



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
23.02.2011 Bulletin 2011/08

(51) Int Cl.:
D06F 58/20 (2006.01) **D06F 75/12** (2006.01)
D06F 39/00 (2006.01) **F22B 1/28** (2006.01)
D06F 73/00 (2006.01)

(21) Application number: **09168039.7**

(22) Date of filing: **18.08.2009**

(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 MK MT NL NO PL PT RO SE SI SK SM TR

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(54) **Method of operating a steam generator of a laundry appliance, and laundry appliance for performing the method**

(57) According to the present invention, a method of operating a steam generator 4 of a laundry appliance 1 is presented, wherein the steam generator 4 comprises a heater 13 to generate steam S from water W and a water supply means 14 to supply water W to the heater 13, the method comprising at least the following steps: measuring a temperature T_{meas} of the heater 13 and, if the measured temperature T_{meas} is below a lower target

temperature T_{Pmin} , decreasing a supply of water W to the heater 13; if the measured temperature T_{meas} is above an upper target temperature T_{Pmax} , increasing a supply of water W to the heater 13; if the measured temperature T_{meas} is between the lower target temperature T_{Pmin} and the upper target temperature T_{Pmax} , keeping the supply of water W to the heater 13 substantially constant. The inventive laundry appliance 1 is adapted to perform the inventive method.

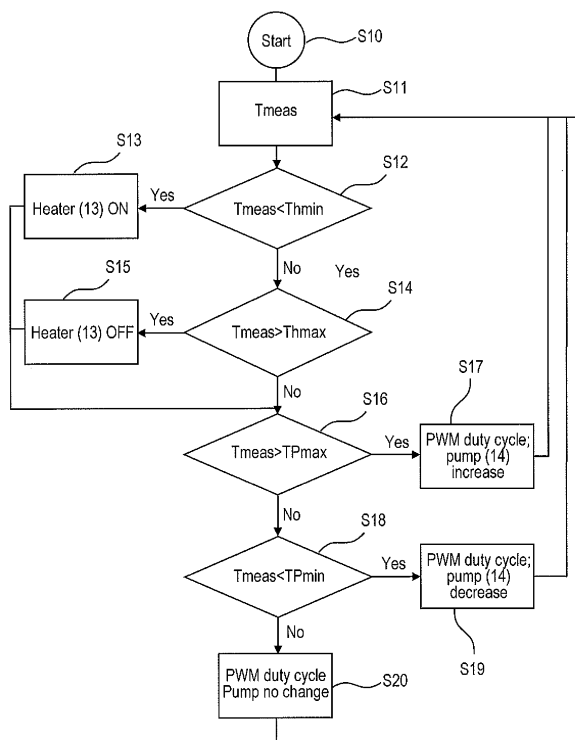


Fig. 7

Description

[0001] The invention relates to a method of operating a steam generator of a laundry appliance, and relates to a laundry appliance for performing the method. A laundry appliance may be a laundry dryer that is adapted to inject hot water steam into a drum for holding the laundry to be dried.

[0002] WO 1996/032607 A1 relates to a steam generator, in particular for housework, and concerns a method and a device for automatically carrying out a replenishment of a tank of the steam generator during normal operation thereof. In particular, it is disclosed that by means of a temperature detector, a temperature is measured inside a cell box which is in communication with the tank. When the level of liquid, e.g. water, inside the cell box reaches a minimum level, the temperature detector is surrounded by steam, the temperature of which is higher with respect to the temperature of the liquid, and enables liquid supply by means for feeding liquid to the cell box, thus replenishing the tank up to an operational level, when the liquid enters the cell box, it cools the temperature detector which disables the liquid feeding means, cutting off inflow of cold liquid to the cell box.

[0003] EP 1 026 306 B1 relates to a automatic refill steam generator for use in conjunction with steam cleaning equipment, clothes irons, fan-assisted ironing boards with refill function, coffee and similar brewing machines. The automatic refill steam generator is provided with at least an electric heating element attached to the outside of the steam generator and equipped with a control thermostat, said steam generator being connected on one side to a water reservoir via a pump and at least a pipe, and being further connected on the other side to the steam using apparatus via another pipe.

[0004] U. S. Patent 4,207,683 relates to a laundry dryer having a touch-up spray for removal of wrinkles from clothing and fabrics and permanent press laundry, in particular without removing possibly present factory set creases. The laundry dryer may include a water heating unit for spraying water of a selected temperature or steam. The steam is applied to remove undesired wrinkles or odours from the laundry being treated and thus provides refreshment to the laundry. Accordingly, this dryer may be designated to be a "Refresher Dryer". It should be remarked that such nomination is not reserved to an appliance which is designed merely to dry laundry besides the refreshing function; instead, it will also be applied to a washer/dryer with a refreshing function.

[0005] It is an object of the present invention to provide a steam generation in a laundry appliance that is low-maintenance and particular user friendly. The object also includes providing a laundry appliance meeting these requirements.

[0006] The object is achieved according to the features of the independent claims. Preferred embodiments can be derived, inter alia, from the dependent claims and the subsequent disclosure, where preferred embodiments of

the inventive method imply preferred embodiments of the inventive laundry appliance in every case, including any case which may not be disclosed explicitly in the subsequent disclosure.

[0007] Accordingly, the object is achieved by a method of operating a steam generator of a laundry appliance, wherein the steam generator comprises a heater to generate steam from water and a water supply means to supply water to the heater, the method comprising at least the following steps: measuring a temperature of the heater; and, if the measured temperature is below a lower target temperature, decreasing a supply of water to the heater; if the measured temperature is above an upper target temperature, increasing a supply of water to the heater; if the measured temperature is between the lower target temperature and the upper target temperature, keeping the supply of water to the heater substantially constant.

[0008] By this method, a whole target temperature range is set where the water supply means may be operated constantly, enabling the control system to abstain from control measures as the measured temperature is kept within the target temperature range by adjusting the supply of water to the heater. Accordingly, as long as the measured temperature is kept between the lower target temperature and the upper target temperature, the water supply means is not necessarily re-adjusted but may be operated substantially constant. This reduces the strain onto the affected components of the water supply means and also reduces a cyclic thermal load on the heater. Both effects extend a lifetime and thus lower the need for maintenance.

[0009] In addition, a constant operation of the water supply means generates a relatively constant sound or noise which will appear less attracting to a user than a varying sound. Thus, the invention also provides a more user friendly operation.

[0010] According to the invention, the water output from the water supply means adjusts a cooling and thus a temperature control of the heater to an extent. For example, if the measured temperature of the heater reaches or exceeds the upper target temperature, the water supply is increased (in case of the water pump by increasing the pump duty cycle or the pump output, for example) to increase steam production in the heater for cooling the heater. Subsequently, a temperature of the steam output from the heater can be controlled easily, too.

[0011] The water supply means may be or include, for example, a water pump or a connection to a household fresh water tap equipped with a respective valve.

[0012] In accordance with a preferred embodiment of the invention, the lower target temperature is set at 110°C, and the upper target temperature is set at 160°C. These preferred settings confirm that the target temperature range for operation of the heater may be selected to be quite broad and substantially deviant from a setting which would relate to a single target temperature only.

[0013] According to another preferred embodiment of the invention, the method further comprises the following steps: if the measured temperature is below a lower threshold temperature, switching on the heater, wherein the lower threshold temperature is lower than the lower target temperature; if the measured temperature is above an upper threshold temperature, switching off the heater, wherein the upper threshold temperature is higher than the upper target temperature. According to this preferred embodiment, a temperature interval for securing safe operation of the steam generator is defined which extends both above and below the target temperature range. This embodiment provides both a safe and quick initial start-up and a safety shut-down of the heater for the case of a malfunction etc. For start-up, the heater will always be switched on as long as the measured temperature is below the lower threshold temperature; the inventive control sequence will assume control of the heater as soon as the lower threshold temperature is passed. In accordance with a more preferred embodiment, the lower threshold temperature is set at 100°C, and wherein the upper threshold temperature is set at 170°C.

[0014] According to a further preferred embodiment, the water supply means is provided to supply water to the heater from a water tank, and the method further comprises the step of measuring a water level of the water tank and, if the measured water level falls below a safety water level threshold, at least the heater is switched off. This preferred embodiment also provides a safety feature in that a sufficient water supply is ensured for operating (while assuring proper cooling of) the steam generator or heater. This is particularly useful in case the supply water is condensate extracted from the laundry which may not be plentiful at times.

[0015] According to yet another preferred embodiment, the water supply means is provided to supply water to the heater from a water tank, and the method further comprises the step of: measuring a water level of the water tank; and, if the measured water level has exceeded a safety water level threshold, the heater is switched on. This preferred embodiment ensures a sufficient water supply before or at the beginning of the operation of the heater. This is again particularly useful in case the supply water is condensate extracted from the laundry, since at the beginning of a drying cycle, there may not be enough condensate. In this case fresh water may be added to the water tank to increase the water level above the safety water level threshold.

[0016] According to even another preferred embodiment, the method comprises increasing and decreasing a supply of water to the heater by respectively increasing and decreasing a water output from the water supply means.

[0017] According to still another preferred embodiment, increasing and decreasing a water output from the water supply means comprises respectively increasing and decreasing a pulse width of control signals for the water supply means. This provides an easy way to control

the water supply means, e.g. a pump duty of the water pump, by a digital logic controller.

[0018] As to operating the water supply means by pulse width modulated (PWM) signals in compliance with usual practice for programmed controls like the digital logic controller under consideration, a nominal pulse width of 100 ms and a nominal duty cycle of 20% are preferred in the present context. Of course, both pulse width and duty cycle will vary within appropriate bounds under operation of the digital logic controller.

[0019] According to another preferred embodiment, the step of measuring a temperature of the heater is performed by a NTC sensor attached to the heater.

[0020] The use of a NTC sensor provides a very accurate temperature measurement. A NTC sensor is also particularly rugged. Assembly is made very easy by mounting the NTC sensor on an outer surface of the heater. It may be noted that, other than prior art practice which generally relies on measuring a temperature of the water to be evaporated, the invention relies on measuring a temperature of the heater body directly. This temperature is much less affected by evaporation effects which limit the measurable temperature to the evaporation temperature of the liquid to evaporate. Accordingly, the invention guarantees a significantly higher precision in determining a true thermal overload of the heater.

[0021] According to yet another preferred embodiment, the method comprises at least the following steps: measuring a water level of the of the water tank and, if the measured water level has exceeded a safety (minimum) water level threshold, the heater is switched on, measuring a temperature of the heater and, if the measured temperature is below the lower target temperature, decreasing a supply of water to the heater; if the measured temperature is above an upper target temperature, increasing a supply of water to the heater, if the measured temperature is between the lower target temperature and the upper target temperature, keeping the supply of water to the heater substantially constant.

[0022] The object is also achieved by a laundry appliance that comprises a steam generator, the steam generator in turn comprising: a water tank, a heater for generating steam from water, a water pump to supply water from the water tank to the heater, and a NTC sensor attached to the heater for measuring a temperature of the heater. The laundry appliance further comprises: a logic controller for receiving and processing sensor signals from the NTC sensor and controlling a duty cycle of the water pump on the basis of the received sensor signals.

[0023] The logic processor may be part of the steam generator or may be a separate entity, e.g. part of a central control unit of the laundry appliance. Placing the logic controller in a distance from the steam generator has the advantage that the logic controller, which may be implemented as an integrated circuit, is not exposed to the heat emanating from the heater.

[0024] According to a preferred embodiment, the laun-

dry appliance further comprises: a water level sensor for measuring a water level of the water tank, wherein the logic processor is adapted to receive and process sensor signals from the water level sensor and controlling a switching on or off of the water pump on the basis of the received sensor signals. This allows protection against a too short supply of water to the heater.

[0025] According to another embodiment, the water level sensor is a combination of a reed sensor and a float sensor. This provides a measurement of the water level with different methods that improve failure safety in its turn.

[0026] According to even another preferred embodiment, the water pump is a vibration pump.

[0027] According to a particularly preferred embodiment, the laundry appliance is a laundry dryer and even more preferred a refresher-dryer.

[0028] In the following sections, particularly preferred embodiments of the invention are described in greater detail, including references to the Figures of the attached drawing. In particular:

- Fig.1 shows an oblique view onto a laundry appliance comprising a steam generator;
- Fig.2 shows an oblique view onto the steam generator of the laundry appliance of Fig.1; and
- Fig.3 shows the steam generator of Fig.2 in a partly transparent view.
- Fig.4 shows an exploded view of the steam generator,
- Fig.5 shows a top view of a NTC sensor of the steam generator;
- Fig.6 shows a steam generation control arrangement comprising a logic controller;
- Fig.7 shows a steam generation cycle of the steam generator;
- Fig.8 shows a control routine performed by the logic controller of Fig.6.

[0029] **Fig.1** shows a laundry appliance 1 that is embodied as laundry dryer 1 in the form of a refresher-dryer that incorporates a clothes or laundry refreshing and de-wrinkling function applying steam. The laundry appliance 1 is shown without housing. In particular, the laundry appliance 1 is embodied as a tumble dryer comprising a rotatable drum 2 which holds the laundry to be dried and which may be operated by being rotated in reversing rotational directions. The drum 2 can be loaded and unloaded through an opening 3. The opening 3 is typically closed by a door (not shown). The operation of a tumble dryer as such is well known.

[0030] To implement the refreshing function, the laundry appliance 1 comprises a steam generator 4 which is located at a bottom of the laundry appliance 1 and mounted on top of a cover 39 of a heat exchanger 40. The steam generator 4 is visible from its front side F (see also Fig.2). The steam generator 4 is used to generate steam from water. Water is supplied to the steam generator 4 via a condensate container shell 5 through a flexible filling

hose 6. The water supplied to the steam generator 4 could be the condensate that is extracted from the damp clothes during the drying process. Alternatively, fresh water may be filled into the steam generator through the condensate container shell 5 at the beginning of a drying cycle, if there is not yet enough condensate to supply the steam generator 4 or if the use of condensate, which may be contaminated by lint which is particulates released from the laundry by the process air during drying..

[0031] The output generated by the steam generator 4 usually contains a mixture of steam and hot water in the form of mist or small droplets and is led to a steam separator 7. The steam separator 7 separates the steam from the hot water. The steam is then fed into the drum 2 via a hose 8 that leads to a nozzle 9. The nozzle 9 opens into the drum 2 and may inject the steam directly onto the laundry. The steam injection may also comprise an injection of steam and a fine mist of water droplets. To this end, the nozzle 9 may have any appropriate shape, e.g. an angular shape that allows orientation of the steam flow. The hot water is returned to a T-connector 42 located in a dryer pump reservoir via a flexible hot water return hose. Thus, the steam separator 7 ensures that only steam with a low or very low liquid content is fed into the drum 2.

[0032] The steam generator 4 further comprises or is connected to a flexible de-aeration hose 43 that connects to a water tank (see fig.3 for further detail) of the steam generator 4. The steam generator 4 further comprises a siphon fixation 47 for holding or fixing a siphon 48.

[0033] **Fig. 2** and **Fig.3** show the steam generator 4 in greater detail by an elevated view onto a rear side B of the steam generator, with Fig.3 being a partly transparent view.

[0034] The rear side B of the steam generator 4 borders on the drum 2 and faces to the inside of the laundry appliance 1 of Fig.1. The front side F of the steam generator 4 is shown in Fig.1.

[0035] The steam generator 4 comprises a water tank 10 for a base that is covered by an upper part 11 of a tank body of the water tank 10. A water level of the water tank 10 is measured by a water level sensor 12 that is realized as a combined reed water level sensor 12a and float water level sensor 12b. The water level sensor 12 is placed inside the water tank 10. The water tank 10 is filled with water via a water inlet 19 that is connected to the filling hose 6 as shown in Fig. 1. The water level sensor 12 may be used to control the function of the steam generator 4.

[0036] On top of the upper part 11 of the water tank 10 there is mounted a heater 13 to heat water and subsequently produce steam, usually mixed with the hot water. A heater body of the heater 13 may be made at least partially from aluminium, with the block of aluminium assisting in keeping the temperature of the heater 13 at low variation. The heater 13 is supported on support columns 21. To this end, the support columns 21 each hold a respective silicone holder 23 laterally mounted to the heater

13. This holding or supporting arrangement of the heater 13 has the advantage that vibrations from or to the heater 13 are suppressed and that a thermal flow from the heater 13 is at least partially blocked by the silicone holders 23. The heater 13 is not arranged horizontally but is slightly angled to the horizontal in order to achieve an improved de-calcification.

[0037] The mixture of steam and hot water generated within the heater 13 is led out of the heater 13 and fed to the steam separator 7 by a steam outlet pipe 15 or hose. A temperature of the heater 13 is monitored by a NTC (negative temperature coefficient) sensor 16 that is mounted on top / on an upper part of the heater 13. The NTC sensor 16 may be regarded as part of the heater 13. Electrical terminals 26 of a heating element of the heater 13 are located at the same side as the water inlet and outlet.

[0038] The heater 13 also comprises or is connected to a safety switch 17 by which the heater 13 may be switched off to prevent overheating.

[0039] The water is supplied from the water tank 10 to the heater 13 by means of a water pump 14 which is implemented as a solenoid-driven vibration pump 14. The pump 14 is supported by a pair of screwed rubber holders 18. This reduces the propagation of vibration and thus reduces the overall noise of the steam generator 4. The suppression of the vibration propagation also enhances the life time of the steam generator 4.

[0040] Fig. 3 shows an exploded view of the steam generator 4 viewing its front side F. The water tank 10 comprises a tank body 20, which is covered by the upper part 11. The upper part 11 comprises the water inlet 19 and a de-aeration outlet 44 for connection with the de-aeration hose 43. The tank body comprises a water outlet 45 that can be connected to a water inlet of the water pump 14 via a water pipe 46. At a bottom of the tank body 20 there is placed a metal insert (not shown) that acts as a barrier against fire in the unlikely case of a melting of the heater 13. The bottom of the tank body 20 also holds the siphon fixation 47.

[0041] The upper surface of the water tank 10 further comprises the support columns 21 for supporting the heater 13. To this end, the support columns 21 each comprise an upper recess 22 for supporting the respective silicone holder 23. Each silicone holder 23 is in turn laterally mounted to the heater 13, in particular fitted onto a respective mounting column 24. This holding arrangement of the heater 13 has the advantage that vibrations from or to the heater 13 are suppressed and that a thermal flow from the heater 13 is at least partially blocked by the silicone holders 23.

[0042] Water supplied into the heater 13 via a water inlet connection 27 is guided within the heater 13 by a water tube 38, to leave the heater 13 as a mixture of hot water and steam by a steam outlet connection 28. The water tube 38 can be heated up by a heating element or heating elements (not visible) of the heater 13. The water tube 38 is located on a top surface of the heater 13. The

water inlet connection 27 is connected to a pressure outlet 29 of the water pump 14 by a connection hose 30. The water inlet connection 27 and the pressure outlet 29 are aligned almost horizontally and facing each other; this ensures a direct / linear connection that acts against a possible pressure drop at the heater 13 and also prevents the hose 30 from coming off. The steam outlet connection 28 is connected to the steam outlet pipe 15. The heater 13 is slightly angled against the horizontal with the end comprising the connections 27, 28 placed lower than the opposite end in order to achieve an improved de-calcification.

[0043] Between the upper part 11 of the water tank 10 and the heater 13 there is inserted a metal insert 25 with soft edges, e.g. round edges. The soft edges prevent possible damage to electrical connections, e.g. damage to an insulation of an electrical cable. The heater 13 is grounded electrically via the metal insert 25, and from the metal insert 25 further to a dryer frame 33 shown in Fig.1. The metal insert 25 may act as a barrier against fire in case of an unlikely melting of the heater 13.

[0044] At the bottom of the heater 13 there is located the safety switch 17. The safety switch 17 uses a duo pack or dual pack comprising a bimetal element and a fuse to prevent overheating of the heater 13. Threshold temperatures where a switching action will occur are presently set at 190°C for the bi-metal element which is reversible, and 260°C for the fuse which is irreversible. Thereby, the safety switch 17 will turn off heater 13 reversibly in case of a minor malfunction which produces a temperature rise of minor criticality, and it will turn off heater 13 irreversibly (that is, irreversibly except by action of a skilled service technician) upon a temperature rise of major criticality. It is understood that problems of less criticality include problems caused by temporary clogs of and water bubbles in the water hoses leading to heater 13 which may be expected to disappear by themselves and do not require attention by a skilled service technician. Accordingly, it is understood to be a sufficient measure to interrupt the action of the heater 13 only reversibly upon encountering such problems. The safety switch 17 may be located near the heating element(s), or the heating element(s) may at least partially be inserted into the safety switch 17.

[0045] The steam outlet pipe 15 and the connection hose 30 are placed above and may be borne on a micanite safety insert 31. The safety insert 31 provides a leakage protection. Furthermore, the safety insert 31 prevents electrical connections from getting in contact with water that may be leaking or condensing at the pump 14 or between the pump 14 and the heater 13. The use of micanite or mica provides for a high dielectric strength, excellent chemical stability, and high resistance to excess heat. Also, the plate-like micanite safety insert 31 is light-transmissive such that it does not inhibit a view to elements located below it.

[0046] The steam generator 4 further comprises a single connection housing 32 for all electrical connections

/ internal wiring 41. The connection housing 32 may be of a type produced, e.g., by AMP Inc. All electrical connections lead into the connection housing 32. The electrical connections / internal wiring 41 include an earth connection line 34 and an electrical connection 35 connected to a temperature protector 36 of the pump 14. The temperature protector 36 is mounted on the pump 14. The connection housing 32 may be connected to the steam generator 4 by clamping.

[0047] The steam generator 4 is in large parts covered by a plastic cover 37. The plastic cover 37 can be clamped onto the tank 10 without the need for screws or other additional fixing elements to provide easy assembly. The plastic cover 37 can be made of a flame retardant material, like a V0 material, to ensure compliance with safety regulations.

[0048] Fig.5 shows the NTC sensor 16 in greater detail. The NTC sensor 16 comprises an NTC thermistor 51 of a temperature dependent semiconducting ceramic material. The semiconductor material has a resistance value which decreases with rising temperature. The material may be a sintered ceramic material, e.g. a sintered polycrystalline titanate or a sintered ceramic material for highly stable thermistors based on $\text{Ni}_x\text{Mn}_{3-z}\text{O}_4$ with $x = 0,84$ to 1, and $0 < z < 1,6$. The B value is about 4000 K.

[0049] The ceramic material is glass encapsulated, inter alia, for good electric insulation.

[0050] To connect the thermistor 51 mechanically and thermally to the surface of the heater 13, the NTC sensor 16 further comprises a ring-shaped metal housing 52 made of brass having a thickness of about 0,5 mm. The use of brass as a relatively malleable material ensures a good contact between the metal housing 52 and the heater 13. Also, brass is a good thermal conductor and relatively resistant to corrosion. A screw-hole circle 52a of the housing 52 has a diameter d1 of about 4 mm while the housing 52 has a diameter d2 of about 8 mm. The screw-hole circle 52a might, for example, accommodate a M3 screw for screwing the housing 52 onto the heater 13 and the aluminium heater body, respectively.

[0051] The thermistor 51 is connected to a pair of wires 53 to conduct sensor signals from the thermistor 51. The wires 53 are each implemented as AWG22 wires which are FPE or PTFE (polytetrafluoroethylene, also known under the brand name Teflon) insulated and which are heat resistant up to at least 200 °C, preferably up to 230 °C. PTFE is highly temperature resistant, friction resistant and wear resistant as well as very inert, e.g. against corrosion.

[0052] The wires 53 are in turn each at least partially covered by a protective sleeve 54 for electrical insulation made of black polyolefin which is heat proof up to at least 200 °C, preferable up to at least 230 °C. The protective sleeve 54 ends after a distance d₃ of about 60 mm from a head 52b of the housing 52. For example, neither water and water-containing substances nor oil and oil-containing substances are wet by PTFE.

[0053] The protected wires 53, 54 are in turn at least

partially surrounded by a common protective sleeve 55 made of a white silicone impregnated glass fiber material. The common protective sleeve 55 is preferably heat resistant up to 200 °C, preferably up to at least 230 °C. The common protective sleeve 55 provides a high wear resistance, e.g. against abrasion. The common protective sleeve 55 may extend over the whole length or part of the length of the protected wires 53, 54.

[0054] Thus, the NTC sensor 16 can endure temperatures up to at least 200°C, preferably up to at least 230 °C, in a high temperature zone extending about d₃ = 60 mm around the housing 52. In other words, within the distance d₃ (which corresponds to a length of a 'high temperature part' of the NTC sensor 16), the NTC sensor 16 may touch the heater 13 (a surface of which might reach but not exceed the temperature maximally endurable by the high temperature part of the NTC sensor 16) without risk of damage. The distance d₃ / the length of the high temperature part of the NTC sensor 16 at least exceeds the width of the heater 13 such that the NTC sensor 16 is protected from the heater 13 at least if the wires 53 are directed or arranged sideways.

[0055] Generally, the operational temperature range of the NTC sensor 16 is between -10 °C and at least 200 °C, preferably 230 °C. The operation of the NTC sensor 16 at its maximum operation temperature of 200 °C, preferably 230 °C, is sustainable for at least for 250 hours.

[0056] Outside of the high temperature zone (away from the heater 13), the NTC sensor 16 sustains working temperatures of up to 90 °C.

[0057] At the end opposite of the housing 52, each of the wires 53 ends in a crimped connector 56 of tin plated brass, having a tab of a dimension 6.3 mm x 0.8 mm with an insulation support. The connectors 56 are stable over at least over a temperature range of -10 °C up to at least 220 °C. A wires pull off force which represents the minimum force required to pull at the wires 53 from a housing of the heater 13 in an axial direction without damage, malfunction or loosening of contacts is not less than 20 N. A tear off force which represents the minimum force required to pull at the connector(s) 56 from the connection housing 32 in an axial direction without damage, malfunction or loosening of contacts is not less than 50 N. The overall length of the NTC sensor 16 from its head 52b to its connectors 56 is between 150 mm and 200 mm.

[0058] The NTC sensor 16 has a characteristic tolerance of less than 3% and a resistance value R_N of 3300 Ohms at a nominal temperature of T_N = 100 °C. The resistance value at 25 °C is about 50 MOhm. The characteristic b value (25/100) of the well known R/T curve is preferably around 4000 K.

[0059] A response time (measured according to a 63% method, with water being at 25 °C and at 85 °C) is below 3 s. The maximum power consumption at 25 °C is around 10 mW. A drift during a lifetime of the NTC sensor 16 at 150 °C is lower than 8 %. A dissipation factor of the thermistor 51 in air is in the range of 2 to 4 mW/K.

[0060] An insulation resistance R_{iso} at U=500V DC

with the NTC sensor 16 immersed is larger than 100 MOhm, so that this insulation resistance is also holding between electrical connections and housing radiator.

[0061] The NTC sensor 16 is further voltage proof in the sense that if a voltage of 1000 V AC at 50 Hz that is applied for 1 sec, no flashover occurs.

[0062] All materials that are in use for the NTC sensor 16 behave chemically neutral among each other. All metal parts of the NTC sensor 16 are protected against corrosion or of a substantially corrosion-proof material (e.g. silver plated or tinned connectors 56 and/or a tinned or brazed housing 52 etc.).

[0063] A lifetime of the NTC 16 sensor is in excess of 2000 work cycles, preferably at least 2500 work cycles, of at least 6 minutes each. A work cycle is presumed to include heating from ambient temperature (e.g. 25 °C) to 170 °C in 30 seconds by operating the heater 13, then staying at 170 °C for 6 minutes, followed by turning off the heater 13 and free cooling. The shown NTC sensor 16 sustains more than 2500 work cycles during 10 years of operation.

[0064] Fig.6 shows a steam generation control arrangement comprising a logic controller embodied as a microcontroller unit (MCU) 61. The MCU 61 is connected to the steam generator 4 of the dryer 1 but not part of the steam generator 4, or at any rate placed separate from the steam generator 4. This distanced arrangement protects the MCU 61 against heat emanating from the steam generator 4 and thus against overheating. The MCU 61 may be part of a central control unit of the laundry appliance 1.

[0065] The MCU 61 receives sensor signals or sensor data R from the NTC sensor 16 of the steam generator 4. These sensor signals R are representative of a current or measured temperature T_{meas} of the heater 13, i.e. $R = f(T_{meas})$.

[0066] The MCU 61 also receives data signals from the water level sensor 12, i.e. the reed sensor 12a and/or the float sensor 12b. The data signals from the water level sensor 12 may comprise information about a measured water level or may comprise information about the water level in the water tank 10 being below or above a certain minimum water level that is required to operate the heater 13.

[0067] The MCU 61 gives out digital control signals to a digitally controlled pulse-width modulator 62 that in turn controls the operation of the water pump 14. In particular, the MCU 61 may send a pulsed digital signal to the pulse-width modulator 62 which in turn generates a pulse-width modulated (PWM) signal to activate the water pump 14. The water pump 14 pumps water W from the water tank 10 to the heater 13.

[0068] Fig.7 shows a control routine performed by the logic controller 61 of figure 6. Steam generation is started in step S10, e.g. at the beginning of a drying section comprising a refreshing and/or de-wrinkling action.

[0069] In a following step S11, MCU 61 reads out temperature data or sensor data R from the NTC sensor 16.

These sensor data R are then translated into an absolute temperature value of the heater 13, the measured temperature T_{meas} .

[0070] In a following step S12, a comparison is performed whether the measured temperature T_{meas} of the heater 13 is smaller than a lower threshold temperature T_{hmin} , i.e. whether the equation $T_{meas} < T_{hmin}$ holds. T_{hmin} represents a temperature below which the heater 13 is merely switched on. If the comparison shows that the actual temperature of the NTC sensor 16 is below T_{hmin} ("Yes"), the control routine proceeds to step S13.

[0071] In step S13, the heater 13 is switched on by the MCU 61.

[0072] If, on the other hand, it is determined that the actual temperature of the heater 13 is equal to or higher than T_{hmin} (result "No" in step S12) then, in a following step S14, the measured / current temperature T_{meas} of the heater 13 is compared to an upper threshold temperature T_{hmax} , i.e. whether $T_{meas} > T_{hmax}$ holds. The upper temperature threshold T_{hmax} represents a temperature above which the heater 13 is switched off. This prevents overheating in case, for example, of a malfunctioning of the heater 13.

[0073] If T_{meas} is higher than T_{hmax} (result "Yes") then the control routine proceeds with step S15 wherein the heater 13 is switched off.

[0074] If T_{meas} is equal to or lower than T_{hmax} ("No") then the control routine proceeds with step S16. Step S16 is also the following step for steps S13 and S15.

[0075] In step S16, MCU 61 compares the measured temperature T_{meas} of the heater 13 with an upper target temperature T_{Pmax} which represents an upper bound of a target temperature range TTB that will be explained in greater detail below. If T_{meas} is higher than T_{Pmax} ("Yes"), then the control routine proceeds to step S17.

[0076] In step S17, the MCU 61 increases the output of the pump 14. This can be done by increasing the PWM duty cycle. If the pump output or pump duty cycle (e.g. as represented by a flow rate) increases, more water W per unit time is flowing through the heater 13. This means that more water W is provided to be heated which balances the relatively high temperature of the heater 13. Additionally, the flow of the water W cools down the heater 13 more strongly. The control routine then proceeds to step S11.

[0077] If, in step S16, the measured temperature T_{meas} does not exceed T_{Pmax} ("No"), the control routine proceeds with step S18. In step S18, the measured temperature T_{meas} to a lower target temperature T_{Pmin} (with $T_{Pmin} < T_{Pmax}$) which represents a lower bound or threshold of the target temperature band TTB. If the T_{meas} of the heater 13 is lower than T_{Pmin} , i.e. $T_{meas} < T_{Pmin}$, this yields the result "Yes", and the control routine proceeds to step S19.

[0078] In step S19, the MCU 61 decreases the water output of the pump 14 of the pump duty, e.g. by decreasing the PWM duty cycle. Thus, water W is flowing through the heater 13 with a lower rate and is thus heated

longer. This balances the relatively low temperature $T_{\text{meas}} < T_{\text{Pmin}}$ of the heater 13 and additionally reduces cooling of the heater 13. As a consequence, the heater 13 heats up. The control routine then proceeds to step S11.

[0079] If in step S18 T_{meas} is equal or higher than T_{Pmin} (result "No"), the control routine proceeds to step S20.

[0080] In step S20, there is no change of the PWM duty cycle and thus no change of the operation of the water pump 14. Following step S20, the control routine will proceed with step S11 subsequently.

[0081] As to concrete temperatures specified in this preferred embodiment, the lower target temperature T_{Pmin} is set at 110°C, and the upper target temperature T_{Pmax} is set at 160°C. Further, the lower threshold temperature T_{hmin} is set at 100°C, and the upper threshold temperature T_{hmax} is set at 170°C.

[0082] As $T_{\text{hmin}} > T_{\text{Pmin}} > T_{\text{Pmax}} > T_{\text{hmax}}$ holds and if the heater 13 is just switched on in step S13, the control routine will give a negative result ("No") for step S16 and a positive result ("Yes") for step S18. In one embodiment, the pump duty of the water pump 14 is zero directly after switching on the heater 13 (water pump 14 is not pumping water W at the beginning of the heating operation) such that step S19 has no effect. In the following, control routine again measures the temperature T of the NTC sensor 16 in step S11. If the measured temperature T_{meas} is still lower than T_{hmin} (result "Yes" in step S12), the heater 13 again gets a signal to be switched on which will not change operation of the heater 13, since it is already switched on. Subsequently, the steps S16, S18, S19 and S11 are performed again.

[0083] Since the flow of water coming from the water pump 14 is not existent or at a very low level, the heater 13 heats up quite fast such that the temperature measured by the NTC sensor 16 rises fast. Therefore, after a relatively short time after switching on the heater in step S13, T_{meas} reaches T_{Pmin} , and step S18 yields the result ("No") such that the pump duty is still not increased (step S20) and heater 13 continues to heat up. In the following, the measured temperature T_{meas} will eventually reach T_{Pmax} such that step S16 yields the result "Yes". Consequently, the pump output or pump duty cycle is increased (step S17) and the heater 13 is thus cooled. The steps S11, S12, S14, S16 and S17 are performed as long as T_{meas} does not reach or fall below T_{Pmax} .

[0084] As to operation of pump 14 by pulse width modulated (PWM) signals in compliance with usual practice for programmed controls like the present MCU 61, a nominal pulse width of 100 ms and a nominal duty cycle of 20% are implemented in the present preferred embodiment. Of course, both pulse width and duty cycle will vary within appropriate bounds under operation of the MCU 61.

[0085] After it has been decided to switch off the heater 13 in step S15 to prevent overheating ($T_{\text{meas}} > T_{\text{hmax}} > T_{\text{Pmax}}$), in the following step S16 typically a decision is made that T_{meas} of the heater 13 is higher than T_{Pmax}

("Yes") is made such that in step S17 the PWM duty cycle is increased which in turn increases the water output from the water pump 14. This cools down the heater 13 such that after one or more cycles of the control routine the actual temperature of the heater 13 is again equal or below T_{hmax} (result "No" in step S14).

[0086] The control routine, by means of steps S14 and S15, prevents overheating of the heater 13. Further, by means of steps S16 to S20, the control routine holds the temperature T_{meas} of the heater 13 within a target temperature band TTB that lies between T_{Pmin} and T_{Pmax} (see also Fig.8). If T_{meas} is within the target temperature band TTB, no action is taken to change the performance of the water pump 14. This ensures that the water pump 14 can be operated uniformly at least for certain time intervals. This increases a life time of the water pump 14 and also leads to a more constant sound. The more constant sound, in turn, is more comfortable for a user.

[0087] Fig.8 shows a steam generation cycle of the steam generator 4 in form of a (t/T_{meas}) diagram of the measured heater temperature T_{meas} over a time t. At a starting time t_{start} , the steam generator 4 is switched on, corresponding to step S10 in figure 7. The heater 13 has an initial temperature T_{start} .

[0088] In the following course of the heating cycle, the heater 13 heats up until it reaches the upper target temperature T_{Pmax} of the target temperature band TTB. In this case, that corresponds to step S16 in figure 7, the pump output is increased, see step S17 in figure 7, such that the heater 13 is getting cooled more strongly. Subsequently, the temperature of the heater 13 again decreases. This increase of the water output or pump duty may take one or more cycles of the control routine of figure 7. After a short while, however, the actual temperature of the heater 13 will be again within the target temperature band TTB. The target temperature band TTB is bound by T_{Pmin} and T_{Pmax} . Depending on the actual control parameters, the measured temperature T_{meas} of the heater 13 may remain within the target temperature band TTB until the steam generator 4 is switched off at a time tend (see diagram).

[0089] On the other hand, it may be that the increase in the water output of the water pump 14 is so high, that the heater 13 falls below the lower target temperature T_{Pmin} of the target temperature band TTB. In this case, the water output of the pump 14 is decreased (corresponding to steps S18 and S19 in figure 7), and the actual temperature of the heater 13 rises again.

[0090] If the actual temperature of the heater 13 is within the target temperature band TTB, then the operation of the pump 14 is not changed. In other words, if the actual temperature of the heater 13 is within the target temperature band TTB, the water pump 14 works uniformly. This gives a respective uniform noise of the water pump 14 and the heater 13 and also has a positive effect on the lifetime at least of the water pump 14.

[0091] The above-described operation of the steam generator 4 has been made under the assumption that

the water tank 10 is filled with enough water to support the operation of the steam generator 4. If, however, the water level falls under a certain threshold, operation of the heater 13 or the steam generator 4 as a whole is stopped to prevent overheating and even melting of components. To raise the safety of this operation, not only the float sensor 12b is used but a combination of the reed sensor 12a and the float sensor 12b. To the same effect, if the sensors 12a, 12b detect a too low water level at the supposed start of the refreshing action, the heater 13 is prevented from being switched on.

[0092] Of course, the invention is not limited to the embodiments shown.

List of Reference Numerals

[0093]

1	laundry appliance
2	drum
3	opening
4	steam generator
5	condensate container shell
6	filling hose
7	steam separator
8	hose
9	nozzle
10	water tank
11	upper part of tank body
12	water level sensor
12a	reed sensor
12b	float sensor
13	heater
14	water pump
15	steam outlet pipe
16	NTC sensor
17	safety switch
18	rubber holders
19	water inlet
20	tank body
21	support columns
22	upper recess
23	silicone holders
24	mounting column
25	metal insert
26	electrical terminals
27	water inlet connection
28	steam outlet connection
29	pressure outlet
30	connection hose
31	safety insert
32	connection housing
33	dryer frame
34	earth connection line
35	electrical connection
36	temperature protector
37	plastic cover
38	water tube

39	heat exchange cover
40	heat exchanger
41	internal wiring
42	T-connector
5	43 de-aeration hose
44	de-aeration outlet
45	water outlet
46	water pipe
47	siphon fixation
10	48 siphon
51	thermistor
52	housing
52a	screw-hole circle
52b	head of the housing
15	53 wire
54	protective sleeve
55	protective sleeve
56	crimped connector
S	steam
20	W water
T _{meas}	measured temperature
T _{Pmin}	lower target temperature
T _{Pmax}	upper target temperature
T _{hmax}	upper threshold temperature
25	T _{hmin} lower threshold temperature

Claims

- 30 1. A method of operating a steam generator (4) of a laundry appliance (1), wherein the steam generator (4) comprises a heater (13) to generate steam (S) from water (W) and a water supply means (14) to supply water (W) to the heater (13), the method comprising at least the following steps:
 - 35 - measuring a temperature (T_{meas}) of the heater (13) and
 - 40 - if the measured temperature (T_{meas}) is below a lower target temperature (T_{Pmin}), decreasing a supply of water (W) to the heater (13),
 - if the measured temperature (T_{meas}) is above an upper target temperature (T_{Pmax}), increasing a supply of water (W) to the heater (13),
 - 45 - if the measured temperature (T_{meas}) is between the lower target temperature (T_{Pmin}) and the upper target temperature (T_{Pmax}), keeping the supply of water (W) to the heater (13) substantially constant.
- 50 2. The method according to claim 1, wherein the lower target temperature (T_{Pmin}) is set at 110°C, and wherein the upper target temperature (T_{Pmax}) is set at 160°C.
- 55 3. The method according to any of claims 1 and 2, further comprising the following steps:

- if the measured temperature (T_{meas}) is below a lower threshold temperature (T_{hmin}), switching on the heater (13), wherein the lower threshold temperature (T_{hmin}) is lower than the lower target temperature (T_{Pmin}); 5
 - if the measured temperature (T_{meas}) is above an upper threshold temperature (T_{hmax}), switching off the heater (13), wherein the upper threshold temperature (T_{hmax}) is higher than the upper target temperature (T_{Pmax}). 10
4. The method according to claim 3, wherein the lower threshold temperature (T_{hmin}) is set at 100°C, and wherein the upper threshold temperature (T_{hmax}) is set at 170°C. 15
 5. The method according to any of the preceding claims, wherein the water supply means (14) is provided to supply water (W) to the heater (13) from a water tank (10), and which method further comprises the steps: 20
 - measuring a water level of the water tank (10) and
 - if the measured water level reaches or falls below a safety water level threshold, at least the heater (13) is switched off. 25
 6. The method according to any of the preceding claims, wherein the water supply means (14) is provided to supply water (W) to the heater (13) from a water tank (10) and which method further comprises the steps: 30
 - measuring a water level of the water tank (10) and 35
 - if the measured water level has reached or exceeded a safety water level threshold, the heater (13) is switched on. 40
 7. The method according to any of the preceding claims, wherein increasing and decreasing a supply of water (W) to the heater (13) comprises respectively increasing and decreasing a water output from the water supply means (14). 45
 8. The method according to claim 7, wherein increasing and decreasing a water output from the water supply means (14) comprises respectively increasing and decreasing a pulse width of control signals for the water supply means (14). 50
 9. The method according to any of the preceding claims, wherein the step of measuring a temperature (T_{meas}) of the heater (13) is performed by a NTC sensor (16) attached to the heater (13). 55
 10. The method according to any of the preceding

claims, wherein the method comprising at least the following steps:

- measuring a water level of the of the water tank (10) and
 - if the measured water level has exceeded a safety water level threshold, the heater (13) is switched on,
 - measuring a temperature (T_{meas}) of the heater (13) and
 - if the measured temperature (T_{meas}) is below the lower target temperature (T_{Pmin}), decreasing a supply of water (W) to the heater (13),
 - if the measured temperature (T_{meas}) is above the upper target temperature (T_{Pmax}), increasing a supply of water (W) to the heater (13),
 - if the measured temperature (T_{meas}) is between the lower target temperature (T_{Pmin}) and the upper target temperature (T_{Pmax}), keeping the supply of water (W) to the heater (13) substantially constant.
11. A laundry appliance (1) for performing the method according to any of the preceding claims, wherein the laundry appliance (1) comprises a steam generator (4), the steam generator (4) comprising:
 - a water tank (10),
 - a heater (13) for generating steam (S) from water (W),
 - a water pump (14) to supply water (W) from the water tank (10) to the heater (13), and
 - a NTC sensor (16) attached to the heater (13) for measuring a temperature of the heater (13), and the laundry appliance (1) further comprising:
 - a logic controller (61) for receiving and processing sensor signals from the NTC sensor (16) and controlling a duty cycle of the water pump (14) on the basis of the received sensor signals.
 12. The laundry appliance (1) according to claim 11 for performing the method according to any of the claims 5 to 10, the laundry appliance (1) further comprising:
 - a water level sensor (12, 12a, 12b) for measuring a water level of the water tank (10),
 - the logic controller (61) to be adapted to receive and process sensor signals from the water level sensor (12, 12a, 12b) and controlling a switching on or off of the water pump (14) on the basis of the received sensor signals.
 13. The laundry appliance (1) according to claim 12, wherein the water level sensor (12, 12a, 12b) is a combination of a reed sensor (12a) and a float sensor (12b).

14. The laundry appliance (1) according to claim 12, wherein the water pump (14) is a vibration pump.
15. The laundry appliance (1) according to any of claims 11 to 14, which is a laundry dryer (1), in particular a refresher/dryer (1).

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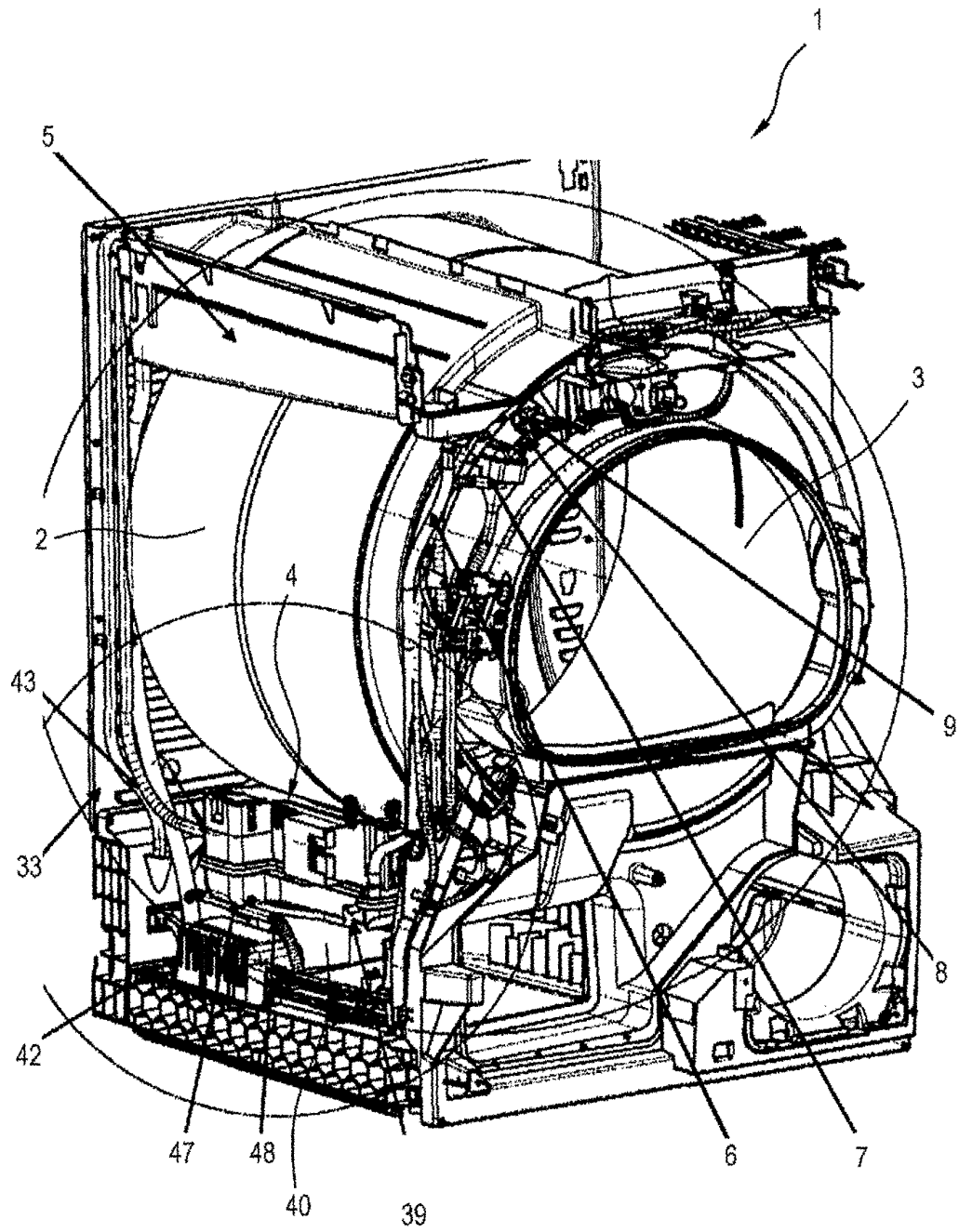


Fig. 1

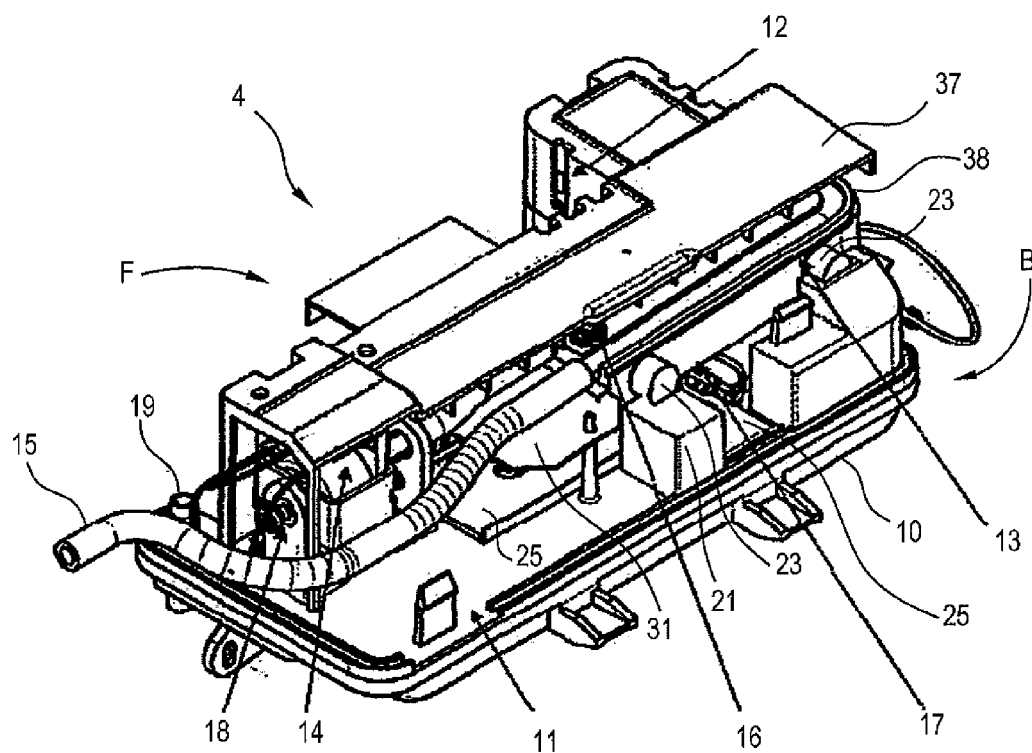


Fig. 2

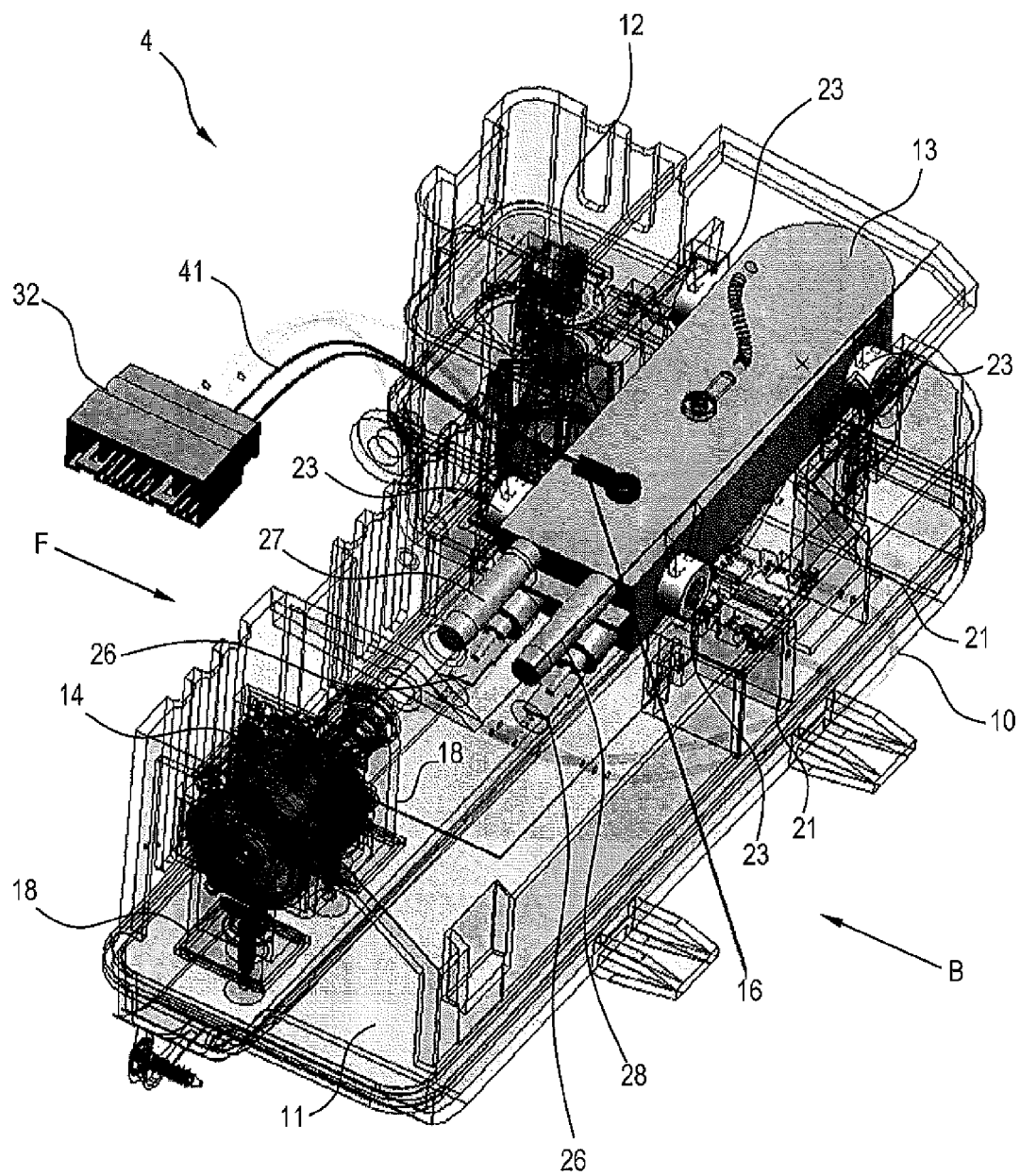


Fig. 3

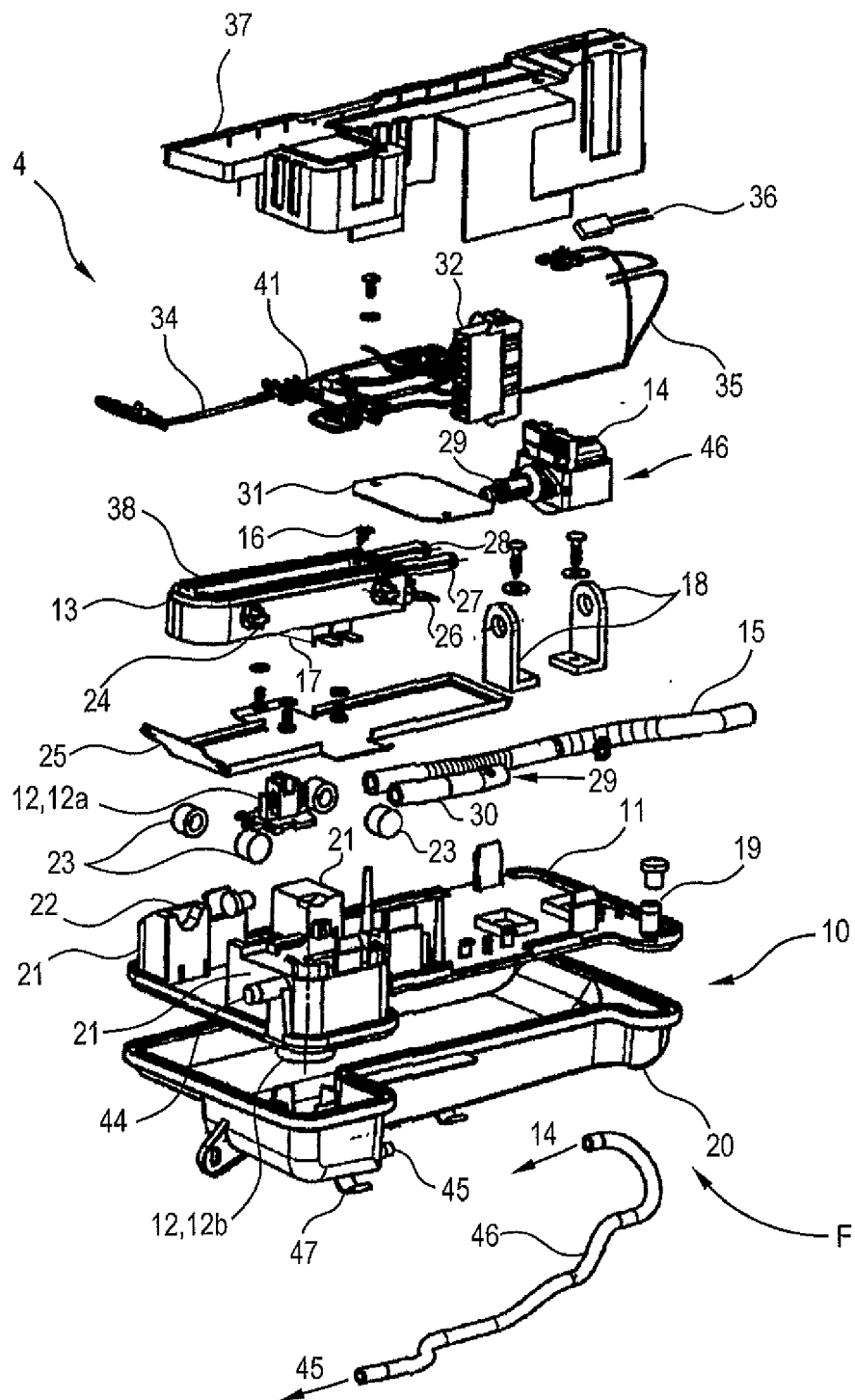


Fig. 4

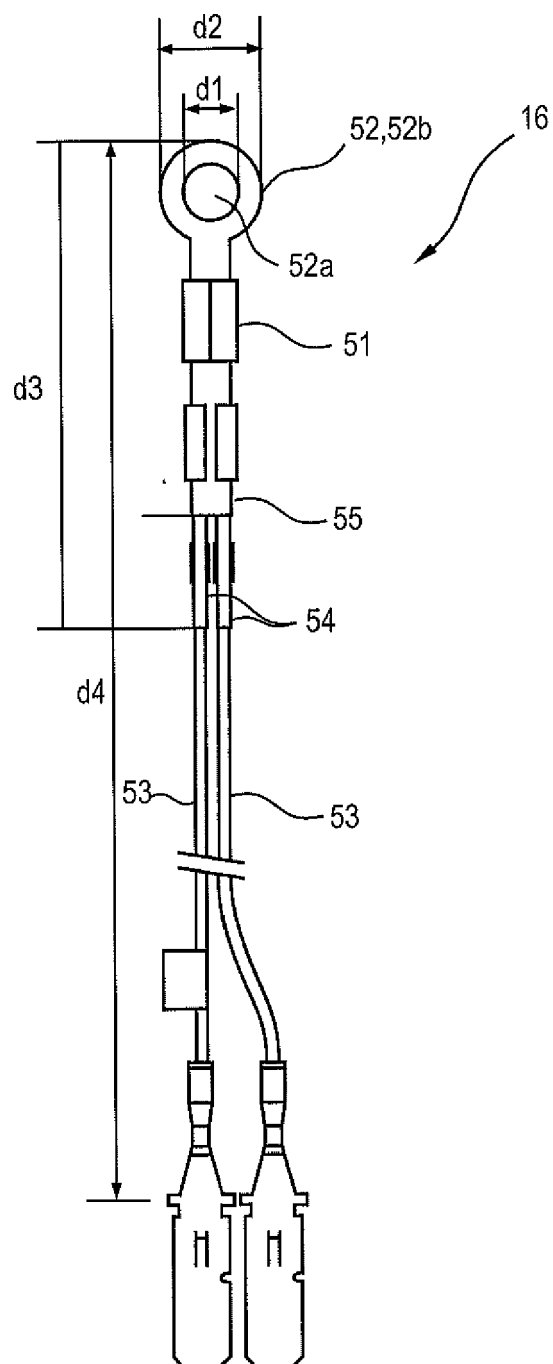


Fig. 5

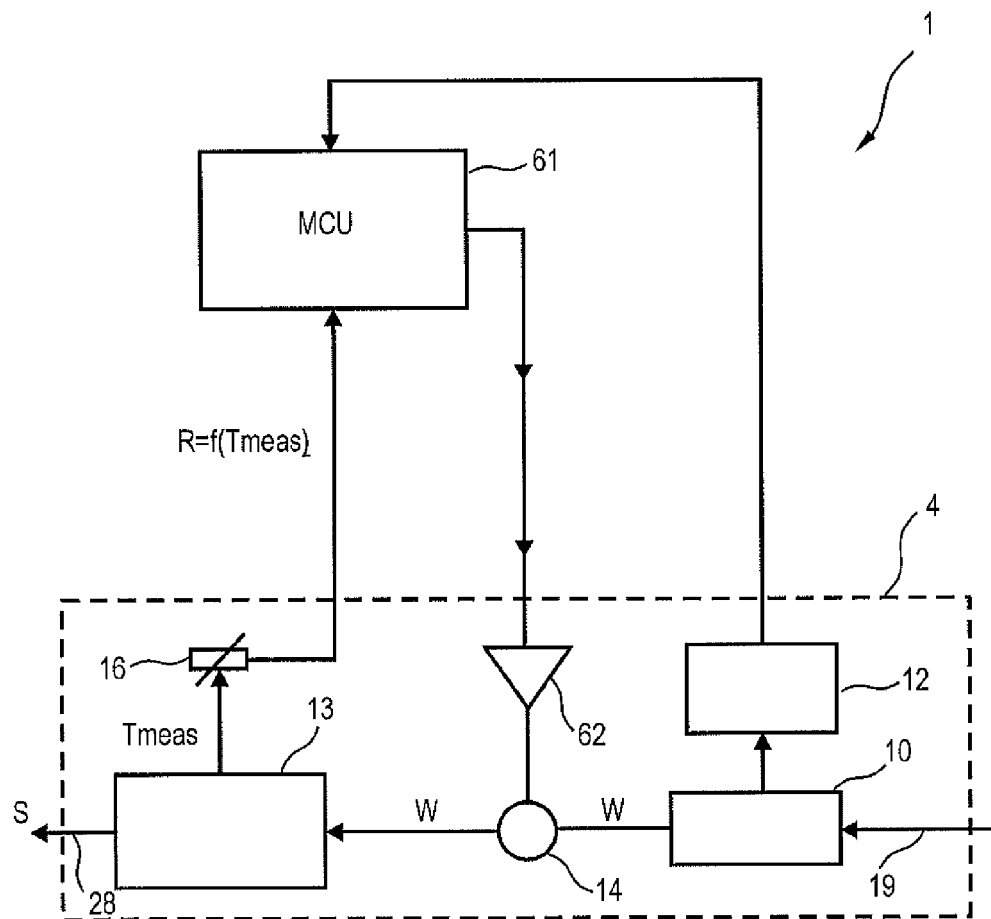


Fig. 6

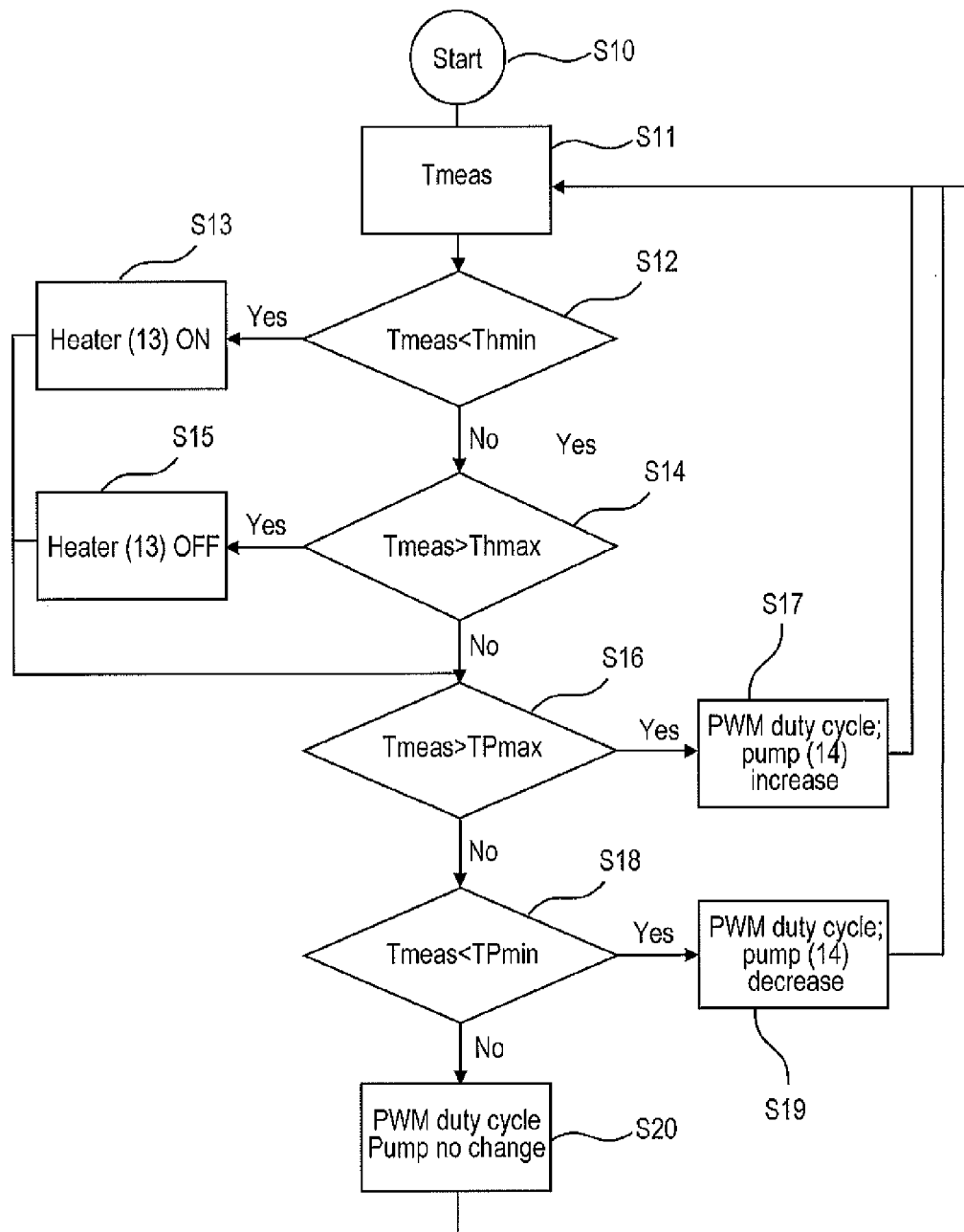


Fig. 7

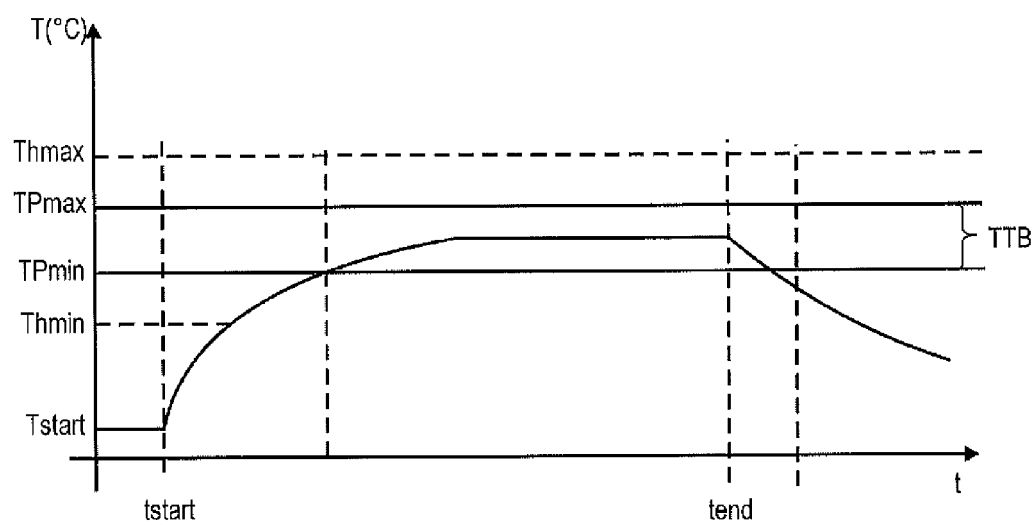


Fig. 8



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Place of search Munich		Date of completion of the search 10 February 2010	Examiner Spitzer, Bettina
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EPO FORM 1503 03.82 (P04C01)



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Place of search Munich		Date of completion of the search 10 February 2010	Examiner Spitzer, Bettina
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