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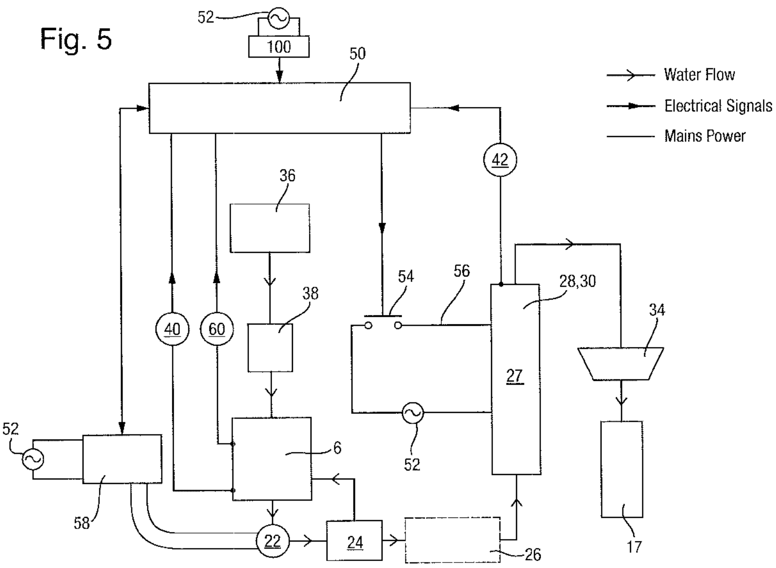
(54) Title: LIQUID HEATING APPARATUS AND OPERATING METHODS

Fig. 5



(57) Abstract: An apparatus for dispensing a predetermined volume of a warm liquid comprises a heater (27), a pump (22) and a temperature sensor (40) sensitive to the temperature of the liquid upstream of the heater (27). A controller (50) is arranged to receive upstream temperature data from the temperature sensor (40), calculate the amount of energy required to reach a desired final temperature, energise the heater (27) for a calculated period of ON time, and dispense liquid for a calculated period of time that is at least partly contemporaneous with the calculated period of ON time. After the heater (27) has been de-energised, the dispensed liquid removes residual heat so that the average temperature after dispensing the predetermined volume is the desired final temperature.

WO 2014/114935 A1

Liquid Heating Apparatus and Operating Methods

This invention relates to methods and apparatuses for heating a predetermined volume of water to a desired temperature, for example warm water for use in the preparation of infant formula milk or other infant food.

The current manufacturing technology does not make it feasible to produce and store sterile powdered infant formula, which is subsequently used to make infant formula milk. The World Health Organisation (WHO) guidelines on preparation of infant formula milk ("Safe preparation, storage and handling of powdered infant formula: Guidelines", WHO, 2007) therefore recommend that the powdered infant formula is reconstituted by mixing it with water that has a temperature of greater than 70°C in order to sterilise the powdered infant formula which can become contaminated with harmful bacteria such as Enterobacter Sakazakii and Salmonella Enterica.

Presently powdered infant formula or infant food is typically reconstituted by using water that was recently boiled in a kettle in order to sterilise the powdered infant formula and then allowing the liquid to cool to a temperature suitable for giving to the infant - e.g. typically approximately body temperature or a few degrees higher. However, this is a time-consuming operation and it can be difficult to judge the correct temperature accurately.

Even if the infant formula milk is not sterilised before administration using very hot water (e.g. > 70°C), it is still desirable to prepare the formula so that the milk has a final temperature around body temperature e.g. 37°C when it is administered to an infant. In practice this often means that the preparation must be left to cool to the desired final temperature after mixing warm or hot water with the formula. There is no reliable way to immediately reconstitute the powdered formula at the right temperature. Although cold water can be added to a preparation to speed up the cooling process, there is a risk of the cold water not being sterile and this can affect the correct dosage as well as the final temperature.

There remains a need for an improved method of dispensing a controlled volume of warm water at a controlled temperature for the reconstitution of infant formula milk, infant food, and other purposes.

When viewed from a first aspect the invention provides a method of operating an apparatus comprising heating means and a pump to dispense a predetermined volume of a warm liquid, said method comprising the steps of: measuring the temperature of the liquid upstream of the heating means; calculating an amount of energy required for the heating means to heat the predetermined volume of the liquid from the upstream temperature to a desired final temperature; calculating a period of "ON" time required for energisation of the heating means to deliver the calculated amount of energy; energising the heating means for the calculated period of "ON" time; operating the pump during a first period of time to dispense a first volume of heated liquid at or above a predetermined initial temperature from an outlet of the apparatus, wherein the first period of time is at least partly contemporaneous with the calculated period of "ON" time; de-energising the heating means; and operating the pump for a second period of time subsequent to the first period of time to dispense a second volume of the liquid from the outlet of the apparatus thereby removing residual heat from the heating means, the first and second volumes together providing the predetermined volume, wherein the average temperature of the first and second volumes of the liquid is the desired final temperature after the predetermined volume has been dispensed.

When viewed from a second aspect the invention provides an apparatus for dispensing a predetermined volume of a warm liquid, comprising heating means, a pump, a temperature sensor sensitive to the temperature of the liquid upstream of the heating means, and control means arranged to: receive upstream temperature data from the temperature sensor, calculate the amount of energy required for the heating means to heat a predetermined volume of the liquid from the upstream temperature to a desired final temperature, calculate a period of "ON" time required for energisation of the heating means to deliver the calculated amount of energy, energise the heating means for the calculated period of "ON" time, operate the pump during a first period of time to dispense a first volume of heated liquid at or above a predetermined initial temperature from an outlet of the apparatus, wherein the first period of time is at least partly contemporaneous with the calculated period of "ON" time, de-energise the heating means, and operate the pump for a second period of time subsequent to the first period of time to dispense a second volume of the liquid from the outlet of the apparatus thereby removing residual heat from the heating means, the first and second volumes together providing the predetermined volume; wherein the average temperature of the first and second volumes of the liquid is the desired final temperature after dispensing the predetermined volume.

Thus the total amount of heat energy required to raise the temperature of the liquid from the upstream temperature to the desired final temperature is calculated and this is separated between the first volume of liquid which can, for example, be used to reconstitute the powdered infant formula at an initial temperature that is greater than 70°C, thus satisfying the WHO guidelines for preparation of the powdered infant formula, and the second volume of liquid at a lower temperature to give the total predetermined volume of dispensed liquid an average temperature equal to the desired final temperature, e.g. at 37°C which is suitable for feeding to an infant. I.e. the desired final temperature is the average temperature of the liquid in the receptacle, e.g. a baby bottle, once all the liquid has been dispensed.

It will therefore be appreciated that the method and apparatus of the present invention allow a predetermined volume of liquid at a desired final temperature to be provided in an accurate and repeatable delivery. As well as calculating the "ON" time where the heating means is energised, i.e. to determine the amount of heat energy available to the liquid, the method may calculate the first and second periods of time for dispensing the first and second volumes of liquid, i.e. to ensure that the first and second volumes together provide the predetermined volume that a user wishes to be dispensed. Accordingly the pump may be operated during a first calculated period of time and for a second calculated period of time subsequent to the first period of time. As will be explained below, the second calculated period of time may follow immediately after the first calculated period of time, or there may be a pause between the first and second periods of pump operation. It will be understood that the calculated period of "ON" time for energisation of the heating means, and the calculated first and second periods for operation of the pump, may be calculated such that the predetermined volume of liquid has the desired final temperature after it has been completely dispensed. This means that a user simply has to initiate the dispensing process and the result will be a predetermined volume of liquid being dispensed with a desired final temperature. The second period of pump operation is calculated so as to remove residual heat from the heating means such that the predetermined volume of liquid has the desired final temperature e.g. 37°C.

The separation of the dispensing between the first and second periods of time may also allow a user to mix the first volume of liquid with the powdered infant formula before the second volume of liquid is dispensed. This can be facilitated in a set of embodiments by preferably providing a pause in the pump operation between the first and second periods of time, as will be discussed below. In other embodiments the pump may be operated continuously through the first and second periods of time, the only difference being that the first period is contemporaneous with energisation of the heating means while the second period is subsequent to de-energisation of the heating means. A pause may not be required for a user to separately add powdered infant formula to the heated liquid, for example where the liquid is dispensed through a powder holder at the outlet, or where a user manually adds powder to the liquid before, during and/or after it is dispensed.

The heating means could comprise a batch heater in which the predetermined volume of liquid is heated for the calculated period of "ON" time before exiting the heating means. However in one set of embodiments the heating means comprises a flow heater in which liquid is permitted to enter and exit the heating means while heating is taking place. The heating means may comprise a standard flow heater or a flow heater e.g. as discussed in the Applicant's published application WO 2010/106349 and background thereto. One example of such a flow heater is the "dual tube" variety in which a liquid flow conduit and a tube containing a sheathed heating element are provided adjacent one another, e.g. brazed together. If a traditional flow heater having a "dual tube" design is used to heat liquid to boiling then the entrained steam can cause problems that prevent liquid from being evenly heated to boiling point. A solution to such problems is a flow heater that permits the separate exit of steam, e.g. as disclosed by WO 2010/106349. Where the flow heater is used to heat liquid to temperatures below boiling then steam may be permitted to escape separately, e.g. as discussed in the Applicant's published application WO 2011/077135, or steam and liquid may simply exit together from the same flow conduit. In present embodiments the desired final temperature is preferably below boiling and there may be no need for the flow heater, or other heating means, to heat liquid to boiling point. The heating means, e.g. a flow heater, may be arranged to heat the liquid to temperatures below boiling so that the phenomenon of spitting owing to hot spots and localised boiling is reduced or avoided. The heating means may be of fixed power, with the nominal heating power rated at 800 W, for example. In various examples the heating means, which is preferably a flow heater, may operate at a relatively low power such as 800 W, 900 W or 1 kW.

The apparatus could be directly connected, e.g. permanently, to a liquid supply for supplying the liquid to the pump and the heating means, for example plumbed into a mains water supply. However in one set of embodiments the apparatus comprises a reservoir for supplying liquid to the heating means. Preferably the reservoir is removable to allow it to be refilled easily by a user, e.g. from a tap. The reservoir may comprise a minimum fill sensor, e.g. connected to the control means, which is arranged to prevent operation of the apparatus (or at least of the heating means and/or pump) when the liquid level in the reservoir is below the minimum fill level. This disabling of the apparatus protects against the heating means overheating, i.e. a boil dry situation which could damage the heating means.

Whether the apparatus is connected in-line with a liquid supply, for example the mains water supply, or provided with a reservoir, the Applicant has appreciated that it may be desirable to treat (and preferably sterilise) liquid before it reaches an outlet of the apparatus. This is most conveniently achieved by providing treatment means upstream of the pump and/or heating means, although in practice the treatment means may be arranged anywhere upstream of the outlet. In one set of embodiments in which the apparatus comprises a reservoir, a treatment means may be provided upstream/downstream of the reservoir, or in the reservoir, or at an inlet/outlet of the reservoir. The treatment means may take the form of a filter, preferably an anti-microbial filter. If a filter is used then it may be preferable for it to be provided upstream of the reservoir so as not to unduly limit the flow rate out of the reservoir during operation of the apparatus. However other forms of treatment may be used instead of, or in addition to, a filter - for example UV treatment, chlorine treatment, ozone treatment, or any combination of such disinfection treatments. The aim of the treatment means is to eliminate biological contaminants and other substances so that the liquid is purified before being dispensed, which can be particularly important when dispensing warm water to make infant formula milk or food.

In one set of embodiments it is envisaged that the treatment means may comprise a heating means arranged to boil the liquid for a minimum period of time so as to achieve sterilisation. The treatment means may use its own heating means for this purpose, but preferably the treatment is carried out during the calculated period of "ON" time that the heating means is energised to deliver the calculated amount of energy to the predetermined volume of liquid. This may require the apparatus to compare the calculated period of "ON" time with a minimum period of time to ensure that sterilisation is achieved. For example, WHO guidelines specify that water should be boiled for "several minutes" to deactivate or kill pathogenic microbes. In such embodiments the apparatus may further comprise a heat exchanger so that the treated liquid can be cooled before being dispensed.

In the set of embodiments in which the apparatus comprises a reservoir, the apparatus may comprise an intermediate holding chamber between the reservoir and the pump, and means for filling the holding chamber from the reservoir to a predetermined level. In accordance with such embodiments the pump does not draw liquid directly from the reservoir but rather from the intermediate holding chamber. Since it is filled to a predetermined level, the pressure head at the pump inlet will be known and can therefore be factored into the calculations of pump speed, flow rate etc. Preferably the intermediate holding chamber has a smaller volume than the reservoir. Even though the level of liquid in the intermediate holding chamber may reduce during dispensing, the variation in pressure is over a smaller range than it would be if the liquid were to be drawn from the larger reservoir.

Where a reservoir is provided, preferably the upstream temperature is measured in the reservoir (or in the intermediate holding chamber, again where provided). In one set of embodiments the step of calculating the energy required for the heating means to heat a predetermined volume of the liquid from the upstream temperature to a desired final temperature comprises measuring the temperature of, or downstream of, the heating means, i.e. the apparatus comprises a temperature sensor sensitive to the temperature of, or downstream of, the heating means. Measuring the temperature of the heating means or the downstream temperature gives an indication of the residual energy in the apparatus, for example owing to the ambient temperature and/or the apparatus having been operated recently and therefore the heating element providing some residual heat, which can be factored into the calculation of the energy required to heat the predetermined volume to the desired final temperature. For example, if the apparatus contains some residual heat energy from a previous operation, the energy required for heating the predetermined volume to the desired final temperature will be lower than if the apparatus had not been used for a long period of time. Thus, for a heating means of fixed power, for example, the calculated period of "ON" time for energising the heating means will be shorter.

The downstream temperature could be sensitive to any residual liquid in the apparatus, but preferably it is sensitive to the temperature of whatever means are used to transport liquid from the heating means to the dispensing outlet, e.g. a conduit or pipe. Thus, at least in some embodiments, the calculated energy includes the thermal capacity of the heating means and any other heat sinks downstream of the heating means. The calculated energy could also compensate for heat losses from the system, particularly if there is a pause between the first and second periods of time. The duration of the pause could be measured and used by the control means in the calculation of the calculated energy. Practically, however, the energy loss may be accounted for by an estimated, or previously calibrated, constant, e.g. 10% of the calculated energy.

The power supplied to the heating means could be varied, e.g. controlled by the control means, in order to match the power of the heating means to the flow rate of the liquid through the heating means. This could be used to ensure that the liquid temperature is kept at (or above) the predetermined initial temperature for the entirety of the first period, compared to having the average temperature of the liquid dispensed in the first period corresponding to the predetermined initial temperature. However, in one set of embodiments the power supplied to the heating means by the control means is constant (although there may be fluctuations in the mains power supply, as will be discussed below). This simplifies the calculation of the energy required.

The apparatus could comprise means for measuring the flow rate of the liquid through the heating means. If this measurement is fed to the control means it allows the control means to control the operation of the pump for the first and second periods of time, i.e. in order to dispense the predetermined volume of liquid. The means for measuring the flow rate could comprise a flow meter, either provided as a separate component or as part of the pump, e.g. the pump could be used to deduce the flow rate. The pump may, in some examples, be relied upon to deliver liquid at a substantially constant flow rate regardless of the liquid pressure (e.g. as set by a mains supply or upstream head of liquid in a reservoir). However, in one set of embodiments the apparatus comprises means for delivering a constant flow rate of the liquid through the heating means, e.g. a flow regulator. This could be provided by an electronic flow rate control, e.g. a valve, but preferably there is provided a flow regulator of the type described in WO 2012/114092, the contents of which are hereby incorporated by reference.

A constant flow rate allows for simpler control of the apparatus as the means for delivering the flow rate sets a constant flow rate of the liquid through the heating means that is preferably independent of the pressure delivered by the pump. For example, some pumps such as a solenoid pump tend to operate an elastomeric diaphragm rather than a piston and may deliver different flow rates depending on the liquid pressure. This may be achieved using a relatively inexpensive component such as a flow regulator. Thus the first and second periods of time can be calculated simply based on the volume of liquid to be dispensed in each of these periods, and then the predetermined volume of liquid is simply dispensed by operating the pump for a fixed period of time overall, i.e. the sum of the first and second periods of time. The means for measuring the flow rate of the liquid through the heating means or the means for delivering a constant flow rate of the liquid through the heating means is preferably located downstream of the pump and upstream of the heating means, i.e. between the pump and the heating means.

A constant flow rate also makes it easier to dispense the first volume of liquid at the predetermined initial temperature, e.g. the means for delivering a constant flow rate could be chosen to match the rate of heat transfer from the heating means into the liquid such that the first volume of liquid is dispensed at a relatively constant temperature over the first period of time. This may be set by the pump itself (e.g. a positive displacement pump) or by a flow regulator downstream of the pump (e.g. a solenoid pump). The constant flow rate is preferably between 100 ml/minute and 300 ml/minute, e.g. between 150 ml/min and 250 ml/min, and preferably about 170 ml/min, and this could be measured during calibration of the apparatus, for example. Alternatively the flow regulator could be preset with a reliable flow rate, e.g. suitable pressure-compensating constant flow valves are available from Netafim (www.netafim.com). Providing a means for delivering a constant flow rate also reduces the effect from variations in the flow rate from the pump with time, supply voltage, wear, etc.

As the total amount of energy required to be delivered by the heating means has been calculated and, in some embodiments, the flow rate of liquid through the heating means is known or calculated, it is not necessary to measure the final liquid temperature, e.g. to check that it has reached the predetermined initial temperature in the first period of time. All that is necessary for this is the measurement of the temperature upstream of the heating means, the calculation of the energy to be delivered to the predetermined volume of liquid and the flow rate of liquid through the heating means. As is discussed below, any fluctuations in the mains power supply that may affect operation of the heating means and/or pump can also be taken into account.

The predetermined initial temperature could be an average temperature of the liquid dispensed in the first period of time or the liquid could be dispensed at a constant predetermined initial temperature in the first period of time. However this is difficult to achieve, at least initially when the system is unlikely to be in equilibrium, and so there is always likely to be at least some minor temperature fluctuations in the dispensed liquid. Therefore the predetermined initial temperature could correspond to a minimum temperature, above which the liquid is dispensed in the first period of time. In a set of embodiments this may correspond to a sterilisation temperature for the bottle and/or the powdered infant formula. Preferably the predetermined initial temperature is greater than 60°C, e.g. greater than 65°C, and further preferably greater than 70°C. The predetermined initial temperature could be set by a user, e.g. via an input on the apparatus, to allow it to be varied between operations or could be programmed into the apparatus. In one set of embodiments the predetermined initial temperature of the initially dispensed first volume of liquid is preset at around 95°C. This ensures sterilisation of the powdered infant formula and is similar to the temperature of just-boiled water that is used conventionally. In general the predetermined initial temperature may be greater than the desired final temperature, i.e. the temperature of the first volume of liquid dispensed is greater than the temperature of the second volume of liquid dispensed.

In some embodiments the predetermined initial temperature may be substantially the same as the desired final temperature or not much higher than the desired final temperature. For example, in situations where the liquid temperature upstream of the heating means is not much lower than the desired final temperature, the calculated amount of energy to be delivered by the heating means may be relatively small and liquid may therefore be dispensed at about the same temperature during the first period of time while the heating means is energised and during the second period of time while residual heat is being removed. This may occur when the apparatus is operated in an environment having a relatively high ambient temperature, for example greater than 25°C, 30°C, 35°C or even greater than 40°C. Where the liquid upstream of the heating means, for example in a reservoir, has a temperature that is already > 35°C then it can be difficult to achieve a predetermined initial temperature greater than 60°C or 70°C during the first period of time and subsequently attain a lower desired final temperature after dispensing the predetermined volume, unless the predetermined volume is large or the dispensing rate is very slow, because the residual heat can not be sufficiently dissipated. Preferably the predetermined initial temperature is greater than ambient temperature, for example greater than 25°C, 30°C, 40°C, or 50°C, but it may not be as high as 70°C, 80°C, 90°C or 95°C. For example, the heated liquid dispensed during the first period of time may have a temperature in the range of 50-70°C. In at least some embodiments a predetermined initial temperature may not be set or programmed at all. Whether the predetermined initial temperature exceeds a minimum temperature, or not, may simply depend on the starting temperature of the liquid upstream of the heating means as compared to the desired final temperature.

When viewed from a further aspect the invention provides a method of operating an apparatus comprising heating means and means for dispensing a predetermined volume of a warm liquid, said method comprising the steps of: measuring the temperature of the liquid upstream of the heating means; calculating an amount of energy required for the heating means to heat the predetermined volume of the liquid from the upstream temperature to a desired final temperature; calculating a period of "ON" time required for energisation of the heating means to deliver the calculated amount of energy; energising the heating means for the calculated period of "ON" time; dispensing a first volume of directly heated liquid from an outlet of the apparatus during a first calculated period of time, wherein the first period of time is at least partly contemporaneous with the calculated period of "ON" time; de-energising the heating means; and dispensing a second volume of liquid from the outlet of the apparatus for a second calculated period of time subsequent to the first period of time, the second volume of liquid being indirectly heated by removing residual heat from the heating means, the first and second volumes together providing the predetermined volume, wherein the average temperature of the first and second volumes of the liquid is the desired final temperature after the predetermined volume has been dispensed.

When viewed from another further aspect the invention provides an apparatus for dispensing a predetermined volume of a warm liquid, comprising heating means, means for dispensing liquid, a temperature sensor sensitive to the temperature of the liquid upstream of the heating means, and control means arranged to: receive upstream temperature data from the temperature sensor, calculate the amount of energy required for the heating means to heat a predetermined volume of the liquid from the upstream temperature to a desired final temperature, calculate a period of "ON" time required for energisation of the heating means to deliver the calculated amount of energy, energise the heating means for the calculated period of "ON" time, calculate a first period of time to dispense a first volume of directly heated liquid from an outlet of the apparatus, wherein the first period of time is at least partly contemporaneous with the calculated period of "ON" time, de-energise the heating means, and calculate a second period of time to subsequent to the first period of time to dispense a second volume of the liquid from the outlet of the apparatus that is indirectly heated by removing residual heat from the heating means, the first and second volumes together providing the predetermined volume; wherein the average temperature of the first and second volumes of the liquid is the desired final temperature after dispensing the predetermined volume.

As the calculated energy is that needed to heat the whole of the predetermined volume of liquid from the upstream temperature to the desired final temperature, the particular temperature profile of the liquid dispensed in the second period of time is not critical. As long as the flow rate of the liquid through the heating means is not too high then all the residual heat energy can be transferred from the heating means to the liquid while the dispensing of the second volume of the liquid in the second period of time is taking place. In practice this is not an issue, e.g. with a flow rate of less than 500 ml/min. Usually the control means does not need to calculate a maximum flow rate for each dispense operation, although it may be a value programmed or preset in the apparatus during factory calibration to limit the flow rate, e.g. in extreme circumstances. The choice of pump and/or use of a flow restrictor between the pump and the heating means may determine a maximum flow rate. Where there is provided means for delivering a constant flow rate through the heating means, such as a flow regulator, this can be chosen to provide a flow rate below the maximum. Therefore in general the liquid dispensed in the second period of time will reach thermal equilibrium with the heating means at or before the end of the second period of time. In other words, it is preferable for all residual heat to be removed during the second period. However, the heating means could be energised for at least the calculated period of "ON" time, i.e. possibly for a period longer than the calculated period of "ON" time, or for an additional ON period at a later time contemporaneous with the second period of time. This would thus leave some residual heat energy in the heating means. The flow rate through the heating means would then need to be calculated more accurately in order to transfer the correct amount of heat energy from the heating means to the liquid flowing therethrough during the second period of time.

The desired final temperature could be any suitable temperature for the particular application of the apparatus. The apparatus may be used, for example, to dispense warm liquid for the preparation of foodstuffs such as powdered soup or cold remedies, or to infuse delicate beverage materials such as white tea or green tea (e.g. brewed at 65°C to 85°C rather than using just-boiled water). However in one set of embodiments, particularly suitable for the preparation of infant formula, the desired final temperature is between 27°C and 47°C, preferably between 32°C and 42°C, and further preferably around 37°C. The desired final temperature could be set by a user, e.g. via an input on the apparatus, to allow it to be varied between operations or it could be programmed into the apparatus. As discussed above, it is not necessary to continuously monitor the final temperature of the heated liquid or a temperature at the outlet owing to the calculation of the energy needed to heat the predetermined volume of liquid to the desired final temperature. However the apparatus may comprise temperature sensing means at the outlet that is sensitive to the temperature of the heated liquid. This can be used as a feedback check to monitor the temperature of the dispensed liquid and may be used by the control means to control the first and second periods of pump operation or even the pump speed (e.g. where this controls the flow rate of the liquid through the heating means rather than a flow regulator) and/or the energisation of the heater (time and/or power) to fine tune the final temperature.

As the first period of time is at least partly contemporaneous with the calculated period of "ON" time, the energisation of the heating means overlaps in time with the first operation of the pump. The first period of time could exactly correspond to the calculated period of "ON" time, i.e. they may be energised simultaneously. Thus in a set of embodiments the method comprises energising the heating means to start the calculated period of "ON" time at substantially the same time as operating the pump to start the first period of time. Accordingly the calculated period of "ON" time may start at the same time as the first period of pump operation, without any preheating. The start of the calculated period of "ON" time may even be after the start of the first period of time, for example so that some of the first volume of liquid is dispensed before the heating means is energised. Such delayed heating might be used where the temperature of the liquid measured upstream of the heating means is above a certain threshold, such that a smaller amount of energy will be required to heat to the desired final temperature. However it may be easier in such circumstances to start the heating means at the same time as the pump and shorten the calculated period of "ON" time.

In one set of embodiments the start of the calculated period of "ON" time is prior to the start of the first period of time. Thus the heating means is energised before liquid is pumped therethrough, allowing the heating means to be preheated to or towards its operating temperature. This ensures that the heating means, e.g. comprising a heating element and a liquid flow conduit, is heated enough such that any residual liquid in the heating means and the initial volume of liquid pumped through the heating means is at the predetermined initial temperature, and avoids the risk that the initial volume of liquid dispensed is cold if the first period of time and the calculated period of "ON" time corresponded exactly. The method may therefore further comprise the step of energising the heating means for a predetermined period before the first period of time starts.

The preheating time for which the heating means is energised before the pump is operated could be fixed. However in one set of embodiments the heating means is energised for a preheating period before operation of the pump until a predetermined preheat temperature is reached. This could be measured by the temperature sensor sensitive to the temperature of, or downstream of, the heating means (where provided). In the set of embodiments comprising a sheathed heating element and a liquid flow conduit provided adjacent to one another, the temperature sensor may be provided in good thermal contact with one or both of the sheathed heating element and the liquid flow conduit. For example, the temperature of the heating means may be measured by a temperature sensing means in thermal communication with both the heating element and the liquid flow conduit, e.g. as is described in the Applicant's published application WO 2013/024286, the contents of which are hereby incorporated by reference. The predetermined preheat temperature of the heating element may be greater than 200°C, e.g.

210°C. Owing to the temperature gradients in the apparatus, typically this would heat the liquid flow conduit to just below 100°C.

In the first period of time, the pump could be operated continuously so as to provide a constant flow. However the inventors have appreciated that when the liquid flows through the heating means at a typical flow rate, e.g. as provided by a flow regulator downstream of the pump, the rate of transfer of heat energy from the heating means to the liquid can be greater than the power of the heater and therefore the heating means may cool down as liquid flows therethrough, particularly when the predetermined initial temperature is suitable for sterilisation, e.g. greater than 70°C. This causes the temperature of the dispensed liquid to vary considerably, i.e. to cool down, during the first period of time. To accommodate this phenomenon, the flow rate delivered to the heating means could be varied such that the rate of transfer of heat energy from the heating means to the liquid is matched to the power of the heater, e.g. by reducing the flow rate. Where liquid is pumped directly to the heating means without using a flow regulator then this may be achieved by adjusting the pump speed. However in one set of embodiments the pump is operated periodically during the first period of time, i.e. in bursts, to adjust the overall flow rate. This is particularly suited to embodiments that use a constant flow regulator between the pump and the heating means. Such pulsed operation allows the heating means to increase in temperature between the time(s) in which liquid is being pumped, so that the liquid pumped during the first period of time can be more accurately dispensed at the predetermined initial temperature.

The end of the first period of time may coincide with the end of the calculated period of "ON" time or even before it, i.e. the pump could stop pumping at or before the time at which the heating means is de-energised. However in one set of embodiments the end of the first period of time is after the end of the calculated period of "ON" time, i.e. preferably the pump continues to pump liquid after the heating means has been de-energised. This prevents overheating of the heating means.

As long as the second period of time starts after the first period of time, and preferably starts after the heating means has been de-energised, there are a number of different possibilities for the start of the second period of time. For example, the second period of time could occur immediately after the first period of time, with continuous operation of the pump. In these embodiments the start of the second period of time would generally be defined by the time at which the heating means is de-energised. Accordingly, the step of de-energising the heating means may end the first period of time (e.g. where liquid is directly heated) and the pump may operate continuously to immediately start the second period of time (e.g. where liquid is indirectly heated by removing residual heat). There may not be any pause between the first and second periods of pump operation. For example, the apparatus may include means for adding infant formula milk powder (or other foodstuff(s) to be reconstituted) to the liquid as it is being dispensed, without user intervention being required.

However in one set of embodiments the pump is stopped between the first and second periods of time, i.e. there is a pause. This means that no liquid is being dispensed in this intermediate period of time and allows, for example, powdered infant formula to be added to a bottle and mixed with the first volume of liquid before the second volume of liquid is dispensed, or the bottle to be shaken or stirred if the powdered infant formula was added to the bottle before the first volume of liquid was dispensed. The pause may be between 30 s and 60 s, e.g. 45 s. This relatively short period of time limits the amount of heat energy lost from the heating means. In practice a pause of short duration, e.g. less than 60 s, may not affect the amount of residual heat remaining. The duration of the pause could be predetermined and occur automatically. However in one set of embodiments the duration of the pause is determined by the user. For example, the user could initiate the second period of time, e.g. by pressing a button. This may allow a user to override a pre-programmed pause when desired to dispense the second volume more quickly.

It will be appreciated that the length of each of the first and second periods of time for pump operation is calculated taking into account the temperature of the liquid upstream of the heating means, which determines the amount of energy required to heat a predetermined volume of liquid to a desired final temperature. Typically the desired final temperature is warmer than ambient temperature, e.g. greater than 25°C, 30°C, 40°C, or 50°C. However such final temperatures may be achieved by directly heating a first volume of liquid that is the same as, or smaller than, the second volume of liquid that is indirectly heated by removing residual heat after the heating means has been de-energised. Accordingly the second volume of liquid may be greater than the first volume of liquid. It has been found that the second period of pump operation may act to make up the predetermined volume by removing substantially all residual heat from the heating means, which can take longer than the first period of direct heating. Accordingly the second period of time may be longer than the first period of time. In fact the second period of time is calculated to ensure an energy balance, so that the desired final temperature is accurately achieved for a given predetermined volume being dispensed.

The first volume of liquid may be between 20 ml and 100 ml, preferably between 20 ml and 60 ml. This is around 20% of the feed size (e.g. 270 ml - 300 ml maximum) for infant formula. The second volume of liquid may be between 50 ml and 250 ml, preferably between 100 ml and 240 ml, i.e. in general the second volume of liquid may be greater than the first volume of liquid. Each of the amounts for the first and the second volumes of liquid could be selected by a user, e.g. via a user interface in which the user inputs a value or selects from a number of pre-programmed options, e.g. standard bottle sizes. However, in one set of embodiments it is the predetermined volume of liquid, i.e. the total volume of liquid dispensed which is selected by a user. The control means then calculates the first and second volumes of liquid, based on the desired final temperature and the predetermined initial temperature of the first volume of liquid. The predetermined volume of liquid may be between 50 ml and 350 ml, preferably between 60 ml and 300 ml, e.g. 200 ml may be typical for infant formula but of course the volume will depend on the age of the infant to be fed. The invention extends to an apparatus as described herein for dispensing a predetermined volume of warm liquid, preferably water, chosen from one or more of: 60 ml, 120 ml, 150 ml, 180 ml, 250 ml, 270 ml, 300 ml, 340 ml.

The pump could be any suitable pump for delivering the required flow rates of liquid through the apparatus. In one set of embodiments the pump comprises a solenoid pump. Such a pump is able, for example, to deliver a pressure of preferably greater than 0.5 bar and preferably up to 4 bar. Where provided, this allows the flow regulator, as discussed above, to deliver a constant flow rate, e.g. of 170 ml/minute. Such constant flow regulators typically need a minimum pressure, e.g. 0.5 bar, to operate and are therefore preferably provided in combination with a solenoid pump to pressurise the flow upstream of the regulator.

In another set of embodiments the pump comprises a positive displacement pump, such as a piston pump. Such pumps can operate at practically constant flow rates (averaged over time) across a wide range of liquid pressure. Where the pump can itself be relied upon to provide a constant flow of liquid to/through the heating means, then a flow regulator as mentioned above may be omitted.

It will be appreciated that other pump arrangements may fall within the scope of the present invention. The apparatus may not even comprise a distinct pump device. It is mentioned above that the apparatus could be directly connected, (e.g. permanently) to an external liquid supply, for example plumbed into a mains water supply. Where the apparatus is connected in-line with a liquid supply such as the mains water supply, it is envisaged that the "pump" may simply comprise a valve to control when liquid is dispensed from the external supply. In such embodiments the flow rate through the heating means may be regulated using a constant flow rate means, for example as already discussed above. In one set of embodiments the apparatus comprises a pressure relief valve arranged to vent excess pressure from the heating means, e.g. in the event of a blockage in or downstream of the heating means. The pressure relief valve could be placed downstream of the heating means, but preferably is located upstream of the heating means, e.g. between the reservoir and the heating means, as this does not interfere with the final dispensing of the heated liquid at the outlet of the apparatus. The pressure relief valve could vent to the atmosphere, e.g. a drain outside of the apparatus, or to a drip tray. Conveniently, however, the pressure relief valve vents back into the reservoir, where provided.

In one set of embodiments the control means receives data from the various inputs in the apparatus, e.g. the temperature and water level sensors, and uses this data to control the pump and/or the heating means, i.e. from the calculations it performs. The control means may comprise a microprocessor in data communication with the various components. As indicated above, the apparatus may be calibrated during its manufacture in a factory and/or by a user before its first operation. The values and relationships determined during calibration are preferably used by the control means to control the operation of the apparatus.

It is mentioned above that the local mains power supply voltage may be taken into account when the apparatus is calibrated before its first use, e.g. in the factory or by a user as part of an initial set-up process. While the heating means may be rated to provide a fixed nominal power output, this can be affected by differences in the mains power supply. For example, the mains supply in Europe is generally 230 V but in China it is 220 V instead. The apparatus may be calibrated for use in other countries, such as the USA where the mains power is only 120 V, or for the 100 V supply in Japan. However, even beyond this calibration there may be fluctuations in the mains power supply during use of the apparatus that can affect its performance, especially when seeking to dispense a predetermined volume of liquid at an accurate final temperature. In a set of embodiments it is therefore preferable for operation to include the step of measuring the mains supply voltage and further preferably adjusting operation of the heating means and/or of the pump to take into account the mains supply voltage.

In the UK the mains power supply is specified as 230 V (+10%, -6%) by EN 61000-4-14. Voltage fluctuations even within this range can have serious effects on the power output of the heating means and/or pump, as power is proportional to voltage squared. Some class 1 electrical equipment is designated as being sensitive to mains power fluctuations and needs to be connected to a protected mains power supply (e.g. using a constant voltage transformer), but domestic appliances in class 2 are intended to be directly connected to the mains supply and do not have any such protection. An apparatus according to the present invention is most likely a class 2 domestic appliance e.g. with a cable for direct connection to the mains power supply.

The mains supply voltage could potentially be predicted depending on the time of day (as fluctuations typically occur according to known usage patterns) but it is more accurate to actually measure the mains supply voltage. The control means may be arranged to measure the mains supply voltage in any suitable way. For example, the control means may include or be connected to a supply voltage sensor (e.g. as sold by Eaton Corp. or other suppliers). In a preferred set of embodiments the control means comprises a voltage measuring circuit connected to the mains power supply of the apparatus. The voltage measuring circuit is preferably part of, or connected to, a microprocessor of the control means that is arranged to adjust operation of the heating means and/or of the pump to take into account the mains supply voltage. The voltage measuring circuit may be an analogue circuit with an analogue-to-digital converter used to provide a digital input to the microprocessor that represents the measured voltage level.

The measured mains supply voltage could be used by the control means to adjust the power of the heating means so as to achieve the same power output regardless of fluctuations in the mains power. However, as is mentioned above, it is preferable that the control means does not adjust the power supplied to the heating means. The energy output of the heating means will therefore vary depending on fluctuations in the mains supply voltage. To ensure that the heating means delivers the calculated amount of energy required, the measured mains supply voltage is preferably taken into account when calculating the period of time required for energisation of the heating means.

This is considered novel and inventive in its own right, and thus when viewed from a further aspect the present invention provides a method of operating an apparatus comprising heating means and a pump to dispense a predetermined volume of warm liquid, the method comprising the steps of: measuring the mains supply voltage provided to the heating means; measuring the temperature of the liquid upstream of the heating means; calculating the amount of energy required for the heating means to heat a predetermined volume of the liquid from the upstream temperature to a desired final temperature; calculating a period of time required for energisation of the heating means to deliver the calculated amount of energy, taking into account the measured mains supply voltage; energising the heating means for the calculated period of "ON" time; and operating the pump to dispense the predetermined volume of liquid.

According to a yet further aspect there is provided an apparatus for dispensing a predetermined volume of warm liquid, comprising heating means, a pump, a temperature sensor sensitive to the temperature of liquid upstream of the heating means, and control means arranged to: measure the mains supply voltage provided to the heating means; receive upstream temperature data from the temperature sensor; calculate the amount of energy required for the heating means to heat a predetermined volume of liquid from the upstream temperature to a desired final temperature; calculate a period of time required for energisation of the heating means to deliver the calculated amount of energy, taking into account the measured mains supply voltage; energise the heating means for the calculated period of "ON" time; and operate the pump to dispense the predetermined volume of liquid.

It will be appreciated that using such a method or apparatus it is possible to adjust the heating process to compensate for fluctuations in the local mains power supply, e.g. that may happen at different times of the day, without needing to adjust the power supplied to the heating means. Furthermore, as it is a predetermined volume of liquid that is being heated rather than a continuous flow (e.g. as in a conventional beverage dispensing apparatus providing hot water for tea, coffee, etc.) the flow rate is not really linked to the final temperature to be achieved as long as the predetermined volume is accurately dispensed (and the calculated amount of energy is transferred effectively from the heating means).

According to embodiments of these further aspects of the invention the predetermined volume of warm liquid may be dispensed by one or more periods of operating the pump. It is envisaged that the pump may be operated before and/or after energising the heating means i.e. for a period of time that is not contemporaneous with the calculated period of "ON" time. This may be used where the heating means comprises a batch heater rather than a flow heater. However in preferred embodiments the pump is operated during a first period of time that is at least partly contemporaneous with the calculated period of "ON" time to dispense a first volume of the liquid, the heating means is de-energised, and the pump is subsequently operated for a second period of time to dispense a second volume of the liquid, wherein the first and second volumes together provide the predetermined volume of liquid. As is discussed above, the pump may operate continuously, so that the second period of time immediately follows the first period of time, or there may be a pause in pump operation between the first and second periods of time.

Preferably, after dispensing the predetermined volume of liquid the average temperature of the first and second volumes is the desired final temperature. Accuracy of the final temperature is ensured as a result of measuring the actual mains supply voltage provided to the heating means and taking this into account when calculating the time period for which the heating means is energised.

Variations in the mains supply voltage may also affect the output of the pump, which can be relevant to embodiments of any of the aspects of the invention. If the pump delivers liquid directly to the heating means, e.g. without a constant flow regulator between the pump and the heating means, then the flow rate will depend on pump speed. In such embodiments the measured mains supply voltage may be taken into account (alternatively or in addition) when calculating the flow rate delivered by the pump and/or the period(s) of time for pump operation. The speed and/or the period of operation of the pump may be controlled accordingly. This can help to ensure that the predetermined volume of warm liquid is accurately dispensed, rather than the volume being over- or under-dispensed as a result of fluctuations in the pump speed. However in a preferred set of embodiments a constant flow regulator is used (as described above) to set a constant flow rate and therefore changes in the pump power do not need to be taken into consideration.

The mains supply voltage could be measured regularly and this information used to update a calculation of the heating time period. However it is preferable to perform a single measurement of the mains supply voltage, e.g. at the start of a dispensing cycle, so as to calculate the heater energisation period once and then proceed to heat and dispense the predetermined volume. A dispensing cycle, and in particular the energisation period of the heating means, will typically only last one or two minutes or less for the predetermined volumes of liquid e.g. water typical for making infant formula milk. This means that there is no need for a closed feedback loop with adjustment of the heating period after the mains supply voltage has been measured at the start. Of course this helps to simplify the calculations performed by the control means while also ensuring accuracy in the heating process.

As used herein the term sterilisation is intended to refer to the process of killing potentially harmful bacteria and germs. It should not be interpreted as implying a particular level of sterility - e.g. meeting a definition of clinically sterile or indeed any other particular definition or effectiveness.

Certain embodiments of the invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Fig. 1 is a perspective view of an appliance in accordance with an embodiment of the invention;

Figs. 2 and 3 are front and rear perspective views of the major internal components of the appliance shown in Fig. 1;

Fig. 4 is a cross-sectional view of the water tank shown in Fig. 2 and 3;

Fig. 5 is a schematic diagram showing the flow of water, power and electrical signals through the appliance;

Fig. 6 is a voltage measuring circuit diagram;

Fig. 7 is flow chart outlining the main steps involved in a complete dispensing cycle according to a first embodiment;

Fig. 8 is a plot of the operation of the appliance;

Fig. 9 is a plot showing a temperature profile for water in the bottle;

Fig. 10 is another flow chart outlining the main steps involved in a complete dispensing cycle according to a second embodiment;

Fig. 11 is a plot showing operation and temperature profiles when dispensing a 120 ml volume of heated liquid according to the cycle of Fig. 10; and

Fig. 12 is a plot showing operation and temperature profiles when dispensing a 330 ml volume of heated liquid according to the cycle of Fig. 10.

Fig. 1 is a perspective view of an embodiment of the invention and shows an appliance 1 for dispensing warm water for the preparation of infant formula milk from powdered infant formula. The appliance is shown with an outer housing 2, in which is provided a window 4 for viewing the water level in the internal water tank 6 (see Figs. 2 and 3). On the right hand side of the housing 2 there are three user input buttons 8. These are used to set the timer when a new water filter has been installed, to run a cleaning cycle of the appliance 1, and to run a descaling cycle. A panel of LEDs 10 display various operational states of the appliance 1, i.e. a warning light to indicate that the water filter need changing. An on-off button 12 and rotatable dispense volume dial 13 are provided above the dispensing outlet 14, which is located above a drip tray 16. A baby bottle or cup 17 (shown in Fig. 5) can be placed on the drip tray 16 such that in use the heated water is dispensed into the bottle or cup 17, with the outer housing 2 having a vertically extending recess 18 between the drip tray 16 and the dispensing outlet 14 to accommodate the bottle 17.

The major internal components of the appliance 1 can be seen in the perspective views of Fig. 2 and 3, from the front and rear of the appliance 1 respectively, in which the outer housing 2 has been removed. The internal water tank 6 with its window 4 is shown on the left, and has an outlet 19 towards its base which feeds a water conduit 20. The water conduit 20 passes first through a pump e.g. solenoid pump 22 and then past a pressure relief valve 24 and through a pressure compensating constant flow valve 26. The pressure relief valve 24 vents back into the water tank 6 in the event of the water conduit 20 becoming over-pressurised. A suitable pressure compensating constant flow valve 26 is available from Netafim (www.netafim.com).

After the pressure compensating constant flow valve 26, the water conduit 20 passes to a flow heater 27 in which a water flow tube 28 is brazed to a sheathed heating element 30. Cold tails 32 at either end of the sheathed heating element 30 connect it to a power supply (not shown). The water flow tube 28 passes to the final section of the water conduit 20 which then feeds to a dispensing head 34 and the outlet 14. The dispensing head 34 may take the form of an intermediate chamber receiving the liquid and/or vapour that exits from the flow heater 27. The dispensing head 34 may help to enable any steam to separate from the heated liquid so that there is a controlled flow out of the outlet 14 without any spitting.

The inside of the water tank 6 can be seen in the cross-sectional view of Fig. 4 which shows that a water hopper 36 is provided inside the top of the water tank 6. It is this water hopper 36 into which untreated water, e.g. tap water, is placed. An anti-microbial filter 38 is located at the bottom of the water hopper 36 to allow water to drain into the bottom of the water tank 6 before it exits the tank via the outlet 19. Also can be seen is the inlet 37 into the water tank 6 from the pressure relief valve 24.

Referring back to Figs. 2 and 3, a number of temperature sensors are placed at various points around the heating system. First a temperature sensor e.g. negative temperature coefficient thermistor 40 protrudes through the wall of the water tank 6 to sense the temperature of the filtered water in the bottom of the water tank 6. A second temperature sensor e.g. negative temperature coefficient thermistor 42 is placed towards the exit end and on the outside of the sheathed heating element 30. Also, two bimetallic actuators e.g. half inch discs or thermal fuses 44, 46 (or other temperature sensing means) are provided on the outside of the flow heater 27, one in contact with just the water flow tube 28 and the other in contact with both the sheathed heating element 30 and the water flow tube 28. The two half inch discs or thermal fuses 44, 46 protect against the sheathed heating element 30 overheating. Such an arrangement of temperature sensing means in thermal communication with both the heating element 30 and the water flow tube 28 is also described in the Applicant's published application WO 2013/024286.

The main components of the appliance 1 can also be seen in schematic form in Fig. 5, in which the flow of water, electrical signals and power is also shown. All the components are directly or indirectly controlled by an electronic controller 50 which receives electronic signals from various components and controls the power delivered to the sheathed heating element 30 and the solenoid pump 22. The electronic controller 50 is connected to a mains power supply 52 via a voltage measuring circuit 100. The sheathed heating element 30 is also connected to the mains power supply 52, with this being controlled by the electronic controller 50 via a switch 54 in the heater power supply circuit 56. In addition the pump 22 is connected to the mains power supply 52, with this being controlled by the electronic controller 50 via a pump power control 58.

The electronic controller 50 receives electrical signals from the negative temperature coefficient thermistor 40 in the water tank 6 and the second negative temperature coefficient thermistor 42 on the sheathed heating element 30, as well as from the pump power control 58 and a water level sensor 60 (not shown in Figs. 2 and 3) which detects that a minimum fill level in the water tank 6 has been reached.

In accordance with other embodiments the solenoid pump 22 may be replaced with another kind of pump, for example a positive displacement pump 22' such as a piston pump. The pressure compensating constant flow valve 26 may be omitted, especially where the pump 22' is able to deliver a substantially constant flow rate through the flow heater 27 despite variations in water pressure. Yet other embodiments may omit a pump altogether, relying instead on a direct connection to an external supply such as the mains water supply and using a constant flow valve or regulator to ensure that the flow rate through the heater is known.

Fig. 6 provides an example of a suitable voltage measuring circuit 100 connected between the live AC_L and neutral AC_N poles of the mains power supply 52 for the appliance 1. The circuit 100 measures the analogue voltage level AC_in and provides this to an A/D converter of the electronic controller 50 to give a digital input. The supply voltage V_in used by the electronic controller 50 is proportional to this digital input.

Operation of the apparatus according to a first set of embodiments will now be described with further reference to Figures 7-9.

When the apparatus starts a new dispensing cycle, it first conducts a preheating phase. The sheathed heating element 30 is turned on. The measured supply voltage V_in is used to calculate the instantaneous heating element power Q_dot according to Equation 1:

Q_dot = ((V_in)^2 / (V_cal)^2) x Q_dot_cal (Eq. 1)

where V_cal and Q_dot_cal are the calibrated values of the heating element voltage and heating element power as determined during an initial calibration of the appliance (either after manufacture or when the appliance is first used). The appliance therefore accounts for variations in the mains supply voltage 52 every time it runs a dispensing cycle. Once the supply voltage V_in has been measured it is not monitored again during the same dispensing cycle.

The electronic controller 50 then calculates the energy needed to heat a predetermined volume of liquid Vol_feed to a desired final temperature T_feed. The liquid volume Vol_feed may be set or selected a user via the input dial 13. The final temperature T_feed may be set or selected by a user, but for a baby formula appliance 1 it is typically pre-programmed e.g. T_feed = 37 °C. The temperature, T_tank, of water in the tank 6 is measured by the negative temperature coefficient thermistor 40 and provided to the electronic controller 50. Of course the ambient temperature for water in the tank 6 will vary depending on the ambient conditions. The total energy Q_total needed to heat the predetermined volume Vol_feed to the desired final temperature T_feed can then be calculated according to Equation 2:

Q_total = Vol_feed x Cp_water x ΔT x K_1 (Eq. 2)

where ΔT = T_feed – T_tank, Cp_water is the specific heat capacity of the liquid being heated, and K_1 is a compensation factor for heat losses. A typical value for K_1 can be empirically determined from factory testing or calibration of the apparatus, and pre-programmed into the controller.

The predetermined volume of liquid Vol_feed is dispensed in two stages, i.e. Vol_feed = Vol_initial + Vol_cold. The first volume V_initial is dispensed at a temperature T_initialdispense > 70 °C to “sterilise” the milk powder in the bottle 17. The second volume V_cold is dispensed to remove the residual heat energy from the sheathed heating element 30 to bring the overall volume Vol_feed to the desired final temperature e.g. T_feed = 37 °C.

It is necessary to preheat the sheathed heating element 30 to ensure that the whole of the initial dispense volume Vol_initial is dispensed hot enough. The sheathed heating element 30 is heated to a nominal target temperature e.g. T_target = 210 °C to ensure that it is hot (due to the temperature gradients the water flow tube 28 should be just below 100°C at this point). The actual temperature, T_element, of the sheathed heating element 30 is measured by the negative temperature coefficient thermistor 42 on the sheathed heating element 30. The energy needed for preheating Q_preheat is calculated according to Equation 3:

Q_preheat = m x Cp x (T_target – T_element) (Eq. 3)

where Cp is the specific heat capacity of the heater and m is the mass of the heater.

The preheat time t_preheat is then given by Equation 4:

t_preheat = Q_preheat / Q_dot (Eq. 4)

The stored energy Q_stored in the system must be taken into account when calculating the total "ON" time (t_heater) for energising the sheathed heating element 30. This is calculated according to Equation 5:

Q_stored = m x Cp x (T_element – T_tank) x K_2 (Eq. 5)

where K_2 is a compensation factor to take account of heat losses etc. which may be empirically determined and pre-programmed into the electronic controller 50. The factor K_2 may be used to tune this part of the process so that the electronic controller 50 can abort a dispensing operation if the sheathed heating element 30 is detected to have overheated by one or both of the half inch discs 44, 46 on the flow heater 27.

The calculated period of "ON" time, t_heater, for energising the sheathed heating element 30 is then calculated according to Equation 6:

t_heater = (Q_total - Q_Stored) / Q_dot (Eq. 6)

The first period of pump operation is required to dispense the first volume V_initial of heated liquid and this is calculated according to Equation 7:

Vol_initial = Q_total / (Cp_water x (T_initialdispense - T_tank) x K_1) (Eq. 7)

where T_initialdispense is preset in the electronic controller 50 at a value of e.g. 95 °C.

The two periods of time for pump operation can then be calculated according to Equations 8 and 9:

t_pump1 = Vol_initial / Flow rate (Eq. 8)

t_pump2 = Vol_cold / flow rate (Eq. 9)

where the flow rate is that of the liquid entering the flow heater 27 as set by the pressure compensating constant flow valve 26. The flow rate is another value that may be calibrated for each appliance (either after manufacture or when the appliance is first used).

Figure 7 is a flow chart outlining the main steps involved in a complete dispensing cycle. It can be seen that the process starts by measuring the mains supply voltage V_in at that time so as to make an accurate calculation of the power Q_dot of the sheathed heating element 30. The electronic controller 50 then takes readings from the negative temperature coefficient thermistor 40 (NTC1) in the water tank 6 and the second negative temperature coefficient thermistor 42 (NTC2) on the sheathed heating element 30. From these inputs it is possible to calculate the preheat time before the pump 22 is operated for a first initial dispensing period, the time period for energisation of the sheathed heating element 30, and the second period of pump operation to dispense the full volume of liquid required to make the infant feed in the bottle 17. The electronic controller 50 may be programmed to pause for a set period of time, t_pause, e.g. 30 s, 40 s, 50 s or 60 s, to allow a user to add infant formula powder to the initially dispensed water, or to stir the feed if the formula powder was already in the bottle 17. However the appliance 1 may be provided with a button or other input allowing a user to start the second dispensing period on demand.

As is mentioned above, the flow rate of liquid entering the flow heater 27 is set by the pressure compensating constant flow valve 26 so as to have a constant value (e.g. 170 ml/min) regardless of any variations in the pump speed e.g. due to voltage fluctuations or as a result of age-related wear. Under certain circumstances it may be necessary to reduce the flow rate to provide the desired dispense temperature and this may be achieved by pulsing the pump on and off. Fig. 8 shows a plot of the operation of the sheathed heating element 30 and the pump 22 overlaid on the temperature profiles sensed for the sheathed heating element 30 i.e. T_element 52, and the outlet temperature 54 measured at the dispensing head of the appliance. Also shown is the heater energisation state 58 and the pump operation state 60. The starting temperature 56 of water in the tank 6 is constant e.g. T_tank = 18 °C. It can be seen that the temperature 54 measured at the dispensing head has an average value of around 85 °C as the first volume of water V_initial is dispensed at this temperature T_initialdispense during the first period of pump operation t_pump1. The outlet temperature 54 then drops and rises again during the pause between the pump operation periods, as it begins to move into thermal equilibrium with the system and its stored heat. When the second period of pump operation, t_pump2, begins, there is a small volume of warm water dispensed through the outlet that has been sitting in the water flow tube 28, but this is quickly followed by most of the volume Vol_cold of unheated water that is pumped through during the period t_pump2. The outlet temperature 54 rapidly falls to match the ambient water (e.g. at 18 °C) that is being pumped through without any heating. The two volumes of water that are dispensed into the bottle 17 mix to provide the predetermined volume V_feed at the desired final temperature T_feed (e.g. set at 37 °C).

Fig. 9 shows a temperature profile 62 for the dispensed water in the bottle throughout the operational cycle of the appliance. After the pump 22 is energised initially the water temperature very quickly rises to about 95°C. At the end of the first period of pump operation, t_pump1, the first volume of water, V_initial, has an average temperature of about 80°C and this remains above 70°C during the pause, t_pause, when the powdered infant formula is added to the bottle, ensuring sterilisation of the powder. As the cooler water is dispensed during the second period of pump operation, t_pump2, the temperature 62 of the water in the bottle falls, reaching a final average of about 37 °C when the final volume of the water has been dispensed to make the overall volume, Vol_feed .

As all the energy Q_dot input by the sheathed heating element 30 is used to heat the system it is not necessary for the appliance to measure the final water temperature T_feed, which can simply be calculated from Equation 10:

$$T\_feed = T\_tank + Q\_dot/(m\_feed \times Cp\_water) \qquad \text{(Eq. 10)}$$

where m_feed is the mass of the overall volume Vol_feed of liquid in the bottle 17.

Operation of the apparatus according to a second set of embodiments will now be described with further reference to Figures 10-12. The flow chart seen in Fig. 10 shows the steps that may be taken when the apparatus is operated to continuously dispense a predetermined volume of warm liquid Vol_feed having a desired final temperature of T_feed e.g. 37 °C. In this scenario the apparatus is not used to dispense a separate first volume V_initial at a particular predetermined initial temperature, i.e. no "hot shot" at 70 °C or higher. However, as can be seen from the heating profiles of Figs. 11 and 12, some of the liquid may be dispensed at such temperatures during a first phase of operation but there is no pause for a user to knowingly mix infant milk formula with the liquid while it is at this temperature.

According to Fig. 10 the heating element 30 is energised at substantially the same time as the pump 22, i.e. there is no preheating of the flow heater 27. As before, a voltage compensation circuit may be used to measure the voltage V_in applied to the flow heater 27. The electronic controller 50 calculates the heating element power according to Eq. 1 and then calculates the predetermined volume Vol_feed from the feed size (kg) input at the user interface MMI. The total energy Q_total needed to heat the predetermined volume Vol_feed to the desired final temperature T_feed can then be calculated according to Eq. 2. As Vol_feed is to be dispensed continuously, the time period for pump operation t_pump can simply be calculated according to Equation 11:

$$t\_pump = Vol\_feed \,/\, flow\ rate \qquad \text{(Eq. 11)}$$

where the flow rate is that of the liquid entering the flow heater 27. This flow rate may be set by an upstream pressure compensating constant flow valve 26, where provided, or it may be a known constant of the pump 22'.

The electronic controller 50 takes readings from the NTC1 thermistor 40 in the water tank 6 and the NTC2 thermistor 42 mounted on the heating element 30 to give temperatures T1 (=T_tank) and T2 (=T_element). The total temperature rise required to reach the desired final temperature T_feed e.g. 37 °C is DT or ΔT = T_feed - T1. The total energy required Q_total is then calculated using Eq. 2. For example, Cp_water = 4180 and losses K_1 = 1.1 (initial value of 10%). In order to take into account any heat energy stored in the system, the controller 50 also calculates G_stored using Eq. 5. The heater ON time t_heater can then be calculated from Eq. 6.

The pump 22, 22' may be operated continuously or the liquid may be dispensing substantially continuously using a pulsed pump operation. For smaller volumes of liquid, the heater ON time t_heater may be almost as long as the pump ON time t_pump, at a constant flow rate, so the controller 50 checks whether pulsed pump operation is required, e.g. if t_heater > t_pump - 3s. The flow heater 27 is de-energised after the time t_heater has lapsed. The pump is operated (continuously or in a pulsed fashion) until t_pump has lapsed and residual heat has been removed such that Vol_feed has the desired temperature T_feed.

Figs. 11 and 12 shows the activation profiles for the heater 27 and pump 22, 22', as well as the temperature profiles for the water in the tank T_tank (measured by NTC1), the heater T_element (measured by NTC2) and the temperature of heated liquid being dispensed into a bottle at the outlet. Fig. 11 shows the profiles for Vol_feed = 120 ml and Fig. 12 shows the profiles for Vol_feed = 330 ml.

It will be appreciated by those skilled in the art that the embodiments described above are merely examples of how the principles of the invention can be employed and there are many possible variants within the scope of the invention. For example, the principles of the invention could be used to produce water or other liquid at a different temperature and for a different purpose than the preparation of infant formula milk. Moreover, the particular type of heater shown is not essential and any other flow heater or batch heater could be used instead. Furthermore, water could be supplied from a plumbed-in source, e.g. the mains water supply, rather than from a hopper within the appliance.

Claims

1. A method of operating an apparatus comprising a heating means and a pump to dispense a predetermined volume of a warm liquid, said method comprising the steps of:

measuring the temperature of the liquid upstream of the heating means;

calculating an amount of energy required for the heating means to heat the predetermined volume of the liquid from the upstream temperature to a desired final temperature;

calculating a period of "ON" time required for energisation of the heating means to deliver the calculated amount of energy;

energising the heating means for the calculated period of "ON" time;

operating the pump during a first period of time to dispense a first volume of heated liquid at or above a predetermined initial temperature from an outlet of the apparatus, wherein the first period of time is at least partly contemporaneous with the calculated period of "ON" time;

de-energising the heating means; and

operating the pump for a second period of time subsequent to the first period of time to dispense a second volume of the liquid from the outlet of the apparatus thereby removing residual heat from the heating means, the first and second volumes together providing the predetermined volume,

wherein the average temperature of the first and second volumes of the liquid is the desired final temperature after the predetermined volume has been dispensed.

2. A method as claimed in claim 1, wherein the heating means comprises a flow heater in which liquid is permitted to enter and exit the heating means while heating is taking place.

3. A method as claimed in claim 2, wherein the flow heater comprises a liquid flow conduit and a tube containing a sheathed heating element provided adjacent one another.

4. A method as claimed in any preceding claim, further comprising treating the liquid upstream of the pump and/or heating means.

5. A method as claimed in any preceding claim, wherein the step of calculating the energy required for the heating means to heat a predetermined volume of the liquid from the upstream temperature to a desired final temperature comprises measuring the temperature of, or downstream of, the heating means.

6. A method as claimed in any preceding claim, further comprising delivering a constant flow rate of the liquid through the heating means.

7. A method as claimed in claim 6, wherein the pump is a positive displacement pump arranged to deliver a constant flow rate of the liquid through the heating means.

8. A method as claimed in claim 6 or 7, wherein the apparatus comprises a flow regulator downstream of the pump to deliver a constant flow rate of the liquid through the heating means.

9. A method as claimed in claim 6, 7 or 8, wherein the constant flow rate is between 100 ml/minute and 300 ml/minute, e.g. between 150 ml/min and 250 ml/min, and preferably about 170 ml/min.

10. A method as claimed in any preceding claim, wherein the predetermined initial temperature is greater than 60°C, e.g. greater than 65°C, and further preferably greater than 70°C.

11. A method as claimed in any of claims 1-9, wherein the predetermined initial temperature is greater than ambient temperature, for example greater than 25°C, 30°C, 40°C, or 50°C.

12. A method of operating an apparatus comprising heating means and means for dispensing a predetermined volume of a warm liquid, said method comprising the steps of:

measuring the temperature of the liquid upstream of the heating means; calculating an amount of energy required for the heating means to heat the predetermined volume of the liquid from the upstream temperature to a desired final temperature;

calculating a period of "ON" time required for energisation of the heating means to deliver the calculated amount of energy;

energising the heating means for the calculated period of "ON" time;

dispensing a first volume of directly heated liquid from an outlet of the apparatus during a first calculated period of time, wherein the first period of time is at least partly contemporaneous with the calculated period of "ON" time;

de-energising the heating means; and

dispensing a second volume of liquid from the outlet of the apparatus for a second calculated period of time subsequent to the first period of time, the second volume of liquid being indirectly heated by removing residual heat from the heating means, the first and second volumes together providing the predetermined volume, wherein the average temperature of the first and second volumes of the liquid is the desired final temperature after the predetermined volume has been dispensed.

13. A method as claimed in any preceding claim, wherein the desired final temperature is between 27°C and 47°C, preferably between 32°C and 42°C, and further preferably around 37°C.

14. A method as claimed in any preceding claim, comprising energising the heating means to start the calculated period of "ON" time at substantially the same time as operating the pump to start the first period of time.

15. A method as claimed in any of claims 1-13, wherein the start of the calculated period of "ON" time is prior to the start of the first period of time.

16. A method as claimed in any preceding claim, comprising energising the heating means for a preheating period before operation of the pump until a predetermined preheat temperature is reached.

17. A method as claimed in claim 16, wherein the predetermined preheat temperature of the heating element is greater than 200°C, e.g. 210°C

18. A method as claimed in any preceding claim, comprising operating the pump periodically during the first period of time.

19. A method as claimed in any preceding claim, wherein the end of the first period of time is after the end of the calculated period of "ON" time.

20. A method as claimed in any preceding claim, comprising stopping the pump between the first and second periods of time.

21. A method as claimed in any of claims 1-18, wherein de-energising the heating means ends the first period of time and the pump is operated continuously to immediately start the second period of time.

22. A method as claimed in any preceding claim, wherein the second period of time is longer than the first period of time.

23. A method as claimed in any preceding claim, wherein the second volume of liquid is greater than the first volume of liquid.

24. A method as claimed in any preceding claim, wherein the first volume of liquid is between 20 ml and 100 ml, preferably between 20 ml and 60 ml.

25. A method as claimed in any preceding claim, wherein the predetermined volume of liquid is selected by a user.

26. A method as claimed in any preceding claim, wherein the predetermined volume of liquid is between 50 ml and 350 ml, preferably between 60 ml and 300 ml, e.g. 200 ml.

27. A method as claimed in any preceding claim, further comprising venting excess pressure from the heating means.

28. A method as claimed in any preceding claim, comprising calculating the first and second periods of time for operating the pump to dispense the first and second volumes of liquid.

29. A method as claimed in any preceding claim, further comprising measuring the mains supply voltage and adjusting operation of the heating means and/or of the pump to take into account the mains supply voltage.

30. A method as claimed in claim 29, comprising taking into account the measured mains supply voltage when calculating the period of "ON" time required for energisation of the heating means.

31. An apparatus for dispensing a predetermined volume of a warm liquid, comprising a heating means, a pump, a temperature sensor sensitive to the temperature of the liquid upstream of the heating means, and control means arranged to:

receive upstream temperature data from the temperature sensor,

calculate the amount of energy required for the heating means to heat a predetermined volume of the liquid from the upstream temperature to a desired final temperature, calculate a period of "ON" time required for energisation of the heating means to deliver the calculated amount of energy,

energise the heating means for the calculated period of "ON" time,

operate the pump during a first period of time to dispense a first volume of heated liquid at or above a predetermined initial temperature from an outlet of the apparatus, wherein the first period of time is at least partly contemporaneous with the calculated period of "ON" time,

de-energise the heating means, and

operate the pump for a second period of time subsequent to the first period of time to dispense a second volume of the liquid from the outlet of the apparatus thereby removing residual heat from the heating means, the first and second volumes together providing the predetermined volume;

wherein the average temperature of the first and second volumes of the liquid is the desired final temperature after dispensing the predetermined volume.

32. An apparatus as claimed in claim 31, wherein the heating means comprises a flow heater in which liquid is permitted to enter and exit the heating means while heating is taking place.

33. An apparatus as claimed in claim 32, wherein the flow heater comprises a liquid flow conduit and a tube containing a sheathed heating element provided adjacent one another.

34. An apparatus as claimed in claim 31, 32 or 33, comprising a reservoir for supplying liquid to the heating means.

35. An apparatus as claimed in claim 34, comprising an intermediate holding chamber between the reservoir and the pump, and means for filling the holding chamber from the reservoir to a predetermined level.

36. An apparatus as claimed in claim 34 or 35, wherein the temperature sensor is located in the reservoir or in the intermediate holding chamber.

37. An apparatus as claimed in any of claims 31 to 36, comprising a liquid treatment means arranged upstream of the pump and/or heating means.

38. An apparatus as claimed in any of claims 31 to 37, comprising a further temperature sensor sensitive to the temperature of, or downstream of, the heating means; wherein the

control means is arranged to calculate the energy required for the heating means to heat a predetermined volume of the liquid from the upstream temperature to a desired final temperature, using the temperature measured by the further temperature sensor.

39. An apparatus as claimed in any of claims 31 to 38, comprising means for delivering a constant flow rate of the liquid through the heating means.

40. An apparatus as claimed in claim 39, wherein the means for delivering a constant flow rate is located downstream of the pump and upstream of the heating means.

41. A method as claimed in claim 39, wherein the means for delivering a constant flow rate comprises a positive displacement pump.

42. An apparatus as claimed in claim 39, 40 or 41, wherein the constant flow rate is between 100 ml/minute and 300 ml/minute, e.g. between 150 ml/min and 250 ml/min, and preferably about 170 ml/min.

43. An apparatus as claimed in any of claims 31 to 42, wherein the predetermined initial temperature is greater than 60°C, e.g. greater than 65°C, and further preferably greater than 70°C.

44. An apparatus as claimed in any of claims 31 to 42, wherein the predetermined initial temperature is greater than ambient temperature, for example greater than 25°C, 30°C, 40°C, or 50°C.

45. An apparatus for dispensing a predetermined volume of a warm liquid, comprising heating means, means for dispensing liquid, a temperature sensor sensitive to the temperature of the liquid upstream of the heating means, and control means arranged to:

receive upstream temperature data from the temperature sensor,

calculate the amount of energy required for the heating means to heat a predetermined volume of the liquid from the upstream temperature to a desired final temperature,

calculate a period of "ON" time required for energisation of the heating means to deliver the calculated amount of energy,

energise the heating means for the calculated period of "ON" time,

calculate a first period of time to dispense a first volume of directly heated liquid from an outlet of the apparatus, wherein the first period of time is at least partly contemporaneous with the calculated period of "ON" time, de-energise the heating means, and

calculate a second period of time subsequent to the first period of time to dispense a second volume of the liquid from the outlet of the apparatus that is indirectly heated by removing residual heat from the heating means, the first and second volumes together providing the predetermined volume;

wherein the average temperature of the first and second volumes of the liquid is the desired final temperature after dispensing the predetermined volume.

46. An apparatus as claimed in any of claims 31 to 45, wherein the desired final temperature is between 27°C and 47°C, preferably between 32°C and 42°C, and further preferably around 37°C.

47. An apparatus as claimed in any of claims 31 to 46, wherein the start of the calculated period of "ON" time is prior to the start of the first period of time.

48. An apparatus as claimed in any of claims 31 to 47, wherein the control means is arranged to energise the heating means for a preheating period before operating the pump until a predetermined preheat temperature is reached.

49. An apparatus as claimed in claim 48, wherein the predetermined preheat temperature of the heating element is greater than 200°C, e.g. 210°C

50. An apparatus as claimed in any of claims 31 to 46, wherein the heating means is energised to start the calculated period of "ON" time at substantially the same time as operating the pump to start the first period of time.

51. An apparatus as claimed in any of claims 31 to 50, wherein the control means is arranged to operate the pump periodically during the first period of time.

52. An apparatus as claimed in any of claims 31 to 51, wherein the end of the first period of time is after the end of the calculated period of "ON" time.

53. An apparatus as claimed in any of claims 31 to 52, wherein the control means is arranged to stop the pump between the first and second periods of time.

54. An apparatus as claimed in any of claims 31 to 50, wherein de-energising the heating means ends the first period of time and the pump is operated continuously to immediately start the second period of time.

55. An apparatus as claimed in any of claims 31 to 54, wherein the second period of time is longer than the first period of time.

56. An apparatus as claimed in any of claims 31 to 55, wherein the second volume of liquid is greater than the first volume of liquid.

57. An apparatus as claimed in any of claims 31 to 56, wherein the first volume of liquid is between 20 ml and 100 ml, preferably between 20 ml and 60 ml.

58. An apparatus as claimed in any of claims 31 to 57, comprising input means to allow the predetermined volume of liquid to be selected by a user.

59. An apparatus as claimed in any of claims 31 to 58, wherein the predetermined volume of liquid is between 50 ml and 350 ml, preferably between 60 ml and 300 ml, e.g. 200 ml.

60. An apparatus as claimed in any of claims 31 to 59, comprising a pressure relief valve arranged to vent excess pressure from the heating means.

61. An apparatus as claimed in any of claims 31 to 60, wherein the control means is arranged to calculate the first and second periods of time for operating the pump to dispense the first and second volumes of liquid.

62. An apparatus as claimed in any of claims 31 to 61, wherein the control means is arranged to measure the mains supply voltage and adjust operation of the heating means and/or of the pump to take into account the mains supply voltage.

63. An apparatus as claimed in claim 62, comprising a voltage measuring circuit connected to the mains power supply of the apparatus.

64. An apparatus as claimed in claim 62 or 63, wherein the control means is arranged to take into account the measured mains supply voltage when calculating the period of "ON" time required for energisation of the heating means.

65. A method of operating an apparatus comprising a heating means and a pump to dispense a predetermined volume of warm liquid, the method comprising the steps of:

measuring the mains supply voltage provided to the heating means; measuring the temperature of the liquid upstream of the heating means;

calculating the amount of energy required for the heating means to heat a predetermined volume of the liquid from the upstream temperature to a desired final temperature;

calculating a period of time required for energisation of the heating means to deliver the calculated amount of energy, taking into account the measured mains supply voltage;

energising the heating means for the calculated period of "ON" time; and

operating the pump to dispense the predetermined volume of liquid.

66. A method as claimed in claim 65, comprising:

operating the pump during a first period of time that is at least partly contemporaneous with the calculated period of "ON" time to dispense a first volume of the liquid,

de-energising the heating means, and

subsequently operating the pump for a second period of time to dispense a second volume of the liquid,

wherein the first and second volumes together provide the predetermined volume of liquid.

67. A method as claimed in claim 66, wherein, after dispensing the predetermined volume of liquid, the average temperature of the first and second volumes is the desired final temperature.

68. A method as claimed in claim 66 or 67, comprising operating the pump continuously or stopping the pump during a pause after de-energising the heating means.

69. An apparatus for dispensing a predetermined volume of warm liquid, comprising a heating means, a pump, a temperature sensor sensitive to the temperature of liquid upstream of the heating means, and control means arranged to:

measure the mains supply voltage provided to the heating means;

receive upstream temperature data from the temperature sensor;

calculate the amount of energy required for the heating means to heat a predetermined volume of liquid from the upstream temperature to a desired final temperature;

calculate a period of time required for energisation of the heating means to deliver the calculated amount of energy, taking into account the measured mains supply voltage;

energise the heating means for the calculated period of "ON" time; and

operate the pump to dispense the predetermined volume of liquid.

70. An apparatus as claimed in claim 69, wherein the control means is arranged to:

operate the pump during a first period of time that is at least partly contemporaneous with the calculated period of "ON" time to dispense a first volume of the liquid,

de-energise heating means, and

subsequently operate the pump for a second period of time to dispense a second volume of the liquid,

wherein the first and second volumes together provide the predetermined volume of liquid.

71. An apparatus as claimed in claim 70, wherein, after dispensing the predetermined volume of liquid, the average temperature of the first and second volumes is the desired final temperature.

72. An apparatus as claimed in claim 70 or 71, wherein the pump is operated continuously, or stopped during a pause, after de-energising the heating means.

Fig. 1

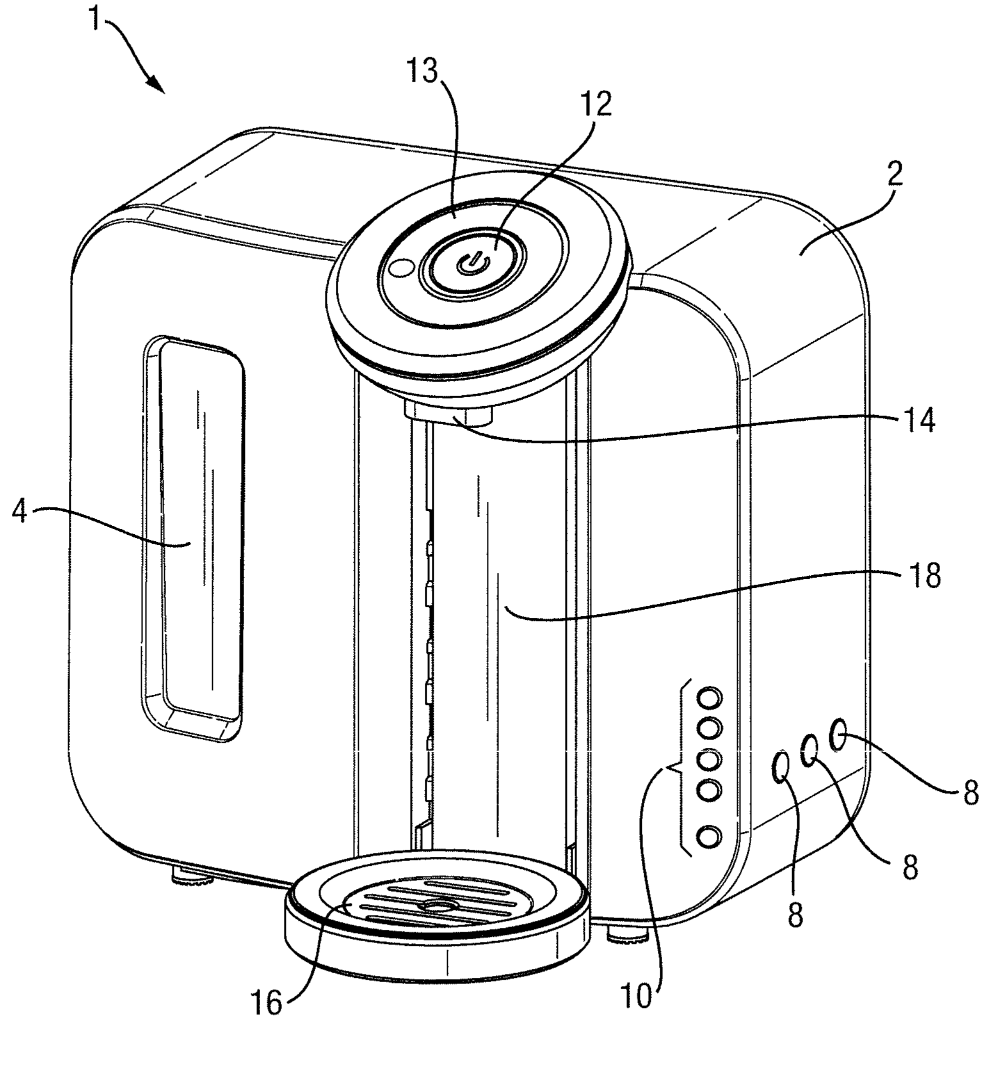


Fig. 2

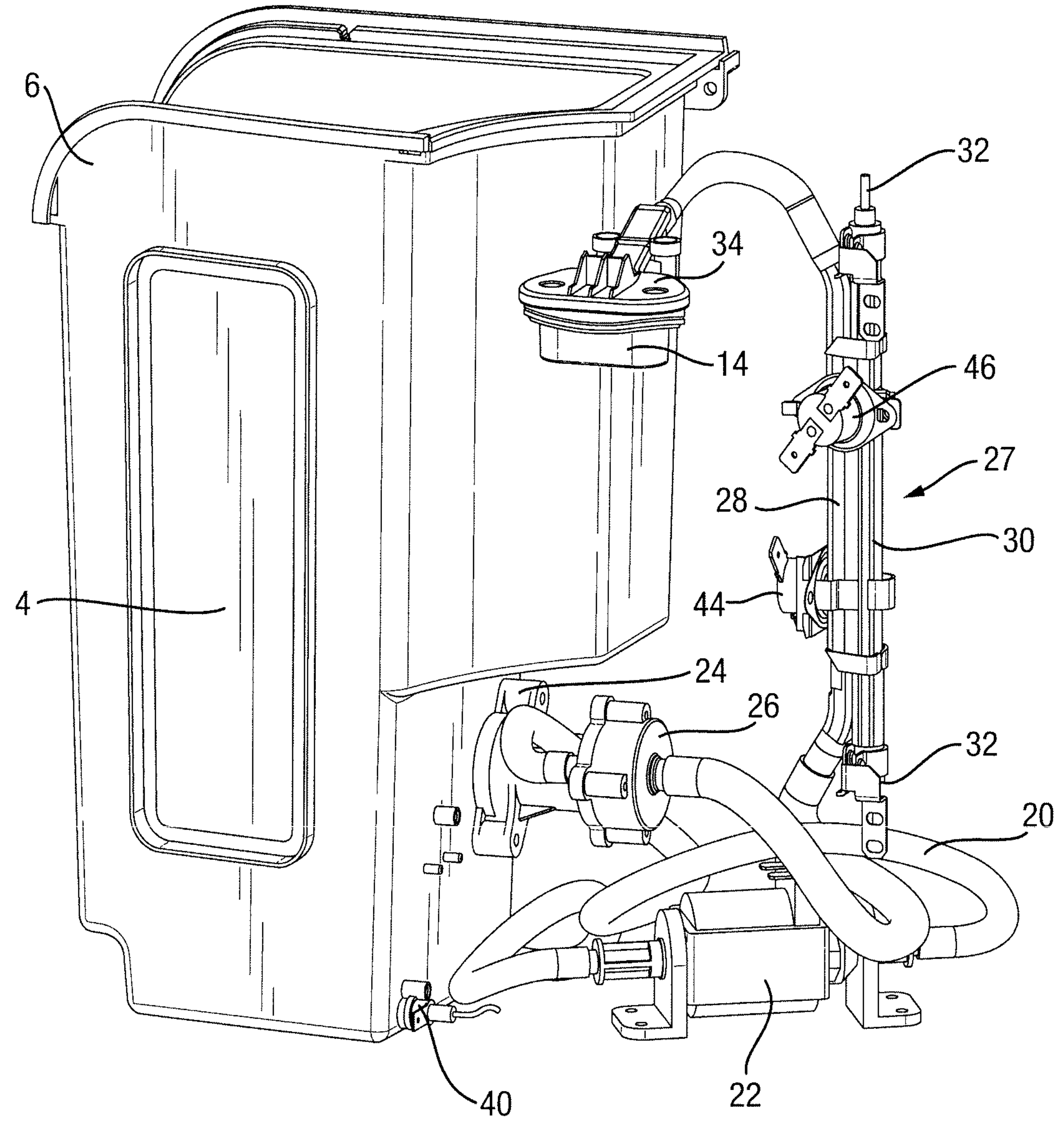


Fig. 3

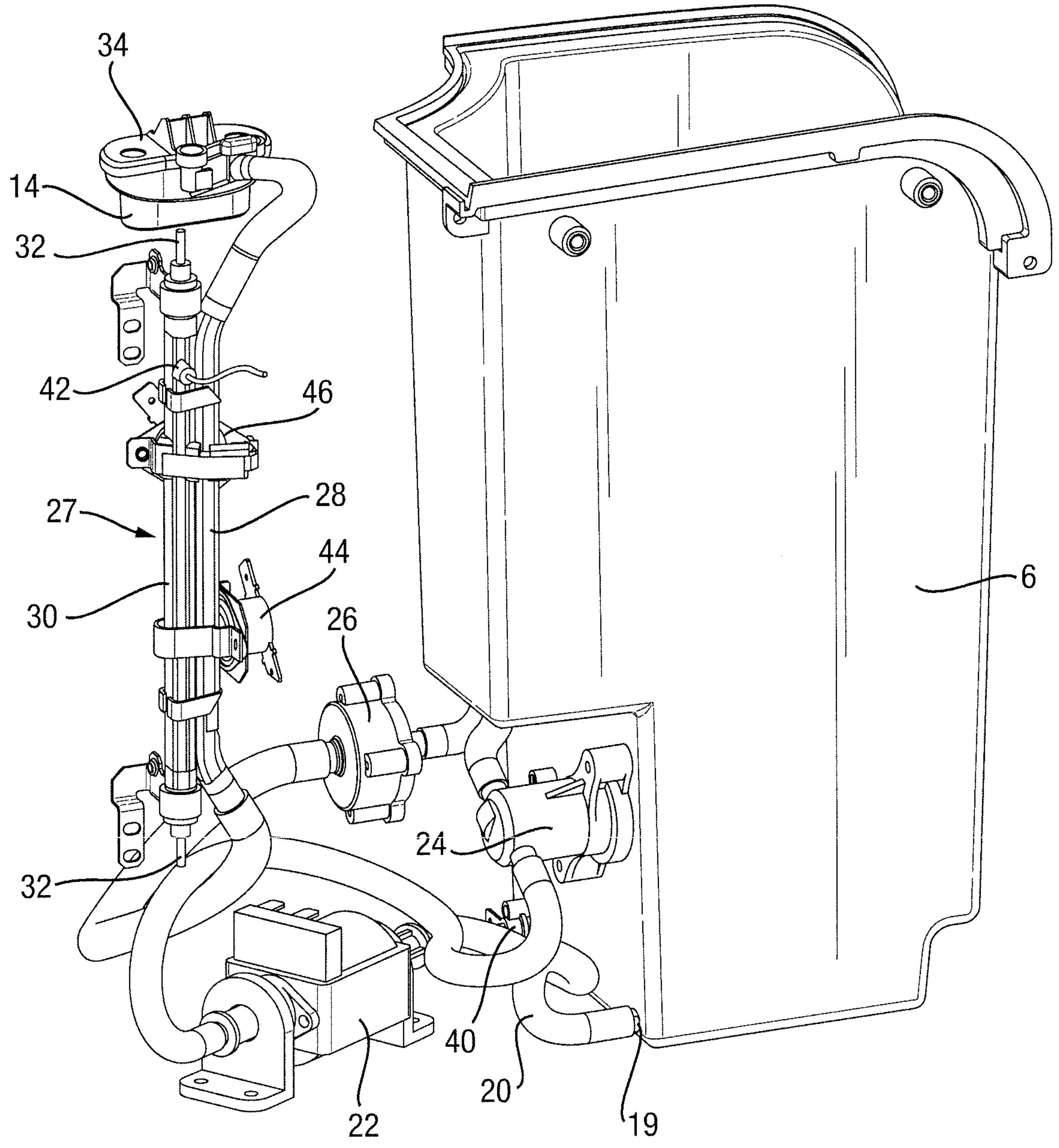
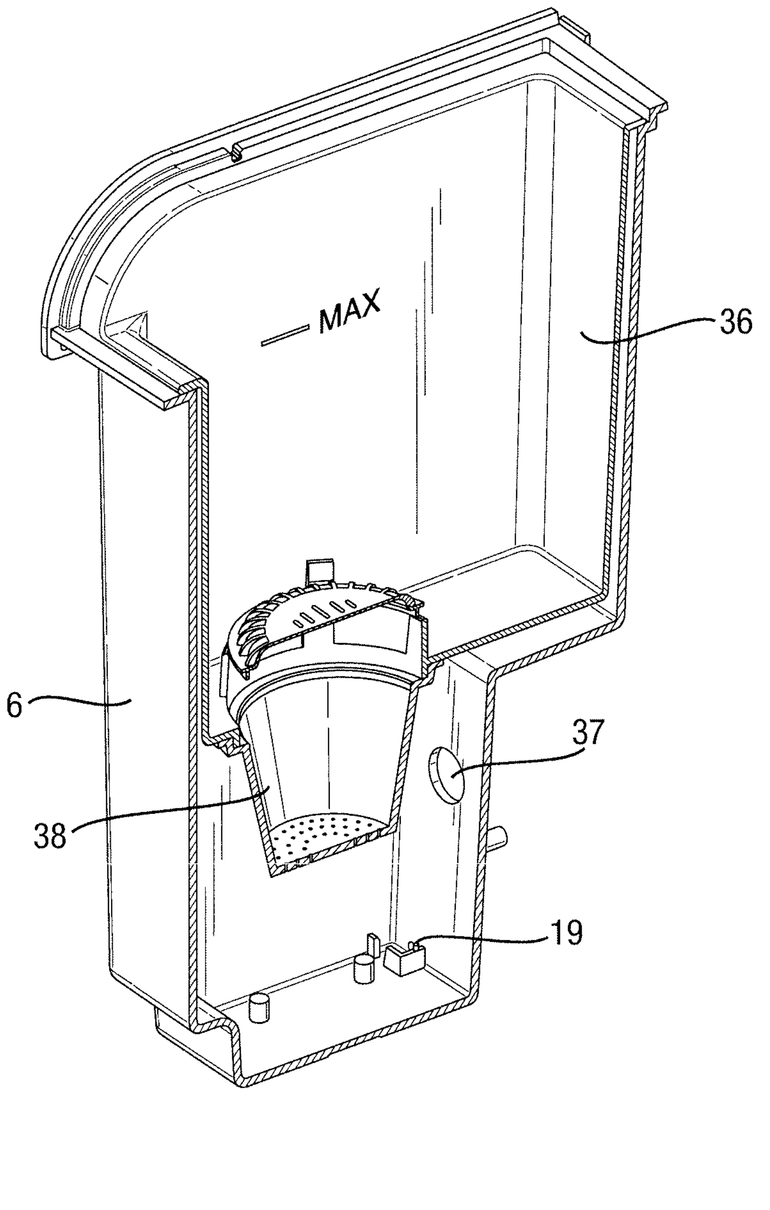


Fig. 4



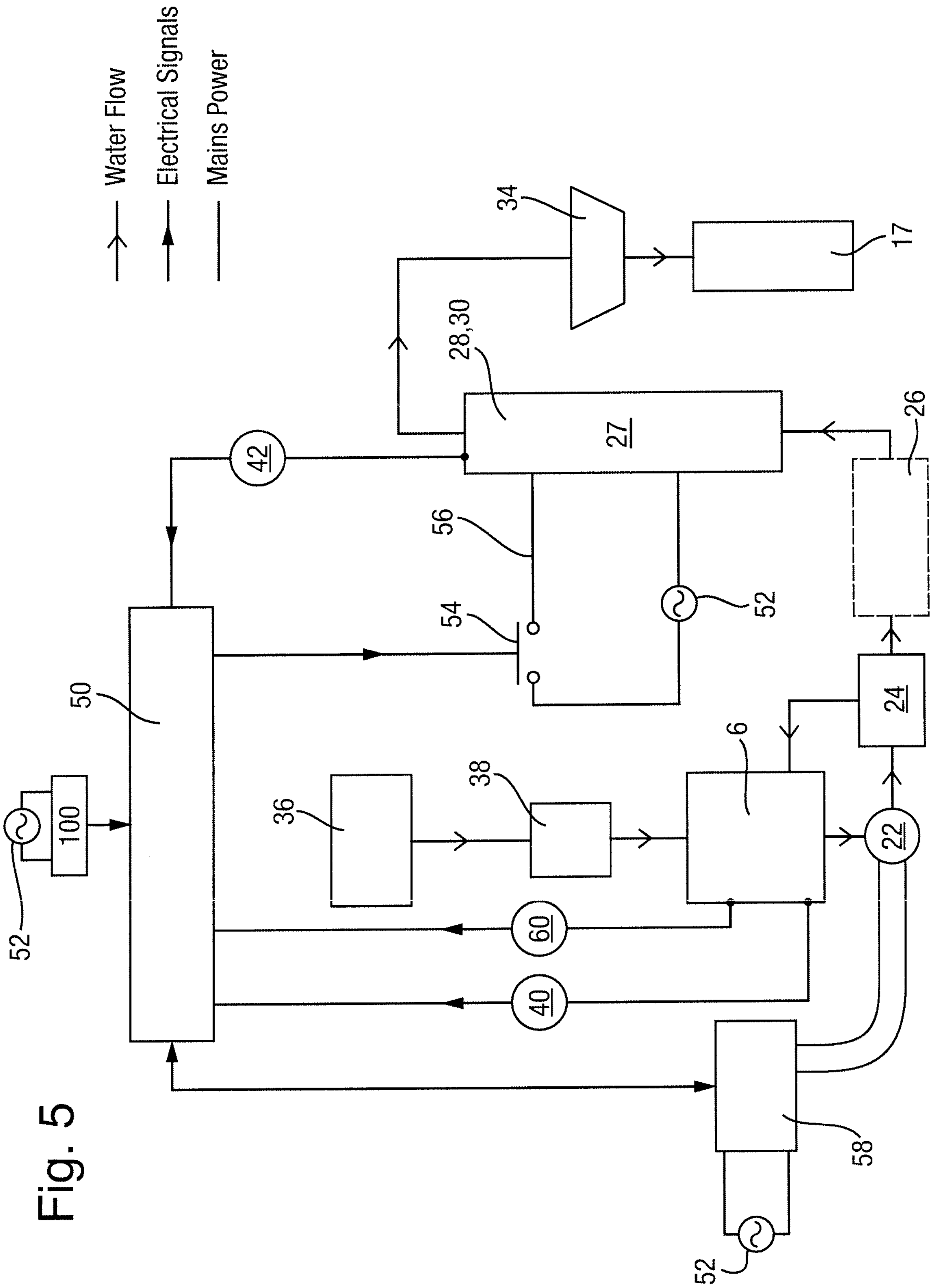

Water Flow
Electrical Signals
Mains Power
34
17
28,30
27
26
42
56
54
52
50
24
6
38
36
100
52
22
60
40
58
52

Fig. 5

Fig. 6

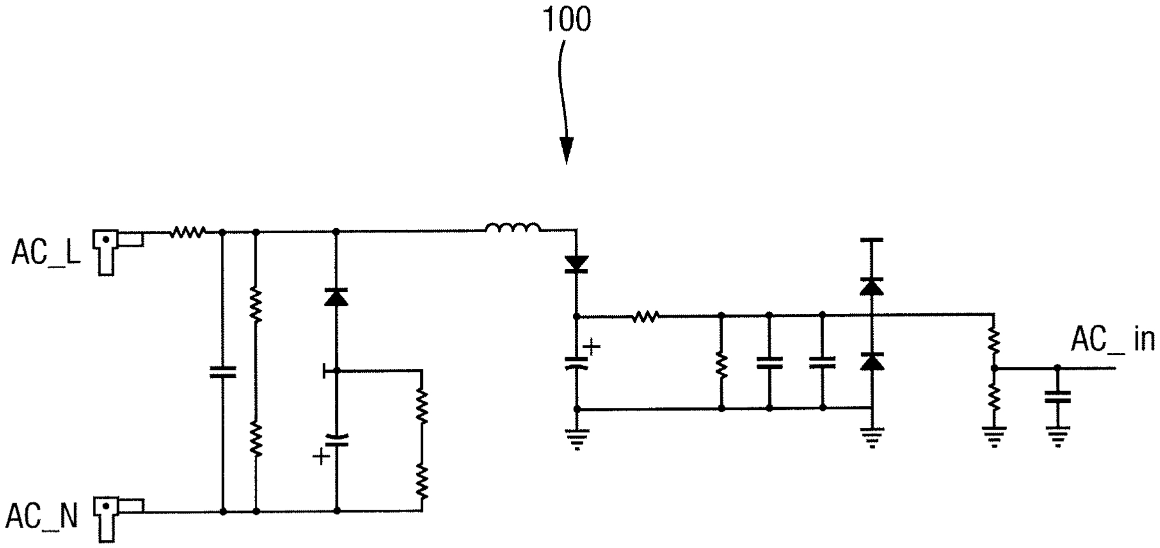


Fig. 7

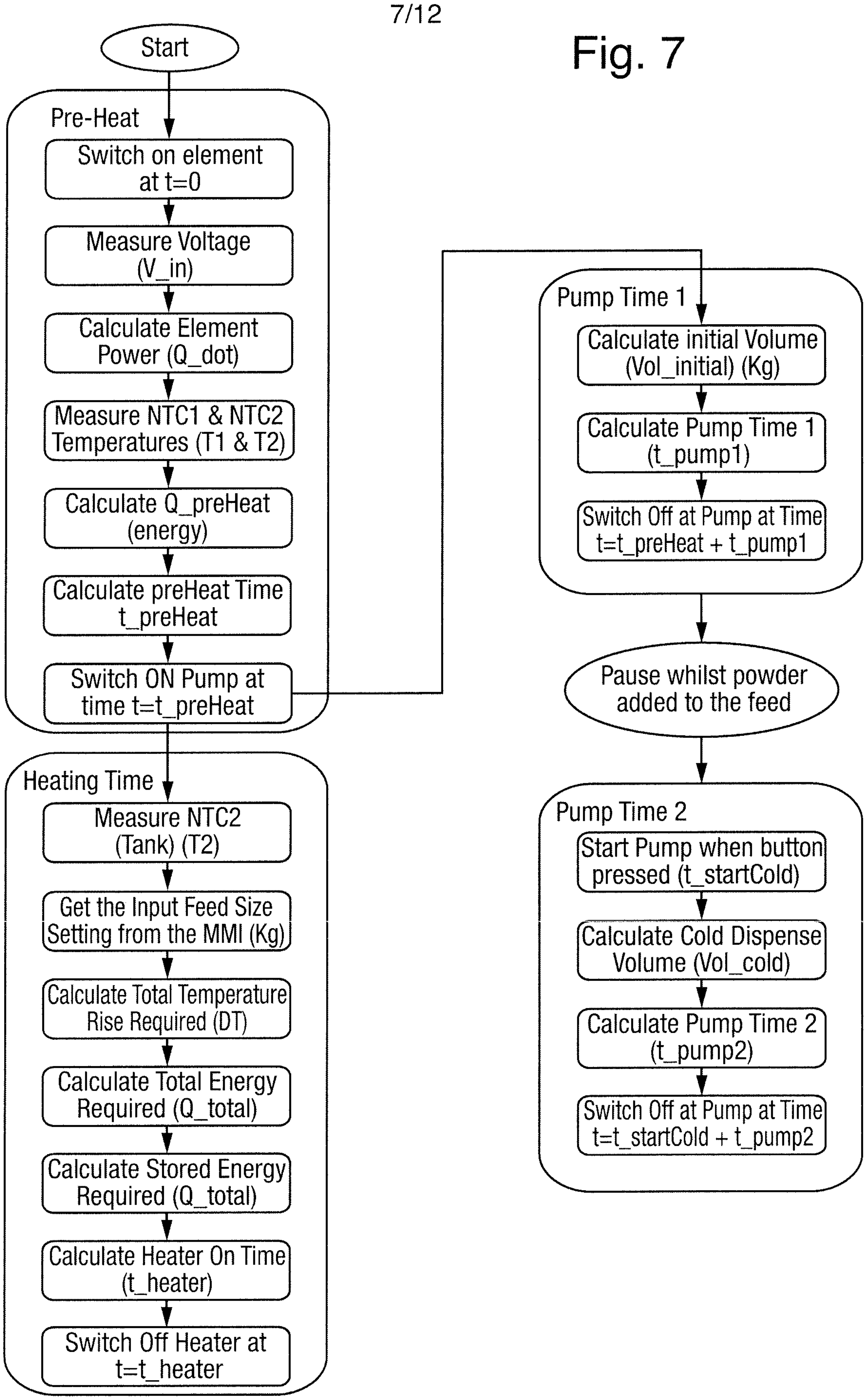

Start
Pre-Heat
Switch on element at t=0
Measure Voltage (V_in)
Calculate Element Power (Q_dot)
Measure NTC1 & NTC2 Temperatures (T1 & T2)
Calculate Q_preHeat (energy)
Calculate preHeat Time t_preHeat
Switch ON Pump at time t=t_preHeat
Heating Time
Measure NTC2 (Tank) (T2)
Get the Input Feed Size Setting from the MMI (Kg)
Calculate Total Temperature Rise Required (DT)
Calculate Total Energy Required (Q_total)
Calculate Stored Energy Required (Q_total)
Calculate Heater On Time (t_heater)
Switch Off Heater at t=t_heater
Pump Time 1
Calculate initial Volume (Vol_initial) (Kg)
Calculate Pump Time 1 (t_pump1)
Switch Off at Pump at Time t=t_preHeat + t_pump1
Pause whilst powder added to the feed
Pump Time 2
Start Pump when button pressed (t_startCold)
Calculate Cold Dispense Volume (Vol_cold)
Calculate Pump Time 2 (t_pump2)
Switch Off at Pump at Time t=t_startCold + t_pump2

Fig. 8

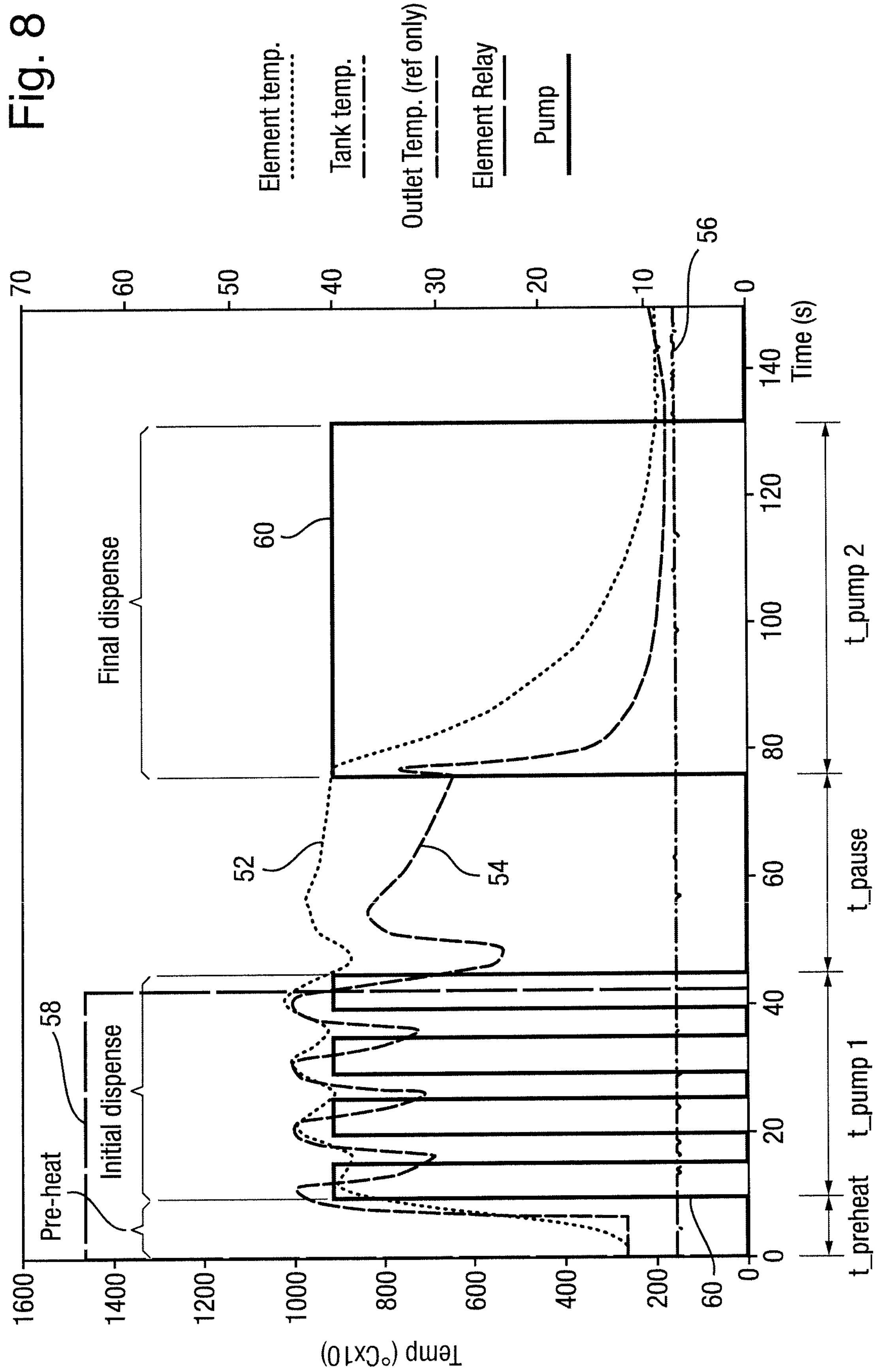

Element temp.
Tank temp.
Outlet Temp. (ref only)
Element Relay
Pump
Temp (°Cx10)
Time (s)
Pre-heat
Initial dispense
Final dispense
t_preheat
t_pump 1
t_pause
t_pump 2
52
54
56
58
60
1600
1400
1200
1000
800
600
400
200
60
0
20
40
60
80
100
120
140
10
30
50
70

Fig. 9

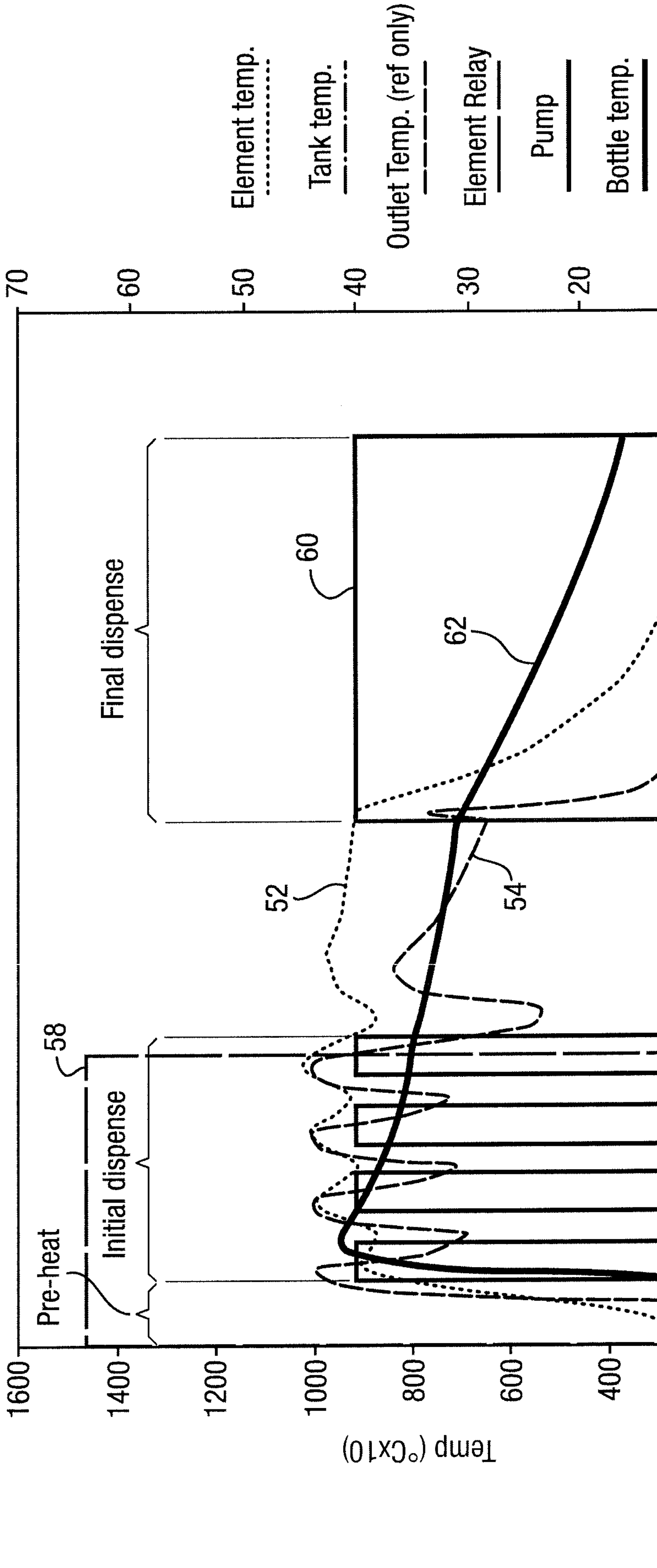
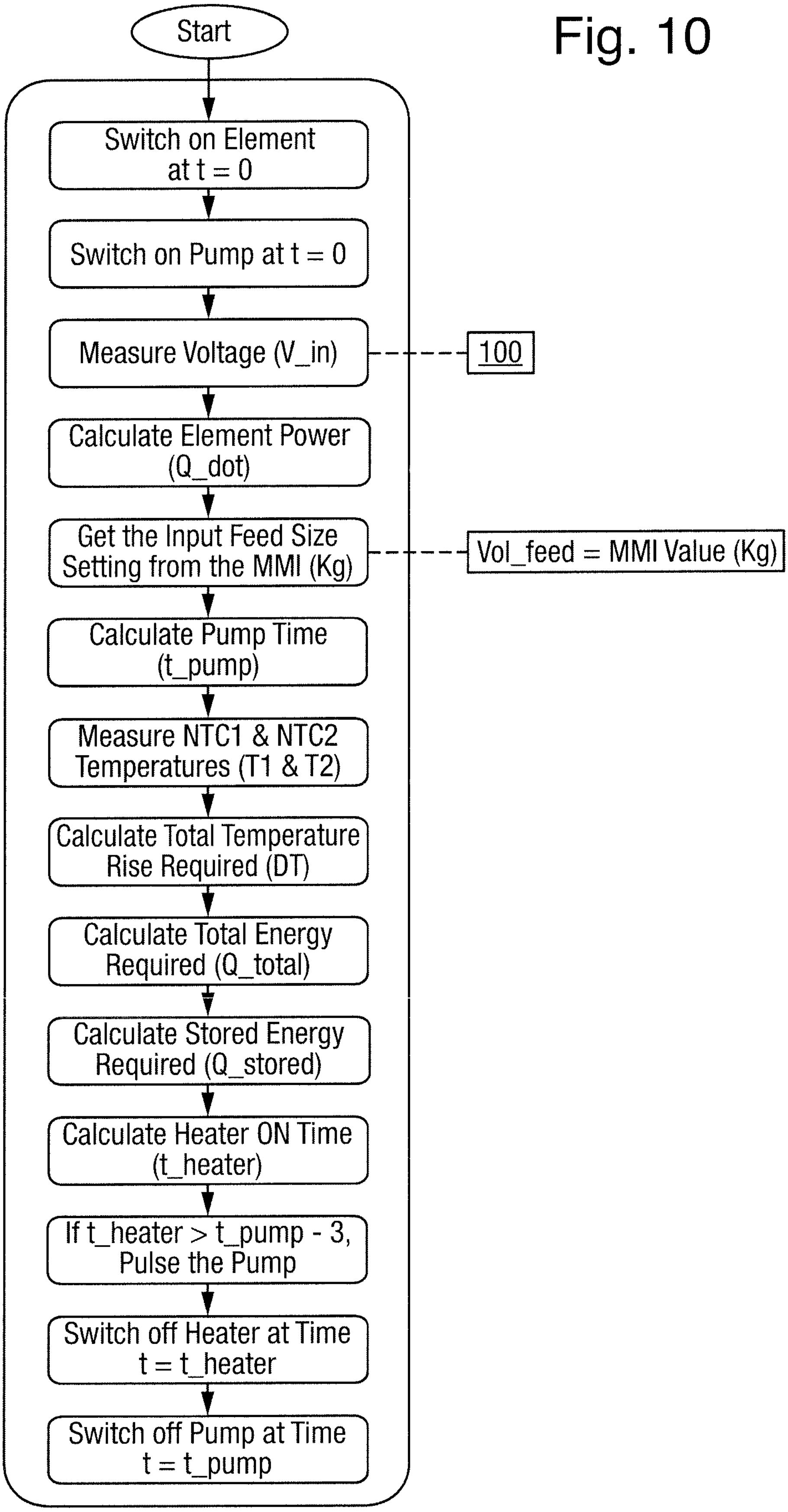

Element temp.
Tank temp.
Outlet Temp. (ref only)
Element Relay
Pump
Bottle temp.
Pre-heat
Initial dispense
Final dispense
58
60
62
52
54
56
Temp (°Cx10)
Time (s)
0
200
400
600
800
1000
1200
1400
1600
20
40
60
80
100
120
140
10
30
50
70

Fig. 10


Start
Switch on Element at t = 0
Switch on Pump at t = 0
Measure Voltage (V_in)
100
Calculate Element Power (Q_dot)
Get the Input Feed Size Setting from the MMI (Kg)
Vol_feed = MMI Value (Kg)
Calculate Pump Time (t_pump)
Measure NTC1 & NTC2 Temperatures (T1 & T2)
Calculate Total Temperature Rise Required (DT)
Calculate Total Energy Required (Q_total)
Calculate Stored Energy Required (Q_stored)
Calculate Heater ON Time (t_heater)
If t_heater > t_pump - 3, Pulse the Pump
Switch off Heater at Time t = t_heater
Switch off Pump at Time t = t_pump

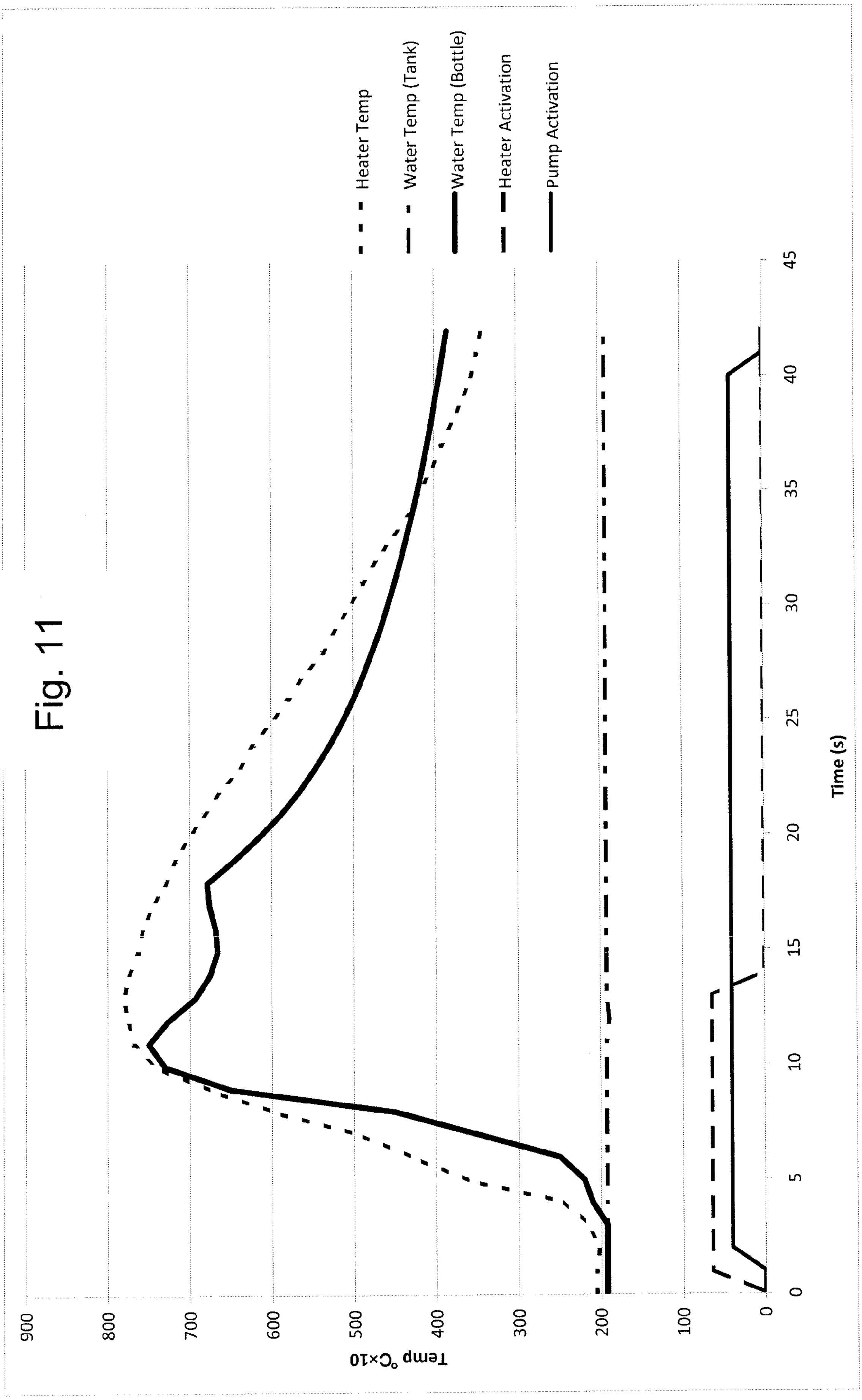

Heater Temp
Water Temp (Tank)
Water Temp (Bottle)
Heater Activation
Pump Activation
Temp °C×10
900
800
700
600
500
400
300
200
100
0
0
5
10
15
20
25
30
35
40
45
Time (s)

Fig. 11

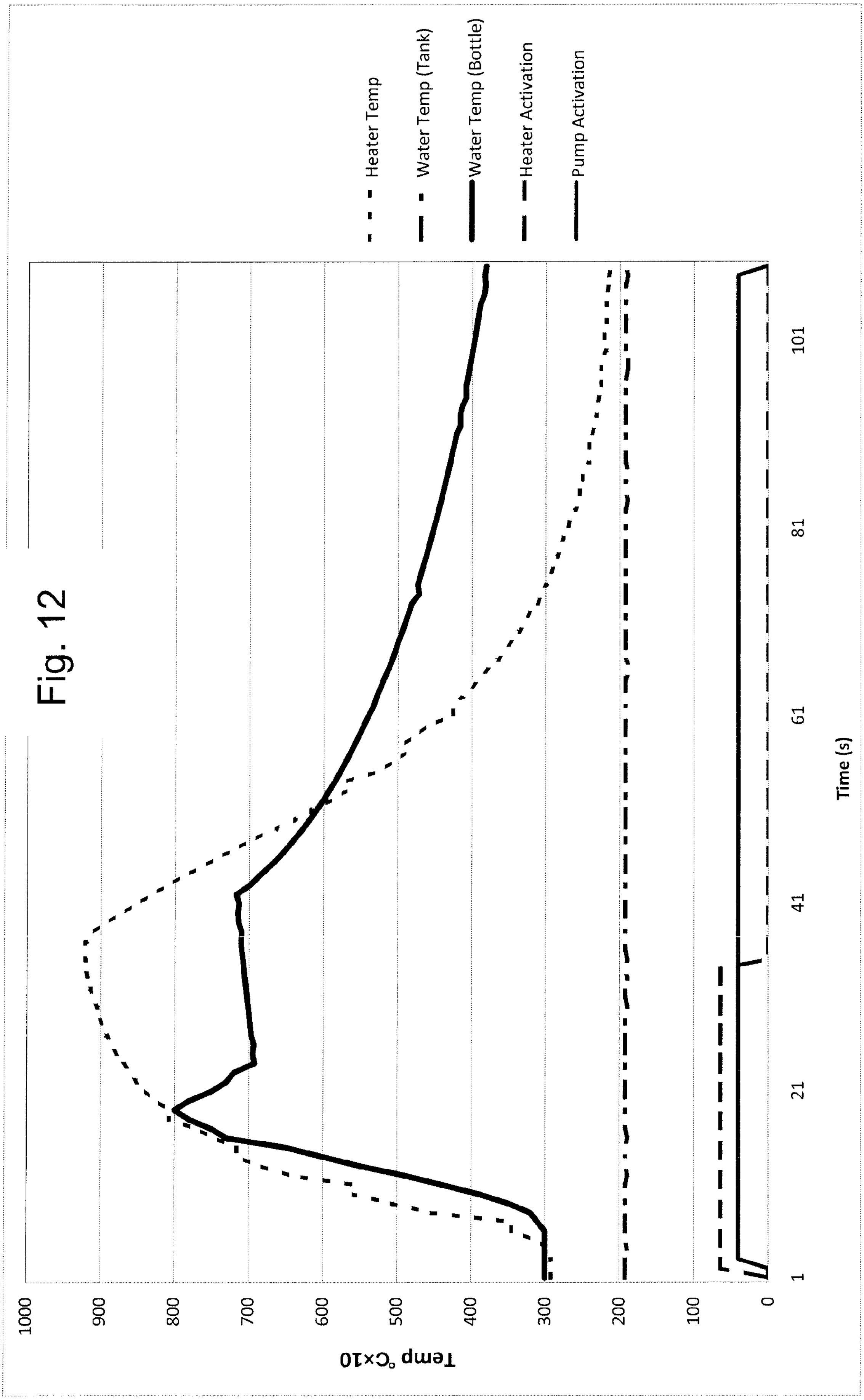

Heater Temp
Water Temp (Tank)
Water Temp (Bottle)
Heater Activation
Pump Activation
Temp °C×10
1000
900
800
700
600
500
400
300
200
100
0
1
21
41
61
81
101
Time (s)

Fig. 12

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2014/050174

A. CLASSIFICATION OF SUBJECT MATTER
INV. A47J31/54 A47J31/56
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A47J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2008/099322 A2 (KONINKL PHILIPS ELECTRONICS NV [NL]; MULDER BERNARDO A [NL]) 21 August 2008 (2008-08-21)	1,12,31, 45,65,69
Y	pages 6,9	2-11, 13-30, 32-44, 46-64, 66-68, 70-72

Y	WO 2012/093269 A2 (STRIX LTD [GB]; FENNA IAIN [GB]; GARVEY VINCENT JOSEPH [GB]; HOWITT JA) 12 July 2012 (2012-07-12) the whole document	2-11, 13-30, 32-44, 46-64, 66-68, 70-72

	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

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Information on patent family members

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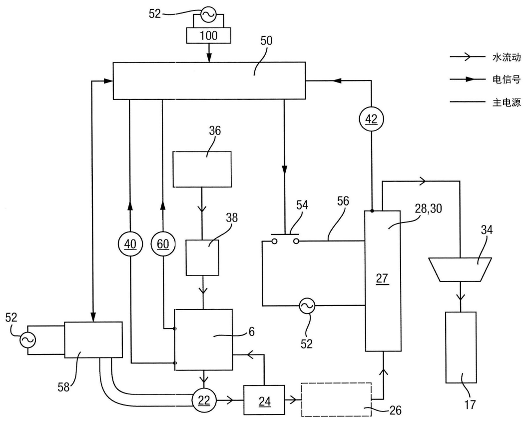
液体加热设备和操作方法

(57)摘要

用于分配预定体积的温液体的设备，包括加热器(27)、泵(22)以及对所述加热器(27)的上游液体的温度敏感的温度传感器(40)。控制器(50)设置成接收来自所述温度传感器(40)的上游温度数据，计算达到所期望的最终温度所需要的能量，使所述加热器(27)通电所计算的开时间段，以及分配液体所计算的时间段，所计算的时间段与所计算的开时间段至少部分地处于相同时段。在加热器(27)已经断电之后，分配的液体去除余热，使得在分配预定体积之后的平均温度是所期望的最终温度。



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1.操作包括加热装置和分配预定体积的温液体的泵的设备的方法,所述方法包括以下步骤：

测量所述加热装置上游的液体的温度；

计算用于所述加热装置将所述预定体积的液体从上游温度加热到所期望的最终温度所需要的能量；

计算用于所述加热装置通电以递送所计算的能量所需要的“开”时间段；

使所述加热装置通电所计算的“开”时间段；

在第一时间段期间操作所述泵,以从所述设备的出口分配在预定初始温度处或在所述预定初始温度之上的第一体积的被加热的液体,其中所述第一时间段与所述所计算的“开”时间段至少部分地处于相同时段；

使所述加热装置断电；以及

在所述第一时间段之后使所述泵操作第二时间段,以从所述设备的出口分配第二体积的液体,从而从所述加热装置去除余热,所述第一体积和所述第二体积一起提供所述预定体积,

其中所述第一体积的液体和所述第二体积的液体的平均温度是在所述预定体积已经分配之后的所期望的最终温度。

2.根据权利要求1所述的方法,其中所述加热装置包括流体加热器,在所述流体加热器中液体允许在加热发生时进入和离开所述加热装置。

3.根据权利要求2所述的方法,其中所述流体加热器包括邻近于彼此设置的液体流导管和包含带护套的加热元件的管。

4.根据前述权利要求中任一项所述的方法,进一步包括处理所述泵和/或所述加热装置上游的液体。

5.根据前述权利要求中任一项所述的方法,其中计算用于所述加热装置将预定体积的液体从所述上游温度加热到所期望的最终温度所需要的能量的步骤包括测量所述加热装置的温度或所述加热装置下游的温度。

6.根据前述权利要求中任一项所述的方法,进一步包括递送恒定流率的液体通过所述加热装置。

7.根据权利要求6所述的方法,其中所述泵是容积泵,所述容积泵设置成递送恒定流率的液体通过所述加热装置。

8.根据权利要求6或7所述的方法,其中所述设备包括在所述泵的下游的流量调节器,以递送恒定流率的液体通过所述加热装置。

9.根据权利要求6、7或8所述的方法,其中所述恒定流率在100ml/分钟与300ml/分钟之间,例如在150ml/min与250ml/min之间,且优选地约170ml/min。

10.根据前述权利要求中任一项所述的方法,其中所述预定初始温度大于60℃,例如大于65℃,并且进一步优选地大于70℃。

11.根据权利要求1-9中任一项所述的方法,其中所述预定初始温度大于环境温度,例如大于25℃、30℃、40℃或50℃。

12.操作包括加热装置和用于分配预定体积的温液体的装置的设备的方法,所述方法包括以下步骤：

测量所述加热装置上游的液体的温度；

计算用于所述加热装置将所述预定体积的液体从上游温度加热到所期望的最终温度所需要的能量；

计算用于所述加热装置通电以递送所述所计算的能量所需要的“开”时间段；

使所述加热装置通电所述所计算的“开”时间段；

在所计算的第一时间段期间从所述设备的出口分配第一体积的直接加热的液体，其中所述第一时间段与所述所计算的“开”时间段至少部分地处于相同时段；

使所述加热装置断电；以及

在所述第一时间段之后从所述设备的所述出口分配第二体积的液体所计算的第二时间段，所述第二体积的液体通过从所述加热装置去除余热而被间接地加热，所述第一体积和所述第二体积一起提供所述预定体积，其中所述第一体积的液体和所述第二体积的液体的平均温度是在所述预定体积分配之后的所述所期望的最终温度。

13.根据前述权利要求中任一项所述的方法，其中所述所期望的最终温度在27℃与47℃之间，优选地在32℃与42℃之间，并且进一步优选地约37℃。

14.根据前述权利要求中任一项所述的方法，包括在与操作所述泵以开始所述第一时间段大致相同的时间处使所述加热装置通电，以开始所计算的“开”时间段。

15.根据权利要求1-13中任一项所述的方法，其中所述所计算的“开”时间段的开始在所述第一时间段的开始之前。

16.根据前述权利要求中任一项所述的方法，包括在所述泵操作之前使所述加热装置通电预热时间段，直到达到预定的预热温度。

17.根据权利要求16所述的方法，其中所述加热元件的所述预定的预热温度大于200℃，例如210℃。

18.根据前述权利要求中任一项所述的方法，包括在所述第一时间段期间周期性地操作所述泵。

19.根据前述权利要求中任一项所述的方法，其中所述第一时间段的结束在所述所计算的“开”时间段的结束之后。

20.根据前述权利要求中任一项所述的方法，包括在所述第一时间段和所述第二时间段之间停止所述泵。

21.根据权利要求1-18中任一项所述的方法，其中使所述加热装置断电终止所述第一时间段，并且所述泵连续地操作以立即开始所述第二时间段。

22.根据前述权利要求中任一项所述的方法，其中所述第二时间段长于所述第一时间段。

23.根据前述权利要求中任一项所述的方法，其中所述第二体积的液体大于所述第一体积的液体。

24.根据前述权利要求中任一项所述的方法，其中所述第一体积的液体在20ml与100ml之间，优选地在20ml与60ml之间。

25.根据前述权利要求中任一项所述的方法，其中所述预定体积的液体由用户选择。

26.根据前述权利要求中任一项所述的方法，其中所述预定体积的液体在50ml与350ml之间，优选地在60ml与300ml之间，例如200ml。

27. 根据前述权利要求中任一项所述的方法，进一步包括从所述加热装置释放过高的压力。

28. 根据前述权利要求中任一项所述的方法，包括计算用于操作所述泵以分配所述第一体积的液体和所述第二体积的液体的所述第一时间段和所述第二时间段。

29. 根据前述权利要求中任一项所述的方法，进一步包括测量主电源电压并且考虑所述主电源电压来调节所述加热装置和 / 或所述泵的操作。

30. 根据权利要求 29 中所述的方法，包括在计算用于使所述加热装置通电所需要的所述“开”时间段时考虑所述所测量的所述主电源电压。

31. 用于分配预定体积的温液体的设备，包括加热装置、泵、对所述加热装置上游的液体的温度敏感的温度传感器，以及控制装置，所述控制装置设置成：

接收来自所述温度传感器的上游温度数据，

计算用于所述加热装置将预定体积的液体从上游温度加热到所期望的最终温度所需要的能量，

计算用于使所述加热装置通电，以递送所述所计算的能量所需要的“开”时间段，

使所述加热装置通电所述所计算的“开”时间段，

在第一时间段期间操作所述泵，以从所述设备的出口分配在预定初始温度处或在预定初始温度之上的第一体积的被加热的液体，其中所述第一时间段与所述所计算的“开”时间段至少部分地处于相同时段，

使所述加热装置断电，以及

在所述第一时间段之后使所述泵操作第二时间段，以从所述设备的出口分配第二体积的液体，从而从所述加热装置去除余热，所述第一体积和所述第二体积一起提供所述预定体积；

其中所述第一体积的液体和所述第二体积的液体的平均温度是在所述预定体积分配之后的所述所期望的最终温度。

32. 根据权利要求 31 所述的设备，其中所述加热装置包括流体加热器，在所述流体加热器中允许在加热发生时液体进入和离开所述加热装置。

33. 根据权利要求 32 所述的设备，其中所述流体加热器包括邻近于彼此设置的液体流导管和包含带护套的加热元件的管。

34. 根据权利要求 31、32 或 33 所述的设备，包括用于将液体供应到所述加热装置的蓄存器。

35. 根据权利要求 34 所述的设备，包括在所述蓄存器和所述泵之间的中间保持腔室，以及用于从所述蓄存器将所述保持腔室填充到预定水位的装置。

36. 根据权利要求 34 或 35 所述的设备，其中所述温度传感器位于所述蓄存器中或位于所述中间保持腔室中。

37. 根据权利要求 31 到 36 中任一项所述的设备，包括液体处理装置，所述液体处理装置设置在所述泵和 / 或所述加热装置的上游。

38. 根据权利要求 31 到 37 中任一项所述的设备，包括进一步的温度传感器，其对所述加热装置的温度或所述加热装置的下游的温度敏感；其中所述控制装置设置成使用由所述进一步的温度传感器测量的温度计算用于所述加热装置将预定体积的液体从所述上游温

度加热到所期望的最终温度所需要的能量。

39. 根据权利要求31到38中任一项所述的设备，包括用于递送恒定流率的液体通过所述加热装置的装置。

40. 根据权利要求39所述的设备，其中所述用于递送恒定流率的装置位于所述泵的下游和所述加热装置的上游。

41. 根据权利要求39所述的方法，其中所述用于递送恒定流率的装置包括容积泵。

42. 根据权利要求39、40或41所述的设备，其中所述恒定流率在100ml/分钟与300ml/分钟之间，例如在150ml/min与250ml/min之间，并且优选地约170ml/min。

43. 根据权利要求31到42中任一项所述的设备，其中所述预定初始温度大于60℃，例如大于65℃，并且进一步优选地大于70℃。

44. 根据权利要求31到42中任一项所述的设备，其中所述预定初始温度大于环境温度，例如大于25℃、30℃、40℃、或50℃。

45. 用于分配预定体积的温液体的设备，包括加热装置，用于分配液体的装置，对所述加热装置上游的液体的温度敏感的温度传感器，以及控制装置，所述控制装置设置成：

接收来自所述温度传感器的上游温度数据，

计算用于所述加热装置将预定体积的液体从所述上游温度加热到所期望的最终温度所需要的能量，

计算用于使所述加热装置通电，以递送所述所计算的能量所需要的“开”时间段，

使所述加热装置通电所述所计算的“开”时间段，

计算从所述设备的出口分配第一体积的直接加热的液体的第一时间段，其中所述第一时间段与所述所计算的“开”时间段至少部分地处于相同时段，

使所述加热装置断电，以及

计算从所述设备的出口分配第二体积的液体的在所述第一时间段之后的第二时间段，所述第二体积的液体通过从所述加热装置去除余热而被间接地加热，所述第一体积和所述第二体积一起提供所述预定体积；

其中所述第一体积的液体和所述第二体积的液体的平均温度是在所述预定体积分配之后的所期望的最终温度。

46. 根据权利要求31到45中任一项所述的设备，其中所述所期望的最终温度在27℃与47℃之间，优选地在32℃与42℃之间，且进一步优选地约37℃。

47. 根据权利要求31到46中任一项所述的设备，其中所述所计算的“开”时间段的开始在所述第一时间段的开始之前。

48. 根据权利要求31到47中任一项所述的设备，其中所述控制装置设置成在操作所述泵之前使所述加热装置通电预热时间段，直到达到预定的预热温度。

49. 根据权利要求48所述的设备，其中所述加热元件的所述预定的预热温度大于200℃，例如210℃。

50. 根据权利要求31到46中任一项所述的设备，其中在与操作所述泵以开始所述第一时间段大致相同的时间处使所述加热装置通电，以开始所述所计算的“开”时间段。

51. 根据权利要求31到50中任一项所述的设备，其中所述控制装置设置成在所述第一时间段周期性地操作所述泵。

52. 根据权利要求31到51中任一项所述的设备，其中所述第一时间段的结束在所述所计算的“开”时间段的结束之后。

53. 根据权利要求31到52中任一项所述的设备，其中所述控制装置设置成在所述第一时间段和所述第二时间段之间停止所述泵。

54. 根据权利要求31到50中任一项所述的设备，其中使所述加热装置断电终止所述第一时间段，并且所述泵连续地操作，以立即开始所述第二时间段。

55. 根据权利要求31到54中任一项所述的设备，其中所述第二时间段长于所述第一时间段。

56. 根据权利要求31到55中任一项所述的设备，其中所述第二体积的液体大于所述第一体积的液体。

57. 根据权利要求 31 到 56 中任一项所述的设备，其中所述第一体积的液体在 20ml 与 100ml 之间，优选地在 20ml 与 60ml 之间。

58. 根据权利要求 31 到 57 中任一项所述的设备，包括输入装置，以允许由用户选择所述预定体积的液体。

59. 根据权利要求 31 到 58 中任一项所述的设备，其中所述预定体积的液体在 50ml 与 350ml 之间，优选地在 60ml 与 300ml 之间，例如 200ml。

60. 根据权利要求 31 到 59 中任一项所述的设备，包括泄压阀，所述泄压阀设置成从所述加热装置释放过高的压力。

61. 根据权利要求31到60中任一项所述的设备，其中所述控制装置设置成计算用于操作所述泵以分配所述第一体积的液体和所述第二体积的液体的所述第一时间段和所述第二时间段。

62. 根据权利要求31到61中任一项所述的设备，其中所述控制装置设置成测量主电源电压并且考虑所述主电源电压调节所述加热装置和 / 或所述泵的操作。

63. 根据权利要求 62 所述的设备，包括连接到所述设备的所述主电源的电压测量电路。

64. 根据权利要求62或63所述的设备，其中所述控制装置设置成在计算用于使所述加热装置通电所需的“开”时间段时考虑所测量的主电源电压。

65. 操作包括加热装置和分配预定体积的温液体的泵的设备的方法，所述方法包括以下步骤 ：

测量提供到所述加热装置的主电源电压 ；测量所述加热装置的上游的液体的温度 ；

计算用于所述加热装置将预定体积的液体从上游温度加热到所期望的最终温度所需要的能量 ；

考虑所测量的主电源电压计算用于使所述加热装置通电以递送所计算的能量所需要的时间段，

使所述加热装置通电所述所计算的“开”时间段 ；以及

操作所述泵，以递送所述预定体积的液体。

66. 根据权利要求 65 所述的方法，包括 ：

在第一时间段操作所述泵，以分配第一体积的液体，所述第一时间段与所述所计算的“开”时间段至少部分地处于相同时段，

使所述加热装置断电，以及

随后操作所述泵第二时间段，以分配第二体积的液体，

其中所述第一体积和所述第二体积一起提供所述预定体积的液体。

67. 根据权利要求 66 所述的方法，其中在所述预定体积的液体分配之后，所述第一体积和所述第二体积的平均温度是所述所期望的最终温度。

68. 根据权利要求 66 或 67 所述的方法，包括在所述加热装置断电之后，连续地操作所述泵或在停顿期间停止所述泵。

69. 用于分配预定体积的温液体的设备，包括加热装置、泵、对所述加热装置上游的液体的温度敏感的温度传感器，以及控制装置，所述控制装置设置成 ：

测量提供到所述加热装置的主电源电压 ；

接收来自所述温度传感器的上游温度数据 ；

计算用于所述加热装置将预定体积的液体从上游温度加热到所期望的最终温度所需要的能量 ；

考虑所述所测量的主电源电压计算用于使所述加热装置通电以递送所述所计算的能量所需要的时间段 ；

使所述加热装置通电所计算的“开”时间段 ；以及

操作所述泵，以分配所述预定体积的液体。

70. 根据权利要求 69 所述的设备，其中所述控制装置设置成 ：

在第一时间段期间操作所述泵，以分配第一体积的液体，所述第一时间段与所述所计算的“开”时间段至少部分地处于相同时段，

使所述加热装置断电，以及

随后操作所述泵第二时间段，以分配第二体积的液体，

其中所述第一体积和所述第二体积一起提供所述预定体积的液体。

71. 根据权利要求 70 所述的设备，其中在分配所述预定体积的液体之后，所述第一体积和所述第二体积的平均温度是所述所期望的最终温度。

72. 根据权利要求 70 或 71 所述的设备，其中在所述加热装置断电之后，所述泵连续地操作，或在停顿期间停止。

液体加热设备和操作方法

技术领域

[0001] 本发明涉及用于将预定体积的水加热到所期望的温度(例如用于在制备婴幼儿配方奶或其他婴幼儿食物中使用的温水)的方法和设备。

背景技术

[0002] 当前的制造技术使得生产和储存随后用于制作婴幼儿奶的无菌婴幼儿配方粉不可行。世界卫生组织(WHO)指导婴幼儿配方奶的制备("婴幼儿配方粉的安全制备、储存和处理:指导",WHO,2007),因此建议通过将婴幼儿配方粉与温度大于70℃的水混合而使其重组,以使可能被诸如阪崎肠杆菌和沙门氏菌的有害细菌污染的婴幼儿配方粉灭菌。

[0003] 目前的婴幼儿配方粉或婴幼儿食物典型地通过使用新近在壶中煮沸的水重组,以使婴幼儿配方粉灭菌,然后允许液体冷却到适合于给婴幼儿的温度——例如,典型地,大约为体温或略高几度。然而,这是耗时间的操作且其可能难以准确地判断正确的温度。

[0004] 即使婴幼儿配方奶在使用非常热的水(例如>70℃)调兑之前没有被灭菌,也仍然期望制备使得奶在被给予到婴幼儿时具有约体温(例如37℃)的最终温度的配方。在实践中,这通常意味着在将温水或热水与配方混合之后制备品必须冷却到所期望的最终温度。没有可靠的方式在正确的温度处立即重组配方粉。尽管冷水可以添加到制备品中,以加速冷却过程,但是这存在冷水不是无菌的风险并且这能够影响正确的剂量以及最终温度。

[0005] 仍然需要一种改进的方法,以在可控的温度下分配可控体积的温水,用于重组婴幼儿配方奶、婴幼儿食物以及其它目的。

发明内容

[0006] 当从第一方面看时,本发明提供操作包括加热装置和分配预定体积的温液体的泵的设备的方法,所述方法包括以下步骤:测量加热装置上游的液体的温度;计算用于加热装置将预定体积的液体从上游温度加热到所期望的最终温度所需要的能量;计算用于加热装置通电以递送所计算的能量所需要的"开"时间段;使加热装置通电所计算的"开"时间段;在第一时间段期间操作泵,以从设备的出口分配在预定初始温度处或在预定初始温度之上的第一体积的被加热的液体,其中第一时间段与所计算的"开"时间段至少部分地处于相同时段;使加热装置断电;以及在第一时间段之后使泵操作第二时间段,以从设备的出口分配第二体积的液体,从而从加热装置去除余热,第一体积和第二体积一起提供预定体积,其中第一体积和第二体积的液体的平均温度是在预定体积已经分配之后的所期望的最终温度。

[0007] 当从第二方面看时,本发明提供用于分配预定体积的温液体的设备,该设备包括加热装置、泵、对加热装置上游的液体的温度敏感的温度传感器以及控制装置,该控制装置设置成:接收来自温度传感器的上游温度数据,计算用于加热装置将预定体积的液体从上游温度加热到所期望的最终温度所需要的能量,计算用于使加热装置通电以递送所计算的能量所需要的"开"时间段,使加热装置通电所计算的"开"时间段,在第一时间段期间操作

泵，以从设备的出口分配在预定初始温度处或预定初始温度之上的第一体积的被加热的液体，其中第一时间段与所计算的“开”时间段至少部分地处于相同时段，使加热装置断电，以及在第一时间段之后使泵操作第二时间段，以从设备的出口分配第二体积的液体，从而从加热装置去除余热，第一体积和第二体积一起提供预定体积，其中第一体积和第二体积的液体的平均温度是在分配预定体积之后的所期望的最终温度。

[0008] 由此，计算使液体的温度从上游温度上升到所期望的最终温度所需要的热能量的总量，并且这在第一体积的液体和第二体积的液体之间是分离的，其中第一体积的液体例如可以用于在大于 70℃的初始温度处重组婴幼儿配方粉，由此满足 WHO 对于制备婴幼儿配方粉的指导，第二体积的液体处于较低的温度，以给总预定体积的分配的液体等于适合于供给到婴幼儿的所期望的最终温度（例如 37℃处）的平均温度。即，一旦所有液体已经被分配，期望的最终温度为容器（例如婴儿奶瓶）中的液体的平均温度。

[0009] 因此，可以了解本发明的方法和设备允许在准确且可重复的递送中提供在所期望的最终温度处的预定体积的液体。与计算加热装置通电的“开”时间（即确定液体可以获得的热能的量）一样，该方法可以计算用于分配第一体积的液体和第二体积的液体的第一时间段和第二时间段，即确保第一体积和第二体积一起提供用户希望分配的预定体积。因此，在所计算的第一时间段期间以及在第一时间段之后的所计算的第二时间段，泵可以被操作。如下文将要解释地，第二计算的时间段可以紧接在第一计算的时间段之后，或在泵操作的第一时间段和第二时间段之间可以有停顿。将要理解的是，可以计算用于使加热装置通电的所计算的“开”时间段以及所计算的泵操作的第一时间段和第二时间段，使得预定体积的液体在其完全分配之后具有所期望的最终温度。这意味着用户仅仅需要开始分配过程，结果将是预定体积的液体以所期望的最终温度分配。计算泵操作的第二时间段，以从加热装置去除余热，使得预定体积的液体具有所期望的最终温度，例如 37℃。

[0010] 在第一时间段和第二时间段之间分配的分离还可以允许用户将第一体积的液体与婴幼儿粉在分配第二体积的液体之前混合。在一组实施例中，这可以通过优选地在第一时间段与第二时间段之间提供泵操作的停顿而变得方便，如下文将要讨论的。在其他的实施例中，泵可以贯穿第一时间段和第二时间段而连续地被操作，仅有的区别在于第一时间段与加热装置的通电同时发生，而第二时间段在加热装置断电之后。例如，在液体通过出口处的奶粉保持器进行分配的情况下，或者在用户在液体分配之前、分配期间或分配之后将奶粉手动添加到液体的情况下，用户并不需要停顿来将婴幼儿配方粉单独地添加到被加热的液体。

[0011] 加热装置可以包括配料加热器，在该配料加热器中，预定体积的液体在离开加热装置之前被加热所计算的“开”时间段。然而，在一组实施例中，加热装置包括流体加热器(flow heater)，在该流体加热器中，液体允许在加热发生时进入和离开加热装置。加热装置可以包括标准的流体加热器或例如在申请人公开的申请 WO 2010/106349 及其背景技术中讨论的流体加热器。这种流体加热器的一个实例是“双管”类，在该“双管”类中，液体流导管和包含带护套的加热元件的管彼此邻近地设置，例如钎焊在一起。如果具有“双管”设计的传统的流体加热器用于将液体加热到沸腾，那么夹带的蒸汽可以引起防止液体均匀地加热到沸点的问题。这种问题的解决方案是允许蒸汽单独离开的流体加热器，例如，如由 WO 2010/106349 所公开的。在流体加热器被用于将液体加热到沸腾以下的温度的情况下，则蒸

汽可以允许单独地逸出，例如，如在申请人公开的申请 WO2011/077135 中所讨论的，或蒸汽和液体可以从同一流导管简单地一起离开。在本实施例中，优选地，所期望的最终温度在沸腾以下，并且可以不需要流体加热器或其他加热装置，以将液体加热到沸点。加热装置（例如流体加热器）可以设置成将液体加热到沸腾以下的温度，从而减小或避免由于热蚀和局部沸腾导致的溅射现象。加热装置可以具有固定功率，例如，其标称加热功率额定在 800W。在不同的实例中，加热装置（优选地为流体加热器）可以在诸如 800W、900W 或 1KW 的相对低的功率下操作。

[0012] 设备可以直接地（例如永久地）连接到用于将液体供应到泵和加热装置的液体源，例如铅垂到供水干路中。然而，在一组实施例中，设备包括用于将液体供应到加热装置的蓄存器。优选地，蓄存器可移除，以允许其由用户容易地例如从龙头重新填充。蓄存器可以包括例如连接到控制装置的最小填充传感器，该最小填充传感器设置为在蓄存器中的液位在最小填充位以下时阻止设备（或至少加热装置和 / 或泵）的操作。设备的此禁用保护加热装置过热，即可能损坏加热装置的干烧情形。

[0013] 无论设备是与液体源（例如供水干路）串联还是设置有蓄存器，申请人已经了解可以期望在液体到达设备的出口之前处理（并且优选地灭菌）液体。这通过在泵和 / 或加热装置的上游提供处理装置可以非常方便地实现，但是在实践中，处理装置可以设置在出口的上游的任何地方。在设备包括蓄存器的一组实施例中，处理装置可以设置在蓄存器的上游 / 下游，或在蓄存器中，或在蓄存器的入口 / 出口处。处理装置可以采取过滤器的形式，优选地为抗菌过滤器。如果使用过滤器，则优选地将其设置在蓄存器的上游，以在设备的操作期间不会过度地限制从蓄存器流出的流体的流率。然而，可以使用其他形式的处理来代替过滤器，或除了过滤器之外可以使用其他形式的处理，例如紫外线处理、氯气处理、臭氧处理或这些灭菌处理的任何组合。处理装置的目的是消除微生物污染和其他物质，使得液体在被分配之前净化，这在分配温水以制作婴幼儿配方奶或食物时是尤其重要的。

[0014] 在一组实施例中，设想处理装置可以包括加热装置，该加热装置设置成以最少的时间段煮沸液体，以实现灭菌。为此目的，处理装置可以使用其自身的加热装置，但是优选地处理在所计算的“开”时间段被执行，在该所计算的“开”时间段，加热装置通电，以将所计算的能量递送到预定体积的液体。这可能需要设备将所计算的“开”时间段与最少的时间段比较，以确保实现灭菌。例如，WHO 指导规定水应当被煮沸“若干分钟”，以使致病微生物失去活性或杀死致病微生物。在这种实施例中，设备可以进一步包括热交换器，使得被处理的液体可以在被分配之前冷却。

[0015] 在设备包括蓄存器的一组实施例中，设备可以包括在蓄存器与泵之间的中间保持腔室，以及用于从蓄存器将保持腔室填充到预定水位的装置。根据这种实施例，泵不会直接地从蓄存器汲取液体，而是从中间保持腔室汲取液体。因为中间保持腔室被填充到预定水位，因此泵入口处的压头将已知，因而在计算泵速、流率等时，其可以作为一个因素被加以考虑。优选地，中间保持腔室具有比蓄存器更小的体积。即使中间保持腔室中的液位在分配期间可以减少，但是压力的变化比液体从较大的蓄存器汲取时覆盖更小的范围。

[0016] 在提供蓄存器的情况下，优选地，上游温度在蓄存器中（或在设置有中间保持腔室的情况下，在中间保持腔室中）测量。在一组实施例中，计算用于加热装置将预定体积的液体从上游温度加热到所期望的最终温度所需要的能量的步骤包括测量加热装置的温度

或加热装置下游的温度，即设备包括对加热装置的温度或加热装置下游的温度敏感的温度传感器。测量加热装置的温度或下游温度给出了设备中的残余能量的指示，例如由于环境温度和／或设备最近被操作，因此加热元件提供一些余热，其可以作为一个因素在计算将预定体积加热到所期望的最终温度所需要的能量时加以考虑。例如，如果设备包含一些来自先前操作的一些余热，则用于将预定体积加热到所期望的最终温度所需要的能量将低于设备还没有被使用很长一段时间所需要的能量。由此，对于固定功率的加热装置，例如，所计算的用于使加热装置通电的“开”时间段将较短。

[0017] 下游温度可以对设备中的任何残余液体敏感，但是优选地，其对用于将液体从加热装置输送到分配出口（例如导管或管）的任何装置的温度敏感。由此，至少在一些实施例中，所计算的能量包括加热装置的热容量和加热装置下游的任何其他的散热。所计算的能量还可以补偿系统的热损失，尤其是如果在第一时间段和第二时间段之间有停顿。在所计算的能量的计算中，停顿的持续时间可以由控制装置测量并使用。然而，实际上，能量损失可能由所计算的能量的估计的或先前校准的常量（例如 10％）而导致。

[0018] 供应到加热装置的功率可以变化，例如由控制装置控制，以将加热装置的功率与经过加热装置的液体的流率匹配。相比于第一时间段中分配的具有对应于预定初始温度的平均温度的液体而言，这可以用于确保对于整个第一时间段，液体温度保持在预定初始温度（或以上）。然而，在一组实施例中，由控制装置供应到加热装置的功率是恒定的（尽管在主电源中可能有波动，如下文将要讨论地）。这简化了所需要的能量的计算。

[0019] 设备可以包括用于测量通过加热装置的液体的流率的装置。如果此测量被供给到控制装置，则其允许控制装置控制泵操作第一时间段和第二时间段，即为了分配预定体积的液体。用于测量流率的装置可以包括流量计，其设置为单个部件或作为泵的一部分，例如泵可以用于推断流率。在一些实例中，可以依赖泵以大致恒定的流率递送液体，而不管液体压力（例如，如由主电源或蓄存器中的上游液体压力所设定）。然而，在一组实施例中，设备包括用于将恒定流率的液体递送通过加热装置的装置，例如流量调节器。这可以由电子流量控制器（例如阀）提供，但是优选地提供有在 WO 2012/114092 中描述的流量调节器类型，WO 2012/114092 的内容通过引用并入本文。

[0020] 因为用于递送流率的装置设定通过加热装置的液体的恒定的流率（其优选地独立于由泵递送的压力），因而恒定的流率允许更简单地控制设备。例如，诸如电磁泵的一些泵倾向于操作弹性隔膜，而不是活塞，且取决于液体压力可以递送不同流率。这可以使用诸如流量调节器的相对不贵的部件实现。由此，第一时间段和第二时间段可以基于在这些时间段的每个时间段中的待分配的液体体积简单地计算，然后通过操作泵总体的固定时间段（即第一时间段和第二时间段的总和）简单地分配预定体积的液体。用于测量通过加热装置的液体的流率的装置或用于递送恒定流率的液体通过加热装置的装置优选地位于泵的下游和加热装置的上游，即在泵和加热装置之间。

[0021] 恒定的流率还使得其较容易分配在预定初始温度处的第一体积的液体，例如，用于递送恒定流率的装置可以选择为匹配从加热装置到液体中的传热速率，使得第一体积的液体在整个第一时间段以相对恒定的温度分配。这可以通过泵本身（例如容积泵）设定或通过泵（例如电磁泵）下游的流量调节器设定。恒定的流率优选地在 100ml/ 分钟与 300ml/ 分钟之间，例如，在 150ml/ 分钟与 300ml/ 分钟之间，且优选地约 170ml/ 分钟，并且这可以

在例如设备的校准期间测量。可替换地，流量调节器可以预设有可靠的流率，例如可以从耐特菲姆公司 (Netafim)(www.netafim.com) 购买到的合适的压力补偿恒流阀。提供用于递送恒定流率的装置还减少来自泵的流率随着时间、供给电压、磨损等的变化的影响。

[0022] 因为已经计算了需要由加热装置递送的能量的总量，并且在一些实施例中，液体通过加热装置的流率已知或校准，所以不需要测量最终的液体温度，例如检验其在第一时间段已经达到预定的初始温度。对此所需要的所有是加热装置上游的温度的测量、待递送到预定体积的液体的能量和经过加热装置的液体的流率的计算。如下文将要讨论地，还可以考虑可能影响加热装置和 / 或泵的操作的主电源中的任何波动。

[0023] 预定初始温度可以是在第一时间段分配的液体的平均温度或液体在第一时间段可以以恒定的预定初始温度分配。然而，至少刚开始在系统不可能处于平衡时难以实现，因此在分配的液体中总是可能存在至少一些小的温度波动。因此，预定初始温度可以对应于最低温度，在第一时间段液体在该最低温度以上分配。在一组实施例中，这可以对应于瓶和 / 或婴幼儿配方粉的灭菌温度。优选地，预定初始温度大于 60℃，例如大于 65℃，并且进一步优选地大于 70℃。预定初始温度可以例如经由设备上的输入件由用户设定，以允许其在操作之间变化，或预定初始温度可以编程到设备中。在一组实施例中，初始分配的第一体积液体的预定初始温度预设在约 95℃。这确保婴幼儿配方粉的灭菌，并且类似于通常使用的刚好沸腾的水的温度。一般来说，预定初始温度可以大于所期望的最终温度，即分配的第一体积的液体的温度大于分配的第二体积的液体的温度。

[0024] 在一些实施例中，预定初始温度可以与所期望的最终温度大致相同或不高于所期望的最终温度。例如，在加热装置上游的液体温度不是比所期望的最终温度低得多的情况下，所计算的由加热装置递送的能量可以相对小，因此当加热装置通电时在第一时间段期间以及当余热移除时的第二时间段期间，液体可以以约相同的温度分配。当设备在具有相对高的环境温度（例如大于 25℃、30℃、35℃或甚至大于 40℃）的环境中操作时，这可能发生。在加热装置上游（例如在蓄存器中）的液体具有已经 >35℃的温度时，则其在第一时间段可能难以实现大于 60℃或 70℃的预定初始温度，并随后在分配预定体积之后获得较低的期望的最终温度，除非预定体积较大或分配率非常低，因为余热不能被充分地分散。优选地，预定初始温度大于环境温度，例如大于 25℃、30℃、40℃或 50℃，但是预定初始温度可以不与 70℃、80℃、90℃或 95℃一样高。例如，在第一时间段分配的被加热的液体可以具有在 50-70℃范围内的温度。在至少一些实施例中，预定初始温度可以不被设定或编程。无论预定初始温度是否超过最小温度，与所期望的最终温度相比，预定初始温度可以仅仅取决于加热装置上游的液体的开始温度。

[0025] 当从进一步的方面看时，本发明提供操作包括加热装置和用于分配预定体积的温液体的装置的设备的方法，所述方法包括以下步骤 ：测量加热装置上游的液体的温度 ；计算用于加热装置将预定体积的液体从上游温度加热到所期望的最终温度所需要的能量 ；计算用于使加热装置通电以递送所计算的能量所需要的“开”的时间段 ；使加热装置通电所计算的“开”时间段 ；在所计算的第一时间段期间从设备的出口分配第一体积的直接加热的液体，其中第一时间段与所计算的“开”时间段至少部分地处于相同时段 ；使加热装置断电 ；并且在第一时间段之后的所计算的第二时间段从设备的出口分配第二体积的液体，第二体积的液体通过从加热装置去除余热而被间接地加热，第一体积和第二体积一起提供预定体

积，其中第一体积的液体和第二体积的液体的平均温度是预定体积被分配之后的所期望的最终温度。

[0026] 当从另一个进一步的方面看时，本发明提供用于分配预定体积的温液体的设备，包括加热装置、用于分配液体的装置、对加热装置上游的液体的温度敏感的温度传感器以及控制装置，该控制装置设置成：接收来自温度传感器的上游温度数据，计算用于加热装置将预定体积的液体从上游温度加热到所期望的最终温度所需要的能量，计算用于使加热装置通电以递送所计算的能量所需要的“开”时间段，使加热装置通电所计算的“开”时间段，计算从设备的出口分配第一体积的直接加热的液体的第一时间段，其中第一时间段与所计算的“开”时间段至少部分地处于相同时段，使加热装置断电，以及计算从设备的出口分配第二体积的液体的在第一时间段之后的第二时间段，该第二体积的液体通过从加热装置去除余热而被间接地加热，第一体积和第二体积一起提供预定体积；其中第一体积液体和第二体积液体的平均温度为在分配预定体积之后所期望的最终温度。

[0027] 由于所计算的能量是将预定体积的液体的全部从上游温度加热到所期望的最终温度所需要的能量，因此在第二时间段分配的液体的具体的温度曲线不是关键的。只要通过加热装置的液体的流率不是太高，则在第二时间段发生第二体积的液体分配时，所有的余热能量可以从加热装置传递到液体。在实践中，这不是问题，例如在小于 500ml/min 的流率的情况下。通常，控制装置不需要计算对于每个分配操作的最大流率，尽管其可以是在工厂校准期间例如在极端的情况下限制流率而在设备中编程的或预设的值。泵的选择和 / 或在泵和加热装置之间的流量限制器的使用可以确定最大流率。在设置有用于递送通过加热装置的恒定流率的装置（诸如流量调节器）的情况下，这可以选择提供最大流率以下的流率。因此，一般来说，在第二时间段分配的液体在第二时间段的结束或在第二时间段的结束之前将达到与加热装置的热平衡。换句话说，在第二时间段期间将所有的余热去除是优选的。然而，可以使加热装置通电至少所计算的“开”时间段，即可能长于所计算的“开”时间段的时间段，或者在与第二时间段处于相同时段的后一时间处的附加的“开”时间段。由此，这将在加热装置中留下一些余热能量。然后，通过加热装置的流率需要更准确地计算，以在第二时间段期间将正确量的热能从加热装置传递到流过该加热装置的液体。

[0028] 所期望的最终温度可以是对于设备的具体应用的任何合适的温度。例如，设备可以用于分配用于制备诸如汤粉或感冒药的食物的温液体或用于注入诸如白茶或绿茶的清淡饮料（例如在 65℃到 85℃时冲泡而不是使用刚刚沸腾的水）。然而，在一组实施例中，尤其适用于制备婴幼儿配方，所期望的最终温度在 27℃与 47℃之间，优选地在 32℃与 42℃之间，进一步优选地约 37℃。所期望的最终温度可以由用户设定，例如经由设备上的输入件，以允许其在操作之间变化，或所期望的最终温度可以编程到设备中。如上文所讨论地，由于计算了将预定体积的液体加热到所期望的最终温度所需要的能量，因此不需要连续地监控被加热液体的最终温度或在出口处的温度。然而，设备可以包括在出口处的温度感测装置，该温度感测装置对被加热的液体的温度敏感。这可以用作反馈检验，以监测分配的液体的温度，并可以由控制装置使用，以控制泵操作的第一时间段和第二时间段或甚至泵速（例如在控制通过加热装置而不是流量调节器的液体的流率情况下）和 / 或加热器的通电（时间和 / 或功率），以很好地调节最终温度。

[0029] 由于第一时间段与所计算的“开”时间段至少部分地处于相同时段，因此加热装置

的通电在时间上与泵的第一操作重叠。第一时间段可以严格对应于所计算的“开”时间段，即它们可以同时通电。由此，在一组实施例中，该方法包括在与操作泵以开始第一时间段大致相同的时间使加热装置通电，以开始所计算的“开”时间段。因此，所计算的“开”时间段可以在与泵操作的第一时间段相同的时间处开始，而不需要任何预热。所计算的“开”时间段的开始甚至可以在第一时间段的开始之后，例如使得第一体积的液体中的一些在加热装置通电之前分配。这种延迟的加热可以在加热装置上游所测量的液体温度在特定阈值之上的情况下使用，使得将需要较小的能量来加热到所期望的最终温度。然而，在这种情况下，可以较容易地使加热装置在与泵相同的时间开始并且缩短所计算的“开”时间段。

[0030] 在一组实施例中，所计算的“开”时间段的开始在第一时间段的开始之前。由此，加热装置在液体泵送经过该加热装置之前通电，从而允许加热装置预热到其操作温度或朝向其操作温度预热。这确保加热装置（例如包括加热元件和液体流导管）被足够地加热，使得加热装置中的任何残余液体以及泵送通过该加热装置的初始体积的液体处于预定初始温度处，并且避免在第一时间段和所计算的“开”时间段严格对应时分配的初始体积的液体是冷的的风险。因此，该方法可以进一步包括使加热装置在第一时间段开始之前通电预定时期的步骤。

[0031] 在泵操作之前用于使加热装置通电的预热时间可以是固定的。然而，在一组实施例中，在泵操作之前使加热装置通电预热时间段，直到达到预定预热温度。这可以通过对加热装置的温度或加热装置下游的温度敏感的温度传感器（在设置有的情况下）测量。在一组实施例中，包括带护套的加热元件和邻近彼此设置的液体流导管，温度传感器可以设置成与带护套的加热元件和液体流导管中的一个或二者良好地热接触。例如，加热装置的温度可以由与带护套的加热元件和液体流导管均热连通的温度感测装置测量，例如如在申请人公开的申请 WO 2013/024286 中所描述的，该申请的内容通过参考并入本文。加热元件的预定预热温度可以大于 200℃，例如 210℃。由于设备中的温度梯度，这典型地将液体流导管加热到刚好在 100℃以下。

[0032] 在第一时间段，泵可以连续地操作，以提供恒定流。然而，发明人已经了解，当液体以典型的流率（例如如由泵下游的流量调节器提供的）流过加热装置时，热能从加热装置到液体的传热率可以大于加热器的功率，并且因此加热装置可以在液体流过该加热装置时冷却下来，尤其地当预定初始温度适合于灭菌，例如大于 70℃时。这引起分配的液体的温度在第一时间段期间的相当大的变化，即冷却下来。为了适应此现象，递送到加热装置的流率可以变化，使得从加热装置到液体的热能的传热率例如通过减小流率与加热器的功率匹配。在液体直接泵送到加热装置而不使用流量调节器的情况下，则这可以通过调节泵速实现。然而，在一组实施例中，泵在第一时间段期间周期性地操作，即小股地泵送，以调节整体流率。这尤其适合于在泵和加热装置之间使用恒定流率调节器的实施例。这种脉冲操作允许加热装置在液体泵送的时间之间增加温度，使得在第一时间段期间泵送的液体可以以预定的初始温度更准确地分配。

[0033] 第一时间段的结束可以与所计算的“开”时间段的结束重合或甚至在其之前，即泵可以在加热装置断电时或之前停止泵送。然而，在一组实施例中，第一时间段的结束在所计算的“开”时间段的结束之后，即优选地，泵在加热装置已经断电之后继续泵送液体。这防止加热装置的过热。

[0034] 只要第二时间段在第一时间段之后开始，并且优选地在加热装置已经断电之后开始，则对于第二时间段的开始存在若干不同的可能性。例如，第二时间段可以在第一时间段之后立即发生，其中泵连续操作。在这些实施例中，第二时间段的开始将由加热装置断电的时间大致地限定。因此，加热装置断电的步骤可以终止第一时间段（例如在液体直接加热的情况下）并且泵可以连续操作，以立即开始第二时间段（例如在液体通过去除余热间接加热的情况下）。泵操作的第一时间段和第二时间段之间可能不会有任何停顿。例如，器具可以包括用于在液体被分配时将婴幼儿配方粉（或其他待重组的食物）添加到液体中的装置，而不需要用户干预。

[0035] 然而，在一组实施例中，泵在第一时间段和第二时间段之间停止，即有停顿。这意味着在此中间时间段不分配液体，并且允许在分配第二体积的液体之前将例如婴幼儿配方粉添加到瓶中并与第一体积的液体混合，或者，如果婴幼儿配方粉在分配第一体积的液体之前添加到瓶中时允许摇晃瓶或搅动瓶。停顿可以在 30s 与 60s 之间，例如 45s。此相对短的时间段限制从加热装置损失的热能的量。在实践中，短期的停顿（例如少于 60s）可能不会影响剩余余热的量。停顿的持续时间可以为预定的并且自动发生。然而，在一组实施例中，停顿的持续时间由用户确定。例如，用户可以例如通过按压按钮开始第二时间段。这可以允许用户在期望快速分配第二体积时无视预编程的停顿。

[0036] 可以了解，用于泵操作的第一时间段和第二时间段中的每个时间段的长度在考虑加热装置上游的液体的温度而加以计算，这确定了将预定体积的液体加热到所期望的最终温度所需要的能量。典型地，所期望的最终温度比环境温度高，例如大于 25℃、30℃、40℃或 50℃。然而，这种最终温度可以通过直接加热第一体积的液体而实现，该第一体积的液体与在加热装置已经断电之后通过去除余热而间接加热的第二体积的液体相同或比第二体积的液体小。因此，第二体积的液体可以大于第一体积的液体。已经发现泵操作的第二时间段可以通过从加热装置移除大致所有的余热而补偿预定体积，这可以比第一阶段的直接加热占用更长的时间。因此，第二时间段可以比第一时间段更长。实际上，计算第二时间段以确保能量平衡，使得对于分配的给定预定体积，所期望的最终温度准确地实现。

[0037] 第一体积的液体可以在 20ml 与 100ml 之间，优选地，在 20ml 与 60ml 之间。这是对于婴幼儿配方的供给大小（例如 270ml-300ml）最大的约 20％。第二体积的液体可以在 50ml 与 250ml 之间，优选地，在 100ml 与 240ml 之间，即，一般来说，第二体积的液体可以大于第一体积的液体。对于第一体积的液体和第二体积的液体的每个的体积量可以由用户选择，例如经由用户界面，在该用户界面中，用户输入一个值或从多个预编程选项中选择，例如标准瓶大小。然而，在一组实施例中是预定体积的液体，即由用户选择的分配的液体的总体积。然后基于第一体积的液体的所期望的最终温度和预定的初始温度，控制装置计算第一体积的液体和第二体积的液体。预定体积的液体可以在 50ml 与 350ml 之间，优选地在 60ml 与 300ml 之间，例如 200ml 可以是典型地用于婴幼儿配方的，但是当然体积将取决于待喂养的婴幼儿的年龄。本发明延伸到本文所描述的用于分配预定体积的温液体（优选地水）的设备，该预定体积从以下的一个或多个中选择 :60ml、120ml、150ml、180ml、250ml、270ml、300ml、340ml。

[0038] 泵可以是用于将所需要的流率的液体递送通过设备的任何合适的泵。在一组实施例中，泵包括电磁泵。例如，这种泵能够递送优选地大于 0.5bar 并且优选地高达 4bar 的压

力。在设置这种泵的情况下，如上文所述地，这允许流量调节器递送例如 170ml/ 分钟的恒定流率。这种恒定流量调节器典型地需要最小的压力（例如 0.5bar），以操作并因此优选地设置为与电磁泵连接，以对调节器上游的流动进行加压。

[0039] 在另一组实施例中，泵包括容积泵，诸如活塞泵。这种泵实际上可以在宽范围的液体压力上以实际恒定流率（在时间上平均）操作。在可以依赖泵本身将恒定流率的液体提供到加热装置 / 通过加热装置的情况下，则如上文所述，流量调节器可以省略。

[0040] 可以了解，其他的泵布置可以落入本发明的范围内。设备甚至可以不包括明确的泵装置。如上文所述地，设备可以直接地（例如永久地）连接到外部液体源，例如铅垂到供水干路中。在设备与诸如供水干路的液体源串联的情况下，设想"泵"可以仅包括当液体从外部源分配时控制的阀。在这种实施例中，通过加热装置的流率可以使用恒定流率装置调节，例如如上文已经讨论地。在一组实施例中，设备包括泄压阀，该泄压阀设置成从加热装置释放过高的压力，例如在加热装置中或加热装置下游堵塞的情况下。泄压阀可以放置在加热装置的下游，但是优选地位于加热装置的上游，例如在蓄存器和加热装置之间，因为这不会干扰被加热的液体在设备的出口处的最终分配。泄压阀可以通向大气，例如设备外侧的排出管，或滴水盘。然而，常规地，在设置有泄压阀的情况下，泄压阀向回通到蓄存器中。

[0041] 在一组实施例中，控制装置从设备中的各个输入件，例如温度传感器和水位传感器接收数据，并且使用此数据即从其执行的计算控制泵和 / 或加热装置。控制装置可以包括与各个部件数据通信的微处理器。如上所指明的，设备可以在其在工厂制造期间校准和 / 或在其初次使用之前由使用者校准。优选地，在校准期间确定的值和关系由控制装置使用，以控制设备的操作。

[0042] 上文所述，当设备在其初次使用之前校准（例如在工厂中或由用户作为初始设定过程的一部分）时，可以考虑当地主电源电压。虽然加热装置可以额定为提供固定的标称功率输出，但是这可以被主电源中的差值影响。例如，欧洲的主电源通常为 230V，但是在中国反而为 220V。设备可以校准，用于在其他国家使用，诸如主电源功率仅为 120V 的美国，或 100V 电源的日本。然而，即使超出此校准，在设备的使用期间在主电源中仍然可能有波动，该波动可以影响设备的性能，特别是当试图以准确的最终温度分配预定体积的液体时。因此，在一组实施例中，优选地，操作包括测量主电源电压的步骤，并且进一步优选地考虑主电源电压而调节加热装置和 / 或泵的操作。

[0043] 在英国，主电源由欧洲标准 61000-4-14 规定为 230V(+10％、-6％）。即使在此范围内的电压波动在加热装置和 / 或泵的功率输出上可以具有严重的影响，因为功率与电压的平方成比例。一些 1 类电子装置是指对主电源波动敏感并且需要连接到受保护的主电源（例如使用恒压变压器），但是 2 类电子装置中的家用器具意欲直接连接到电源而不具有任何这种保护。根据本发明的设备最有可能是 2 类家用器具，例如具有用于直接连接到主电源的缆线。

[0044] 主电源电压可以取决于一天的时间而潜在地预测（因为波动根据已知的使用模式典型地发生），但是更准确的是实际测量主电源电压。控制装置可以设置成以任何合适方式测量主电源电压。例如，控制装置可以包括或连接到电源电压传感器（例如如由伊顿公司 (Eaton Corp.）或其他供应商所售卖的）。在优选的一组实施例中，控制装置包括连接到设备的主电源的电压测量电路。优选地，电压测量电路是控制装置的微处理器的一部分或

连接到控制装置的微处理器，该控制装置的微处理器设置成考虑主电源电压而调节加热装置和／或泵的操作。电压测量电路可以是具有模拟／数字转换器的模拟电路，该模拟／数字转换器用于给微处理器提供代表所测量的电压等级的数字输入。

[0045]　所测量的主电源电压可以由控制装置使用，以调节加热装置的功率，以实现相同的功率输出而不管主电源中的波动。然而，如上所述地，优选地，控制装置不会调节供应到加热装置的功率。因此，加热装置的能量输出取决于主电源电压中的波动而变化。为确保加热装置递送所需要的所计算的能量，在计算加热装置通电所需要的时间段时，优选考虑测量的主电源电压。

[0046]　这就其本身被认为是新颖且有创造性的，并且因此当从进一步的方面看时，本发明提供操作包括加热装置和分配预定体积的温液体的泵的器具的方法，该方法包括以下步骤：测量提供到加热装置的主电源电压；测量加热装置上游的液体的温度；计算用于加热装置将预定体积的液体从上游温度加热到所期望的最终温度所需要的能量；考虑所测量的主电源电压计算用于使加热装置通电以递送所计算的能量所需要的时间段；使加热装置通电所计算的“开”时间段；以及操作泵，以分配预定体积的液体。

[0047]　根据另一个进一步的方面，提供用于分配预定体积的温液体的设备，包括加热装置、泵、对加热装置上游的液体的温度敏感的温度传感器以及控制器，该控制器设置成：测量提供到加热装置的主电源电压；接收来自温度传感器的上游温度数据；计算用于加热装置将预定体积的液体从上游温度加热到期望的最终温度所需要的能量；考虑所测量的主电源电压计算用于使加热装置通电以递送所计算的能量所需要的时间段；使加热装置通电所计算的“开”时间段；以及操作泵以分配预定体积的液体。

[0048]　可以了解，使用这种方法和设备可以调节加热过程，以补偿当地主电源中的波动，例如该波动可以发生在一天的不同时间，而不需要调节供应到加热装置的功率。此外，由于是预定体积的液体被加热而不是连续的流（例如在提供用于茶、咖啡等的热水的常规的饮料分配设备中），因此流率不完全与待实现的最终温度有关，只要准确地分配预定体积（并且所计算的能量从加热装置有效地传递）即可。

[0049]　根据本发明的这些进一步的方面的实施例，预定体积的温液体可以由操作泵的一个或多个时间段分配。设想泵可以在加热装置通电一时间段之前和／或之后操作，该时间段与所计算的“开”时间段处于不同的时间段操作。这可以在加热装置包括配料加热器而不是流体加热器的情况下使用。然而，在优选的实施例中，泵在第一时间段期间操作，该第一时间段至少部分地与所计算的“开”时间段处于相同时段，以分配第一体积的液体，使加热装置断电，随后泵操作第二时间段，以分配第二体积的液体，其中第一体积和第二体积一起提供预定体积的液体。如以上所讨论地，泵可以连续地操作，使得第二时间段紧跟第一时间段，或在第一时间段和第二时间段之间的泵操作中可以有停顿。

[0050]　优选地，在预定体积的液体分配之后，第一体积和第二体积的平均温度是期望的最终温度。由于测量提供到加热装置的实际主电源电压并在计算加热装置通电的时间段时将此考虑进去，因此确保了最终温度的准确性。

[0051]　主电源电压中的变化还可以影响泵的输出，这可以与本发明的任何方面的实施例相关。如果泵将液体直接递送到加热装置，例如在泵和加热装置之间没有恒流调节器，则流率将取决于泵速。在这种实施例中，当计算由泵递送的流率和／或泵操作的时间段时，可以

考虑(可替换地或额外地)测量的主电源电压。泵速和/或泵操作的时间段可以相应地控制。这可以帮助确保准确地分配预定体积的温液体,而不会由于泵速的波动而导致体积在被分配之上或之下。然而,在优选的一组实施例中,使用恒流调节器(如上文所说明的),以设定恒定的流率,并因此不需要考虑泵功率的改变。

[0052] 主电源电压可以定期地测量,并且此信息可以用于更新加热时间段的计算。然而,优选地,执行主电源电压的单个测量(例如在分配循环的开始处),以一次计算加热器通电时间段,然后继续加热和分配预定体积。对于预定体积的液体(例如典型地用于制作婴幼儿奶的水)而言,分配循环,尤其是加热装置的通电时间段,典型地将仅持续一或两分钟或更少。这意味着在主电源电压已经在开始处测量之后不需要具有调节加热时间段的闭合反馈回路。当然,这帮助简化由控制装置执行的计算,同时也确保加热过程的准确性。

[0053] 如本文所使用的术语"灭菌"意指涉及杀死潜在的有害的病菌和细菌的过程。其应当解释为隐含灭菌的特殊等级——例如,满足临床灭菌目的或实际满足任何其他具体的目的或效果。

附图说明

[0054] 现在将参考附图仅通过实例的方式说明本发明的特定实施例,在附图中:

[0055] 图 1 是根据本发明的实施例的器具的立体图;

[0056] 图 2 和 3 是图 1 中示出的器具的主要内部部件的主视立体图和后视立体图;

[0057] 图 4 是图 2 和 3 中示出的水罐的横截面视图;

[0058] 图 5 是示出通过器具的水流量、功率和电信号的示意图表;

[0059] 图 6 是电压测量电路图表;

[0060] 图 7 是列出在根据第一实施例的完整的分配循环中涉及的主要步骤的流程图;

[0061] 图 8 是器具的操作的绘图;

[0062] 图 9 是示出用于瓶中的水的温度曲线的绘图;

[0063] 图 10 是列出在根据第二实施例的完整的分配循环中涉及的主要步骤的另一个流程图;

[0064] 图 11 是示出当根据图 10 的循环分配 120ml 体积的被加热的液体时的操作和温度曲线的绘图;以及

[0065] 图 12 是示出当根据图 10 的循环分配 330ml 体积的被加热的液体时的操作和温度曲线的绘图。

具体实施方式

[0066] 图 1 是本发明的实施例的立体图,并且示出用于分配温水以从婴幼儿配方粉制备婴幼儿配方奶的器具 1。该器具示出具有外壳体 2,在该外壳体 2 中设置有用于观察内部水罐 6(见图 2 和 3)中的水位的窗口 4。在壳体 2 的右手侧有三个用户输入按钮 8。这些输入按钮用于在新的水过滤器已经安装时设定计时器,用于进行器具 1 的清洗循环,以及用于进行除垢循环。LEDs 的面板 10 显示器具 1 的各种操作状态,即警示灯指示水过滤器需要更换。开-关按钮 12 和可旋转的分配体积刻度盘 13 设置在位于滴水盘 16 上方的分配出口 14 之上。婴儿瓶或杯 17(图 5 中示出)可以放置在滴水盘 16 上,使得在使用中被加热

的水被分配到瓶或杯 17 中，其中外壳体 2 具有在滴水盘 16 和分配出口 14 之间的竖直延伸的凹陷部 18，以容纳瓶 17。

[0067] 在图 2 和 3 的立体图中可以看见器具 1 的主要的内部部件，图 2 和 3 分别从器具 1 的前部和后部看，其中已经移除了外壳体 2。具有窗口 4 的内部水罐 6 在左边示出，且具有朝向其基部的出口 19，该出口 19 供给水导管 20。水导管 20 首先经过泵（例如电磁泵 22），然后经过泄压阀 24 并且通过压力补偿恒流阀 26。在水导管 20 过度加压的情况下，泄压阀 24 向回通向水罐 6 内。从耐特菲姆公司 (www.netafim.com) 可以购买到合适的压力补偿恒流阀 26。

[0068] 在压力补偿恒流阀 26 之后，水导管 20 通到流体加热器 27，在该流体加热器 27 中，水流管 28 被钎焊到带护套的加热元件 30。带护套的加热元件 30 的任一端的不通电的引线 (cold tails)32 将其连接到电源（未示出）。水流管 28 通到水导管 20 的最终区段，然后该最终区段供给到分配头 34 和出口 14。分配头 34 可以采取中间腔室的形式，该中间腔室接收从流体加热器 27 离开的液体和 / 或蒸气。分配头 34 可以帮助使得任何蒸汽能够从被加热的液体分离，使得受控的流动从出口 14 流出而不会有任何喷溅。

[0069] 在图 4 的横截面视图中可以看见水罐 6 的内侧，图 4 示出送水漏斗 36 设置在水罐 6 的顶部内侧。未处理的水（例如供水干路）放置到此送水漏斗 36 中。抗菌过滤器 38 位于送水漏斗 36 的底部，以允许水在其经由出口 19 离开水罐 6 之前排到罐的底部中。还可以看见从泄压阀 24 进入到水罐 6 中的入口 37。

[0070] 返回参考图 2 和 3，多个温度传感器围绕加热系统放置在各个点处。首先，温度传感器（例如负温度系数热敏电阻器 40）突出通过水罐 6 的壁，以感测在水罐 6 的底部中的过滤水的温度。第二温度传感器（例如负温度系数热敏电阻器 42）朝向排出端且在带护套的加热元件 30 的外侧上放置。此外，两个双金属致动器（或其他温度感测装置）设置在流体加热器 27 的外侧上，一个仅与水流管 28 接触，另一个与带护套的加热元件 30 和水流管 28 二者接触。双金属致动器例如为半英寸盘或热熔丝 44、46。两个半英寸盘或热熔丝 44、46 防止带护套的加热元件 30 过热。在申请人的公开申请 WO 2013/024286 中也说明了温度感测装置与加热元件 30 和水流管 28 二者热连通的这种布置。

[0071] 在图 5 的示意形式中也可以看见器具 1 的主要部件，在图 5 中，还示出了水的流动、电信号和功率。所有的部件由电控制器 50 直接或间接地控制，该电控制器 50 从各个部件接收电信号并控制递送到带护套的加热元件 30 和电磁泵 22 的功率。电控制器 50 经由电压测量电路 100 连接到主电源 52。带护套的加热元件 30 也连接到主电源 52，其中带护套的加热元件由电控制器 50 经由加热电源电路 56 中的开关 54 控制。另外，泵 22 连接到主电源 52，其中泵由电控制器 50 经由泵功率控制器 58 控制。

[0072] 电控制器 50 从水罐 6 中的负温度系数热敏电阻 40 和带护套的加热元件 30 上的第二负温度系数热敏电阻 42 以及从泵功率控制器 58 和检测水罐 6 中的最低填充水位已经达到的水位传感器 60（图 2 和 3 中未示出）接收电信号。

[0073] 根据其他的实施例，电磁泵 22 可以用其它种类的泵代替，例如诸如活塞泵的容积泵 22'。压力补偿恒流阀 26 可以省略，特别是在泵 22' 能够将大致恒定的流率递送通过流体加热器 27 而不管水压的变化的情况下。其他的实施例还可以完全省略泵，而依赖于直接连接到诸如供水干路的外部源，并且使用恒流阀或调节器，以确保通过加热器的流率是已

知的。

[0074]　图6提供连接在用于器具1的主电源52的火线AC_L极和中性线AC_N极之间的合适的电压测量电路100的实例。电路100测量模拟电压水平$AC_{_输入}$并且将此提供到电控制器50的A/D转换器，以给出数字输入。由电控制器50使用的供电电压$V_{_输入}$与此数字输入成比例。

[0075]　现在将进一步参考图7-9说明根据第一组实施例的设备的操作。

[0076]　当设备开始新的分配循环时，其首先执行预热阶段。带护套的加热元件30接通。测量的供电电压$V_{_输入}$用于根据公式1计算瞬时加热元件功率$Q_{_点}$：

[0077]　$Q_{\_点}=((V_{\_输入})^2/(V_{\_校准})^2)\times Q_{\_点\_校准}$　　（公式1）

[0078]　其中$V_{_校准}$和$Q_{_点_校准}$为在器具的初始校准期间（在制造之后或当器具首次使用时）确定的加热元件电压和加热元件功率的校准值。因此，在每次器具运行一个分配循环时，其导致主电源电压52的变化。一旦供电电压$V_{_输入}$已经被测量，其在相同的分配循环期间不会再次被监控。

[0079]　然后，电控制器50计算将预定体积的液体$Vol_{_供给}$加热到期望的最终温度T_供给所需的能量。液体体积$Vol_{_供给}$可以由用户经由输入刻度盘13设定或选择。最终温度$T_{_供给}$可以由用户设定或选择，但是对于婴儿配方器具1，其典型地被预编程，例如$T_{_供给}=37℃$。罐6中的水的温度$T_{_罐}$由负温度系数热敏电阻40测量且提供到电控制器50。当然，罐6中的水的环境温度将取决于环境条件而变化。然后，可以根据公式2计算将预定体积$Vol_{_供给}$加热到所期望的最终温度$T_{_供给}$所需要的总能量Q_总：

[0080]　$Q_{\_总}=Vol_{\_供给}\times Cp_{\_水}\times\Delta T\times K_1$　　（公式2）

[0081]　其中$\Delta T=T_{_供给}-T_{_罐}$，$Cp_{_水}$为被加热的液体的比热容，K_1为用于热损失的补偿因子。K_1的典型的值可以从设备的工厂测试或校准凭经验确定并且预编程到控制器中。

[0082]　预定体积的液体$Vol_{_供给}$在两个阶段中分配，即$Vol_{_供给}=Vol_{_初始}+Vol_{_冷却}$。第一体积$V_{_初始}$在温度$T_{_初始分配}$>70℃处分配，以使瓶17中的奶粉"灭菌"。分配第二体积$V_{_冷却}$以从带护套的加热元件30去除余热量，以引起全部体积$Vol_{_供给}$到期望的最终温度，例如$T_{_供给}=37℃$。

[0083]　需要将带护套的加热元件30预热以确保整个的初始分配体积$Vol_{_初始}$被足够热地分配。带护套的加热元件30被加热到标称目标温度，例如$T_{_目标}=210℃$，以确保其是热的（由于温度梯度，在此点处水流管28应当刚好在100℃以下）。带护套的加热元件30的实际温度$T_{_元件}$由带护套的加热元件30上的负温度系数热敏电阻42测量。用于预热所需要的能量$Q_{_预热}$根据公式3计算：

[0084]　$Q_{\_预热}=m\times Cp\times(T_{\_目标}-T_{\_元件})$　　（公式3）

[0085]　其中Cp为加热器的比热容，m为加热器的质量。

[0086]　然后由公式4给出预热时间$t_{_预热}$：

[0087]　$t_{\_预热}=Q_{\_预热}/Q_{\_点}$　　（公式4）

[0088]　当计算用于使带护套的加热元件30通电的总的"开"时间（$t_{\_加热器}$）时，必须考虑系统中储存的储存能量$Q_{_储存}$。这根据公式5计算：

[0089]　$Q_{\_储存}=m\times Cp\times(T_{\_元件}-T_{\_罐})\times K_2$　　（公式5）

[0090]　其中K_2为考虑热损失等的补偿因子，其可以凭经验确定并预编程到电控制器50

中。因子 K_2 可以用于调整程序的此部分，从而在由流体加热器 27 上的一个或两个半英寸盘 44、46 检测到带护套的加热元件 30 过热时，电控制器 50 可以停止分配操作。

[0091] 然后，所计算的用于使带护套的加热元件 30 通电的“开”时间段 $t_{\_加热器}$ 根据公式 6 计算：

[0092] $t_{\_加热器}=(Q_{\_总}-Q_{\_储存})/Q_{\_点}$ （公式 6）

[0093] 泵操作的第一阶段需要分配第一体积 $V_{\_初始}$ 的加热液体，并且这根据公式 7 计算：

[0094] $Vol_{\_初始}=Q_{\_总}/(Cp_{\_水}\ x(T_{\_初始分配}-T_{\_罐})x\ K_1)$ （公式 7）其中 $T_{\_初始分配}$ 为以例如 95℃的值预设在电控制器 50 中。

[0095] 然后，用于泵操作的两个时间段可以根据公式 8 和 9 计算：

[0096] $t_{\_泵1}=Vol_{\_初始/流率}$ （公式 8）

[0097] $t_{\_泵2}=Vol_{\_冷却/流率}$ （公式 9）

[0098] 其中，流率为由压力补偿恒流阀 26 设定的进入到流体加热器 27 的液体的流率。流率为可以用于每个器具校准（在制造之后或当器具首次使用时）的另外的值。

[0099] 图 7 是列出完整的分配循环中涉及的主要步骤的流程图。可以看见，程序通过测量在该时间的主电源电压 $V_{\_输入}$ 开始，以建立带护套的加热元件 30 的功率 $Q_{\_点}$ 的准确计算。然后，电控制器 50 从水罐 6 中的负温度系数热敏电阻 40(NTC1) 和带护套的加热元件 30 上的第二负温度系数热敏电阻 42(NTC2) 读取读数。从这些输入，可以计算泵 22 操作第一初始分配阶段之前的预热时间段，带护套的加热元件 30 的通电时间段以及泵操作的第二时期，以分配制作瓶 17 中的婴幼儿食物所需要的全部体积的液体。电控制器 50 可以编程为停顿设定时间段 $t_{\_停顿}$，例如 30s、40s、50s 或 60s，以允许用户将婴幼儿配方粉添加到初始分配的水，或者在配方粉已经在瓶 17 中时允许用户搅动食物。然而，器具 1 可以设置有按钮或其他允许用户根据要求开始第二分配阶段的输入件。

[0100] 如上所述，进入流体加热器 27 的液体的流率由压力补偿恒流阀 26 设定，以具有恒定值（例如 170ml/min）而不管例如由于电压波动或由于与年限相关的磨损的泵速的任何变化。在某些情况下，可能有需要减小流率，以提供所期望的分配温度，并且这可以通过使泵脉冲地开和关而实现。图 8 示出带护套的加热元件 30 的操作的图表，并且泵 22 覆盖感测的带护套的加热元件 30 温度曲线（即 $T_{\_元件52}$）和在器具的分配头处测量的出口温度 54。还示出了加热器通电状态 58 和泵操作状态 60。罐 6 中的水的开始温度 56 是恒定的，例如 $T_{\_罐}=18℃$。可以看见，在泵操作的第一时期 $t_{\_泵1}$ 期间，当第一体积的水 $V_{\_初始}$ 在此温度 $T_{\_初始分配}$ 处分配时，在分配头处测量的温度 54 具有约 85℃的平均值。然后出口温度 54 下降，并且由于其开始移动到与系统以及其储存的热量热平衡，在泵操作的不同时期之间的停顿期间再次上升。当泵操作的第二时期 $t_{\_泵2}$ 开始，有小体积的温水通过已经位于水流管 28 中的出口分配，但是这迅速地跟随有在阶段 $t_{\_泵2}$ 期间泵送的大体积 $Vol_{\_冷}$ 的未被加热的水。出口温度 54 迅速地下降，以匹配泵送的没有任何加热的（例如在 18℃的）环境水。分配到瓶 17 中的两个体积的水混合，以提供在期望的最终温度 $T_{\_供给}$（例如设定在 37℃）的预定体积 $V_{\_供给}$。

[0101] 图 9 示出贯穿器具的操作循环的瓶中的分配的水的温度曲线 62。在泵 22 初始通电之后，水温非常迅速地上升到约 95℃。在泵操作的第一时期的结束 $t_{\_泵1}$ 处，第一体积的水 $V_{\_初始}$ 具有约 80℃的平均温度，并且其在婴幼儿配方粉添加到瓶中时在停顿 $t_{\_停顿}$ 期间保

持在 70℃以上，以确保粉的灭菌。由于在泵操作的第二时期 $t_{\_泵2}$ 期间，冷水被分配，所以瓶中的水的温度 62 下降，当最终体积的水已经被分配以形成总体积 $Vol_{\_供给}$ 时达到约 37℃的最终平均温度。

[0102] 由于由带护套的加热元件 30 输入的所有能量 $Q_{\_点}$ 用于加热系统，所以对于器具而言没有必要测量最终水温度 $T_{\_供给}$，这可以从公式 10 简单地计算：

[0103] $T_{\_供给} = T_{\_罐} + Q_{\_点} / (m_{\_供给} \times Cp_{\_水})$ （公式 10）

[0104] 其中，m_ 供给是瓶 17 中的全部体积的液体 Vol_ 供给的质量。

[0105] 现在将进一步参考图 10-12 描述根据第二组实施例的设备的操作。图 10 中所见的流程图示出当设备被操作以连续地分配预定体积的具有期望的最终温度 $T_{\_供给}$（例如 37℃）的温液体 $Vol_{\_供给}$ 时可以采取的步骤。在此方案中，设备不用于在特定的预定初始温度处分配单独的第一体积 $V_{\_初始}$，即不会在 70℃或更高处“过热冲击”。然而，从图 11 和 12 的加热曲线可以看见，在操作的第一时期期间，一些液体可以在这种温度处被分配，但是没有停顿以使用户知道当其在此温度处时将婴幼儿配方奶与液体混合。

[0106] 根据图 10，加热元件 30 以与泵 22 大致相同的时间通电，即流体加热器 27 没有预热。如之前，电压补偿电路可以用于测量施加到流体加热器 27 的电压 $V_{\_输入}$。电控制器 50 根据公式 1 计算加热元件功率，然后从在用户界面 MMI 处输入的供给大小 (kg) 计算预定体积 $Vol_{\_供给}$。然后可以根据公式 2 计算将预定体积 $Vol_{\_供给}$ 加热到期望的最终温度 $T_{\_供给}$ 所需要的总能量 $Q_{\_总}$。由于 $Vol_{\_供给}$ 被连续地分配，所以可以根据公式 11 简单地计算用于泵操作的时间段 $t_{\_泵}$：

[0107] $t_{\_泵} = Vol_{\_供给/流率}$ （公式 11）

[0108] 其中流率为进入流体加热器 27 的液体的流率。如果设置有上游压力补偿恒流阀 26 的话，此流率可以由其设定，或此流率可以为泵 22’的已知常量。

[0109] 电控制器 50 读取来自水罐 6 中的 NTC1 热敏电阻 40 和安装在加热元件 30 上的 NTC2 热敏电阻 42 的读数，以给出温度 T_1（$= T_{\_罐}$）和 T_2（$= T_{\_元件}$）。达到期望的最终温度 $T_{\_供给}$（例如 37℃）所需要的总温度升高为 DT 或 $\Delta T = T_{\_供给} - T_1$。然后使用公式 2 计算所需要的总能量 $Q_{\_总}$。例如 $Cp_{\_水} = 4180$ 并且损失 $K_1 = 1.1$（初始值的 10％）。为了考虑储存在系统中的任何热能，控制器 50 还使用公式 5 计算 $G_{\_储存}$。然后加热器开时间 $t_{\_加热器}$ 可以从公式 6 计算。

[0110] 泵 22、22’可以连续操作或液体可以使用脉冲泵操作大致连续地分配。对于较小体积的液体，加热器开时间 $t_{\_加热器}$ 可以几乎和泵开时间 t_ 泵一样长，以恒定的流率，所以控制器 50 检查是否需要脉冲泵操作，例如，如果 $t_{\_加热器} > t_{\_泵} - 3s$。流体加热器 27 在时间 $t_{\_加热器}$ 已经终止后断电。泵被操作（连续或以脉冲方式）直到 $t_{\_泵}$ 已经终止并且余热已经去除，使得 Vol_ 供给具有期望的温度 $T_{\_供给}$。

[0111] 图 11 和 12 示出用于加热器 27 和泵 22、22’的激活曲线，以及用于罐中的水的温度曲线 $T_{\_罐}$（由 NTC1 测量），加热器的温度曲线 $T_{\_元件}$（由 NTC2 测量）以及在出口处分配到瓶中的被加热的液体的温度。图 11 示出用于 $Vol_{\_供给} = 120ml$ 的曲线，图 12 示出用于 $Vol_{\_供给} = 330ml$ 的曲线。

[0112] 本领域技术人员可以了解，以上描述的实施方式仅仅是本发明的原理可以如何应用的示例，并且在本发明的范围内有很多可能的变型。例如，本发明的原理可以用于产生不

同温度的水或其他液体，并且可以用于与制备婴幼儿配方奶不同的目的。此外，示出的加热器的具体的类型不是必要的，可以代替使用任何其他的流体加热器或配料加热器。此外，水可以从铅垂源（例如供水干路）供应，而不是从器具内的漏斗。

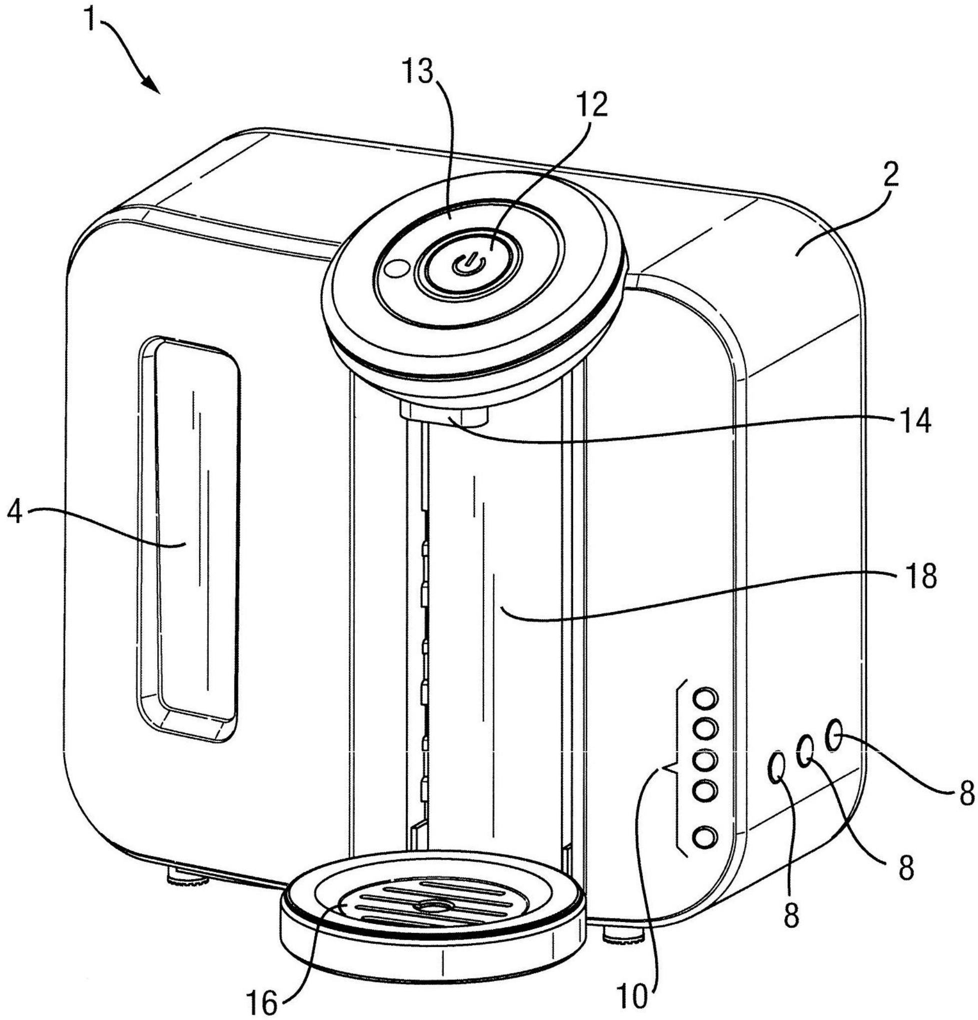

图 1

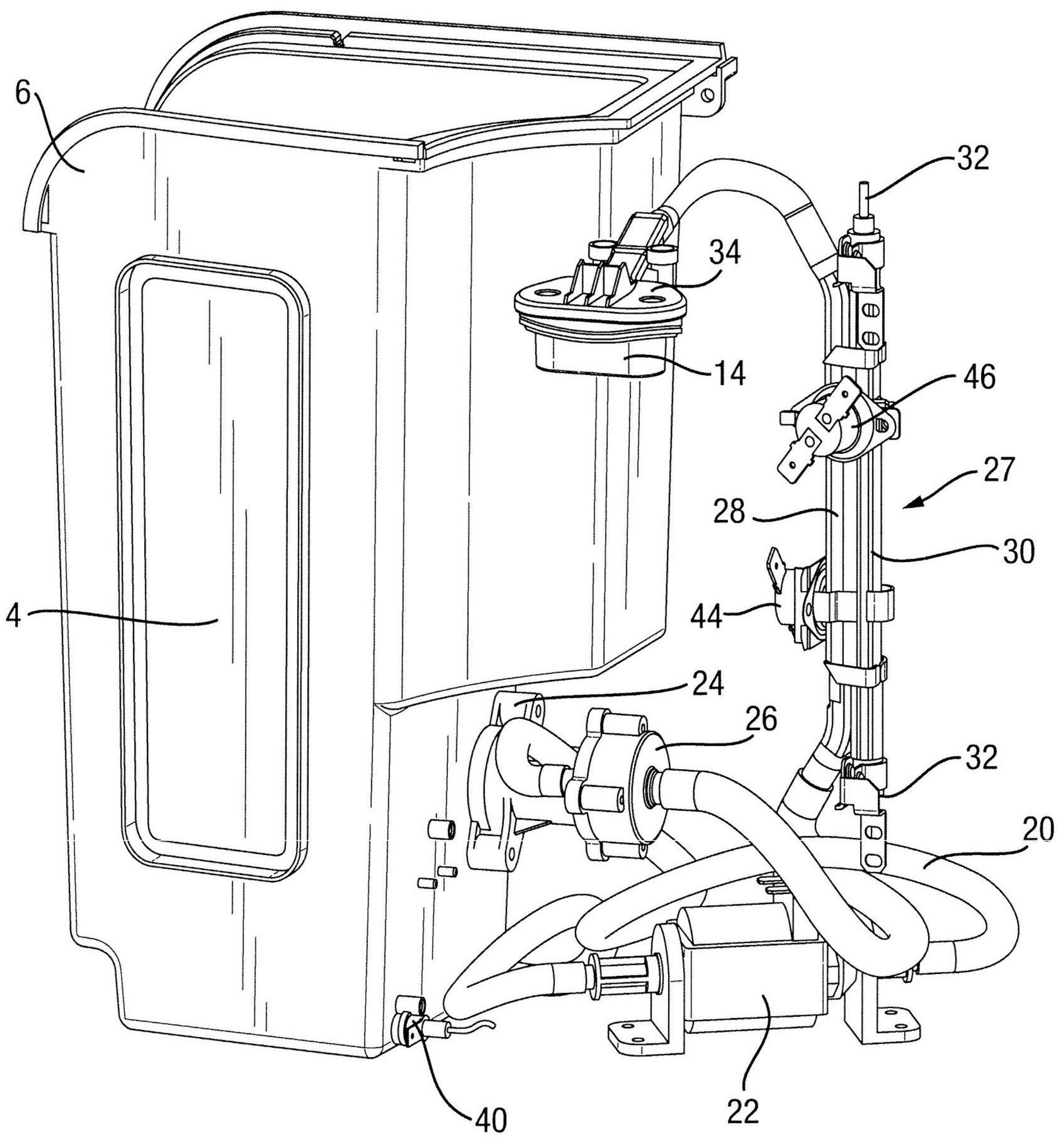

图 2

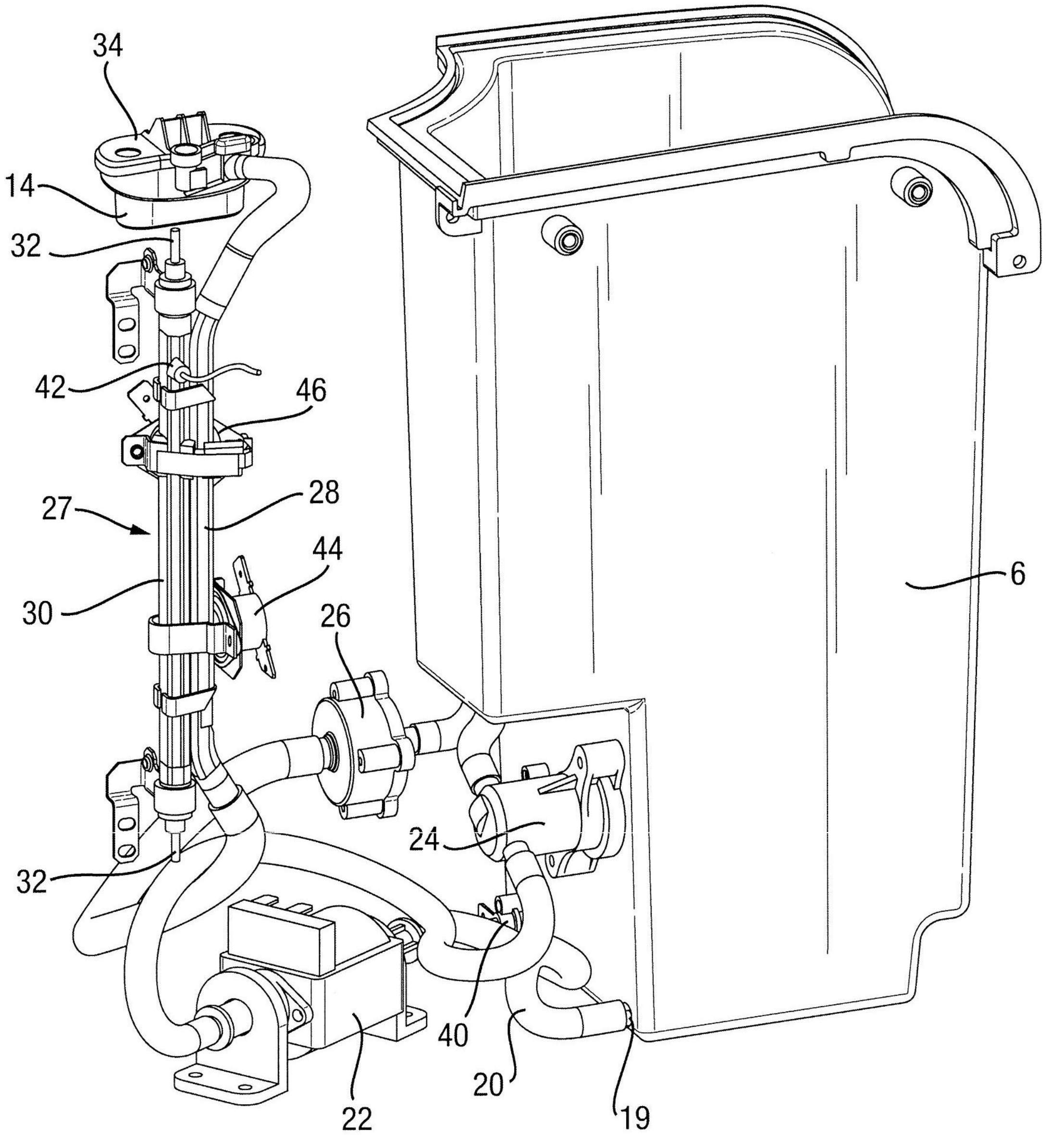

图 3

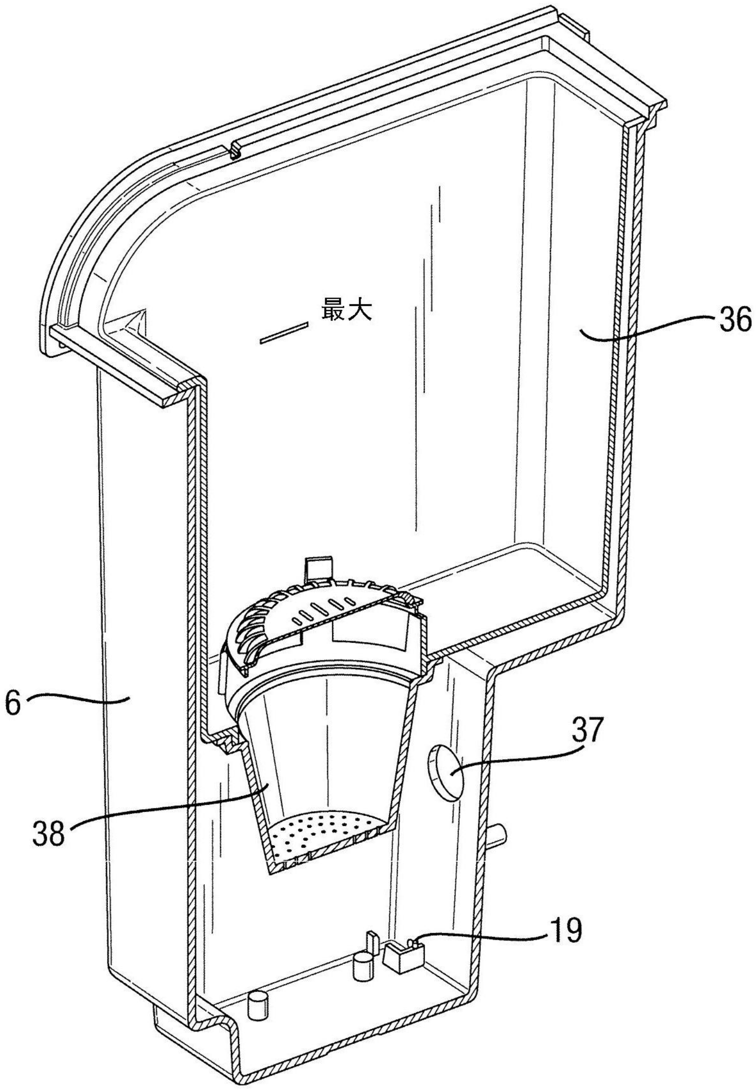

图 4

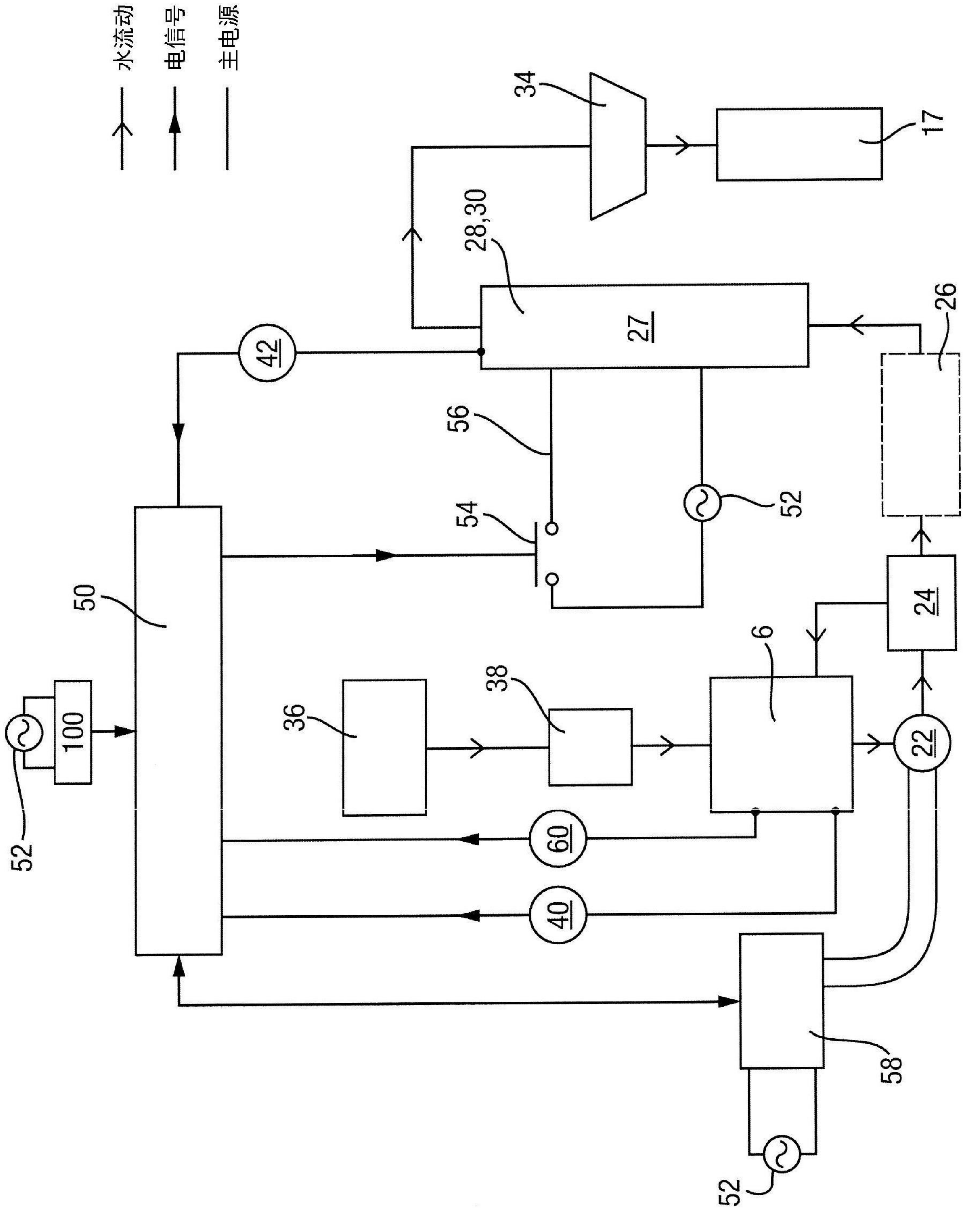
水流动
电信号
主电源
34
17
28,30
27
42
26
56
52
54
50
6
24
38
36
100
22
60
40
58
52
52

图 5

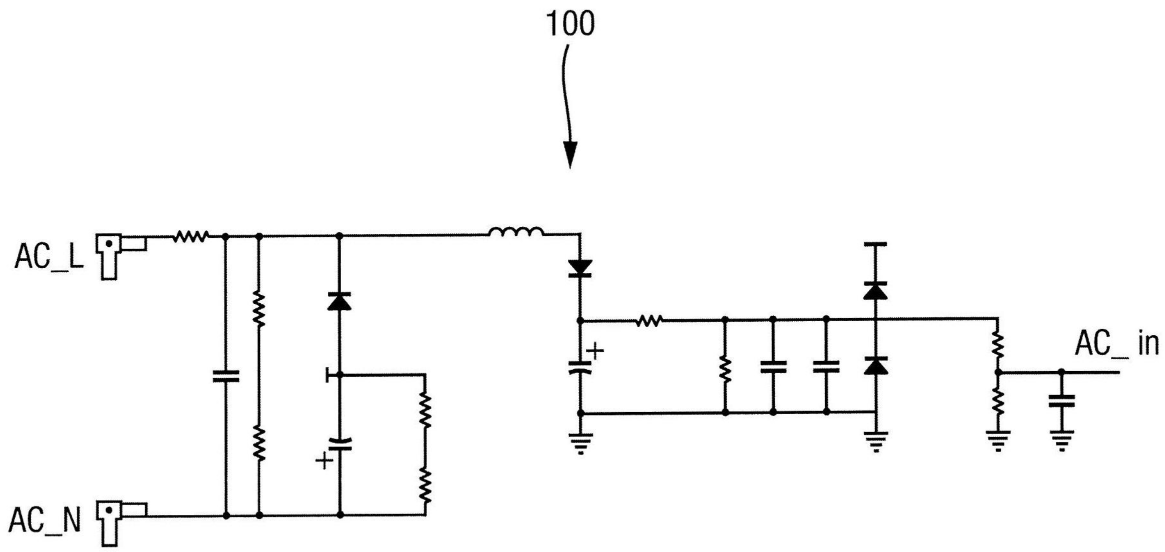

图 6

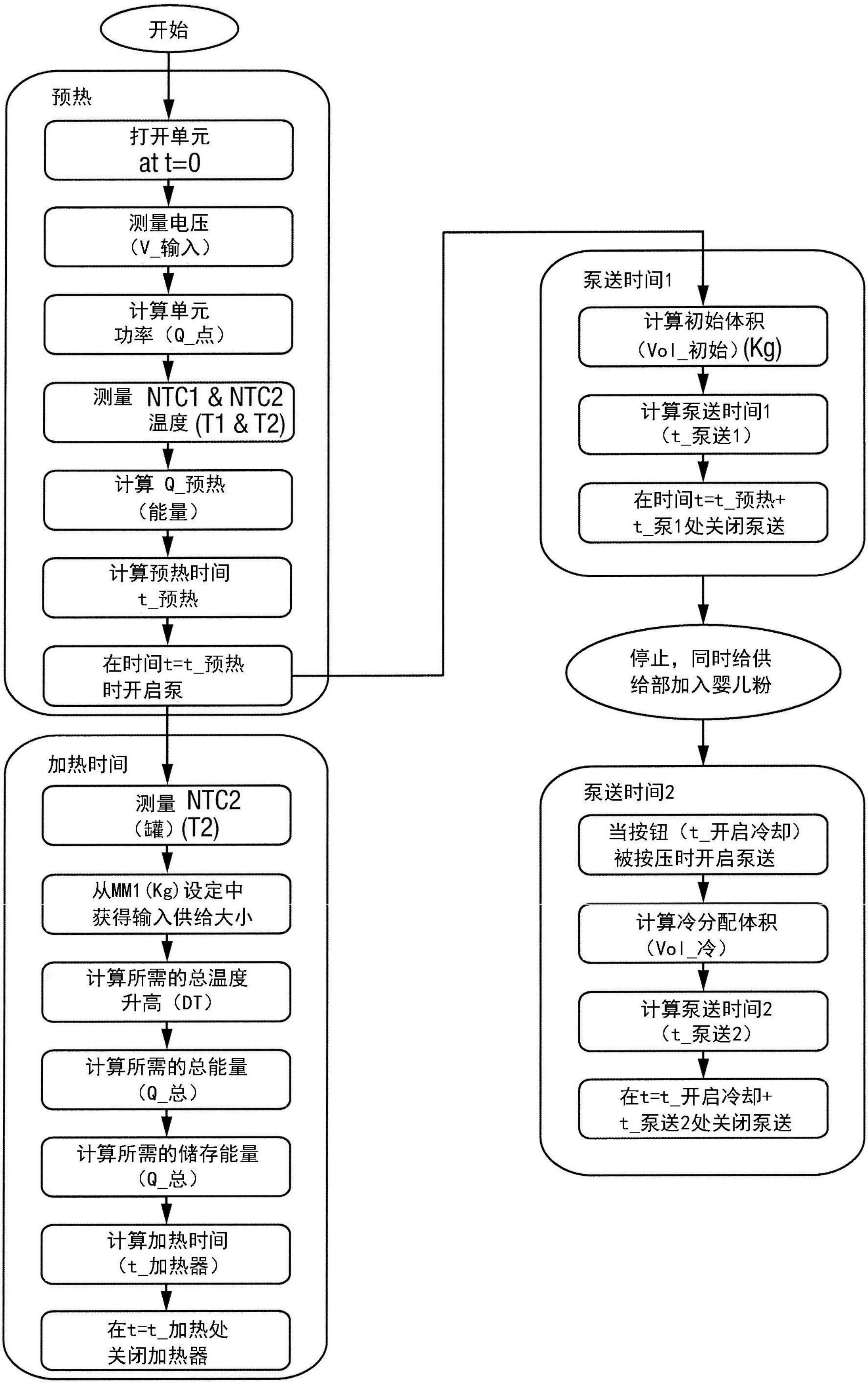
开始
预热
打开单元
at t=0
测量电压
(V_输入)
计算单元
功率 (Q_点)
测量 NTC1 & NTC2
温度 (T1 & T2)
计算 Q_预热
(能量)
计算预热时间
t_预热
在时间t=t_预热
时开启泵
泵送时间1
计算初始体积
(Vol_初始)(Kg)
计算泵送时间1
(t_泵送1)
在时间t=t_预热+
t_泵1处关闭泵送
停止，同时给供
给部加入婴儿粉
泵送时间2
当按钮(t_开启冷却)
被按压时开启泵送
计算冷分配体积
(Vol_冷)
计算泵送时间2
(t_泵送2)
在t=t_开启冷却+
t_泵送2处关闭泵送
加热时间
测量 NTC2
(罐)(T2)
从MM1(Kg)设定中
获得输入供给大小
计算所需的总温度
升高 (DT)
计算所需的总能量
(Q_总)
计算所需的储存能量
(Q_总)
计算加热时间
(t_加热器)
在t=t_加热处
关闭加热器

图 7

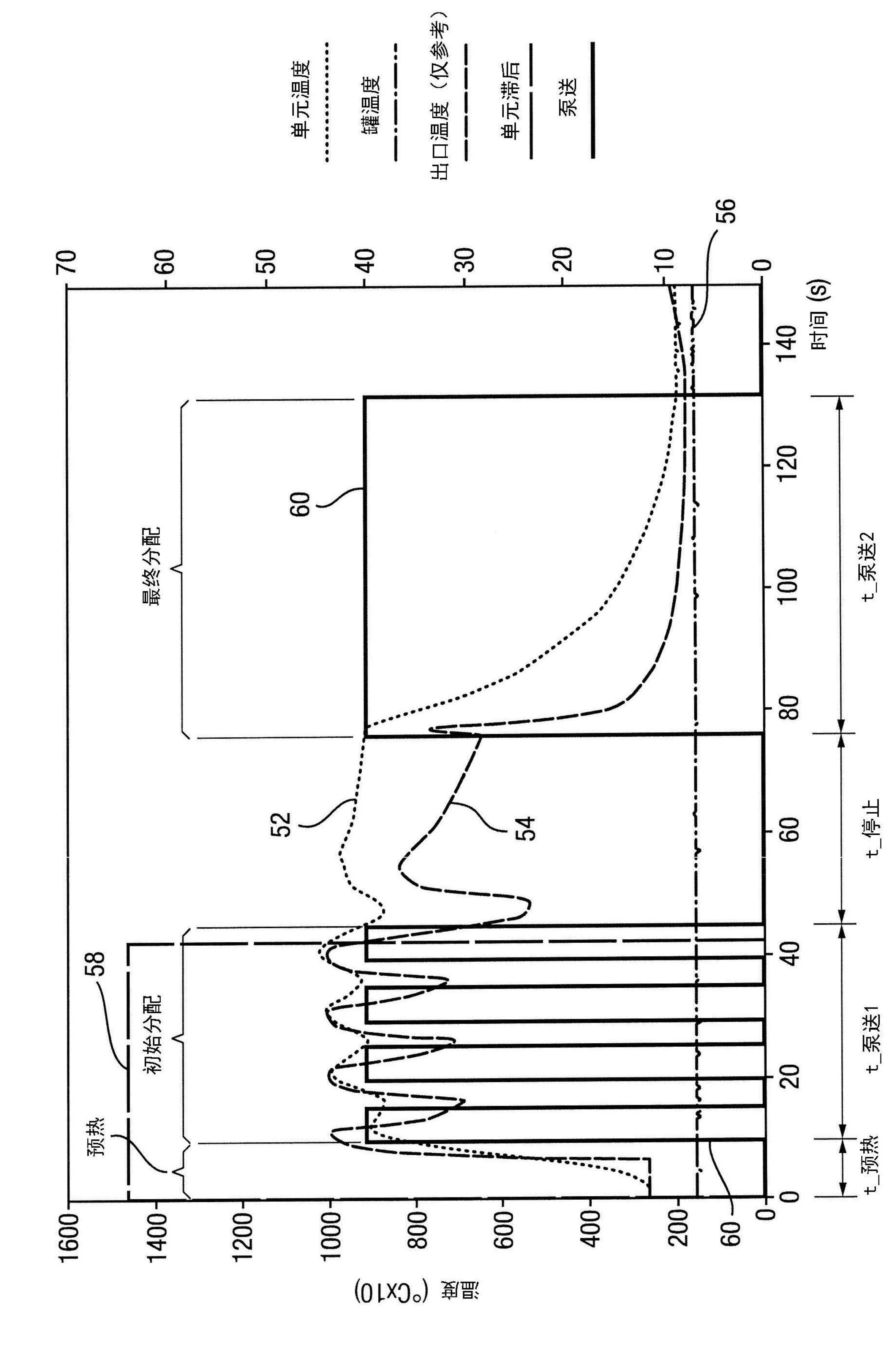
单元温度
罐温度
出口温度（仅参考）
单元滞后
泵送
预热
初始分配
最终分配
58
60
52
54
56
t_预热
t_泵送1
t_停止
t_泵送2
时间 (s)
温度 (°Cx10)
0
20
40
60
80
100
120
140
0
60
200
400
600
800
1000
1200
1400
1600
0
10
20
30
40
50
60
70

图 8

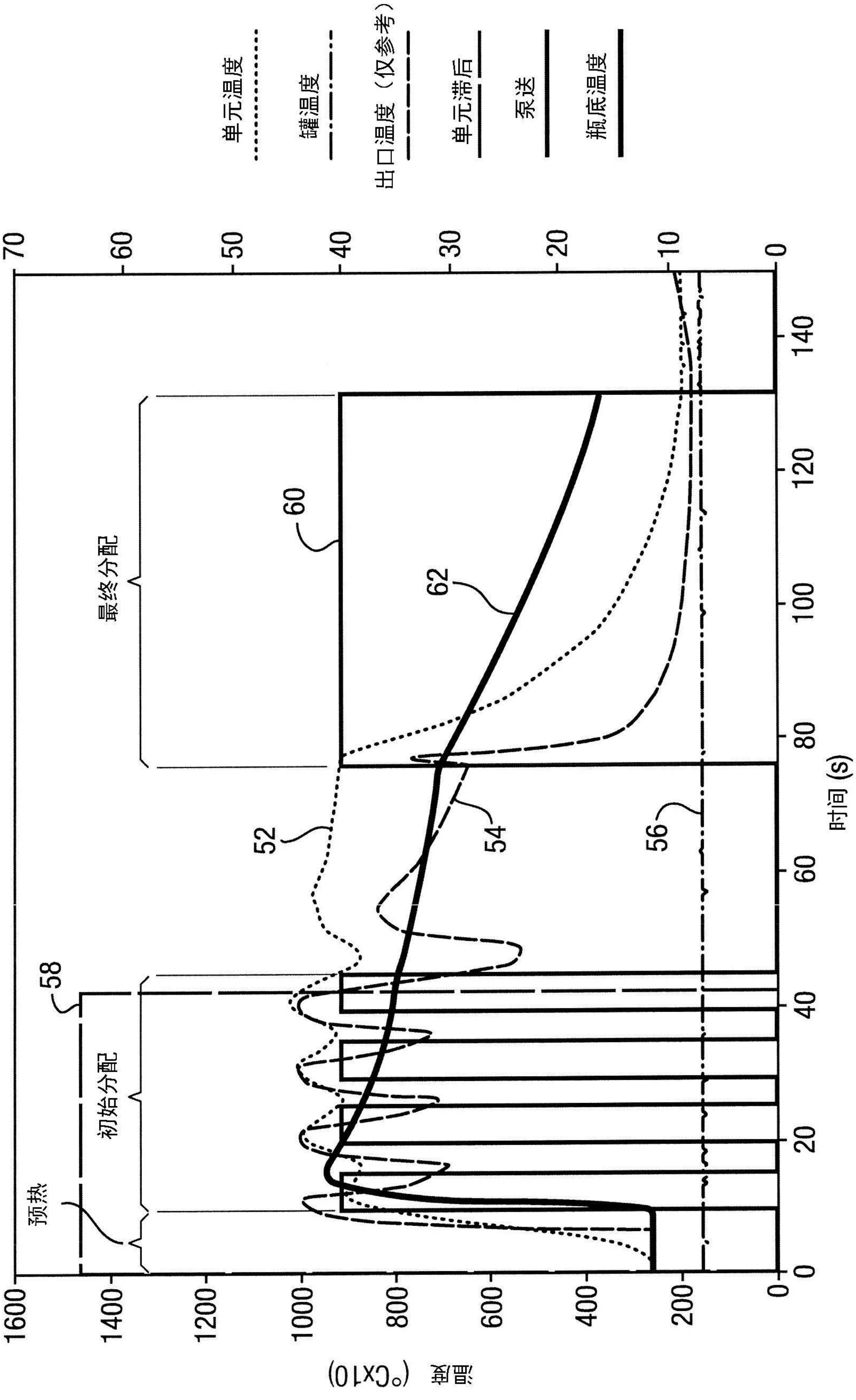
单元温度
罐温度
出口温度（仅参考）
单元滞后
泵送
瓶底温度
预热
初始分配
最终分配
52
54
56
58
60
62
温度 (°Cx10)
时间 (s)
0
200
400
600
800
1000
1200
1400
1600
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
140

图 9

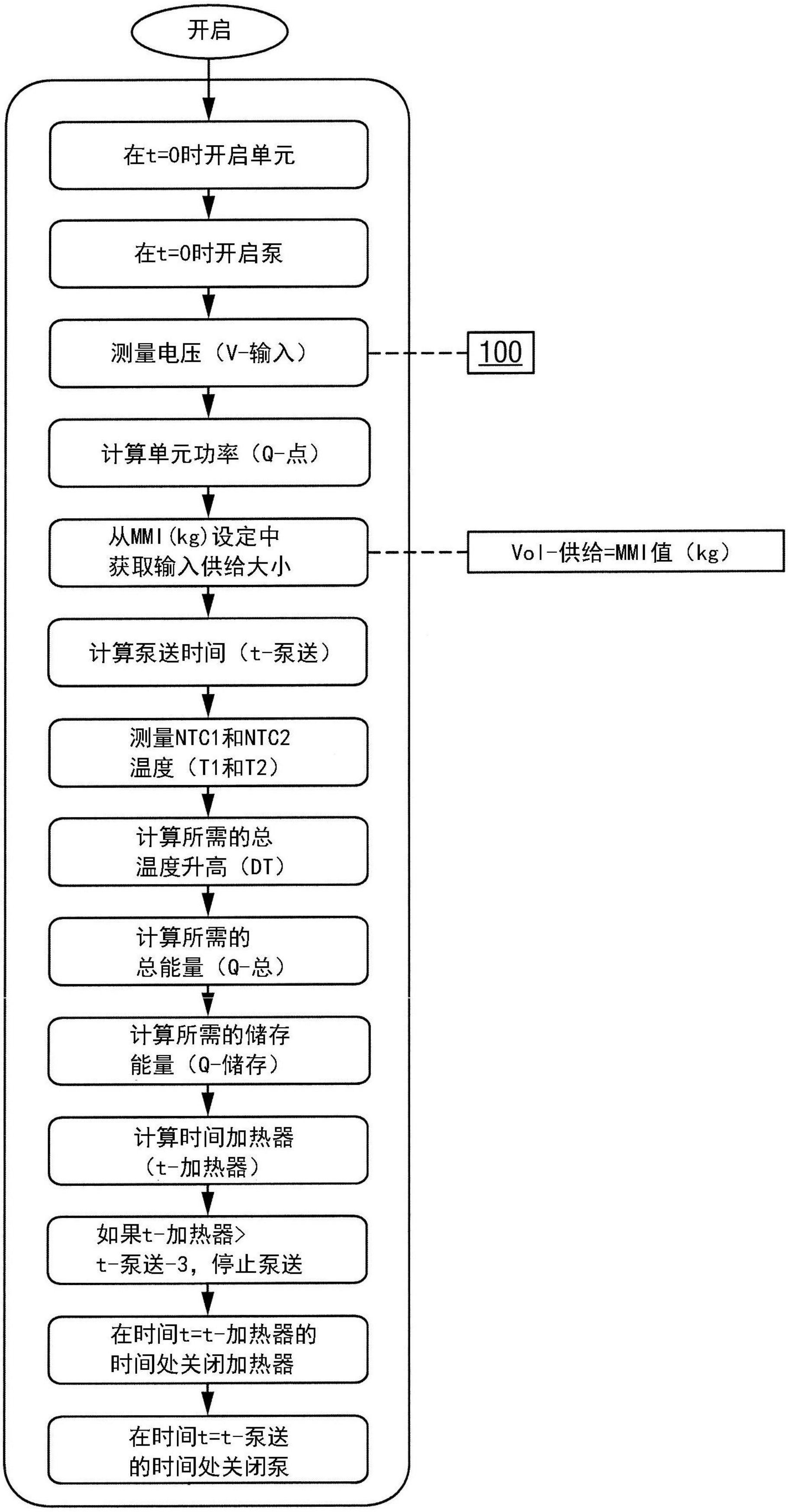
开启
在t=0时开启单元
在t=0时开启泵
测量电压（V-输入）
100
计算单元功率（Q-点）
从MMI(kg)设定中
获取输入供给大小
Vol-供给=MMI值（kg）
计算泵送时间（t-泵送）
测量NTC1和NTC2
温度（T1和T2）
计算所需的总
温度升高（DT）
计算所需的
总能量（Q-总）
计算所需的储存
能量（Q-储存）
计算时间加热器
（t-加热器）
如果t-加热器>
t-泵送-3，停止泵送
在时间t=t-加热器的
时间处关闭加热器
在时间t=t-泵送
的时间处关闭泵

图 10

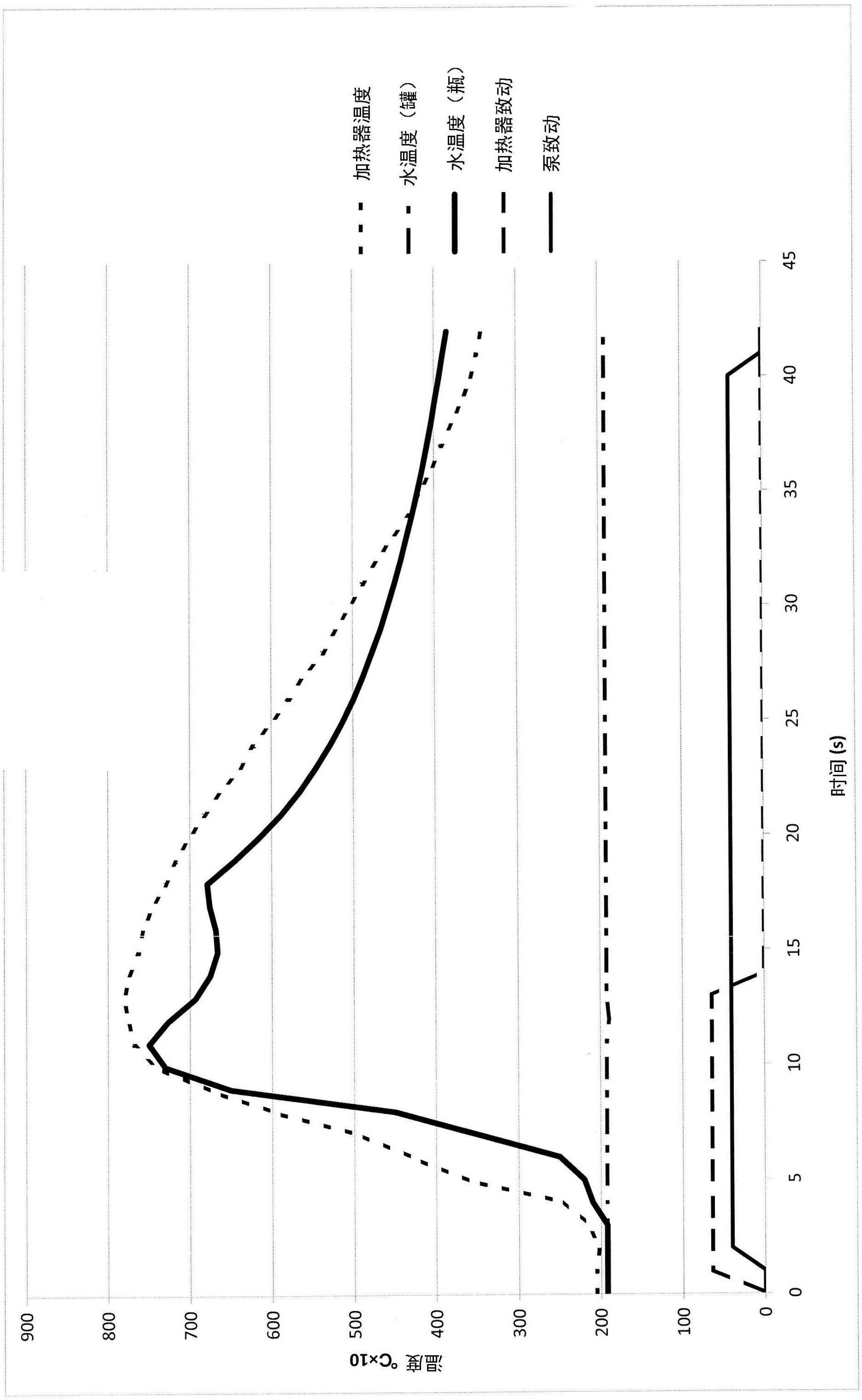
加热器温度
水温度（罐）
水温度（瓶）
加热器致动
泵致动
温度 °C×10
时间 (s)
0
100
200
300
400
500
600
700
800
900
0
5
10
15
20
25
30
35
40
45

图 11

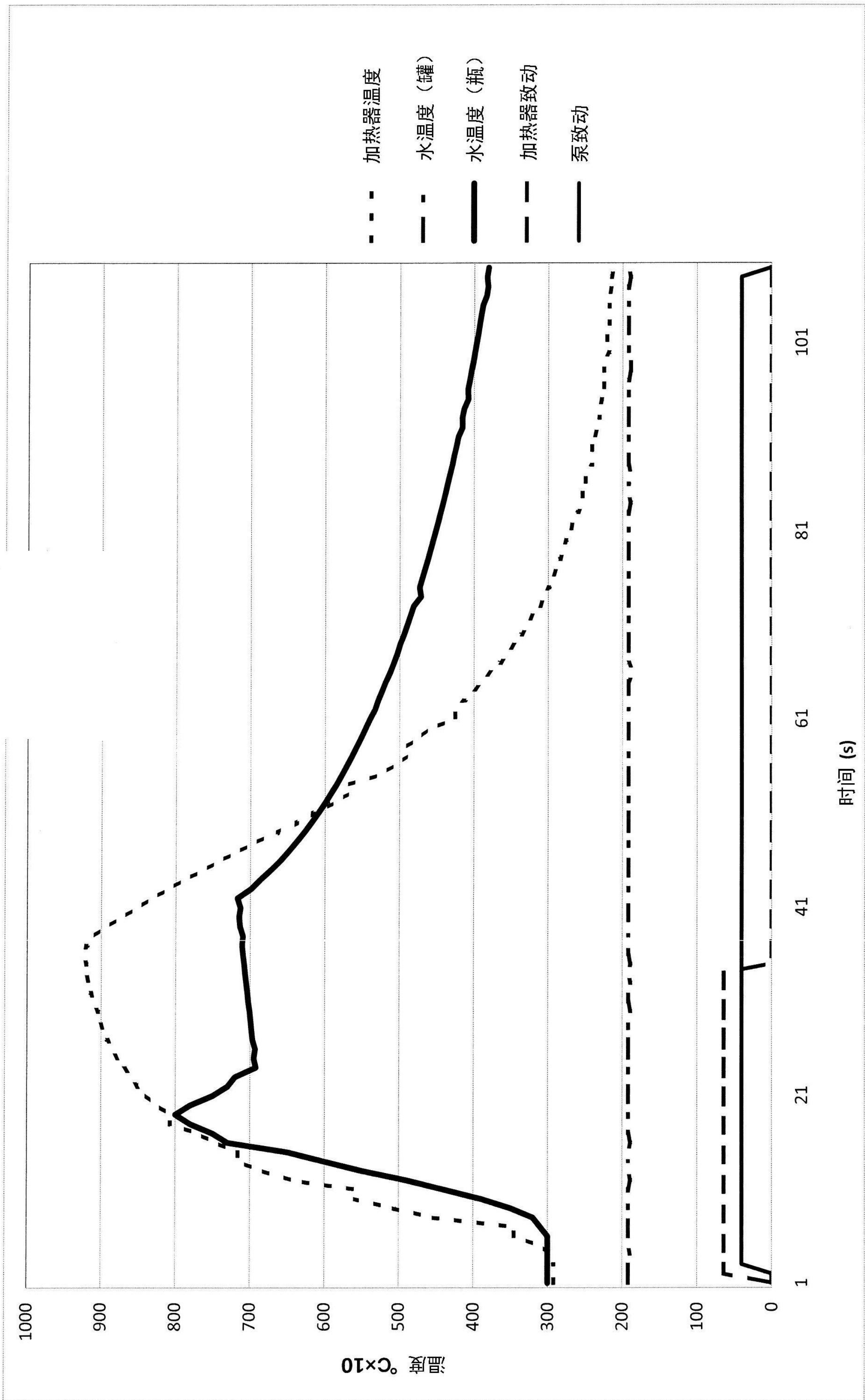
加热器温度
水温度（罐）
水温度（瓶）
加热器致动
泵致动
温度 °C×10
0
100
200
300
400
500
600
700
800
900
1000
时间 (s)
1
21
41
61
81
101

图 12

Abstract

An apparatus for dispensing a predetermined volume of a warm liquid comprises a heater (27), a pump (22) and a temperature sensor (40) sensitive to the temperature of the liquid upstream of the heater (27). A controller (50) is arranged to receive upstream temperature data from the temperature sensor (40), calculate the amount of energy required to reach a desired final temperature, energise the heater (27) for a calculated period of ON time, and dispense liquid for a calculated period of time that is at least partly contemporaneous with the calculated period of ON time. After the heater (27) has been de-energised, the dispensed liquid removes residual heat so that the average temperature after dispensing the predetermined volume is the desired final temperature.