(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 108 730 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
28.07.2010 Bulletin 2010/30

(51) Int Cl.:
D06F 39/00 *(2006.01)* ***D06F 33/02*** *(2006.01)*
D06F 58/24 *(2006.01)*

(21) Application number: **08425240.2**

(22) Date of filing: **10.04.2008**

(54) **Washer/dryer and relevant operating cycle**

Wasch-/Trockenvorrichtung und entsprechender Betriebszyklus

Machine à laver/sécher et cycle de fonctionnement associé

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

(43) Date of publication of application:
14.10.2009 Bulletin 2009/42

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Description

[0001] The present invention relates to washers/dryers, and in particular to a washer/dryer in which the drying system includes a feedback loop that allows an operation suitable to optimize time and consumptions of the laundry drying phase at the end of the washing cycle, as known e.g. from EP-A-1,666,655.

[0002] It is known that in washing machines that also perform the drying of the washed laundry there is provided a circuit to circulate air between the laundry-containing drum and a condensing unit, in which the moisture removed from the laundry is condensed and discharged by means of the drain pump of the machine. Specific reference will be made hereafter to a condensing unit that consists of a simple condensing duct into which water is admitted through an electrovalve, but it is clear that what is being said applies to a washer/dryer provided with a condensing unit of any kind that can even use a condensing fluid different from water.

[0003] During the drying step a fan creates an air stream in the circuit and a resistor heats the air circulating in said circuit. After this initial phase, an electrovalve is opened to admit condensing water into a condensing duct, where the condensing water is kept in suspension by the suction created by the fan.

[0004] In this way, the vapor sucked in from the tank encounters the suspended water and partially condenses toward the drain pump through a suitable drain pipe. Therefore, the fan receives partially cooled and dried air that is heated again by the resistor and returned to the tank. The air heating resistor is turned off during the last minutes of the drying cycle, whereas the fan keeps on working so as to perform a laundry cooling step otherwise the laundry would be too hot for the user to remove it safely from the drum.

[0005] The most serious drawback of this known arrangement is that the fluid used to condense the moisture is continuously introduced into the condensing unit during the whole drying step without any feedback control. In this way it is not possible to maintain the optimum drying conditions, that are found only within a specific temperature range.

[0006] In fact since the process of condensing the moisture removed from the laundry is not monitored and controlled as far as temperature is concerned, using too much condensing fluid results in cooling down too much the system that has then to be taken back to the correct temperature with a waste of energy, whereas using too little condensing fluid results in condensing little moisture and therefore extending the drying time.

[0007] This results in a poor condensing effectiveness and/or a long drying time, with a subsequently high power consumption due to the long operating period of the fan and resistor and possibly even a waste of condensing fluid.

[0008] Therefore the object of the present invention is to provide a washer/dryer which overcomes said drawbacks, and a relevant operating cycle. This object is achieved by means of a washer/dryer including at least three temperature sensors to detect the air temperature respectively in the tank, at the outlet of the condensing unit and downstream from the heating resistor. Other advantageous features of the present washer/dryer are disclosed in the dependent claims.

[0009] The main advantage of this washer/dryer is that of carrying out the drying cycle while maintaining the optimum temperature conditions at the various points in the circuit, so as to increase the condensing effectiveness and decrease the drying time, with a subsequently lower consumption of power and condensing fluid.

[0010] A second important advantage of the present machine is that of optimizing the consumption of power and condensing fluid by adapting it to the extent of the laundry load to be dried.

[0011] Another significant advantage of this arrangement comes from its structural simplicity that allows to achieve the above-mentioned improvement in effectiveness without affecting the overall size of the machine and with only a minimum increase in manufacturing cost.

[0012] These and other advantages and characteristics of the washer/dryer according to the present invention will be clear to those skilled in the art from the following detailed description of an embodiment thereof, with reference to the annexed drawings wherein:

Fig.1 is a front perspective view showing the drying circuit, where the wash tank is omitted for the sake of clarity;

Fig.2 is a time/temperature chart showing the course of the air temperature in the tank and at the outlet of the condensing unit;

Fig.3 is a time/temperature chart showing the course of the air temperature downstream from the resistor; and

Fig.4 is a flow chart showing the feedback operation of the drying system.

[0013] Referring to Fig.1, there is seen that in a washer/dryer according to the present invention the drying circuit conventionally includes a centrifugal fan F connected to a condensing duct C where the stream of moist air, coming from the tank through an air entrance AE, flows in a direction opposite to the condensing water CW introduced in duct C through a relevant water entrance WE. The moisture condensed in duct C is conveyed to the drain pump through a bottom drain D.

[0014] A resistor R, with a relevant safety thermostat T, is arranged downstream from fan F in a return duct H to heat air prior to returning it to the tank. The air temperature downstream from fan F is detected by a temperature sensor S3, in order to prevent the introduction into the tank of excessively hot air.

[0015] The novel aspect of the present invention is the presence of other two temperature sensors, namely a sensor S1 (not shown) detecting the air temperature in

the tank and a sensor S2 arranged at the top of the condensing duct C, i.e. at the outlet of the condensing unit prior to the entrance of the air into fan F. Thanks to these two sensors S1, S2 it is possible to achieve a feedback loop that controls the operation of the condensing unit, as it will be explained hereunder with reference to Figs. 2-4.

[0016] The first time/temperature chart illustrated in Fig.2 shows the course of temperatures TS1 and TS2, i.e. the temperatures detected by sensors S1 and S2 respectively, and indicates three temperature thresholds Z0, W and Z1 at which different steps of the drying cycle take place. There is also indicated a time tr at which there is performed a preliminary "sensor reset" step required to take into account the inevitable manufacturing tolerances of the sensors.

[0017] In fact since sensors S1 and S2 at the beginning of the cycle, or in any case prior to turning on the condensing unit, should detect the same temperature, at time tr the difference between the temperatures detected by the two sensors is read and stored by the control unit, that will then use it as a correction factor for the temperatures detected during the condensing step.

[0018] In other words, the "sensor reset" step implies that, called ΔT the difference detected at time tr, the values of TS1 and TS2 will be corrected by $\pm \Delta T/2$ or one of the two values will be used as a reference and the other one will be corrected by $\pm \Delta T$, the sign of the correction depending on which sensor detects the higher temperature at time tr and/or is used as a reference.

[0019] It should be noted that said "sensor reset" step could be performed even only once, as long as one of the two sensors S1 or S2 is not replaced, since the detected difference depends on the manufacturing tolerances. However, since the sensors may get dirty or deteriorate during the machine life, without having to be replaced for this reason, in order to guarantee a correct operation of the machine it is preferable to perform this step at each operating cycle or at least periodically.

[0020] The second time/temperature chart illustrated in Fig.3 shows the course of temperatures TS3 detected by sensor S3 in the duct that introduces the air heated by resistor R into the tank. Furthermore, there are indicated the two temperature thresholds U3 and V3 representing respectively the maximum temperature at which resistor R is turned off and the minimum temperature at which the latter is turned back on.

[0021] With reference now also to the flow chart illustrated in Fig.4, there is described the simple and effective operation of the washer/dryer according to the present invention.

[0022] At the start of the operating cycle there is first turned on fan F to create an air stream, and then the "sensor reset" step is performed at time tr as explained above. Whereafter, resistor R is turned on for a period of operation defined by sensor S3 that achieves a feedback loop such that temperature TS3 remains within the U3-V3 range as previously mentioned.

[0023] The hot air introduced in the tank increases temperature TS1 detected by sensor S1, which controls the performing of a centrifugation that lasts a few minutes upon reaching the first threshold 20. It should be noted that said centrifugation is present also in the conventional drying cycle, but it is carried out at a fixed moment in the cycle regardless of the laundry conditions. On the contrary, in the present machine this step is performed at the precise time when the tank reaches a preset temperature Z0, detected by S1, of maximum yield for extracting the residual moisture from the laundry. The feedback provided by sensor S1 therefore allows to control the time of centrifugation in order to achieve the maximum power and performance yield.

[0024] The step following the centrifugation is that of turning on the condensing unit, i.e. admitting the condensing water CW into duct C through entrance WE in the case of the embodiment illustrated in Fig.1. Said turning on takes place only when sensor S1 detects that temperature TS1 in the tank has reached a second threshold Z1.

[0025] Subsequently, the time of turning off the condensing unit is determined by sensor S2 that detects when temperature TS2 decreases below the temperature threshold W, in order to prevent an excessive decrease in temperature of the air reaching resistor R. In this way, the feedback provided by the pair of sensors S1, S2 allows to optimize both the consumption of condensing fluid in duct C and the power consumption by resistor R.

[0026] The iterative operation of the resistor and condensing unit continues as illustrated in Fig.4 until the drying system determines that the laundry is dry, through a moisture sensor and/or according to the operating time. Whereafter, fan F continues to operate for some minutes to perform the final laundry cooling step and finally the drying cycle ends (these last cycle steps are omitted in Fig.4).

[0027] It should be noted that the "sensor reset" step not only allows to use as temperature sensors even inexpensive components such as NTC thermistors rather than other more expensive types of sensors, but it also serves to prevent machine malfunctionings in case of "converging" manufacturing tolerances of sensors S1 and S2. In fact, since the temperature thresholds W and Z1 are very close it could happen that with a sensor S1 erring by excess and a sensor S2 erring by defect the operation of the condensing unit is immediately stopped because the tolerance ranges of sensors S1, S2 overlap.

[0028] The operating cycle of the washer/dryer according to the present invention can therefore be summarized in the following steps:

a) turning on fan F;
b) "resetting" the temperature sensors S1, S2;
c) turning on resistor R;
d) performing a centrifugation when temperature TS1 detected by sensor S1 reaches a first temper-

ature threshold Z0;
e) turning on the condensing unit when temperature TS1 reaches a second temperature threshold Z1;
f) turning off the condensing unit when temperature TS2 detected by sensor S2 reaches a third temperature threshold W;
g) iterating steps e) and f);
h) turning off and turning back on resistor R so as to maintain the temperature TS3 detected by sensor S3 within a range U3-V3;
i) iterating steps g) and h) until the laundry is deemed dry;
j) turning off resistor R and the condensing unit;
k) turning off fan F after a period of air circulation suitable to cool the laundry.

[0029] It should be noted that the exact sequence of steps f)-h) depends on the value of thresholds W, U3, V3 since the operating periods of the condensing unit and resistor R depend respectively on the sensor pair S1, S2 and on sensor S3 that operate independently of each other.

[0030] It is clear that the above-described and illustrated embodiment of the washer/dryer according to the invention is just an example susceptible of various modifications. In particular, the exact type and arrangement of the temperature sensors can change according to specific manufacturing needs, and the "sensor reset" step can take place even before turning on the fan or after the centrifugation as long as it is set prior to turning on the condensing unit.

Claims

1. Washer/dryer having a drying circuit in which air circulates between a wash tank and a condensing unit under the action of a fan (F), is heated by a resistor (R) and the air temperature downstream from said resistor (R) is detected by at least a first temperature sensor (S3) prior to introducing it into said tank, **characterized in that** it includes at least a second temperature sensor (S1) suitable to detect the air temperature in the tank and a third temperature sensor (S2) suitable to detect the air temperature at the outlet of said condensing unit, all three temperature sensors (S1, S2, S3) being operatively connected to a control unit that controls the operation of the resistor (R) and of the condensing unit.

2. Washer/dryer according to claim 1, **characterized in that** one or more temperature sensors (S1, S2, S3) are NTC thermistors.

3. Washer/dryer according to claim 1 or 2, **characterized in that** it further includes a laundry moisture sensor.

4. Washer/dryer according to one of the preceding claims, **characterized in that** the condensing unit comprises a condensing duct (C) where the stream of moist air coming from the tank through an air entrance (AE) flows in the opposite direction with respect to condensing water (CW) introduced into said condensing duct (C) through a relevant water entrance (WE), the moisture condensed in the duct (C) being conveyed to a drain pump through a bottom drain (D).

5. Operating cycle for a washer/dryer according to one of the preceding claims, **characterized in that** it includes the following steps:

   a) turning on the fan (F);
   b) "resetting" the second (S1) and third (S2) temperature sensors;
   c) turning on the resistor (R);
   d) performing a centrifugation when the temperature (TS1) detected by the second sensor (S1) reaches a first threshold (Z0);
   e) turning on the condensing unit when said temperature (TS1) reaches a second threshold (Z1);
   f) turning off the condensing unit when the temperature (TS2) detected by the third sensor (S2) reaches a third threshold (W);
   g) iterating steps e) and f);
   h) turning off and turning back on the resistor (R) so as to maintain the temperature (TS3) detected by the first sensor (S3) within a preset range (U3-V3);
   i) iterating steps g) and h) until the laundry is deemed dry;
   j) turning off the resistor (R) and stopping the introduction of condensing fluid in the condensing duct (C);
   k) turning off the fan (F) after a period of air circulation suitable to cool the laundry.

6. Operating cycle according to claim 5, **characterized in that** in step i) the laundry is deemed dry according to the moisture level detected by a suitable sensor.

7. Operating cycle according to claim 5 or 6, **characterized in that** step b) can be performed at any time prior to step e).

8. Operating cycle according to one of claims 5 to 7, **characterized in that** step b) can be performed only on the occasion of the first cycle or only periodically.

Patentansprüche

1. Wasch-/Trockenvorrichtung mit einem trocknenden Kreislauf, in dem Luft zwischen einem Waschbehälter und einer Kondensationseinheit unter der Einwir-

kung eines Gebläses (F) mittels eines Widerstands (R) erwärmt wird und die Lufttemperatur stromabwärts von dem Widerstand (R) von mindestens einem ersten Temperatursensor (S3) vor der Einführung in den Waschbehälter erfasst wird, **dadurch gekennzeichnet, dass** der Waschtrockner zumindest einen zweiten Temperatursensor (S1) umfasst, der geeignet ist, die Lufttemperatur im Behälter zu erfassen und einen dritten Temperatursensor (S2), der geeignet ist, die Lufttemperatur am Ausgang der Kondensationseinheit zu erfassen, wobei alle drei Temperatursensoren (S1,S2, S3) in Wirkverbindung mit einer Steuereinheit verbunden sind, die einen Betrieb des Widerstands (R) und der Kondensationseinheit steuert.

2. Wasch-/Trockenvorrichtung gemäß Anspruch 1, **dadurch gekennzeichnet, dass** einer oder mehrere Temperatursensoren (S1, S2, S3) NTC-Widerstände sind.

3. Wasch-/Trockenvorrichtung gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** er ferner einen Feuchtigkeitssensor der Wäsche umfasst.

4. Wasch-/Trockenvorrichtung gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Kondensationseinheit eine Kondensationsleitung (C) umfasst, in der der Strom von feuchter Luft, der aus dem Behälter durch einen Lufteinlass (AE) kommt, in die entgegengesetzte Richtung bezüglich des kondensierenden Wassers (CW) fließt, das in der Kondensationsleitung (C) durch einen relevanten Wassereinlass (WE) eingeführt wird, und die in der Leitung (C) kondensierte Feuchtigkeit auf eine Ablaufpumpe durch einen Bodenablauf (D) übertragen wird.

5. Betriebszyklus für einen Waschtrockner gemäß einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** es folgende Schritte umfasst:

(a) Anschalten des Gebläses (F);
(b) "Zurücksetzen" von dem zweiten (S1) und dem dritten (S2) Temperatursensor;
(c) Umscfralten des Widerstands (R);
(d) Durchführen eines Schleudergangs, wenn die von dem zweiten Sensor (S1) erfasste Temperatur (TS1) eine erste Schwelle (Z0) erreicht;
(e) Einschalten der Kondensationseinheit, sobald die Temperatur (TS1) eine zweite Schwelle (Z1) erreicht;
(f) Ausschalten der Kondensationseinheit, sobald die von dem dritten Sensor (S2) erfasste Temperatur (TS2) eine dritte Schwelle (W) erreicht;
(g) Wiederholen der Schritte (e) und (f);
(h) Ausschalten und den Widerstand (R) zurückdrehen, um die von dem ersten Sensor (S3) erfasste Temperatur (TS3) innerhalb eines voreingestellten Bereichs (U3-V3) zu erhalten;
(i) Wiederholen der Schritte (g) und (h), bis die Wäsche trocken ist;
(j) Ausschalten des Widerstands (R) und Stoppen der Einführung eines Kondensaüonsfluids in die Kondensationsleitung (C);
(k) Ausschalten des Gebläses (F), dem eine Zeitdauer der Luftzirkulation durchgeführt wurde, die geeignet war, um die Wäsche zu kühlen.

6. Betriebszyklus nach Anspruch 5, **dadurch gekennzeichnet, dass** im Schritt (i) die Wäsche als getrocknet angesehen wird gemäß dem Feuchtigkeitsniveau, das von einem geeigneten Sensor erfasst wird.

7. Betriebszyklus nach Anspruch 5 oder 6, **dadurch gekennzeichnet, dass** Schritt (b) zu jeder Zeit vor dem Schritt (e) ausgeführt werden kann.

8. Betriebszyklus nach einem der Ansprüche 5 bis 7, **dadurch gekennzeichnet, dass** Schritt (b) nur auf Veranlassung des ersten Zyklus oder nur periodisch ausgeführt werden kann.

Revendications

1. Lave-linge / sèche-linge ayant un circuit de séchage dans lequel de l'air circule entre une cuve de lavage et une unité de condensation sous l'action d'un ventilateur (F), est chauffé par une résistance (R) et la température de l'air en aval de ladite résistance (R) est détectée par au moins un premier capteur de température (S3) avant de l'introduire dans ladite cuve, **caractérisé en ce qu'**il comprend au moins un deuxième capteur de température (S1) approprié pour détecter la température de l'air dans la cuve et un troisième capteur de température (S2) approprié pour détecter la température de l'air à la sortie de ladite unité de condensation, les trois capteurs de température (S1, S2, S3) étant raccordés de manière opérationnelle à une unité de commande qui commande le fonctionnement de la résistance (R) et de l'unité de condensation.

2. Lave-linge / séche-linge selon la revendication 1, **caractérisé en ce que** un ou plusieurs capteurs de température (S1, S2, S3) sont des thermistors NTC.

3. Lave-linge / sèche-linge selon la revendication 1 ou 2, **caractérisé en ce qu'**il comprend en outre un capteur d'humidité de linge.

4. Lave-linge / sèche-linge selon l'une quelconque des revendications précédentes, **caractérisé en ce que**

l'unité de condensation comprend un conduit de condensation (C) où le courant d'air humide provenant de la cuve à travers une entrée d'air (AE) s'écoule dans la direction opposée par rapport à l'eau de condensation (CW) introduite dans ledit conduit de condensation (C) par une entrée d'eau appropriée (WE), l'humidité condensée dans le conduit (C) étant transportée jusqu'à une pompe d'évacuation par un drain inférieur (D).

5. Cycle de fonctionnement pour un lave-linge / sèche-linge selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il comprend les étapes suivantes consistant à :

a) mettre en marche le ventilateur (F) ;
b) « réinitialiser » les deuxième (S1) et troisième (S2) capteurs de température ;
c) mettre en marche la résistance (R) ;
d) réaliser une centrifugation lorsque la température (TS1) détectée par le deuxième capteur (S1) atteint un premier seuil (Z0) ;
e) mettre en marche l'unité de condensation lorsque ladite température (TS1) atteint un deuxième seuil (Z1) ;
f) arrêter l'unité de condensation lorsque la température (TS2) détectée par le troisième capteur (S2) atteint un troisième seuil (W) ;
g) répéter les étapes e) et f) ;
h) arrêter et remettre en marche la résistance (R) afin de maintenir la température (TS3) détectée par le premier capteur (S3) dans une plage prédéterminée (U3 - V3) ;
i) répéter les étapes g) et h) jusqu'à ce que le linge est considéré comme étant sec ;
j) arrêter la résistance (R) et arrêter l'introduction du fluide de condensation dans le conduit de condensation (C) ;
k) arrêter le ventilateur (F) après une période de circulation d'air appropriée pour refroidir le linge.

6. Cycle de fonctionnement selon la revendication 5, **caractérisé en ce qu'**à l'étape i) le linge est considéré comme étant sec selon le niveau d'humidité détecté par un capteur approprié.

7. Cycle de fonctionnement selon la revendication 5 ou 6, **caractérisé en ce que** l'étape b) peut être réalisée à n'importe quel moment avant l'étape e).

8. Cycle de fonctionnement selon l'une quelconque des revendications 5 à 7, **caractérisé en ce que** l'étape b) peut être réalisée uniquement à l'occasion du premier cycle ou uniquement de manière périodique.

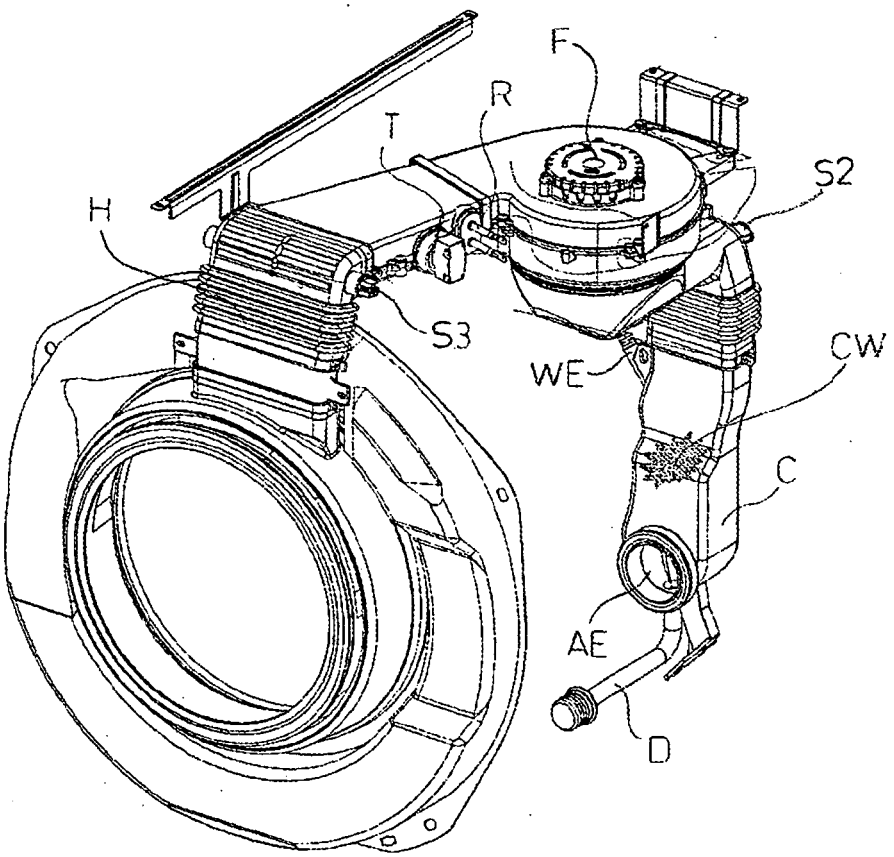


Fig.1

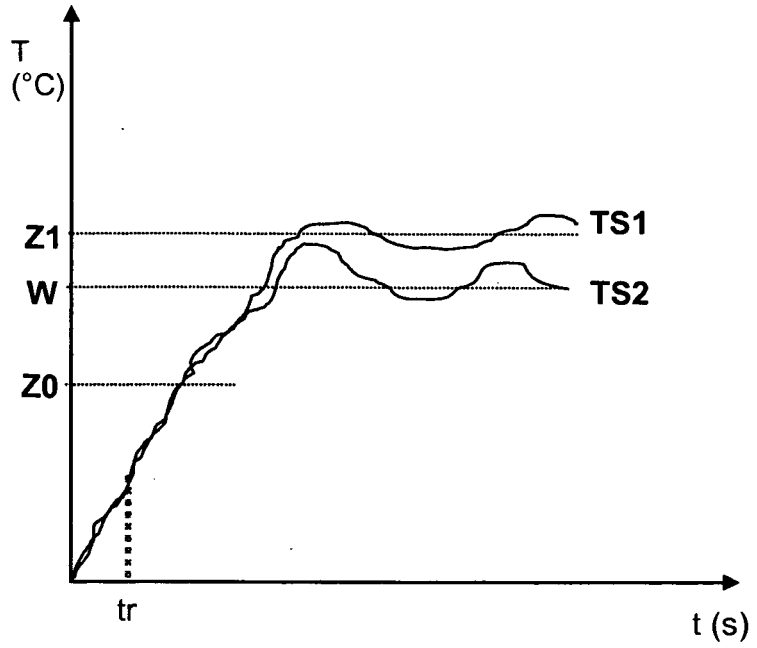


Fig.2

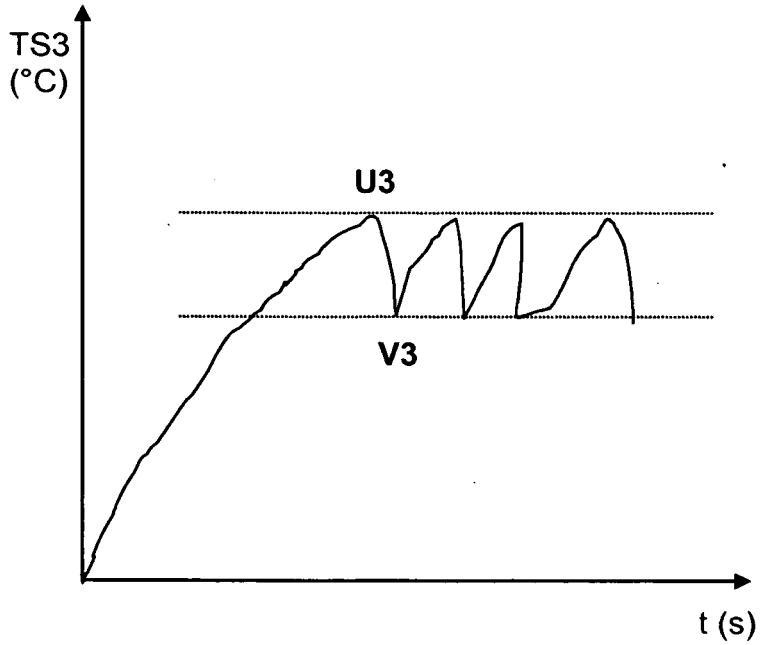


Fig.3

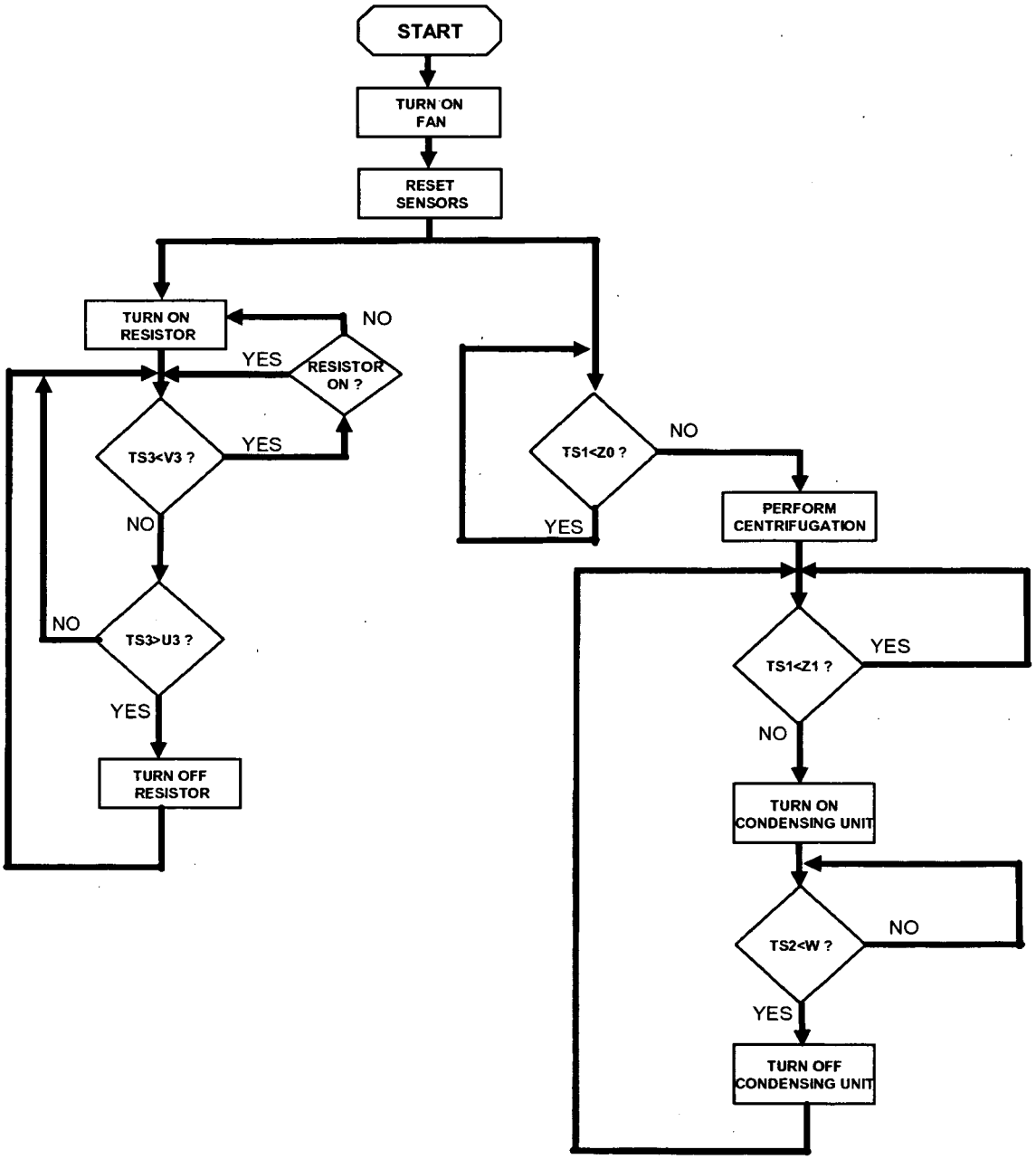

START
TURN ON FAN
RESET SENSORS
TURN ON RESISTOR
NO
YES
RESISTOR ON ?
TS3<V3 ?
YES
NO
NO
TS3>U3 ?
YES
TURN OFF RESISTOR
TS1<Z0 ?
NO
YES
PERFORM CENTRIFUGATION
TS1<Z1 ?
YES
NO
TURN ON CONDENSING UNIT
TS2<W ?
NO
YES
TURN OFF CONDENSING UNIT

Fig.4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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