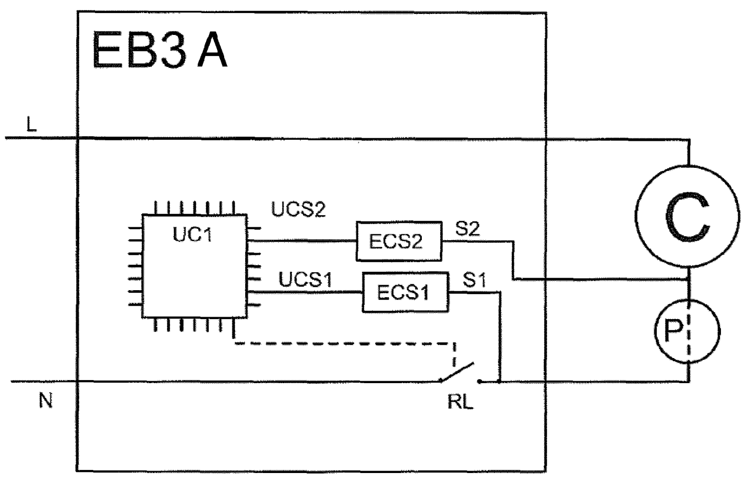

Fig. 8

EP 2 679 718 A1

Description

Field of technology

[0001] The present disclosure relates to laundry or tableware treating machines, e.g. laundry drying and/or washing machines or dish-washer, more particularly to a method and system for operating a treating machine.

Background

[0002] The present description is referring to a laundry drying appliance, but this is only an example, as the same problems and the same solutions here described could be implemented also in a laundry washing machine or other kinds of treating machine like tableware treating machine, e.g. a dishwasher. Generally, a drying appliance (e.g. a tumble dryer, cabinet dryer) includes a drying chamber for the articles to be dried, i.e. clothes, which chamber (in case of tumble dryer) is rotatably supported within a cabinet and made to rotate by means of a driving device, typically including an electric motor connected to the drying chamber e.g. via a belt. With reference to Figure 1, laundry treating machines of known type generally comprise a cabinet assembly 1 including a base element 2, a front panel 3, a rear panel 4, two side panels 5 and a top panel 6.

[0003] Front panel 3 has an opening, closed by a shutter 15, used to introduce in the machine the laundry to be treated. Alternative solutions include the possibility of an opening on the top side. Moreover, the cabinet assembly 1 typically supports also operational component parts of the machine which are required for drying laundry, such as a rotating drum 16, a control panel 17, air circulating conduits, heating devices (e.g. a heat pump with a compressor), filters, liquid draining apparatus and so on.

[0004] The laundry being dried is inserted into and removed from the drum through an opening closed e.g. by a shutter 15 and the drum is normally adapted for rotating around an horizontal axis by means of a motor.

[0005] Other components, such as a driving belt and so on, are included inside the cabinet assembly 1 for the operation of the dryer, and will not be further described as they are well known to those skilled in the art.

[0006] In drying machines with a rotating drum (e.g. Tumble Dryers) a flow rate of hot air passes through the drum, removing water from wet clothes. Inside the drum, the hot air is cooled down and the heat released by the air allows the evaporation of the water from the clothes. In heat pump dryer, the drying air is heated up via the condenser before entering the drum and the drying air exiting the drum is cooled down via the evaporator.

[0007] In electronic controlled machines almost all active loads like heaters, motor, pumps, compressor etc. have their own part of circuit that allow to detect certain type of faults like activator (relay or triac) non working, wiring problems. It is known to act on these active switches to improve the performances of the machine and trying to prevent unwanted situation as described e.g. on US Patent Application 2011/0173838.

[0008] In addition to these active switches, the laundry treating machine can be equipped with a passive switch which interrupts the power supply to the heat pump compressor when predetermined thresholds of heat or voltage load or current are exceeded. The passive switch opens when a threshold temperature of the heat pump compressor is reached or when a power load or current through the passive switch is reached, for example due to voltage peaks from the mains .

[0009] When normal functioning conditions are re-established the passive switch (e.g. a thermo protector) is adapted to go back to operative status closing the circuit, however there is a considerable delay before this happens. It is to be noted, in fact, that compressor thermo protector has a big inertia for turning back to the closed position, typically about 30 minutes.

[0010] Thermo protector opening is not an event that should happen in the cycle in normal conditions, therefore it would be very useful to recognize when this occurs so as to discover possible problems of current settings and possibly to apply corrective actions to mitigate the issue and preventing the passive switch from opening again in the same drying cycle or in subsequent cycles

[0011] Prior art laundry treating machines are not able to detect the opening of such compressor passive switch, and this can cause problems to the correct functioning of the machine.

[0012] It is not known in the prior art a method and system for detecting such thermo protector activation.

Objects of the disclosure

[0013] It is an object of the present disclosure to overcome at least some of the problems associated with the prior art.

Summary

[0014] The present disclosure provides a method and system as set out in the accompanying claims.

[0015] According to one aspect of the present disclosure there is provided a laundry and/or tableware treating machine

including: a treating chamber where the items can be introduced to be treated with a treating medium, a control unit UC1, a heat pump system including a compressor C, a first heat exchanger for heating a refrigerant, a second heat exchanger for cooling the refrigerant and heating the treating medium and expansion means; at least an active switching device RL, controllable by the control unit UC1, for selectively switching ON/OFF the compressor C; wherein it further comprises: at least a passive switching device not controllable by control unit UC1, and including a thermo protector circuit P adapted to cut the power supply to the compressor C when predetermined temperature or voltage load or current thresholds are exceeded, monitoring means to detect the opening of the thermo protector circuit P to cut the power supply to the compressor C, wherein the monitoring means includes at least one of the following: a system for monitoring the temperature of the refrigerant; a sensing circuit to detect a change of potential and/or current at an assembly comprising the compressor C and the thermo protector circuit P.
Preferably, control unit UC1 is adapted to implement a corrective action in response to the activation of the thermo protector circuit P being detected, the corrective action includes at least one of the following:

- switching ON a compressor cooling fan;
- adjusting an upper threshold temperature of the refrigerant for driving the switching ON of compressor cooling fan;
- adjusting a lower threshold temperature of the refrigerant for driving the switching OFF of a compressor cooling fan;
- adjusting the rotational speed of a compressor cooling fan;
- adjusting an upper threshold temperature of the refrigerant for driving the switching ON of fan for cooling an auxiliary heat exchanger of the heat pump system;
- adjusting a lower threshold temperature of the refrigerant for driving the switching OFF of a fan for cooling an auxiliary heat exchanger of the heat pump system;
- adjusting the rotational speed of a fan for cooling an auxiliary heat exchanger of the heat pump system;
- modifying a safety threshold temperature of the refrigerant at which the control unit switches OFF the compressor C via the active switching device RL.
- adjusting the rotational speed of a fan adapted to circulate the treating medium through the treating chamber;
- adjusting the rotational speed and/or the rotation direction of a motor adapted to drive into rotation the treating chamber, particularly reducing the time period of the treating chamber inversion rotation;
- adjusting the rotational speed of a compressor electric motor.

[0016] Preferably, the system for monitoring the temperature of the refrigerant comprises the control unit UC1 and at least a sensor adapted to measure the temperature of the refrigerant at a predetermined position of the heat pump system and convey the information to the control unit UC1.

[0017] Preferably, the control unit UC1 is able to recognize the opening of the thermo protector circuit P when the temperature of the refrigerant reaches or decrease below a predetermined value and the active switching device RL is in switching ON position for the compressor C.

[0018] Preferably, the system for monitoring the temperature of the refrigerant is adapted to maintain in a storage area a reference parameter for an expected temperature measured in a predetermined position of the heat pump system, monitor temperature values detected by the sensor, responsive to an anomaly of the monitored values with respect to the at least one reference parameter, determining the activation of the thermo protector circuit P.

[0019] Preferably, the reference parameter includes a predetermined threshold in the variation in the gradient of a curve representing the values of monitored temperature over time, and wherein the step of determining an anomaly includes the steps of:

- building a curve with the detected values of temperature over time
- measuring the gradient of the curve at regular time intervals;
- comparing successive measured gradients for determining if the difference exceeds the predetermined threshold.

[0020] Preferably, the step of determining the existence of an anomaly includes filtering the curve with a low-pass numeric filter.

[0021] Preferably, wherein the temperature is measured at the outlet second heat exchanger and/or at the inlet expansion means.

[0022] Preferably, the sensing circuit comprises at least an electrical detecting circuit ECS1, ECS2, ECSH1, ECSH2 connected to at least one of the following:

- a connection point located between the thermo protector circuit P and the compressor C;
- a connection point located between the thermo protector circuit P and the line or the neutral of the power mains to which the compressor C is connected;
- a connection point located between the compressor C and the line or the neutral of the power mains to which the

compressor C is connected.

[0023] Preferably, the compressor C is connected in series with the thermo protector circuit P, the assembly formed by the compressor C and the thermo protector circuit P being connected to a power main, and wherein the sensing circuit comprises:

- the control unit UC1, connected to the at least first active switching device RL;
- at least a first electrical detecting circuit ECS2 connected to a connection point between the thermo protector circuit P and the compressor C, on one hand, and to the control unit UC1, on the other hand;
- the control unit UC1 evaluating the output of the at least first electrical detecting circuit ECS2 in accordance with the active switching RL device being in deactivating or activating condition, in order to evaluate the status of thermo protector circuit P.

[0024] Preferably, the thermo protector circuit P is electrically connected to the active switching device RL, the control unit UC1 detecting the output of the detecting circuit ECS2 when the active switching device RL is open and closed.

[0025] Preferably, the compressor C is electrically connected to the active switching device RL, the control unit UC1 detecting the output of the detecting circuit ECS2 when the active switching device RL is open and closed.

[0026] Preferably, the control unit UC1 is also connected to a connection point located between the compressor C and the active switching device RL or located between the thermo protector circuit P and the active switching device RL, through a second detecting circuit ECS1.

[0027] Preferably, the compressor C is connected in series with the thermo protector circuit P, the assembly formed by the compressor C and the thermo protector circuit P being connected to a power main, and wherein the sensing circuit comprises:

- the control unit UC1 connected to the active switching device RL;
- a shunt evaluation electrical circuit ECSH1, ECSH2 connected to a shunt device, SH1, SH2, placed in series to the assembly formed by the compressor C and the thermo protector circuit P, so as to monitor the current flowing in the shunt device, SH1, SH2,
- the control unit UC1 evaluating the output of the shunt evaluation electrical circuit ECSH1, ECSH2 in accordance with the active switching device RL being switching ON position for the compressor C, in order to evaluate the status of the thermo protector circuit P.

[0028] Preferably, the shunt device SH1 SH2 is placed between at least one of the following:

- compressor C and line or neutral of the power mains;
- thermo protector circuit P and active switching device RL;
- compressor C and active switching device RL;
- thermo protector circuit P and line or neutral of the power mains;
- compressor C and thermo protector circuit P.

[0029] The method and system according to preferred embodiments of the present invention allows to detect the activation of the thermo protector circuit and gives the possibility of arranging some corrective actions to decrease the likelihood of future occurrence of such activation.

[0030] The present invention offers a number of benefits. One of the advantages of the method according to a preferred embodiment of the present invention is that of increasing efficiency of the drying (or washing/drying) machine by limiting the occurrence of machine interruption caused by an excessive temperature reached by the compressor or an excessive load. If the activation of the thermo protector circuit is promptly detected, the microcontroller can put in place corrective actions aimed at increasing the future efficiency and the reliability of the machine (e.g. a heat pump tumble dryer).

<u>Brief description of the drawings</u>

[0031] Reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a laundry drying machine which can implement the method and system of the present disclosure;

Figure 2 is a schematic representation of the main components of a machine implementing the method and system of the present invention;

Figure 3 is a schematic representation of the main components of a machine implementing the method and system of the present invention;

Figure 4 is a schematic representation of the main components of a machine implementing the method and system of the present invention;

Figure 5 is a graphic representation of the curve of a compressor condenser temperature and corresponding slope curve, showing the behavior of the slope curve when the thermo protector interrupts the power supply to the compressor;

Figure 6 shows the same graphic curve, when the thermo protector is de-activated and the power supply to the compressor is re-established;

Figure 7 is a diagram of the method steps of a first embodiment of the present disclosure;

Figures 8-13 show alternative embodiments of the system according to the present disclosure, using a circuit to detect the activation of the thermo protector circuit.

Detailed description of preferred embodiments

[0032] The system and method according to a preferred embodiment of the present invention aims at detecting the activation of a thermo protector circuit during the normal cycle of laundry treatment (e.g. drying) in a laundry treating machine (e.g. a tumble dryer or washing/drying machine).
As mentioned above the present description makes reference to a heat pump laundry dryer machine (e.g. a heat pump tumble dryer), but the same solutions here described can be applied to other kind of laundry treating machines, e.g. washing machines or washing/drying machine.

[0033] Generally a laundry treating machine according to the present invention includes a treating chamber where the laundry items can be introduced to be treated with a treating medium; a circuit where the treating means circulate (the treating means can be e.g. air in case of tumble dryer or water in case of washing machine); a heat pump system including a compressor C, a first heat exchanger for heating a refrigerant, a second heat exchanger for cooling the refrigerant and heating the treating medium; at least an active switching device for selectively activating/deactivating the compressor; at least a passive switching device including a thermo protector circuit P adapted to cut the power supply to the compressor C when predetermined temperature or load thresholds are exceeded.

[0034] Figure 2 schematically shows a possible laundry treating machine implementing the present invention, more particularly a heat pump tumble dryer:, the machine apparatus includes a drying chamber 201, preferably a drum rotatably mounted in an outer cabinet and accommodating the devices of the machine. The clothes or items to be dried are introduced into the drying chamber, through an aperture of the cabinet, in particular into a rotatable drum, possibly enclosed within a water bearing chamber (normally in case of washing/drying apparatus, while for simple dryer a water bearing chamber is normally not needed). The drum is set into rotation by means of a driving system for instance an electric motor 203 e.g. connected to the drum via a belt. An air inlet path is connected to a side of the drying chamber and an air outlet path is connected to the other side of the drying chamber. The air inlet path, the air outlet path and the drying chamber define a drying air circuit 205. A fan 207 is normally provided for moving drying air along the circuit. A dedicated motor 209 can be coupled to the fan 207, but in a possible simpler implementation the same motor can operate the fan 207 and the drum 201 (in other words only one of the two motor 203 and 207 can be present).
The drying system includes a heat pump system comprising a compressor C, a first heat exchanger 211 (also called evaporator), acting as a cold sink (i.e. evaporator or gas heater in case refrigerant operates at least at critical pressure), a second heat exchanger 213, acting as a hot sink (i.e. condenser or gas cooler in case the refrigerant operates at least at critical pressure). A throttle 215 is normally provided between the first heat exchanger 211 and the second heat exchanger 213. Alternative solutions to the throttle include expansion means, capillary tube or controlled expansion valve. In the embodiment shown in figure 2 the drying air circuit forms a substantially closed loop and the second heat exchanger 213 is arranged downstream the first heat exchanger 211.
Preferably, a cooling fan 217 is provided to cool down the compressor.
In a further embodiment, shown in figure 4, the heat pump system may further comprises an auxiliary heat exchanger 219, preferably arranged downstream the second heat exchanger 213 and acting as an auxiliary condenser for removing heat from the heat pump system. An auxiliary cooling fan 221 is provided to move an air stream through the auxiliary heat exchanger 219. In a preferred embodiment only a single cooling fan can be used to both cool down the compressor C and to flow air towards the auxiliary condenser 219.
A control unit UC1 operates the compressor cooling fan 217 and the fan 221 for cooling the auxiliary condenser 219

according to predetermined temperature of the refrigerant.

[0035] The laundry treating machine implementing the method and system according to a preferred embodiment of the present disclosure is preferably controlled by a control unit UC1 which receives information by the system for monitoring the temperature of the refrigerant and/or by the sensing circuit to detect a change of potential and or current at the assembly including the compressor C and the thermo protector circuit P. When the activation (i.e. opening) of the thermo protector circuit P is detected, the information is transmitted to the control unit UC1 which can take one or more of a possible set of corrective actions. Also, with the ability to detect the opening of the passive switching device this, it is possible to log this event inside a control unit UC1, to help service people to correctly diagnose possible machine malfunction causes.

[0036] As mentioned above, thermo protector opening is not an event that should happen in the cycle in normal conditions.

So if this kind of event is detected, assumptions on the malfunctioning of the machine can be made; this can be due to different causes like non optimal installation, ambient temperature, clogged filters etc.

An additional advantage related to the ability to detect thermo protector opening is the chance to apply cycle parameters modification in order to reduce the probability of another cut-off event in the same cycle in which the event takes place and most of all to reduce the probability of occurrence of a cut-off event in the future/subsequent cycles, so as to not affect the normal cycle duration and consumption.

[0037] According to the present invention, two different ways of detecting the activation of the thermo protector circuit can be implemented: the first one includes monitoring the temperature of the refrigerant by means of temperature sensors; the second one includes monitoring the electric assembly comprising the compressor and the thermo protector circuit by means of dedicated sensing circuits. The information of the detected activation is provided to the control unit UC1 which can then evaluate and perform a corrective action, e.g. a cycle parameters modification which can be implemented irrespective of the way the thermo protector opening is detected.

[0038] A possible corrective action is to modify the compressor cooling fan 217 behaviour:

- Immediately switch on the compressor cooling fan 217 when thermo protector opening is detected to decrease the time needed by thermo protector to close again; (particularly when thermo protector opening is due to current absorption peak or line micro-interruptions, since when the opening (activation) is due to excessive heat it is likely that the fan is already on;
- Modify an upper threshold temperature of the refrigerant which drives the switching ON of the compressor cooling fan and/or modify a lower threshold temperature of the refrigerant which drives the switching OFF of the compressor cooling fan to ensure better compressor cooling. For example, the upper threshold temperature of the refrigerant at which the fan is switched on can be decreased, (e.g. from 56°C to 52°C with reference to the refrigerant temperature detected at the outlet of the second heat exchanger 213). Additionally or alternatively, the lower threshold temperature of the refrigerant at which the fan is switched off could be decreased (e.g. from 54°C to 48°C with reference to the refrigerant temperature detected at the outlet of the second heat exchanger 213). Preferably, the operating time interval of the compressor cooling fan 217 is increased to allow a better and faster cooling;
- Modify the rotational speed of the fan, e.g. above a predetermined refrigerant temperature to improve the cooling of the compressor, particularly increasing the rotational speed of the fan. A further possible corrective action is to modify the behaviour of the fan 221 for cooling the auxiliary heat exchanger:

  Increasing the rotational speed of the fan 221 or increasing the activation time interval of the same.

[0039] Another action that could be done to affect compressor functionality is:

- Modify (decrease) the refrigerant temperature at which the compressor is switched-off by the control unit via the above mentioned active switching device in order prevent the thermo protector circuit from opening.

In fact when refrigerant temperature exceeds a configured maximum value, the compressor is switched-off for a while, until right conditions to restart are satisfied. The advantage is that in this case the compressor remains off for a shorter time (~3 to 5 min) than in the case of thermo protector opening (~30 min), allowing the cycle duration not be to particularly affected and maintaining safety conditions for the compressor at the same time. Such configured maximum value can be adjusted down, e.g. from 70 to 65 degrees, with the refrigerant temperature detected at the outlet of the second heat exchanger, for example.

A further action can be **adjusting the rotational speed of the electric motor of the compressor so as to reduce the compressor output at an average lower operating value, thereby reducing the temperature of the compressor.**

[0040] Also modifications to drum/process fan motor parameters can be applied to try to ensure better cycle conditions:

- Modify (increase) motor speed of the process fan to ensure higher air flow. This could help especially when filters are clogged and with cycles with reduced air flow like the ones with night cycle/silent option.
- Modify drum motor reversing behaviour, this is relevant when a single motor drives both the process fan and the drum as shown in figure 3. During motor reversing phase, the rotation direction of the motor is changed to better tumble the laundry, however the process fan provides only a part of the nominal flow rate available when the process fan rotates in the main direction and the decrease of dying air flow can worsen compressor working condition. To try to improve this aspect, it is possible to:

- Reduce motor stop time and/or reduce the time interval of the motor rotation direction inversion phase;
- Reduce reversing frequency include the chance to completely avoid any reversing for the reaming duration of the cycle;
- Increase motor speed during motor rotation direction inversion phase to increase the available drying air flow during this phase.

[0041] In a first embodiment of the present invention, a temperature sensor is used to measure the variations of the refrigerant temperature. In particular an NTC thermistor is placed in such a way to measure the refrigerant temperature at condenser outlet and/or at expansion means inlet, additionally or alternatively the temperature sensor can be arranged at different location of the heat pump system for example at the outlet of compressor C.

Evaluating the behaviour of this signal, it is possible to understand if the compressor thermo protector has temporarily disconnected the compressor from the line after a current absorption peak or temperature too high or line micro-interruptions. In fact, when thermo protector opens the circuit that supplies the compressor, after a short time, temperature start to decrease. The detection of this temperature fall provides a clear indication that the compressor has been deactivated by the thermo protector cut-off.

For example if the refrigerant temperature at the condenser outlet decreases particularly below a predetermined value, it turns out that the thermo protector is open. It is to be stressed that the active switching device RL is obviously still in closed position, so according to the control unit UC1, the compressor should be running, therefore it is evident the need for the control unit UC1 to recognize and improper deactivation of the compressor due to the opening of the thermo protector.

Preferably, the control unit UC1 monitors the status of the active switching device RL by means of an electrical detecting circuit so as to detect when the active switching device RL is in open or closed position.

[0042] According to a preferred embodiment of the present disclosure the temperature slope is calculated to determine the occurrence of the thermo-protector activation. Condenser temperature during cycle has various oscillation due for example to compressor cooling fan activation or temporary decrease of air flow due to drum motor (connected to process fan) reversing. If the slope falls negative without any apparent reason, we could suppose that the cause is thermo protector cut-off.

[0043] In Figure 5 an example curve of such measured temperature is shown, where we can see that the negative value of the slope in this case is particularly evident with respect to other causes like drum motor reversing.

[0044] Temperature slope can be determined, for example, with the following formula to be calculated every seconds:

$$\text{Slope}(t) = \text{Temp}(t)\text{-}\text{Temp}(t\text{-}5\text{sec})$$

[0045] The result is then filtered to avoid peak with a low-pass filter:

$$\text{Filt\_Slope}(t) = \text{Filt\_slope}(t\text{-}1)^*(1\text{-}\ \alpha) + \text{Slope}(t)\ ^*\ \alpha$$

With $\alpha < 1$.

[0046] In Figure 5, the curve A represent the Condenser temperature over time, while curve B is the slope of the temperature curve A, filtered with a low pass filter.

Line C represents the two possible states of the Compressor (ON or CUT OFF) following thermo protector circuit activation. As shown in Figure 5 a small Slope Decrease SD can be simply due to normal machine behavior (e.g. caused by a motor reversing), while a consistent Slope Fall SF (e.g. exceeding a predetermined threshold) is a reasonable indication that a cut-off occurred because of a thermo protector circuit activation. The method in a preferred embodiment of the present invention is based on the assumption that a slope exceeding a predetermined threshold is considered a detection of the activation of thermo protector circuit. Those skilled in the art will appreciate that such threshold can be adjusted and tuned according to machine characteristics and/or historic data.

[0047] In the same way as we have just detected thermo protector opening, it's possible also to detect the restoring of working conditions: again the control unit can be programmed to perform certain actions reacting to the modified conditions. The same curves A, B and C of Figure 3 are now represented in Figure 6 showing the case when the thermo protector circuit is de-activated causing a Slope Run over a predetermined threshold.

[0048] Figure 7 schematically shows a diagram representing the method steps of the first embodiment of the present disclosure. The process is a method for detecting the activation of a thermo protector circuit, e.g. during a drying cycle in a drying or washing or washing/drying machine, more generally laundry treating machine. The process starts at circle 501 and it is transferred to box 503 where an expected temperature over time is estimated. This step could be skipped in case the machine has one or more predetermined sets of values stored in an internal memory. The process is then passed to step 505 where the temperature of a condenser of the laundry treating machine is monitored: in the present example we consider a heat pump type tumble dryer, but the same method could be implemented on other kinds of laundry treating machines. As mentioned above this can be done by means of sensors able to detect the temperature; the sensors can be placed e.g. next to the condenser associated to the compressor C. When an anomaly in the expected temperature is detected (step 509) a corrective action is started (step 511). The way of determining an anomaly can be implemented in several different ways, from a simple threshold comparison to a more sophisticated analysis of the detected temperature curve with expected values as described above. Also the corrective actions can be implemented in several different manners as explained above and as immediately appreciated by those skilled in the art. It should also be understood that the temperature monitoring could be done even in an indirect way, e.g. by monitoring the pressure within the refrigerant circuit. The process then goes back to step 505 and starts over again, until the end (507) of the treating cycle is reached. This determination of end of cycle can be done in several different ways, e.g. when a predetermined drying time has expired, but it can be more sophisticated, taking into consideration e.g. the temperature or a dryness parameter of the laundry.

[0049] An alternative solution for determining the activation of the thermo protector circuit is through a sensing circuit aimed at detecting change of state of the thermo protector circuit. Possible implementations of this second embodiment are represented in Figures 8 to 13. With this embodiment, it is possible to understand if the thermo protector circuit P is open or closed directly interpreting the information received by the circuit itself.

First implementation of sensing circuit is represented in Figure 8 where compressor C is connected in series with a thermo protector circuit P, and the assembly formed by the compressor C and the thermo protector circuit P is connected to the line wire L and to the neutral wire N of a power main.

An active switching device RL, typically a relay or a solid state device, such as a triac, etc., is placed along the neutral wire N for the control unit UC1 to activate/deactivate the compressor C. The active switching device will be always referred to as "relay" in the following, but it is understood that it could be a different switching device

According to this implementation, the system for detecting the thermo protector circuit P status includes a first electrical detecting circuit ECS 1, a second electrical detecting circuit ECS2 and the control unit UC1.

Connections and operation of these components is described in detail in the following, whereas structure and operation of the control unit UC1 will not be explained in detail, since it will appear obvious to those skilled in the art.

Compressor C is electrically connected to the line wire L and the thermo protector circuit P is electrically connected to the relay RL, at the terminal opposite to the one connected to the neutral wire N. In other words, the compressor C is connected to the neutral wire N of the power main, when the relay is in activating condition.

Having reference first to Figure 8, the first electrical detecting circuit ECS1 is connected, through a sensing wire S1, to the neutral wire N, on one hand, immediately downstream of the relay RL. On the other hand, the first electrical detecting circuit ECS1 is connected to control unit UC1.

A second electrical detecting circuit ECS2 is connected to the connection point between the thermo protector circuit P and the compressor C, on one hand, through a sensing wire S2. On the other hand, the second electrical detecting circuit ECS2 is connected to control unit UC1.

The control unit UC1 is also connected to the relay RL, to control its condition. With this configuration, the control unit UC1, by evaluating the output of the first electrical detecting circuit ECS 1 when the relay RL is in deactivating condition, is able to evaluate the status of the thermo protector circuit P, to establish if it is open or closed.

In fact if the thermo protector circuit P is closed, first electrical detecting circuit ECS1 detects substantially the line potential, whereas if the thermo protector circuit P is open, first electrical detecting circuit ECS1 detects substantially the neutral potential.

When the relay RL is in activating condition, however, the sensing wire S1 is directly connected to neutral wire N and its output is directly dependant on the neutral-line circuit, independently from the thermo protector circuit P status.

In such case, the control unit UC1, by evaluating the output of the second electrical detecting circuit ECS2 is able to evaluate the status of the thermo protector circuit P.

In fact if the thermo protector circuit P is closed, the second electrical detecting circuit ECS2 detects substantially the neutral potential, whereas if the thermo protector circuit P is open, the second electrical detecting circuit ECS2 detects substantially the line potential.

[0050] With reference to Figure 9, in a possible different configuration of the apparatus, in which the thermo protector circuit P is electrically connected to the line wire L and the compressor C is electrically connected to the relay RL, the situation is reversed.

With this configuration, the control unit UC1, by evaluating the output of the first electrical detecting circuit ECS1 and the second electrical detecting circuit ECS2 when the relay RL is in deactivating condition, is able to evaluate the status of the thermo protector circuit P, and to establish if it is open or closed.

In fact if the thermo protector circuit P is closed, first electrical detecting circuit ECS1 detects substantially a potential pulled up to line potential, whereas if the thermo protector circuit P is open, first electrical detecting circuit ECS1 detects substantially a floating junction connected neither to line not to neutral.

Further, if the thermo protector circuit P is closed, the second electrical detecting circuit ECS2 detects substantially the line potential, whereas if the thermo protector circuit P is open, the second electrical detecting circuit ECS2 detects substantially the neutral potential. In this configuration a double check about the status of the thermo protector circuit P is provided for improving reliability of the sensing circuit.

When the relay RL is instead in the activating condition, the sensing wire S1 is directly connected to neutral wire N and its output is dependant on the neutral-line, independently from the thermo protector circuit P status, through the neutral-line circuit. In this condition of the relay, the control unit UC1 by evaluating the output of the second electrical detecting circuit ECS2 is able to evaluate the status of the thermo protector circuit P, and to establish if it is open or closed. In fact if the thermo protector circuit P is closed, the second electrical detecting circuit ECS2 detects substantially the line potential, whereas if the thermo protector circuit P is open, the second electrical detecting circuit ECS2 detects substantially the neutral potential.

[0051] A simpler implementation of the second embodiment of the present invention is possible, taking into consideration that the activation (i.e. opening) of thermo protector circuit P is likely to happen only when the active switching device RL is closed, i.e. when the compressor is connected and activated. With reference to Figure 10, a simpler version of the above mentioned circuit includes only one electrical detecting circuit ECS2, which is connected to a connection point between the thermo protector circuit P and the compressor C through a sensing wire S2. In this case, the control unit UC1, by evaluating the output of the second electrical detecting circuit ECS2 is able to evaluate the status of the thermo protector P only when the active switching device RL is closed, with the compressor C connected to the line wire L and the thermo protector P connected to the neutral wire N. In fact if the thermo protector circuit P is closed, the second electrical detecting circuit ECS2 detects substantially the neutral potential, whereas if the thermo protector circuit P is open, the second electrical detecting circuit ECS2 detects substantially the line potential.

[0052] Instead when the active switching device RL is open, the second electrical detecting circuit ECS2 detects always the line potential irrespective of the status of the thermo protector circuit P.

[0053] Conversely, as shown in Figure 11, with the compressor C connected to the neutral wire N and the thermo protector P connected to the line wire L the control unit UC1 is able to evaluate the status of the thermo protector P even if the active switching device RL is open.

The sensing circuit according to the implementation shown in Figures 11 by evaluating the output of the second electrical detecting circuit ECS2 is able to evaluate the status of the thermo protector P when the active switching device RL is closed. In fact if the thermo protector circuit P is closed, the second electrical detecting circuit ECS2 detects substantially the line potential, whereas if the thermo protector circuit P is open, the second electrical detecting circuit ECS2 detects substantially the neutral potential.

Additionally, as mentioned above, the sensing circuit according to the implementation shown in Figures 11 by evaluating the output of the second electrical detecting circuit ECS2 is able to evaluate the status of the thermo protector circuit P also when the active switching device RL is open. In fact if the thermo protector circuit P is closed, the second electrical detecting circuit ECS2 detects substantially the line potential, whereas if the thermo protector circuit P is open, the second electrical detecting circuit ECS2 detects substantially a floating junction connected neither to line not to neutral.

[0054] With reference to Figure 12, another implementation of the second embodiment of the present disclosure is described.

With this implementation, it is possible to understand if the thermo protector circuit P is open or closed by measuring the current flowing through the assembly formed by the compressor and thermo protector circuit P. Moreover, with this embodiment, the sensing wire S2 connected to a connection point between the thermo protector circuit P and the compressor C can be avoided.

This allows manufacturing cost saving and less complexity, because there is no need to have an additional wire form the electronic board to the compressor/thermo protector system.

As in the previous embodiment, the compressor C is connected in series with the thermo protector circuit P and to the power main.

Also in the present embodiment the system for detecting the thermo protector circuit P status includes the control unit UC1, connected to the relay RL for activating/deactivating the compressor C.

An electrical detecting circuit ECS1 is connected, on one side, to the neutral wire N, through a sensing wire S1, between the relay RL and the thermo protector circuit P, and, on the other side, to the control unit UC1, similarly to previously described implementation.
A shunt evaluation electrical circuit ECSH1 is connected to a shunt device SH1 placed in series with the thermo protector circuit P and the compressor C. The shunt device SH1 is placed next to the compressor, along the line wire L.
The shunt evaluation electrical circuit ECSH1 is connected to the control unit UC1.
With this configuration, the control unit UC1 evaluates the output of the electrical detecting circuit ECS1, when the relay RL is closed. The status of the relay RL is monitored by the control unit UC1 by means of the first electrical detecting circuit ECS1
When the relay is in the compressor activating condition, the control unit UC1 verifies if a current is flowing in the shunt device SH1, by the shunt evaluation electrical circuit ECSH1, and establishes if the thermo protector circuit P is closed or open.
A different configuration of the apparatus is shown in figure 13, where the shunt device SH2 is placed between the thermo protector circuit P and the active switching device RL.

[0055] It will be appreciated that alterations and modifications may be made to the above without departing from the scope of the disclosure. Naturally, in order to satisfy local and specific requirements, a person skilled in the art may apply to the solution described above many modifications and alterations. Particularly, although the present disclosure has been described with a certain degree of particularity with reference to preferred embodiment(s) thereof, it should be understood that various omissions, substitutions and changes in the form and details as well as other embodiments are possible; moreover, it is expressly intended that specific elements and/or method steps described in connection with any disclosed embodiment of the disclosure may be incorporated in any other embodiment as a general matter of design choice.

Claims

1. A laundry and/or tableware treating machine including:

- a treating chamber (16) where the items can be introduced to be treated with a treating medium;
- a control unit (UC1);
- a heat pump system including a compressor (C), a first heat exchanger (211) for heating a refrigerant, a second heat exchanger (213) for cooling the refrigerant and heating the treating medium and expansion means;
- at least an active switching device (RL), controllable by the control unit (UC1), for selectively switching ON/OFF the compressor (C);

characterized in that it further comprises:

- at least a passive switching device not controllable by control unit (UC1), and including a thermo protector circuit (P) adapted to cut the power supply to the compressor (C) when predetermined temperature or voltage load or current thresholds are exceeded;
- monitoring means to detect the opening of the thermo protector circuit (P) to cut the power supply to the compressor (C), wherein the monitoring means includes at least one of the following: a system for monitoring the temperature of the refrigerant; a sensing circuit to detect a change of potential and/or current at an assembly comprising the compressor (C) and the thermo protector circuit (P).

2. The treating machine of claim 1, wherein the system for monitoring the temperature of the refrigerant comprises the control unit (UC1) and at least a sensor adapted to measure the temperature of the refrigerant at a predetermined position of the heat pump system and convey the information to the control unit (UC1).

3. The treating machine of claim 1 or 2, wherein the control unit (UC1) is able to recognize the opening of the thermo protector circuit (P) when the temperature of the refrigerant reaches or decrease below a predetermined value and the active switching device (RL) is in switching ON position for the compressor (C).

4. The treating machine of claim 2 or 3 wherein the system for monitoring the temperature of the refrigerant is adapted to

- maintain in a storage area a reference parameter for an expected temperature measured in a predetermined position of the heat pump system;
- monitor temperature values detected by the sensor;

- responsive to an anomaly of the monitored values with respect to the at least one reference parameter, determining the activation of the thermo protector circuit (P).

5. The treating machine of claim 4 wherein the reference parameter includes a predetermined threshold in the variation in the gradient of a curve representing the values of monitored temperature over time, and wherein the step of determining an anomaly includes the steps of:

- building a curve with the detected values of temperature over time
- measuring the gradient of the curve at regular time intervals;
- comparing successive measured gradients for determining if the difference exceeds the predetermined threshold.

6. The treating machine of claim 4 or 5 wherein the step of determining the existence of an anomaly includes filtering the curve with a low-pass numeric filter.

7. The treating machine of any claim 1 to 6 wherein the temperature is measured at the outlet second heat exchanger and/or at the inlet expansion means.

8. The treating machine of claim 1, wherein the sensing circuit comprises at least an electrical detecting circuit (ECS1, ECS2, ECSH1, ECSH2) connected to at least one of the following:

- a connection point located between the thermo protector circuit (P) and the compressor (C);
- a connection point located between the thermo protector circuit (P) and the line or the neutral of the power mains to which the compressor (C) is connected;
- a connection point located between the compressor (C) and the line or the neutral of the power mains to which the compressor (C) is connected.

9. The treating machine of claim 1 or 8, wherein the compressor (C) is connected in series with the thermo protector circuit (P), the assembly formed by the compressor (C) and the thermo protector circuit (P) being connected to a power main, and wherein the sensing circuit comprises:

- the control unit (UC1), connected to the at least first active switching device (RL);
- at least a first electrical detecting circuit (ECS2) connected to a connection point between the thermo protector circuit (P) and the compressor (C), on one hand, and to the control unit (UC1), on the other hand;
- the control unit (UC1) evaluating the output of the at least first electrical detecting circuit (ECS2) in accordance with the active switching device (RL) being in deactivating or activating condition, in order to evaluate the status of thermo protector circuit P.

10. The treating machine of any claim 8, 9, wherein the thermo protector circuit (P) is electrically connected to the active switching device (RL), the control unit (UC1) detecting the output of the detecting circuit (ECS2) when the active switching device (RL) is open and closed.

11. The treating machine of any claim 8, 9, wherein compressor (C) is electrically connected to the active switching device (RL), the control unit (UC1) detecting the output of the detecting circuit (ECS2) when the active switching device (RL) is open and closed.

12. The treating machine of claim 1, wherein the compressor (C) is connected in series with the thermo protector circuit (P), the assembly formed by the compressor (C) and the thermo protector circuit (P) being connected to a power main, and wherein the sensing circuit comprises:

- the control unit UC1 connected to the active switching device (RL);
- a shunt evaluation electrical circuit (ECSH1, ECSH2) connected to a shunt device (SH1, SH2) placed in series to the assembly formed by the compressor (C) and the thermo protector circuit (P), so as to monitor the current flowing in the shunt device (SH1, SH2)
- the control unit (UC1) evaluating the output of the shunt evaluation electrical circuit (ECSH1, ECSH2) in accordance with the active switching device (RL) being switching ON position for the compressor (C), in order to evaluate the status of the thermo protector circuit (P).

13. The treating machine of claim 12, wherein the shunt device (SH1 SH2) is placed between at least one of the following:

- compressor (C) and line or neutral of the power mains;
- thermo protector circuit (P) and active switching device (RL);
- compressor (C) and active switching device (RL);
- thermo protector circuit (P) and line or neutral of the power mains;
- Compressor (C) and thermo protector circuit (P).

14. The treating machine of ant claim 8-13, wherein the control unit (UC1) is also connected to a connection point located between the compressor (C) and the active switching device (RL) or located between the thermo protector circuit (P) and the active switching device (RL), through a second detecting circuit (ECS1).

15. The treating machine of any claim 1-14 wherein the control unit (UC1) is adapted to implement a corrective action in response to the activation of the thermo protector circuit (P) being detected, the corrective action includes at least one of the following:

- switching ON a compressor cooling fan (217);
- adjusting an upper threshold temperature of the refrigerant for driving the switching ON of compressor cooling fan (217) ;
- adjusting a lower threshold temperature of the refrigerant for driving the switching OFF of a compressor cooling fan (217);
- adjusting the rotational speed of a compressor cooling fan (217);
- adjusting an upper threshold temperature of the refrigerant for driving the switching ON of fan (221) for cooling an auxiliary heat exchanger (219) of the heat pump system;
- adjusting a lower threshold temperature of the refrigerant for driving the switching OFF of a fan (221) for cooling an auxiliary heat exchanger (219) of the heat pump system;
- adjusting the rotational speed of a fan (221) for cooling an auxiliary heat exchanger (219) of the heat pump system;
- modifying a safety threshold temperature of the refrigerant at which the control unit (UC1) switches OFF the compressor (C) via the active switching device (RL).
- adjusting the rotational speed of a fan (207) adapted to circulate the treating medium through the treating chamber (16);
- adjusting the rotational speed and/or the rotation direction of a motor (209) adapted to drive into rotation the treating chamber, particularly reducing the time period of the treating chamber inversion rotation;
- adjusting the rotational speed of a compressor electric motor.

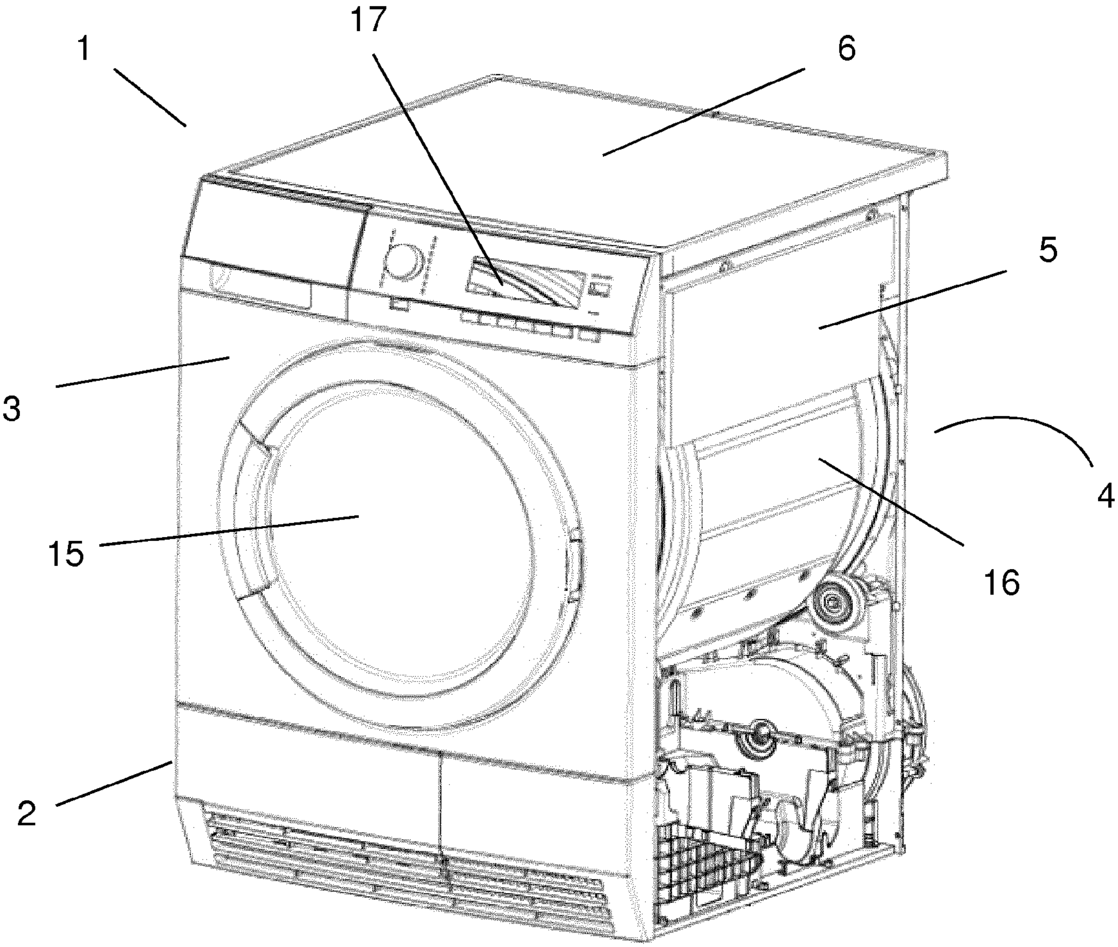

Fig. 1

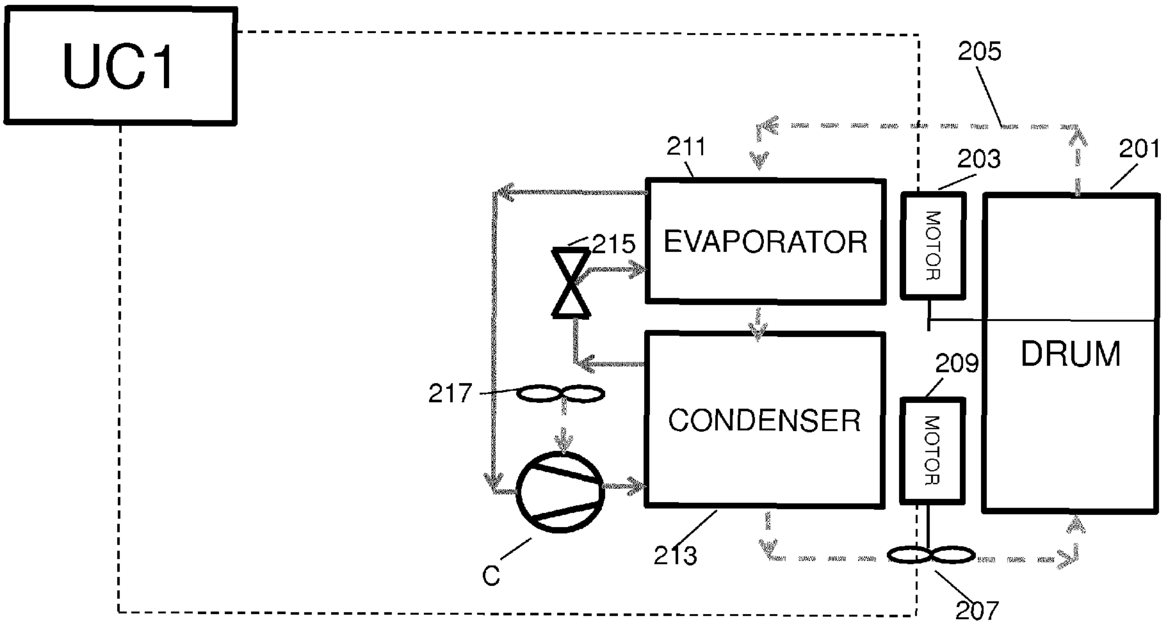
UC1
205
211
203
201
215
EVAPORATOR
MOTOR
DRUM
209
217
CONDENSER
MOTOR
213
C
207

Fig. 2

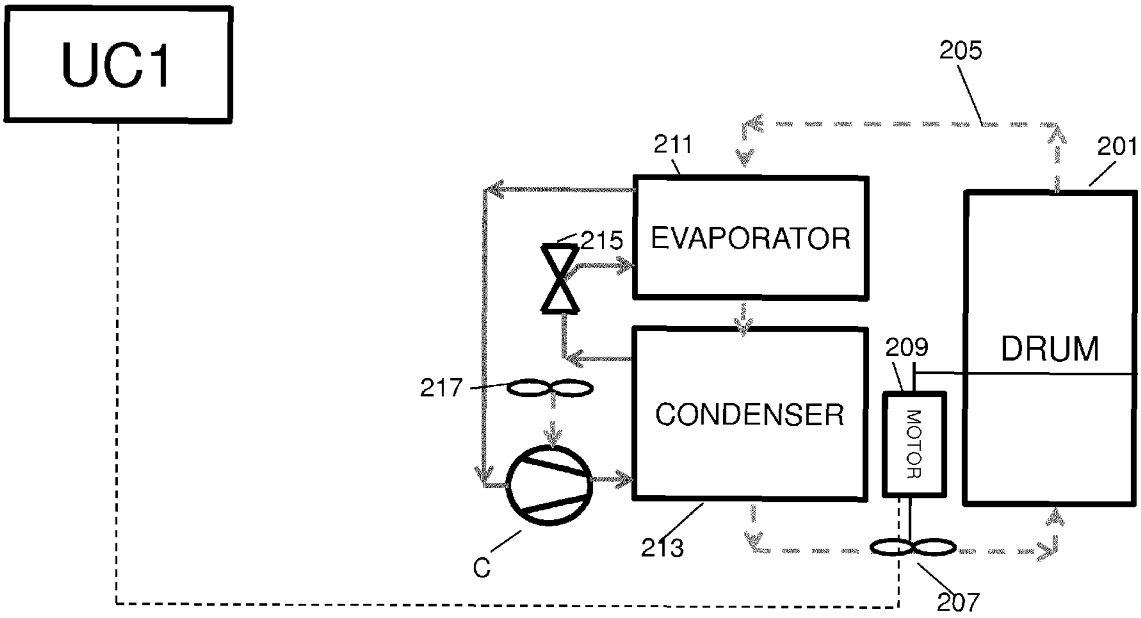
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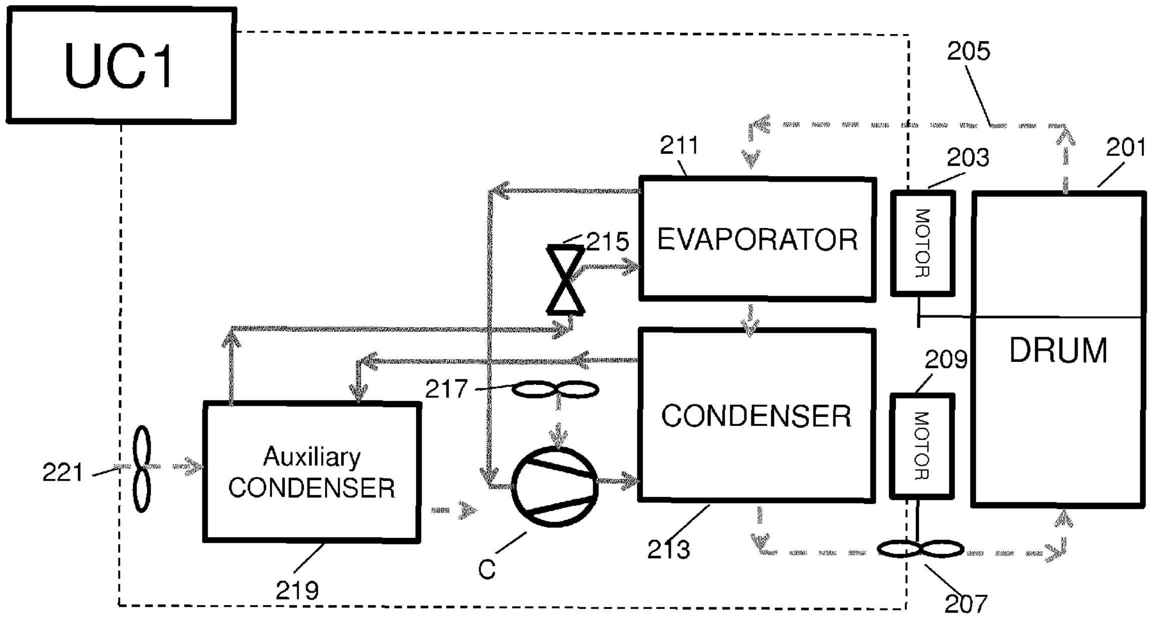
Fig. 3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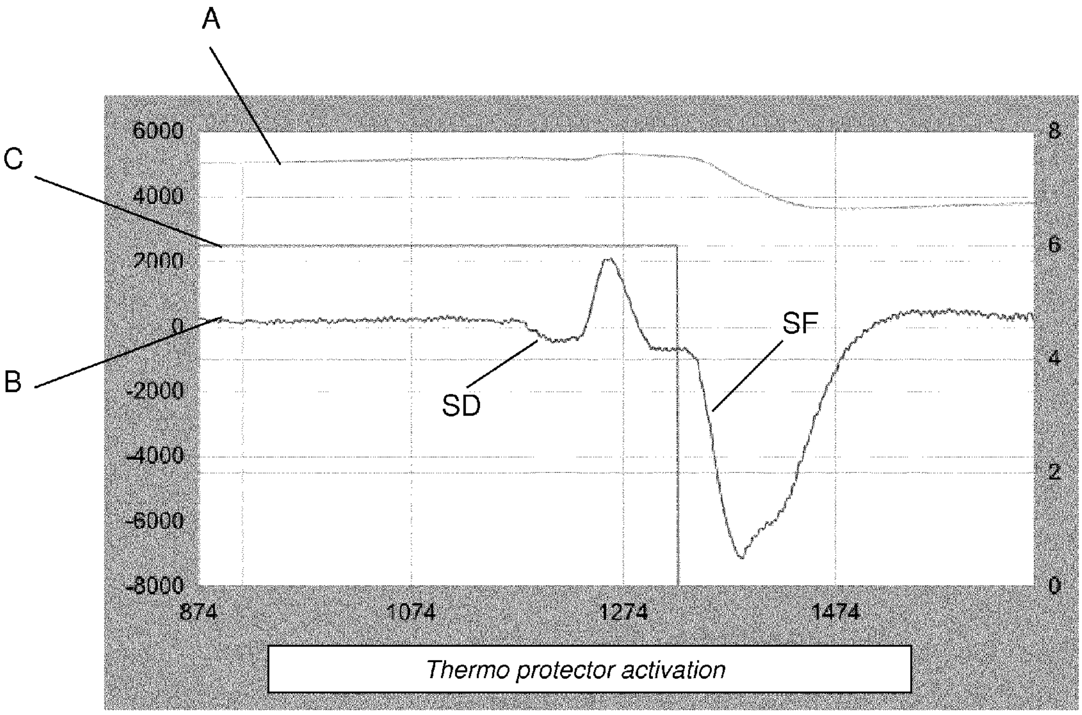
213
C
219
207

Fig. 4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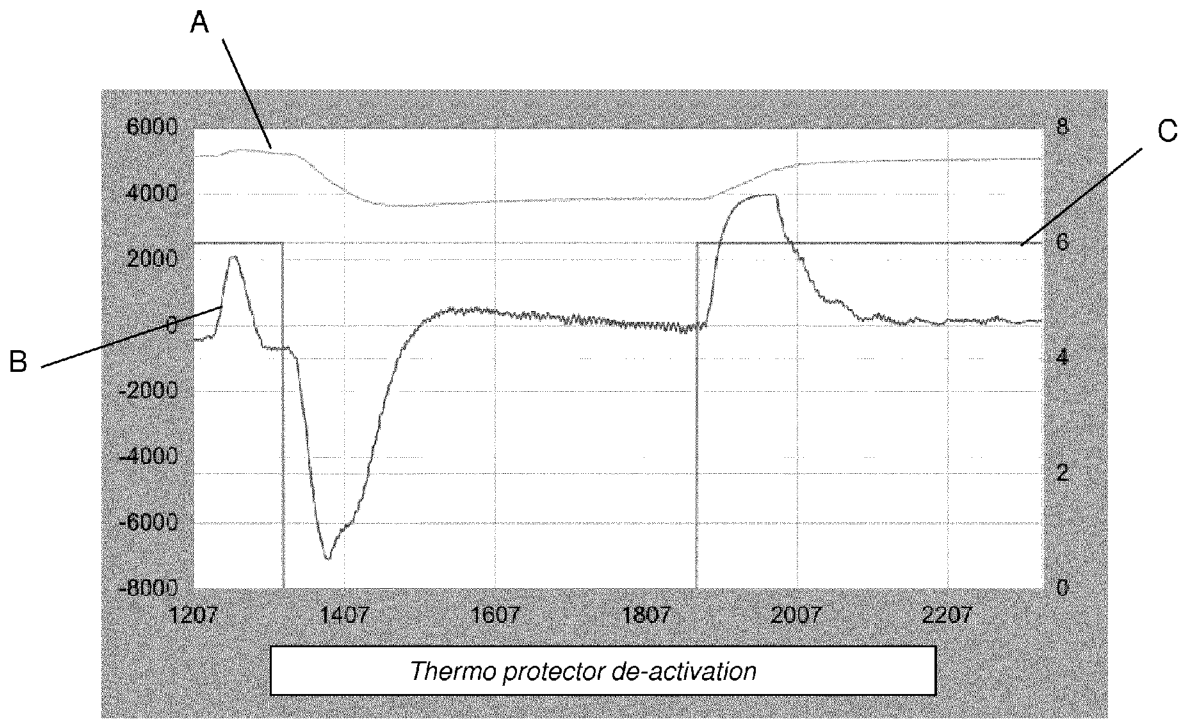
1074
1274
1474
Thermo protector activation

Fig. 5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6
4
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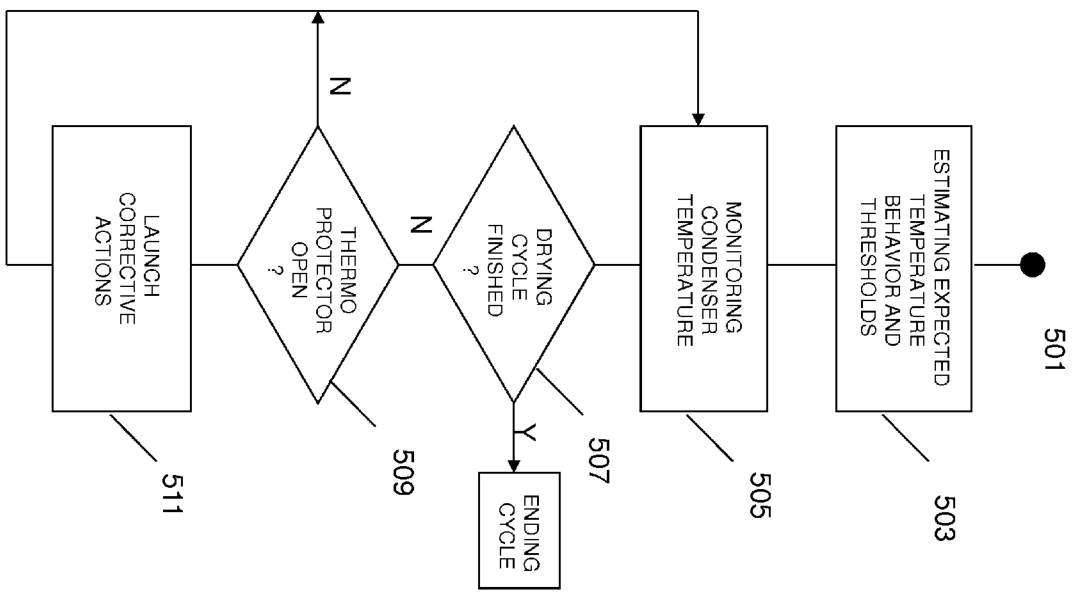
1607
1807
2007
2207
Thermo protector de-activation

Fig.6


501
ESTIMATING EXPECTED TEMPERATURE BEHAVIOR AND THRESHOLDS
503
MONITORING CONDENSER TEMPERATURE
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DRYING CYCLE FINISHED ?
507
Y
ENDING CYCLE
N
THERMO PROTECTOR OPEN ?
509
N
LAUNCH CORRECTIVE ACTIONS
511

Fig. 7

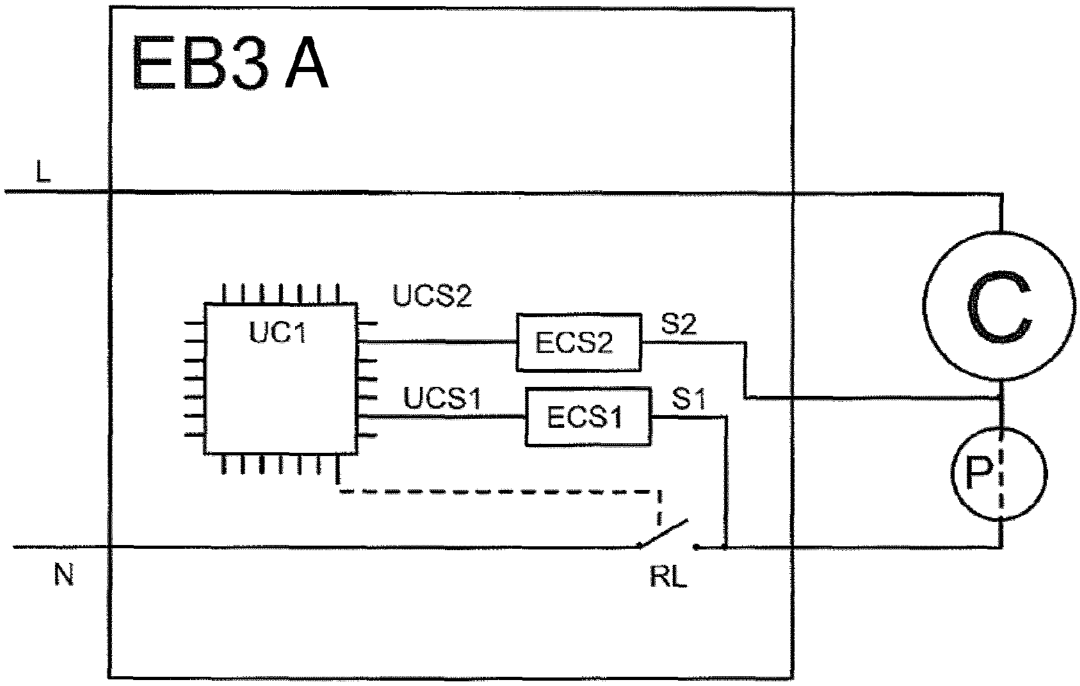

Fig. 8

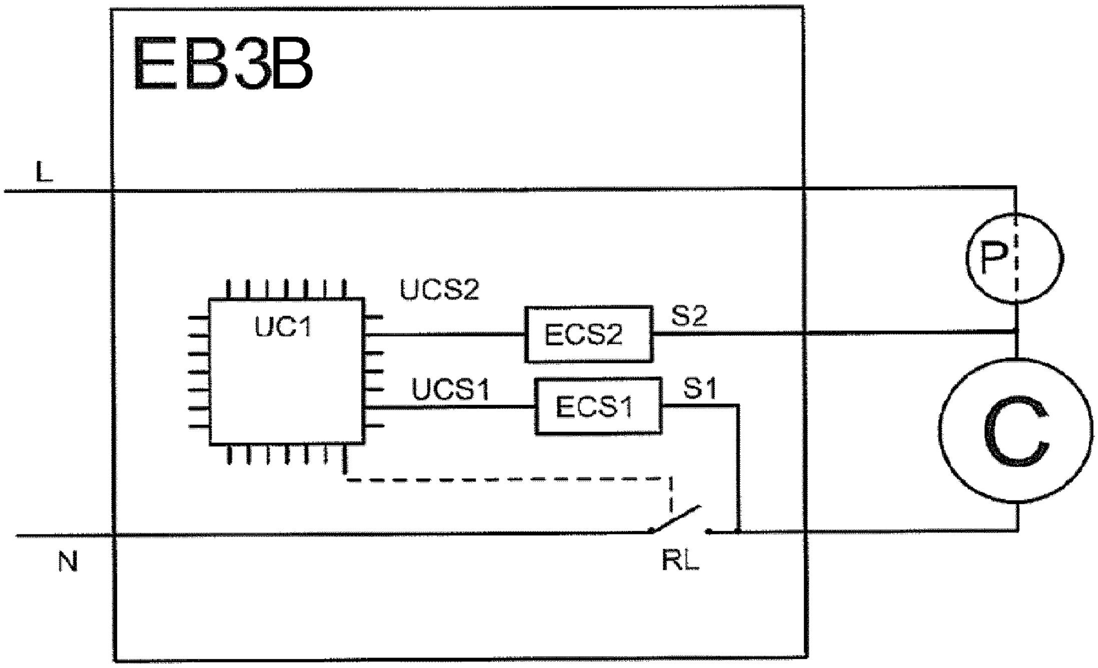

Fig. 9

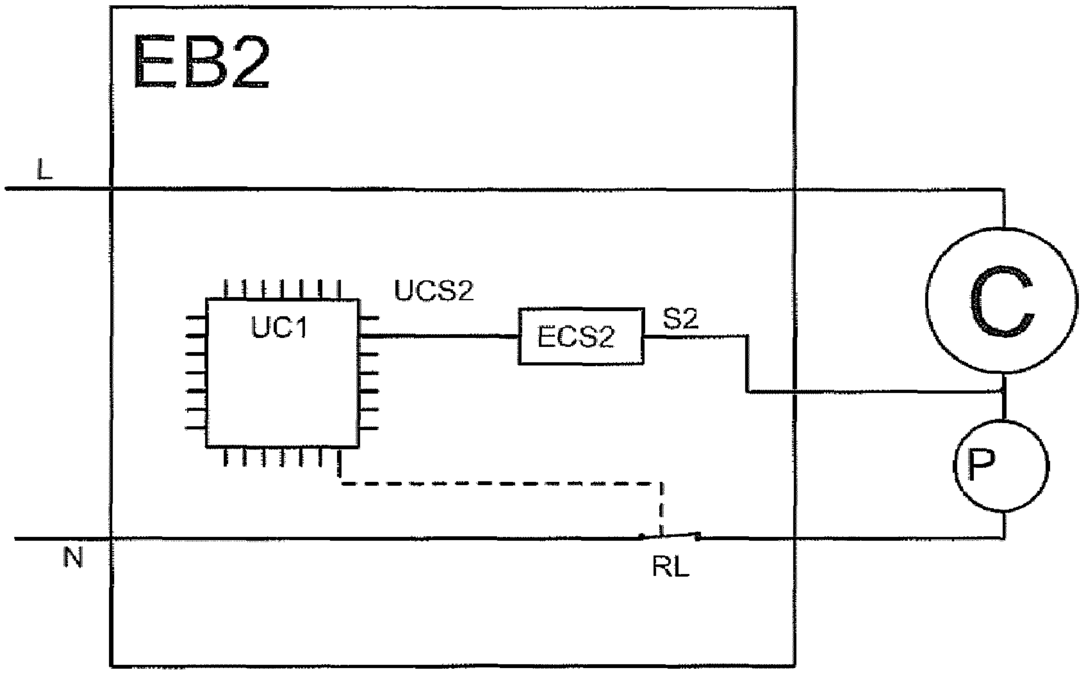

Fig. 10

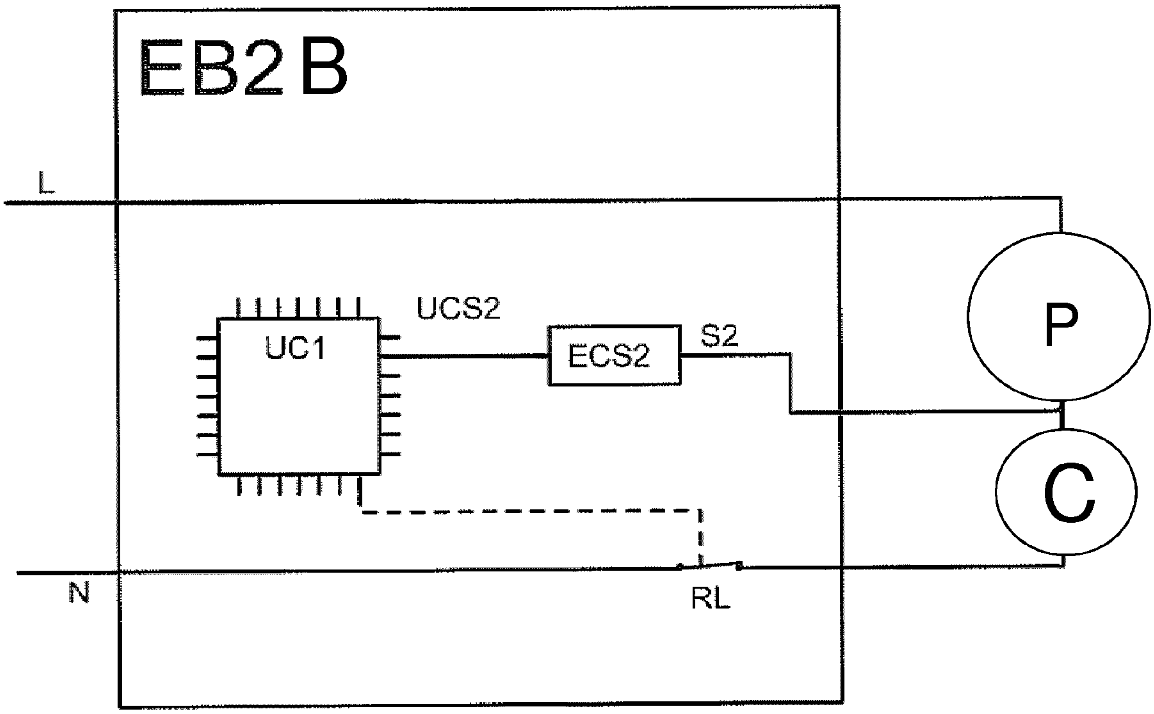

Fig. 11

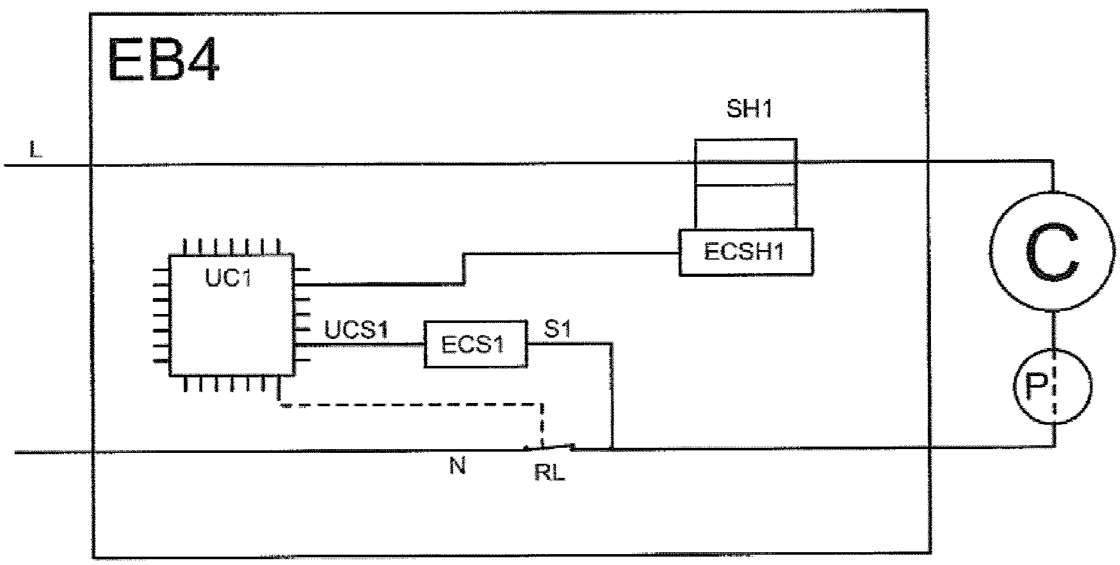

Fig. 12

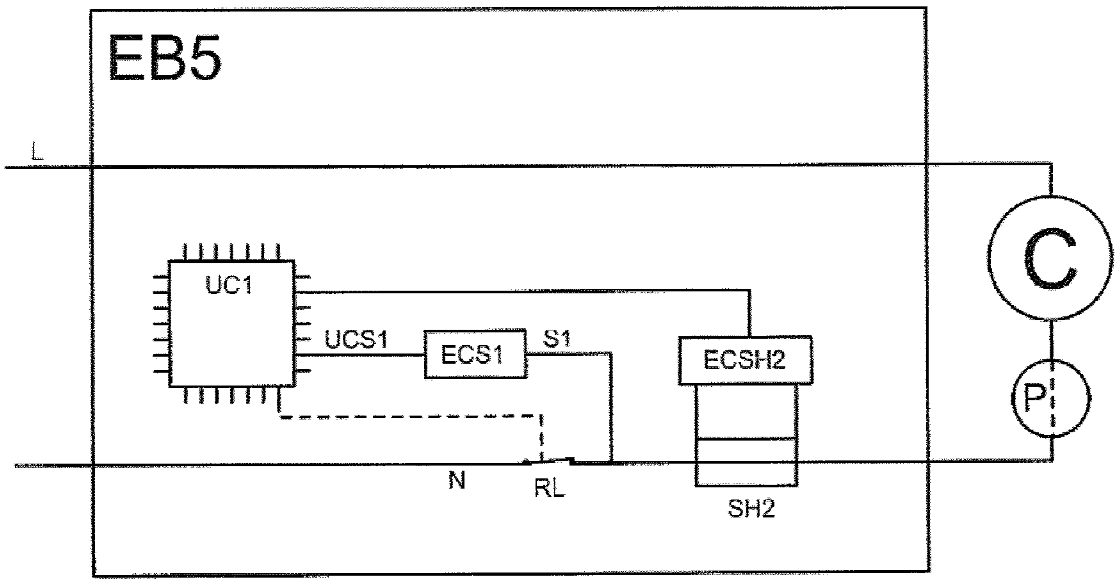

Fig. 13

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European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 12 17 4262

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2009/098158 A1 (BSH BOSCH SIEMENS HAUSGERAETE [DE]) 13 August 2009 (2009-08-13) * page 9, line 20; claim 1; figure 1 * -----	1-15	INV. D06F58/20 D06F58/28
A,D	US 2011/173838 A1 (NAWROT THOMAS [DE] ET AL) 21 July 2011 (2011-07-21) * claims 20-21; figures * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			D06F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	7 December 2012	Stroppa, Giovanni

CATEGORY OF CITED DOCUMENTS

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07-12-2012

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