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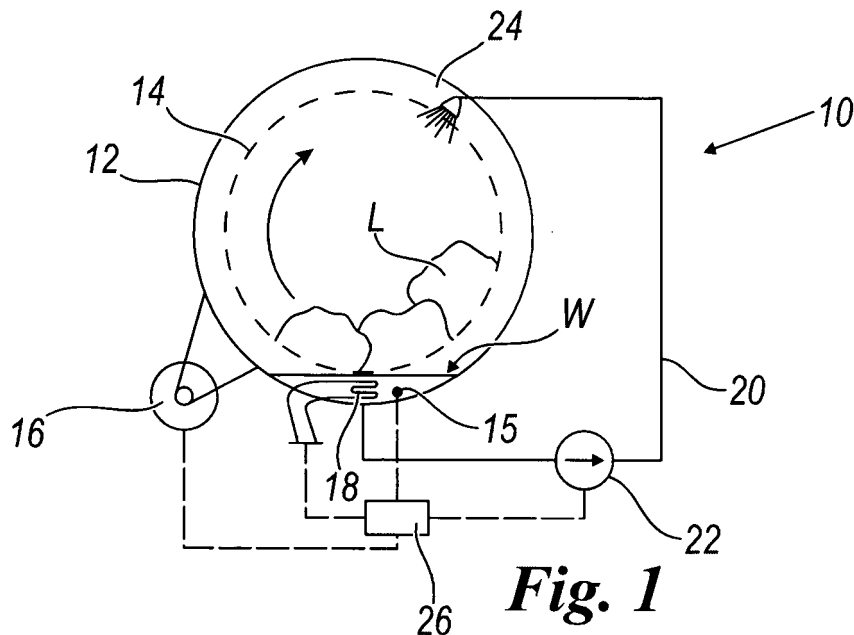
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(54) **Method for washing laundry in a spray washing machine**

(57) A method for washing laundry in a washing machine (10), preferably a horizontal axis washing machine, having a drum (14) rotatably mounted in a tub (2), a recirculation pump (22) for recirculating a washing liquid on the laundry (L) and a heating device (18) in the tub

for heating washing liquid, comprises increasing the drum speed up to a predetermined low spin speed (S) while recirculation pump (22) is switched off in order to increase water level in the tub (12) and then switching on the heating device (18).



Description

[0001] The present invention relates to a method for washing laundry in a horizontal axis washing machine comprising a drum rotatably mounted in a tub, a recirculation pump for recirculating a washing liquid on the laundry and a heating device placed in the tub for heating washing liquid.

[0002] So called "jet" or "spray" washing machines are well known in which the washing liquor is sprayed onto the laundry while the drum is rotated at a predetermined tumbling speed or spinning speed. The main advantage of such known washing method is an increase of washing efficiency due to the high detergent concentration and the overall reduction of water amount.

[0003] With such known washing machines a further reduction of water amount is prevented by the consequence of having a too low level of water in the tub which creates problems with a safe working of the heater. In theory, it is possible to further reduce the water needed in the washing cycle (and to beneficially increase detergent concentration), but the above technical problem prevents from such further reduction (if a traditional heater in the tub is used, which has a lower cost if compared to in-flow heaters).

[0004] It is therefore an object of the present invention to solve the above technical problem therefore allowing a further reduction of the amount of water and a further increase of detergent concentration.

[0005] Such object is reached thanks to the features listed in the appended claims.

[0006] With a method according to the invention it is not only possible to get advantages of a spray washing, but also it is possible to use a very low amount of water, with a lower energy consumption if compared to known recirculation washing machines.

[0007] According to the present invention it is possible to increase water level in the tub so that heater can be switched on without safety problems (entire heater submerged). Water already warmed can be distributed efficiently by recirculating it directly onto the laundry. According to a preferred feature of the invention, an increase of water level up to 20 mm is obtained in the tub so that heater can be safely switched on.

[0008] One of the main feature of the invention is the application of a low speed spinning sufficiently high to generate a centrifugal force which forms and maintains at least partially an annular layer of clothes against the drum wall to free water from laundry and to increase water level in the wash tub. During such low speed spinning phase

[0009] (which can be defined also as a high speed tumbling phase) water recirculation is interrupted. After such spinning phase, water heating in the tub is carried out preferably with a slow motion movement (tumbling). Such water heating is preferably carried out for a predetermined period of time (and not on the basis of a temperature feedback). This predetermined time is set on the basis of the total energy which has to be transferred to the laundry (as it will be clear in the following detailed description). Temperature in the sump of the tub is therefore not monitored (a part from its sensing for safety reasons). After heating, the drum is rotated again at a low spinning speed during which water already warmed is recirculated directly to the laundry.

[0010] Further advantages and features of a method and washing machine according to the present invention will become clear from the following detailed description, with reference to the attached drawings, in which:

- figure 1 is a schematic view of a spray washing machine;
- figure 2 is a diagram showing changes of water level in the tub vs. time in a washing method according to the invention;
- figure 3 shows the on/off cycle of the recirculation pump associated to the level diagram of figure 2;
- figure 4 is a diagram showing the speed of the drum vs. time, particularly in association with the washing method referred to in figure 2;
- figure 5 is a diagram showing water temperature vs., time in a conventional spray washer (dotted line) and in a spray washing machine according to the invention (solid line);
- figure 6 is a diagram showing how in the same washing machines referred to in figure 5 the temperature of the laundry changes with time;
- figure 7 is a diagram showing energy consumption vs. time of the same washing machines referred to in figures 5 and 6; and
- figures 8-9 are diagrams similar to figures 5 and 7 in a different working condition.

[0011] With reference to the drawings, with 10 it is indicated a spray washing machine having a tub 12, a rotating drum 14 inside the tub 12 and driven by a motor 16, an electric heater 18 in the lower portion of the tub 12, a recirculation conduit 20 provided with a circulation pump 22 and a spray nozzle 24 for spraying washing liquid onto the laundry L. With the term "washing liquid" we mean either water or a mixture of water plus detergents or the like. Of course the washing machine has other components, as the drain pump, possible water storage tank, detergent distributors, water level sensors etc. but these will not be described in the following since they are not specifically related to the invention. The heater 18, the motor 16 and the pump 22 are electrically connected to a control unit 26 which drives all such components according to a predetermined sequence.

[0012] A general advantage of using a recirculation system as shown in figure 1 is an improvement of the cleaning performances, for instance when such performances are tested according to the "red wine stain" standard procedure. Such advantage in cleaning performances is mainly due to a higher concentration of detergent.

[0013] When recirculation is carried out, free water in the tub 12 of the washing machine 10 is minimal, and water level W (figure 1) measured in the tub goes to zero. This necessarily requires an addition of water in the tub 12 so that heater 18 is submerged and can therefore heat water. This addition of water does ensure a safe water level W during heating, but is disadvantageous in terms of detergent concentration and energy saving. According to the invention, such addition of water is avoided or at least reduced by stopping recirculation pump 22, increasing the speed of the drum in order to extract water from the laundry L by centrifugal force and switching on the heater for water heating. Such behavior is shown in figures 2-4 where with S is indicated the above spinning phase. Before switching on the heater 18, water level W in the tub 12 is preferably measured and in case such level is lower than a predetermined threshold (indicated with T in figure 2), a partial refill is carried out.

[0014] During heating of water a gentle tumbling of laundry L is carried out either for avoiding noise in the measurement of water level W or for obtaining a faster warm up of the free water near the heater 18. Such tumbling, at a speed comprised between 20 and 70 rpm, preferably around 50 rpm, is shown in figure 4 by short movement of the drum indicated with G. To such short movements corresponds a small and sudden decrease of water level W in the tub 12 (figure 2). After a predetermined time is elapsed (about 400 s in the example of figures 2-4) during which water in the tub 12 has increased its temperature, the heater 18 is switched off and recirculation pump 22 is switched on in order to spray heated water on laundry L by means of the spray nozzle 24. As shown in the right portion of figure 4, when the recirculation pump 22 is switched on the speed of the drum 14 is increased so that, similarly to what has been carried out when the recirculation pump has been switched off before water heating, a centrifugal force is generated which forms and maintains an annular layer of clothes against the drum wall. Such small spin, indicated with reference B in figure 4, contributes to obtain a better distribution of water directly to the laundry L, such speed creating a satellization of the laundry L which increases the possibility to reach a better temperature balance. Even if the small spin B can be carried out at a speed different from the spinning phase S, such drum speeds are preferably identical. Also the duration of the small spin B is not critical, but it is preferably comprised between 10 and 50 s.

[0015] For the purposes of the present invention it is quite irrelevant the timing of the water heating and related slow spin phases S and B; it depends on the actual washing program selected by the user and by the presence of any pre-washing phase with cold or warm water. Generally speaking, the slow spin phase S, at a speed preferably comprised between 80 and 120 rpm, and more preferably around 100 rpm, is carried out after detergent is added in the tub 12. At any rate, the method according to the invention can be carried out by adding detergent at the end of the heating phase, or at any time during the heating phase. The overall duration of the spinning phase S, even if carried out in sequential phases (for instance by changing rotation direction one or more times), is preferably comprised between 10 and 50 s, more preferably between 20 and 40 s.

[0016] According to a further preferred embodiment of the invention the control unit 26 of the washing machine 10 is running an algorithm for assessing the heating time after the slow spin phase S. The first step of such algorithm is the measure of ambient temperature T1 by means of a NTC temperature sensor 15 placed in the tub. Such measure is carried out before feeding any water in the tub. This temperature is also assumed to be the temperature of the laundry dry load L. If a washing cycle has been recently terminated, the control unit 26 will assume as ambient temperature the T1 of the previous washing cycle.

[0017] Then an assessment of the mass Ml of the dry load L is carried out, using anyone of the known methods (for instance by a measure of the torque during acceleration of the drum). Then an estimation of the load ΔTl is carried out:

$$\Delta Tl = Tt - T1$$

[0018] Where Tt is the target temperature and T1 is ambient temperature.

[0019] Next step is to calculate the energy El which is needed for heating up the load L by multiplying the mass of load Ml by ΔTl and by thermal capacitycl of the load L:

$$El = Ml * Cl * \Delta Tl$$

[0020] Next step is calculation of water mass Mw by multiplying load mass Ml by specific absorption A of the load, by also adding a predetermined amount of free water Mwl:

$$M_w = M_l * A + M_{wl}$$

5 **[0021]** After such initial calculation phase, water is fed in the tub 12 and by means of NTC temperature sensor 15 water temperature T2 is measured. Then difference water temperature ΔT_w is calculated by subtracting T2 from the target temperature Tt:

$$10 \quad \Delta T_w = T_t - T_2$$

[0022] Energy needed for heating water is calculated in a way similar to the calculation of energy for the load:

$$15 \quad E_w = M_w * C_w * \Delta T_w$$

[0023] where Cw is thermal capacity of water. Then total energy for heating up water and load is calculated:

$$E_{risc} = E_w + E_l$$

25 **[0024]** A certain energy loss towards environment is estimated by multiplying ΔT (Ttarget-T1) by a coefficient k which depends on the washing machine, to be experimentally assessed for each type of washing machine:

$$30 \quad E_{risc} = E_w + E_l$$

[0025] Total energy to be used in the heating process is then calculated:

$$35 \quad E = E_{risc} + Losses$$

[0026] By knowing such total energy, and knowing heating power P of the heater 18, it is then possible to calculate time t which is necessary for heating:

$$40 \quad t = E/P$$

45 **[0027]** It is also possible to introduce in the above algorithm the value of power calculated from the voltage V, since power depends on the square voltage. Value of voltage V is normally measured by control unit 26 since it is used to drive the motor 16 (i.e. such value is already "available"). Therefore power P can be calculated as:

$$50 \quad P = \frac{V^2}{R}$$

[0028] Where R is resistance of the heater 18.

[0029] The final equation for calculating heating time t is:

$$55 \quad t = \frac{(M_l * A + M_{wl}) * C_w * (T_t - T_2) + (M_l * C_l * (T_t - T_1) + (T_t - T_1) * k}{V^2} * R$$

[0030] Figures 5-7 show a comparison of the traditional spray washing cycle (dotted lines) and a washing cycle according to the invention (solid lines), and in which the same target temperature of laundry is used. The applicant has discovered that in above condition, i.e. if it is desired to reach the same temperature of the laundry at the end of the heating phase, a lower energy is needed in the method according to the invention. The applicant has measured an energy saving of at least 0,06 kWh for each washing cycle (this is shown in figure 7).

[0031] Instead of fixing the target laundry temperature, further comparison tests have been carried out by the applicant by fixing a predetermined heating time. In this condition the applicant has seen an increased final temperature reached by water or by the laundry, with differences between 3° and 5°C and 1° and 3° C respectively. In figure 8 the difference of final water temperature is shown, while in figure 9 the two curves are substantially coincident (same energy consumption). Applicant believes that the above difference of about 2-3°C is due to a higher efficiency of the spray system to reach, distribute and keep higher temperatures in the laundry vs. conventional spray systems. Even if the method according to the invention is preferably used for horizontal axis washing machines, the same method can be used for vertical axis washing machines as well.

Example

[0032] With an ambient temperature of 23°C, a horizontal axis washing machine is loaded with a cotton load MI (thermal capacity 1,26 kJ/kg°C, specific absorption 2 l/kg).

[0033] After determination of load mass MI, water at 15°C has been added to the tub, with a target temperature of 40°C. Measured voltage is 220 V, and coefficient k is 2. Free water MIw is 2 litres. Heating resistance of the heater is 25 Ω. Thermal capacity of water is 4,186 kJ/kg°C. Heating time t depends only on the load mass MI:

$$t = \frac{(MI * 2 + 2) * 4.186 * (40 - 15) + (4 * 1.26 * (40 - 23) + (40 - 23) * 2}{220^2} * 25$$

[0034] If the measured mass of the load MI is 4 kg, the above formula gives a time t = 450 s for heating. With a voltage value of 230V, heating time would be 412 s.

Claims

1. Method for washing laundry in a washing machine (10), preferably a horizontal axis washing machine, comprising a drum (14) rotatably mounted in a tub (12), a recirculation pump (22) for recirculating a washing liquid on the laundry (L) and a heating device (18) for heating washing liquid, **characterized in that** it comprises increasing the drum speed up to a predetermined low spin speed (S) while recirculation pump (22) is switched off in order to increase water level (W) in the tub (12) and then switching on the heating device (18).
2. Method according to claim 1, wherein the heating device (18) is switched on for a predetermined period of time.
3. Method according to claim 2, wherein said predetermined period of time is based on the actual energy to be transferred to laundry (L).
4. Method according to claim 3, wherein said period of time is calculated according to the formula:

$$t = \frac{(MI * A + Mwl) * Cw * (Tt - T2) + (MI * Cl * (Tt - T1) + (Tt - T1) * k}{V^2} * R$$

where MI = mass of laundry in the tub;

A = specific absorption of the laundry

Mwl = mass of free water

Cw = thermal capacity of water

Tt = target temperature of the load + water

T2 = temperature of water loaded in the tub

Cl = thermal capacity of load

T1 = ambient temperature

K = experimental coefficient for taking care of heat loss

R = resistance of the heater in the tub

V = voltage of electrical current used by the heater

5. Method according to any of the preceding claims, wherein said low spin speed is comprised between 80 and 120 rpm.
6. Method according to any of the preceding claims, wherein the low spin speed (S) is maintained for an overall time comprised between 10 and 50 s.
7. Method according to any of the preceding claims, wherein during the phase in which the heating device (18) is switched on, the drum (14) is rotated, at least intermittently, at a tumbling speed (G).
8. Method according to claim 6, wherein the tumbling speed (G) is comprised between 10 and 70 rpm.
9. Method according to any of the preceding claims, wherein after the heating device (18) is switched off, the drum (14) is rotated at a second low spin speed (B) for a predetermined period of time.
10. Method according to claim 8, wherein the second low spin speed (B) is substantially identical to the first spin speed (S).
11. Washing machine (10), preferably horizontal axis washing machine, comprising a drum (14) rotatably mounted in a tub (12), a recirculation pump (22) for recirculating a washing liquid on the laundry (L), a motor (16) for rotating the drum (14) and a heating device (18) for heating washing liquid, **characterized in that** it comprises a control unit (26) adapted to drive the motor (16) in order to increase the drum speed up to a predetermined low spin speed (S) while recirculation pump (22) is switched for increasing water level (W) in the tub (12) and assuring that the heating device (18) is fully submerged.
12. Washing machine according to claim 11, wherein the control unit (26) is adapted to drive the heating device (18) of a predetermined period of time.
13. Washing machine according to claim 12, wherein said predetermined period of time is calculated by the control unit (26) on the basis if the actual energy to be transferred to laundry (L).
14. Washing machine according to claim 11, wherein the control unit (26) is adapted to drive the drum (14), at least intermittently, at a tumbling speed (G) while said heating device (18) is switched on.
15. Washing machine according to claim 11, wherein the control unit (26) is adapted to drive the motor (16), after heating device (18) is switched off, so that the drum (14) is rotated at a second low spin speed (B) for a predetermined period of time.

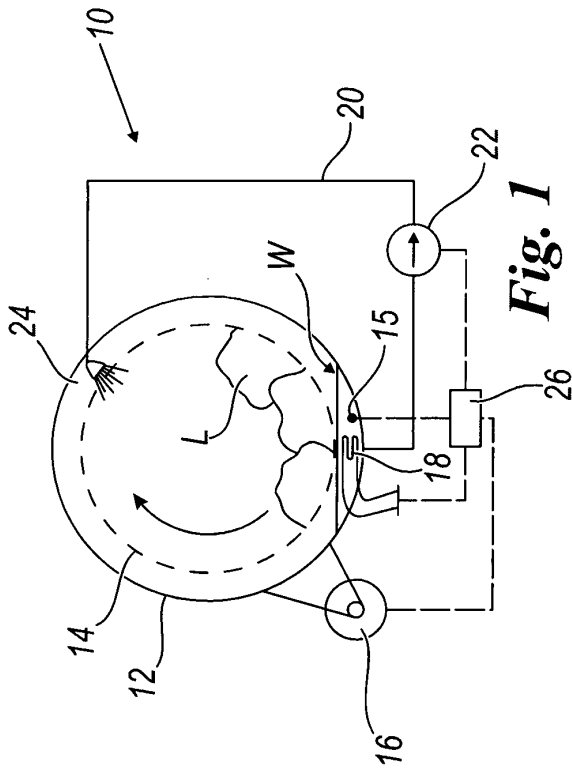


Fig. 1

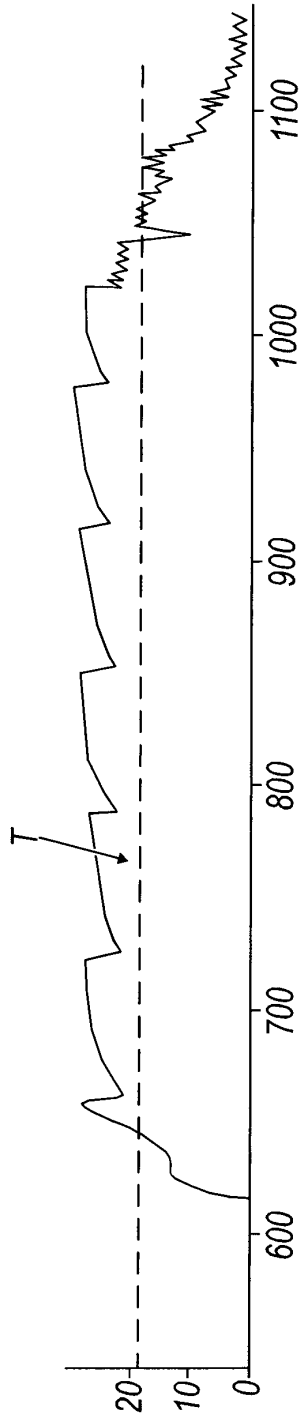


Fig. 2

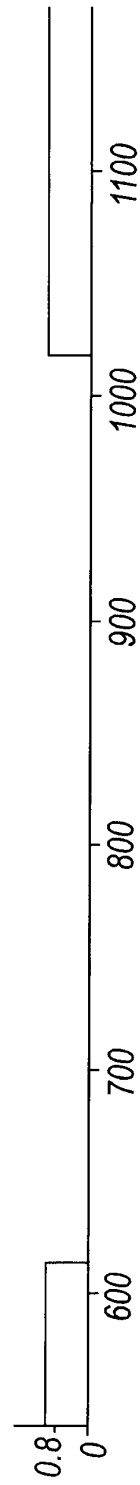


Fig. 3

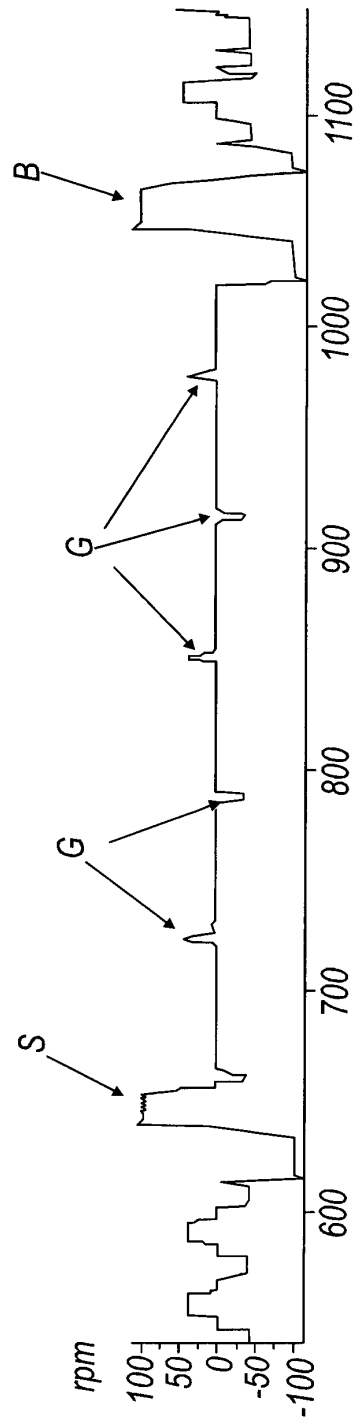


Fig. 4

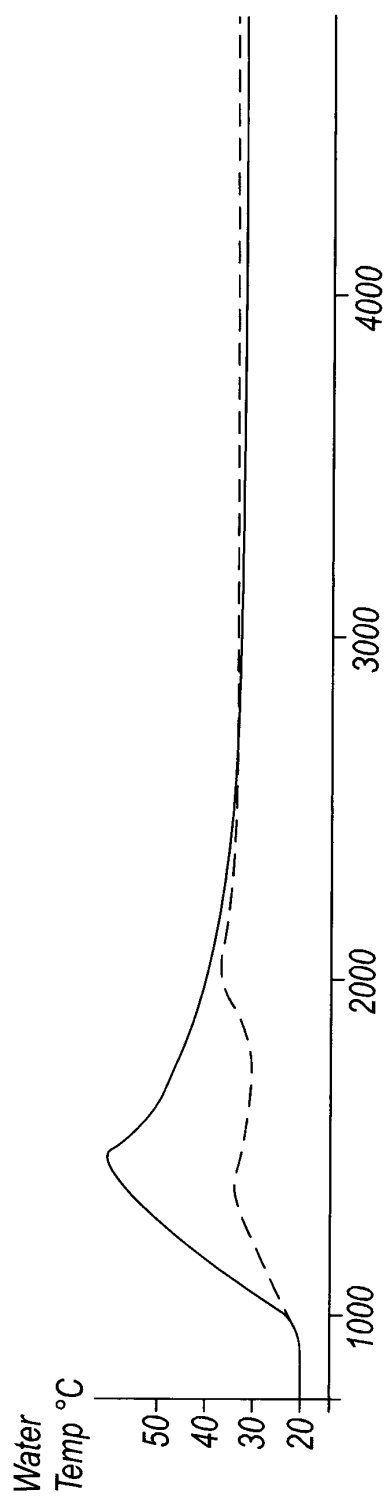


Fig. 5

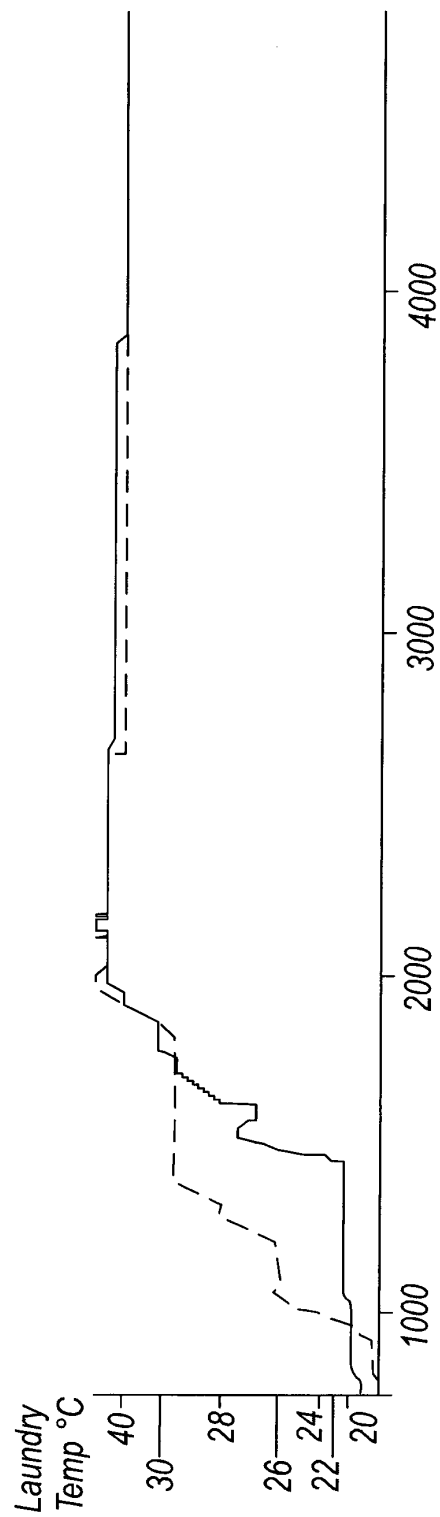


Fig. 6

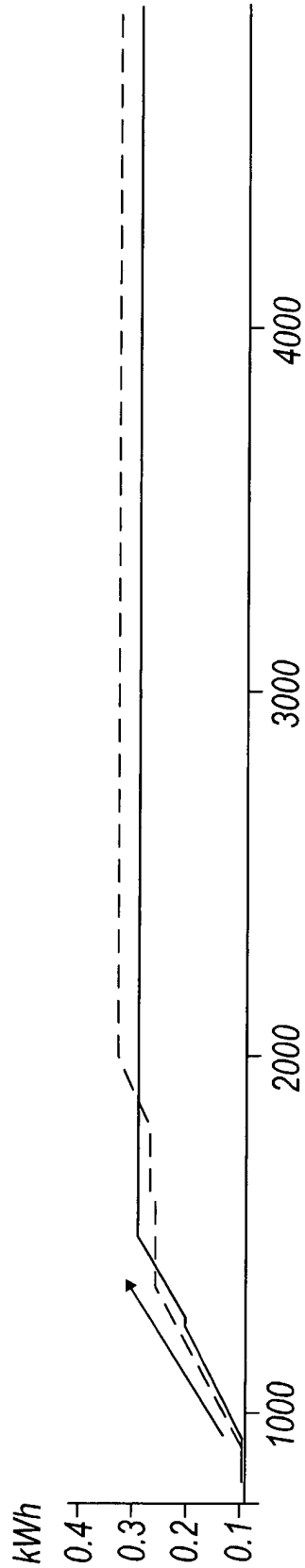


Fig. 7

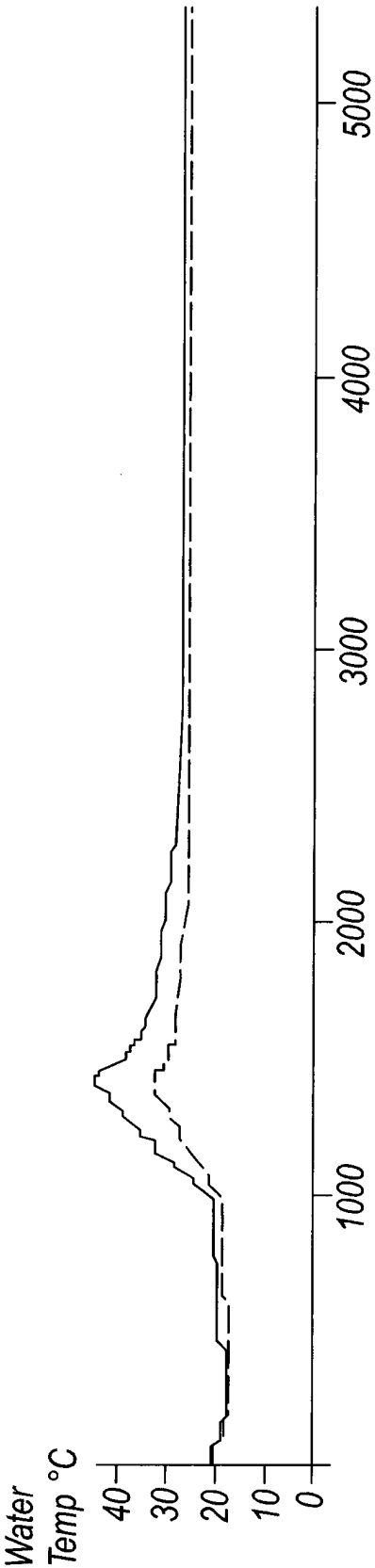


Fig. 8

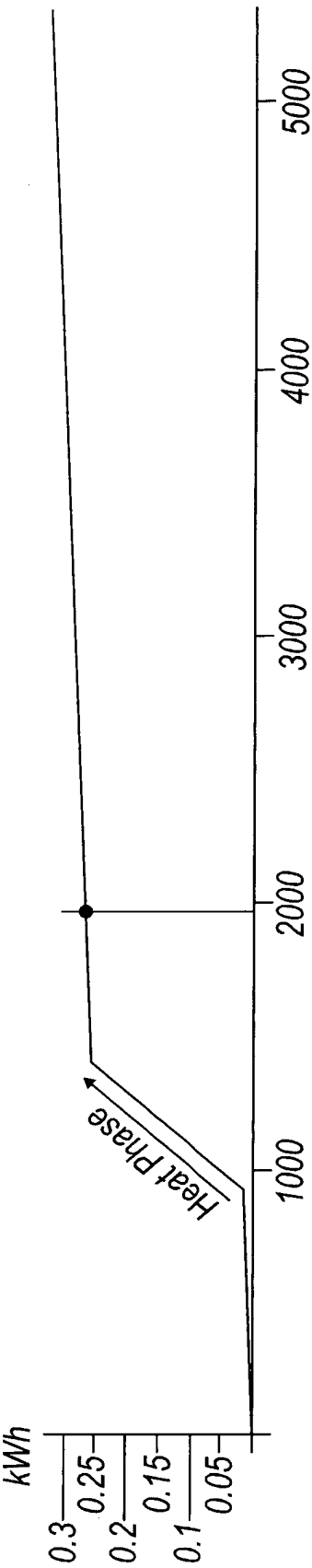


Fig. 9



EUROPEAN SEARCH REPORT

Application Number
EP 13 16 4308

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 1 961 854 A1 (SAMSUNG ELECTRONICS CO LTD [KR]) 27 August 2008 (2008-08-27) * paragraphs [0014], [0044]; figures *	1-15	INV. D06F35/00
A	FR 2 559 798 A1 (ESSWEIN SA [FR]) 23 August 1985 (1985-08-23) * claims 1-4; figures *	1-15	
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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			D06F

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Place of search

Munich

Date of completion of the search

10 September 2013

Examiner

Stroppa, Giovanni

CATEGORY OF CITED DOCUMENTS

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EP 13 16 4308

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