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(54) Title of the Invention: **Liquid heating appliances and flow heaters**
Abstract Title: **Liquid heating appliance with flow heater, reservoir having a maximum liquid fill level and conveyor pump**

(57) A liquid heating appliance 2 for providing heated liquid on demand comprising: a flow heater 4 with entrance 4a, exit 4b, a liquid reservoir 6 having a maximum liquid fill level 14; a pump 8 for conveying liquid from the reservoir through the heater; and an outlet for dispensing heated liquid from the exit of the heater. The liquid heating appliance further comprises a bi-directional flow path from the reservoir to the outlet, the bi-directional flow path passing through the pump and the heater, the heater entrance is higher than the maximum liquid fill level of the reservoir. The heater may comprises and arcuate shaped tube 16 extending upwards to an apex 26 that is higher than the entrance, and the exit of the heater is higher than the maximum liquid fill level of the reservoir. The bi-directional flow may comprises a user-adjustable restrictor valve, preferably arranged between the pump and the flow heater. Optional means for delaying operation of the pump to convey liquid from the reservoir through the flow heater after energising the flow heater, depending on the temperature of the heater and time used, by using a a thermo-mechanical switch, such as a bimetallic actuator

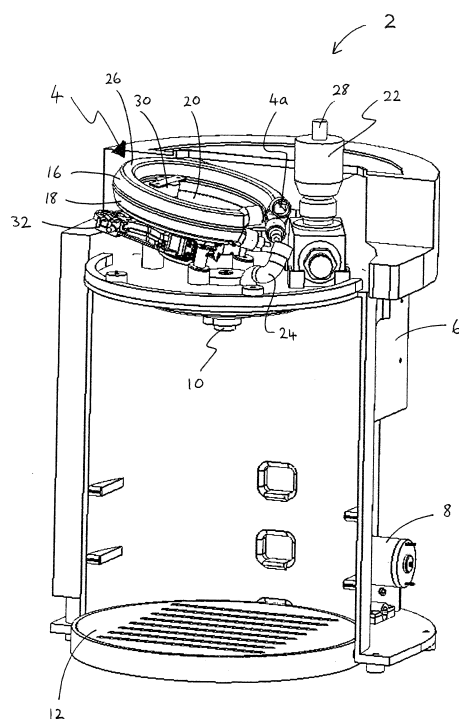


FIGURE 1

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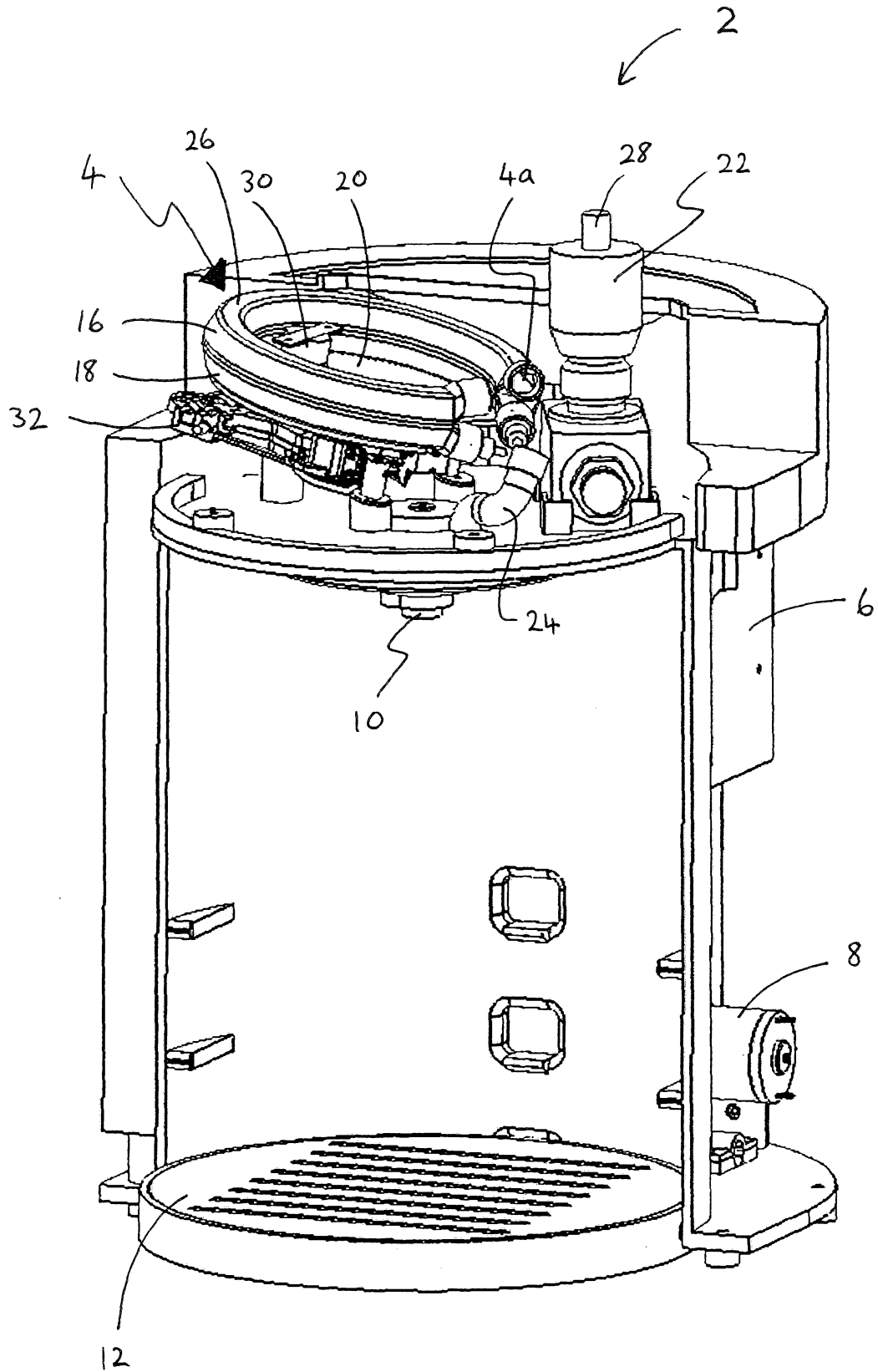


FIGURE 1

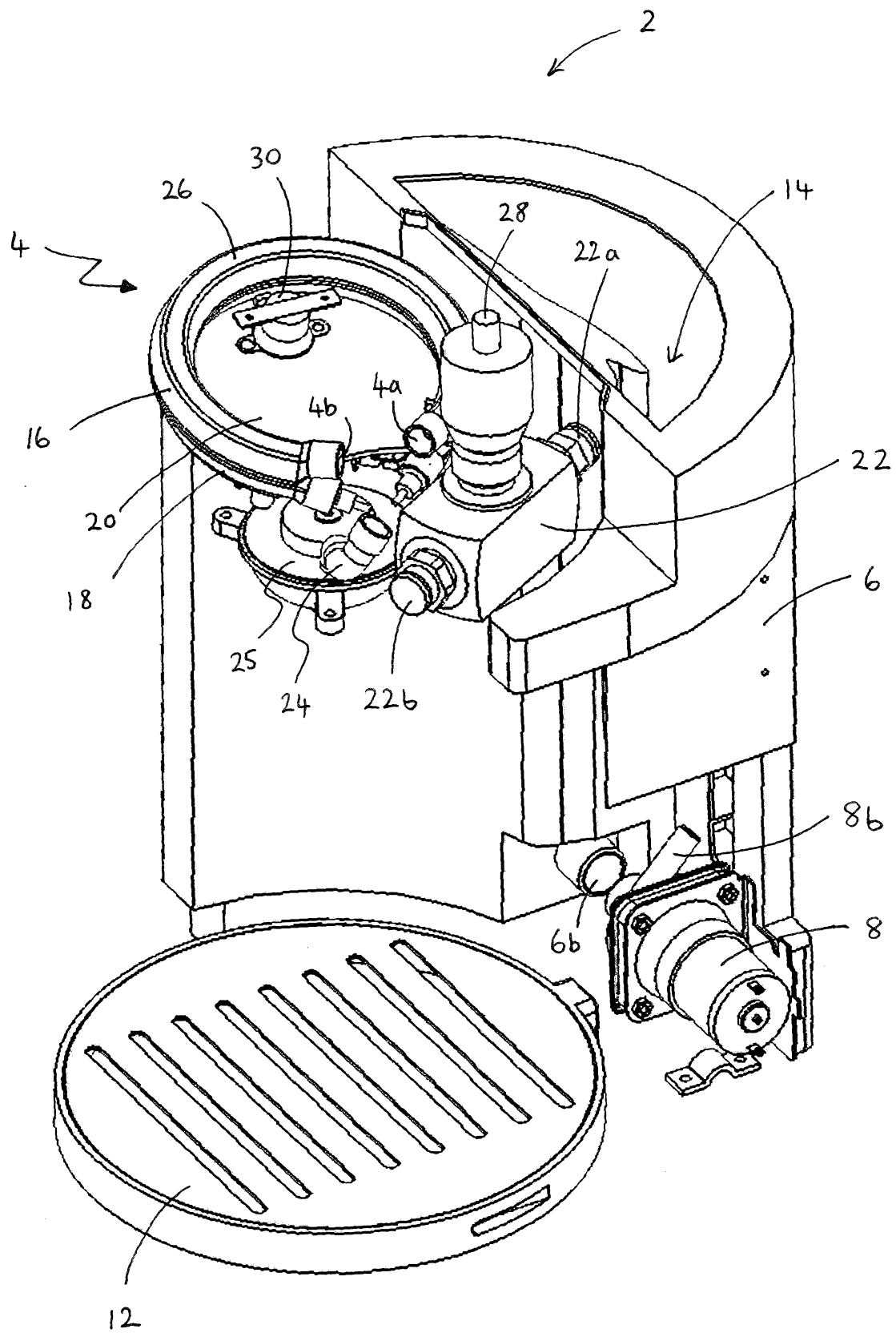


FIGURE 2

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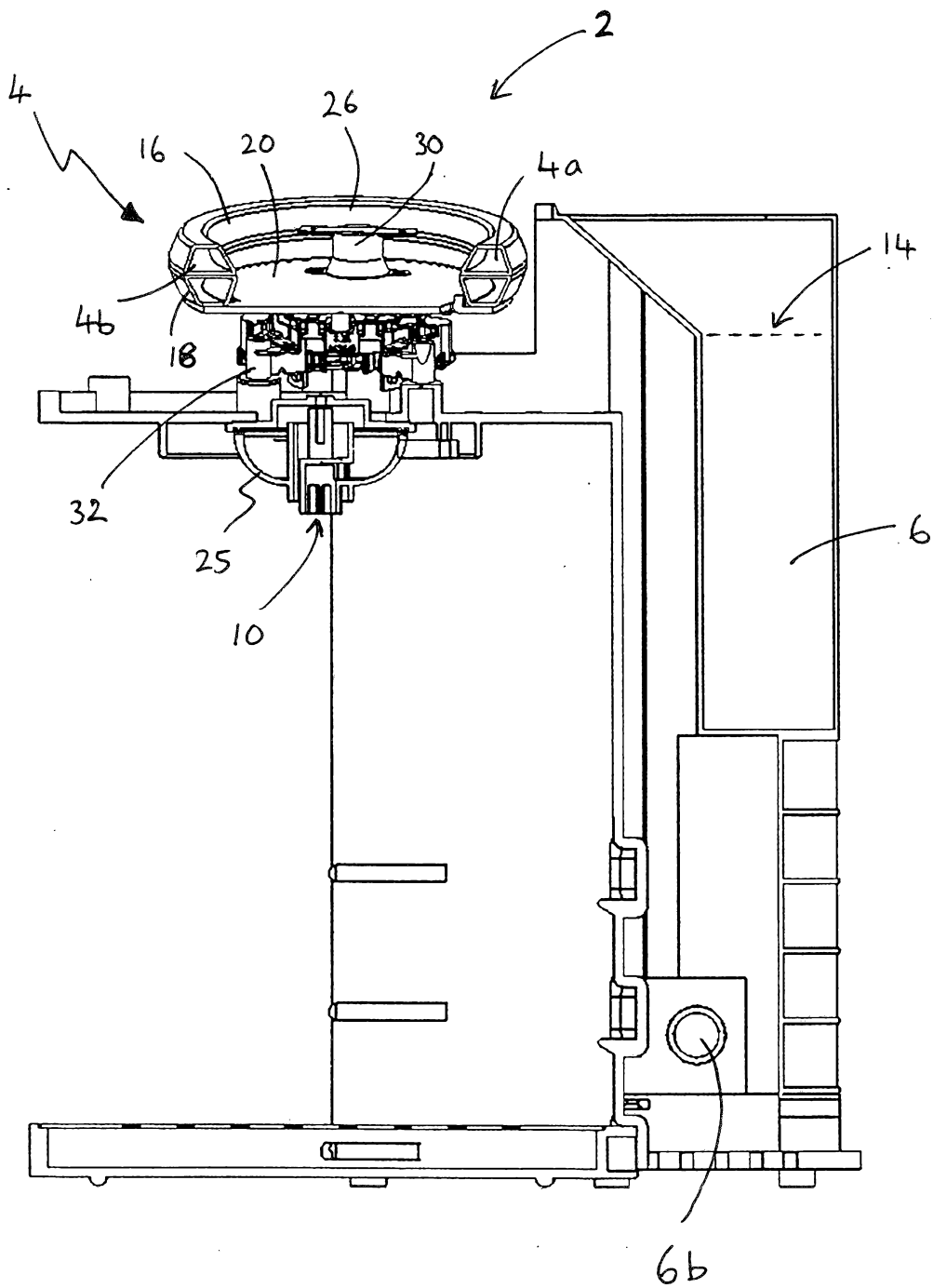


FIGURE 3

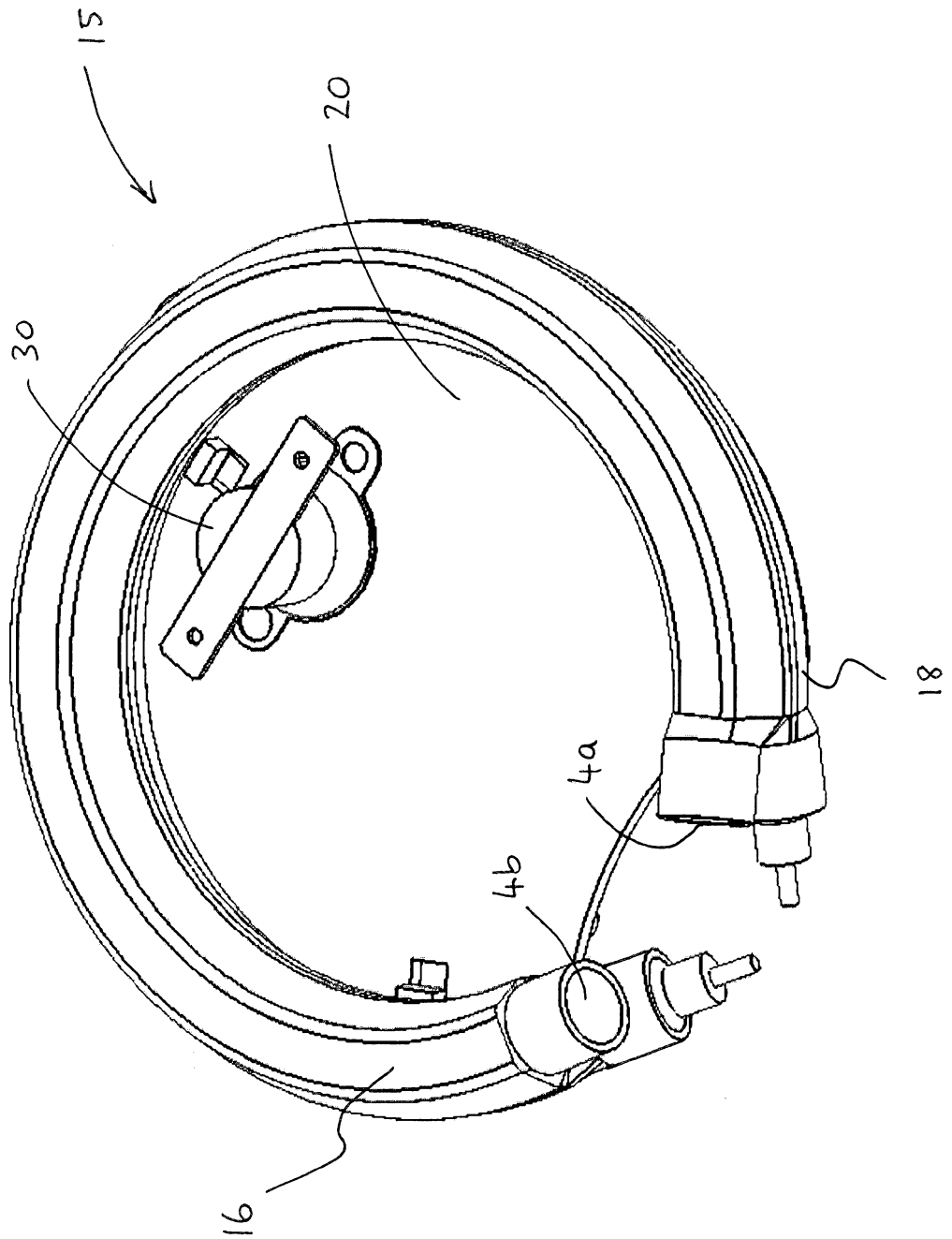


FIGURE 4

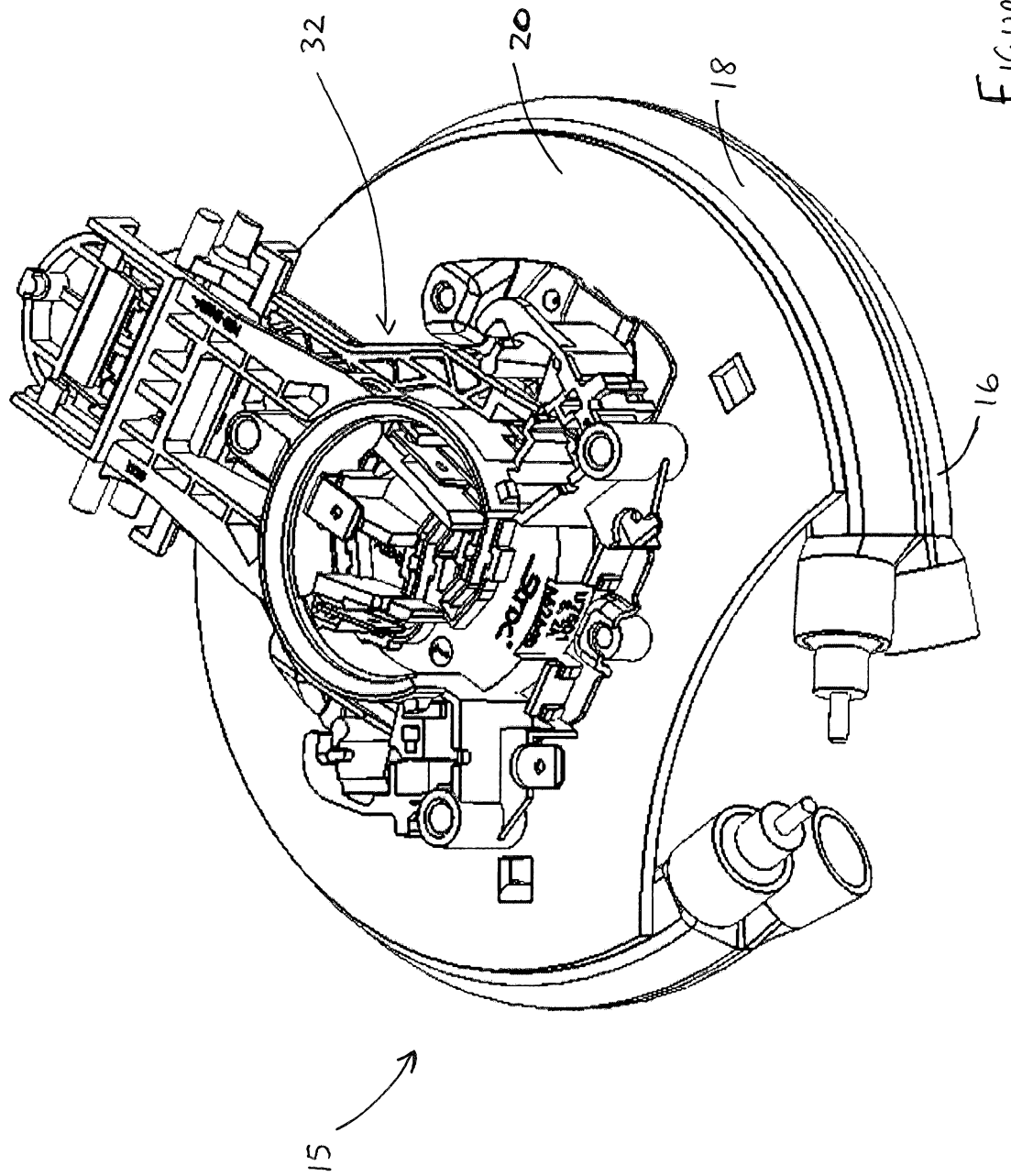


FIGURE 5

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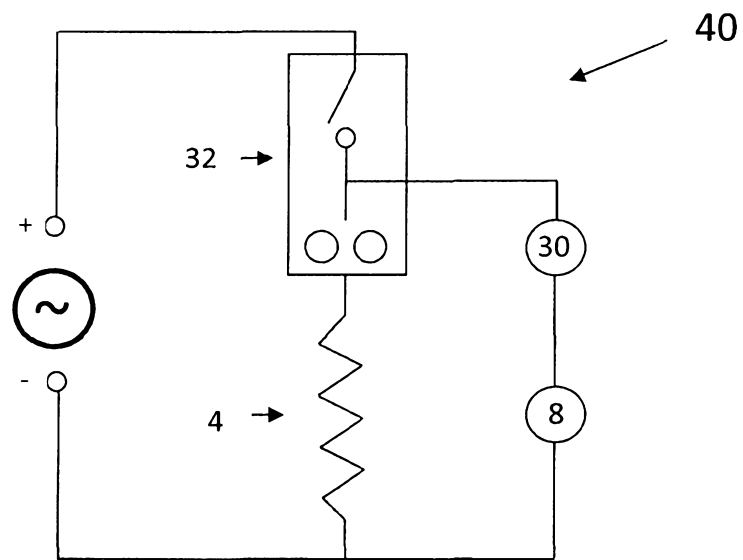


Figure 6

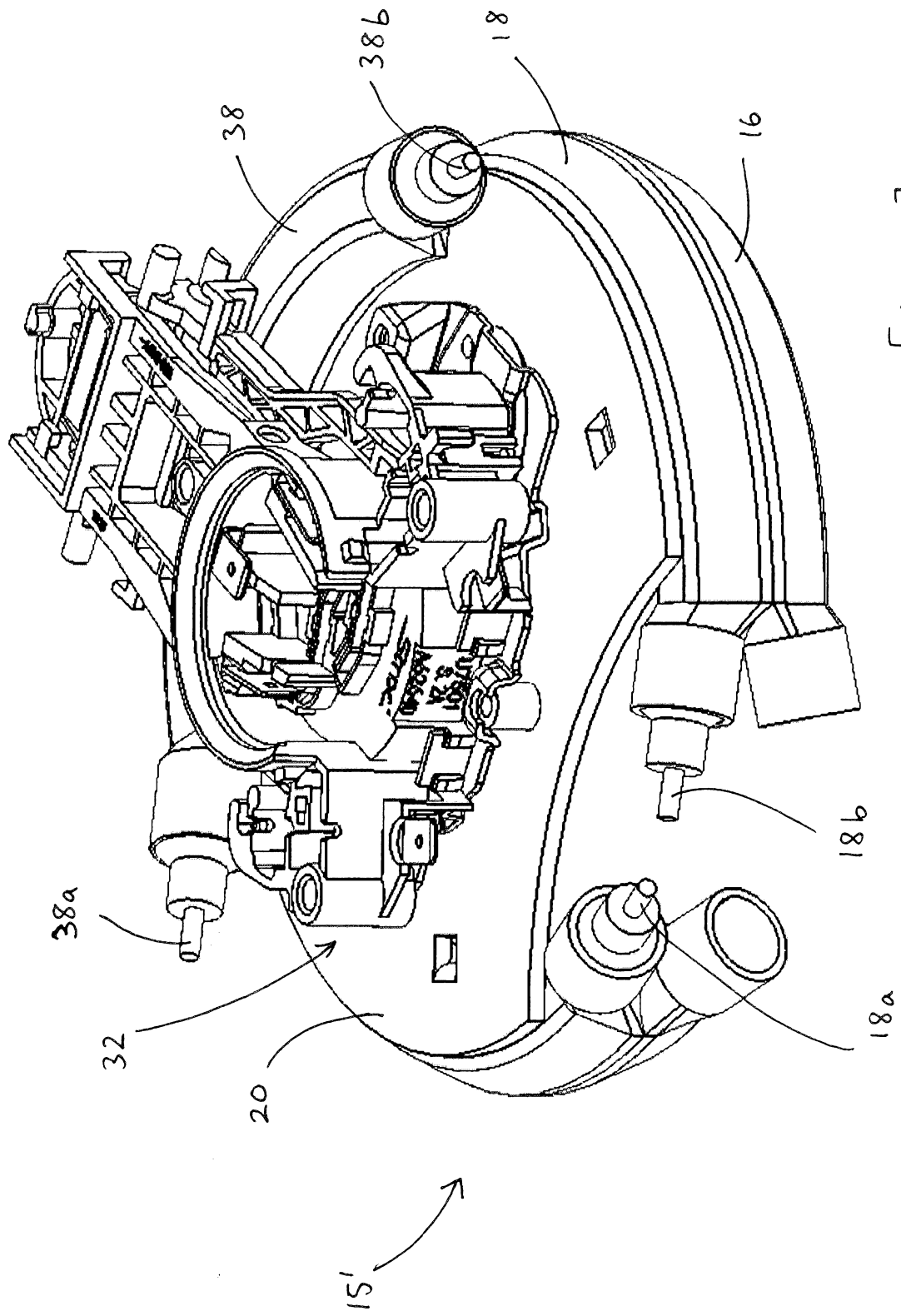


FIGURE 7

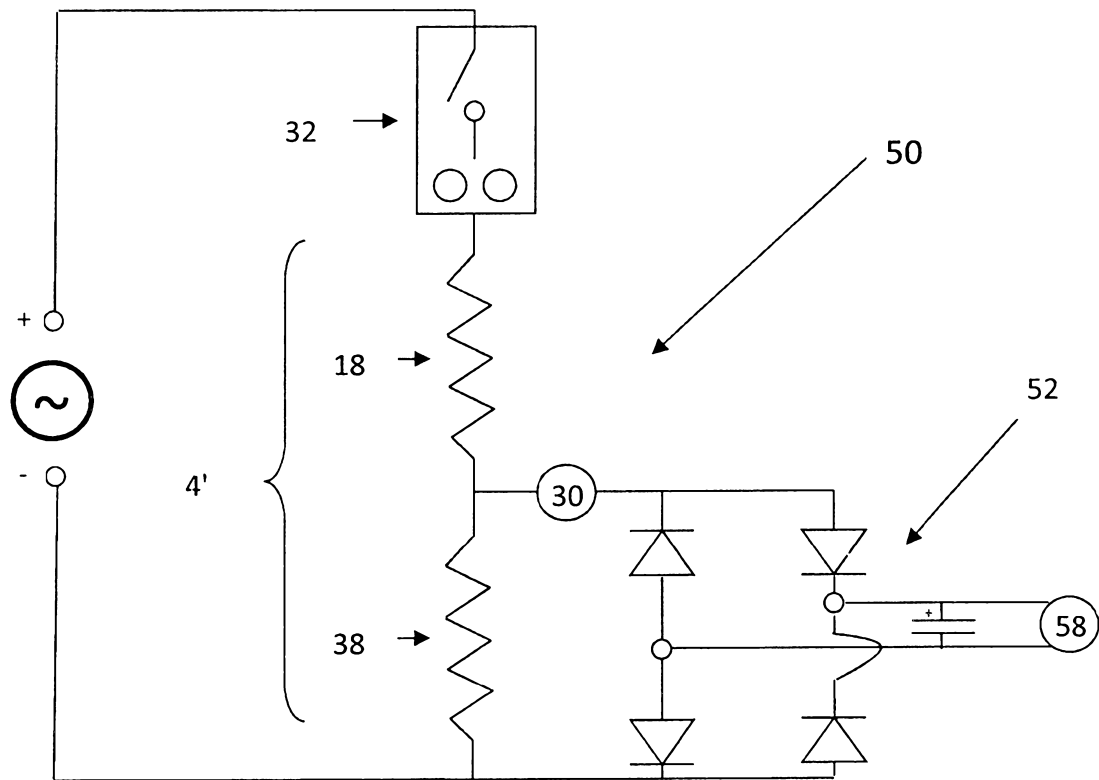


Figure 8

LIQUID HEATING APPLIANCES AND FLOW HEATERS

- 5 The present invention relates to liquid heating appliances of the type that deliver heated liquid on demand, and to flow heaters for such appliances. Such appliances may be user-adjustable to heat liquid to a selected temperature, for example finding use as hot water dispensers and beverage makers of various kinds.
- 10 Liquid flow heating appliances typically use an electrical pump to convey liquid from a static reservoir through a flow heater and dispense a volume of heated liquid on demand. Unlike flow heating systems that pump water from the mains supply or a large tank (e.g. shower heaters), domestic countertop appliances need to be relatively compact but their overall size and footprint is dictated to a degree by the
- 15 size of the requisite reservoir e.g. water tank. In order to minimise the size of the appliance, the flow heater is often arranged to run vertically alongside the reservoir. In the appliance seen in WO2010/106349, the flow heater is arranged to run horizontally below the water tank and an intermediate holding chamber is arranged between the reservoir and the centrifugal pump so as to provide a constant
- 20 pressure head for the pump.

In prior appliances it is usual for a residual volume of liquid to remain in the flow heater, and the flow path connecting the flow heater to the reservoir, after the pump is turned off. When the appliance is again operated to heat liquid to a desired

25 temperature, the control electronics will take into account the ambient temperature of liquid sitting in the appliance as a result of previous operation. For example, a thermistor projecting into the flow heater may provide a temperature reading that is used to calculate when to turn on the pump and/or the flow rate to be provided by the pump. The control electronics operate a feedback control system that controls

30 and adjusts operation of the pump to ensure that liquid is dispensed at the desired temperature.

However it would be desirable to avoid the need for control electronics in liquid flow heating appliances without loss of functionality. It is also desirable to reduce the

35 cost of flow heaters for such appliances.

When viewed from a first aspect, the present invention provides a liquid heating appliance for providing heated liquid on demand, comprising:

- 5 a flow heater having an entrance and an exit;
- a liquid reservoir having a maximum liquid fill level;
- a pump for conveying liquid from the reservoir through the flow heater;
- an outlet for dispensing heated liquid from the exit of the flow heater;
- a bi-directional flow path from the liquid reservoir to the outlet, the bi-directional flow path passing through the pump and the flow heater;
- 10 wherein at least the entrance of the flow heater is higher than the maximum liquid fill level of the reservoir.

Thus it will be understood that such an appliance comprises a flow heater that is arranged to be self-draining, because the maximum liquid fill level of the reservoir is
15 below the entrance of the flow heater. The bi-directional flow path is arranged to allow liquid to drain from the flow heater back through the pump to the reservoir. This means that there is no residual volume of water sitting in the flow heater between uses. When a user operates the appliance, the time that will be taken for the flow heater to reach a given temperature is a known parameter not affected by
20 an unknown volume and temperature of water that might otherwise sit in the flow heater.

As there is a bi-directional flow path from the liquid reservoir to the outlet, the exit of the flow heater could be the same height as, or lower than, the maximum liquid fill
25 level of the reservoir. When the pump is stopped, at least some of remaining liquid in the flow heater may then flow out through the exit to the outlet. However this may be perceived by a user as an undesirable "dribble" following the main dispensing operation. It is therefore preferable that the exit of the flow heater is higher than the maximum liquid fill level of the reservoir. This encourages any
30 remaining liquid in the flow heater to flow out through the entrance and back along the flow path to the reservoir.

As long as the whole flow heater lies at a level that is higher than the maximum liquid fill level of the reservoir, in theory liquid will tend to drain out and flow back
35 down to the reservoir. However, in reality, surface tension effects and/or

manufacturing tolerances may result in some pooling of liquid in the flow heater and this should be avoided. Thus in some preferred embodiments the flow heater comprises a liquid flow tube extending upwards to an apex that is higher than the entrance. This means that liquid in the flow tube will always tend to drain out of the entrance. The liquid flow tube may simply be inclined to form an apex at its highest point. The flow tube may be straight, angled or curved. In some embodiments the liquid flow tube may also extend downwards from the apex to the exit. The liquid flow tube may be shaped to form the apex, e.g. an apex arranged between the entrance and exit.

In one or more embodiments the liquid flow tube has an arcuate shape extending between the entrance and exit. The arcuate e.g. horseshoe-shaped liquid flow tube may be oriented or inclined to provide an apex that is higher than the entrance and exit. An advantage of an arcuate liquid flow tube is that the flow heater may be more compact than one comprising a straight tube. As will be described further below, another advantage of an arcuate liquid flow tube is that the flow heater may be made using a standard sheathed electrical heating element of the type found in the heated base of kettles.

It will be understood that whether one part of the appliance is higher than another is an absolute feature that can always be determined when the appliance is sat on a surface in use. For example, a plumb line can be used to determine the vertical direction and then height measured against the vertical. The appliance is always intended to be operated on a level surface as an inclined surface may affect the self-draining function of the flow heater. Furthermore, it will be understood that what is meant by an outlet for dispensing heated liquid is an outlet from the appliance e.g. for dispensing heated liquid into a user's cup or other receptacle. Preferably the outlet is lower than the exit of the flow heater to ensure that heated liquid does not stagnate at the exit.

While there is a bi-directional flow path from the liquid reservoir to the outlet, i.e. a flow path that allows liquid to flow both out of and back into the reservoir, it will be appreciated that the flow path may optionally be restricted at one or more points to control the flow rate along the flow path. In one or more embodiments, the bi-directional flow path comprises a restrictor valve, preferably arranged between the

pump and the flow heater. In some embodiments the restrictor valve may be a pressure-compensating constant flow valve of the type that provides a uniform flow rate to the flow heater regardless of upstream variations in pressure, e.g. resulting from factors such as pump speed variability (caused by operational variability and/or fluctuations in the mains electrical supply, if used), and varying pressure head in the reservoir. This is known from WO2012/114092, the contents of which are hereby incorporated by reference. Such a restrictor valve, that controls the flow rate to the flow heater so that it is constant, may be employed to ensure that liquid is heated in a more repeatable manner.

The Applicant has recognised that it is often desirable for a user to be able to vary the temperature of the dispensed liquid, for example choosing different temperatures for different beverages. In prior appliances, the operating speed of the pump is varied in response to a user input. This typically requires electronic control of the pump. The Applicant has appreciated that the bi-directional flow path passing through the pump and the flow heater may be restricted upstream of the flow heater so as to vary the flow rate therethrough and hence the temperature to which liquid is heated. The higher the flow rate, the lower the liquid temperature. In one or more embodiments, the bi-directional flow path comprises a variable restrictor valve, preferably arranged between the pump and the flow heater.

A variable restrictor valve is a convenient way to provide user control over flow rate without needing an electronic control. Thus in some preferred embodiments the appliance further comprises a user-adjustable restrictor valve arranged to adjust the flow rate of liquid through the flow heater. Such a restrictor valve may be manually adjustable. Adjusting the flow rate will directly control the dispensed liquid temperature without needing to control the pump.

This is considered novel and inventive in its own right, and thus when viewed from a second aspect, the present invention provides a liquid heating appliance for providing heated liquid on demand, comprising:

- a flow heater;
- a liquid reservoir;
- a pump for conveying liquid from the reservoir through the flow heater;
- an outlet for dispensing heated liquid from the flow heater; and

a user-adjustable restrictor valve arranged to adjust the flow rate of liquid through the flow heater.

5 As is mentioned above, the restrictor valve is preferably arranged between the pump and the flow heater, so that it does not change the pressure head experienced by the pump. This can be important in embodiments where the pump comprises a centrifugal pump, which is sensitive to pressure fluctuations. Using such a restrictor valve to adjust the dispensed liquid temperature, the pump speed is not adjusted (although the pump speed may vary as a result of other factors e.g. 10 due to mains power fluctuations).

As in the first aspect of the invention, it is preferable that the flow heater has an entrance that is higher than a maximum liquid fill level of the reservoir so that it is self-draining. In embodiments of either the first or second aspects of the invention, 15 the pump is preferably a mechanical pump that allows for the back flow of liquid to the reservoir. The pump is not the reciprocating type, such as a solenoid-driven pump. Rather, the pump is an impeller-based pump, such as a centrifugal pump.

As is mentioned above, the self-draining function of the flow heater means that the 20 time taken for the flow heater to reach a given temperature, e.g. before the pump starts to convey liquid therethrough, is not affected by a residual volume of liquid. However the time taken for the flow heater to heat up will depend on its starting temperature and this may be affected by variables such as ambient temperature and the amount of time that has passed since the appliance was last operated. In 25 one or more embodiments the appliance further comprises means for delaying operation of the pump to convey liquid from the reservoir through the flow heater after energising the flow heater. For example, the operation of the pump may be delayed for a predetermined period of time or until the flow heater has reached (or is expected to have reached) a predetermined operating temperature. The flow 30 heater may be energised during a period of pre-heating before the pump is operated.

The means for delaying operation of the pump may be any suitable mechanical or electronic solution. In some embodiments the delay may be fixed, e.g. a fixed time 35 delay that is expected to ensure that the flow heater will have reached the

predetermined operating temperature across a range of likely starting temperatures. A fixed time delay may be implemented by a timer or a fluid storage delay, for example an intermediate reservoir (with a small drain in the bottom) that is filled before overflowing into the flow heater. In the latter example, the pump may be operated simultaneously with the flow heater and the delay added into the flow path between the pump and the flow heater.

In other embodiments the delay is preferably variable. A variable delay can try to take into account fluctuations in the initial temperature of the flow heater. The means for delaying operation of the pump preferably provides a variable delay depending on the actual or expected temperature of the flow heater at the time of use. In some examples, an electronic timer may be coupled to a capacitor that decays at a similar rate to that of the flow heater, i.e. modelling how the flow heater will cool down between uses. In other examples, the delay is variable and based on an actual temperature of the flow heater. The means for delaying operation of the pump may comprise an electronic or thermomechanical temperature sensor coupled to the flow heater. An electronic temperature sensor is known from the prior art, in particular a thermistor extending through the wall of a flow heater to be in contact with the liquid flowing therethrough. However many of these solutions add unwanted complexity to an appliance that is ideally controlled without needing any electronics.

In some preferred embodiments the means for delaying operation of the pump comprises a thermomechanical switch, such as a bimetallic actuator, arranged in thermal contact with the flow heater. The switch may be arranged in the electrical power supply to the pump and normally open until it operates (e.g. upon sensing that the heater has reached a predetermined operating temperature) to close and energise the pump. The pump may be connected in parallel with the flow heater in a common electrical power supply circuit, the switch being connected in series with the pump to prevent the pump from being energised until after energising the flow heater. This is a simple and cost effective solution that does not require any electronic (e.g. microprocessor-based) control. In various embodiments of the first or second aspect of the invention, it is preferable that the appliance does not include an electronic controller (such as microprocessor) for either the flow heater or the pump.

In order for a thermomechanical switch, such as a bimetallic actuator, to accurately sense a temperature indicative of the overall temperature of the flow heater, the Applicant has appreciated that the flow heater may be designed to have a relatively uniform temperature. This is known to be the case for so-called underfloor heaters in kettles that comprise a sheathed electrical heating element bonded to a heat diffuser plate. Thus in one or more embodiments the flow heater comprises a heater assembly comprising: a liquid flow tube; a sheathed electrical heating element arranged in good thermal contact with the liquid flow tube; and a heat diffuser plate arranged in good thermal contact with the heating element.

In such embodiments, a bimetallic actuator is preferably mounted in good thermal contact with the heater assembly to sense the temperature of the flow heater. A bimetallic actuator is ideal as it will operate at a predetermined temperature that can be defined to within tight tolerances during its manufacture. The operation of the pump can therefore be reliably delayed until the flow heater has reached a predetermined operating temperature as sensed by the bimetallic actuator.

This is considered novel and inventive in its own right, and thus when viewed from a third aspect, the present invention provides a flow heater comprising:

- a heater assembly comprising:
 - a liquid flow tube;
 - a sheathed electrical heating element arranged in good thermal contact with the liquid flow tube; and
 - a heat diffuser plate arranged in good thermal contact with the heating element;
- a pump operable to convey liquid through the liquid flow tube; and
- a bimetallic actuator mounted in good thermal contact with the heater assembly to sense the temperature of the heater assembly;

wherein the sensed temperature of the heater assembly is used to delay operation of the pump after energising the sheathed electrical heating element.

Preferably the delay is varied depending on the sensed temperature of the heater assembly. For example, the sensed temperature of the heater assembly may be used to delay operation of the pump until the heater assembly has reached a

predetermined temperature. As is discussed above, delayed operation of the pump is conveniently implemented without needing an electronic control system. The flow heater preferably comprises an electrical power supply circuit wherein the pump is connected electrically in parallel with the sheathed electrical heating element, and wherein the bimetallic actuator is arranged to operate a switch connected in series with the pump. The switch may be normally open. The bimetallic actuator may operate, upon sensing a predetermined temperature for the heater assembly, to close the switch. This means that operation of the pump is delayed after energising the sheathed electrical heating element. The bimetallic actuator may be mounted in good thermal contact with at least one of the liquid flow tube, the heating element and/or the heat diffuser plate in order to sense the temperature of the heater assembly.

In some embodiments the flow heater may comprise a thermomechanical or electronic control arranged to operate the pump after a temporal delay based on the sensed temperature of the heater assembly. In some embodiments the bimetallic actuator may simply operate a switch in an electrical power supply circuit for the pump. Furthermore, such a heater assembly can provide a low cost alternative to typical flow heaters. Sheathed electrical heating elements have been virtually unchanged in their construction for decades and can now be manufactured in high volumes without the need for skilled labour and at very low cost. The manufacturing techniques used to bond other aluminium components, such as the diffuser plate and liquid flow tube, to the heater assembly are also well-known and enable high volumes to be produced at low cost.

Another benefit of the flow heater comprising a heater assembly with a heat diffuser plate is that a standard thermomechanical control may easily be mounted to the heater assembly, again using standard kettle manufacturing techniques. The heat diffuser plate may include one or more mounting bosses for a thermo-mechanical control to be mounted in good thermal contact therewith. The bimetallic actuator may be standalone or provided by such a control mounted to the heater assembly.

In some preferred embodiments the flow heater further comprises a thermomechanical control mounted to the heater assembly. The control may be provided to interrupt electrical power to the sheathed heating element in the event

of overheat e.g. when no water is flowing through the heater assembly. The control may comprise one, and preferably two, bimetallic actuators of its own to sense an overheat condition. In addition, the bimetallic actuator arranged to sense the pre-heat temperature of the heater assembly may be a third bimetallic actuator of the control. All three actuators can then conveniently be mounted by the control in a single unit.

In some embodiments the thermomechanical control is mounted on one face of the heat diffuser plate and the bimetallic actuator is mounted on the other face of the heat diffuser plate. The electrical connections to the control can then be kept separate to the electrical connections to the bimetallic actuator used to provide a delay in operation of the pump. Furthermore, such an arrangement may be preferred in embodiments wherein the heat diffuser plate is sandwiched between the liquid flow tube and the sheathed electrical heating element. This means that preferably the liquid flow tube is arranged against a first face of the heat diffuser plate while the sheathed electrical heating element is arranged against the other face of the heat diffuser plate. The bimetallic actuator may be mounted in good thermal contact with either face of the heat diffuser plate. In these embodiments, it may be preferable that the control is mounted in good thermal contact with the other face of the heat diffuser plate, i.e. the face that carries the sheathed electrical heating element rather than the liquid flow tube. This can ensure that the control operates rapidly in response to an overheat situation, even if there is liquid in the flow tube during operation.

As described above, in some embodiments the heat diffuser plate could be sandwiched between the sheathed electrical heating element and the liquid flow tube. However, in other embodiments, the heat diffuser plate may be arranged on a bottom side of the sheathed electrical heating element and the liquid flow tube may be arranged on a top side of the sheathed electrical heating element. A first face of the heat diffuser plate may therefore carry both the sheathed electrical heating element and the liquid flow tube. In such embodiments the bimetallic actuator is preferably mounted to the first face of the heat diffuser plate, so as to most accurately sense the actual temperature of the heater assembly. A thermomechanical control, where provided, may conveniently be mounted to the other face of the heat diffuser plate. In any of these embodiments, the heat diffuser

plate, sheathed electrical heating element and liquid flow tube may be stacked on top of one another in a compact heater assembly.

5 As mentioned above, the liquid flow tube may have an arcuate shape extending between the entrance and exit. In order to make the heater assembly compact, the sheathed electrical heating element may also have a similar or matching arcuate e.g. horseshoe shape. The heat diffuser plate may be substantially circular. The liquid flow tube, sheathed electrical heating element and heat diffuser plate may together define a common arcuate perimeter for the heater assembly. Thus in 10 some embodiments the liquid flow tube and the sheathed electrical heating element are arcuate, extending in a horseshoe arrangement, and the diffuser plate spans the horseshoe arrangement. The heater assembly, minus the liquid flow tube, may therefore resemble a standard underfloor heater assembly for a kettle and be made using the same standard manufacturing techniques.

15 Regardless of the order in which the liquid flow tube, sheathed electrical heating element and heat diffuser plate are stacked to form the heater assembly, it is desirable to ensure good thermal conduction between the components so that ideally the heater assembly has a uniform temperature distribution. Preferably 20 the heat diffuser plate is bonded directly to the sheathed electrical heating element. For example, they may be brazed together. In at least some embodiments the liquid flow tube has a flat surface area arranged in contact with the heat diffuser plate or the sheathed electrical heating element. In addition, or alternatively, the sheathed electrical heating element may have a flat surface area arranged in contact with the 25 heat diffuser plate or the liquid flow tube. The flat surfaces can increase the surface area available for thermal conduction.

In at least some embodiments the heat diffuser plate and the sheathed electrical heating element may be formed of aluminium. Although the liquid flow tube may 30 also be formed of aluminium for its high thermal conductivity, stainless steel may be preferred to avoid any risk of liquid contamination.

In a set of embodiments the heater assembly may comprise more than one sheathed electrical heating element, for example first and second sheathed 35 electrical heating elements. It is preferable that both the first and second sheathed

electrical heating element are mounted to a face of the heat diffuser plate. This may be the same face, if there is space on the heat diffuser plate, or opposite faces with the heat diffuser plate sandwiched between the first and second sheathed electrical heating elements. In some of these embodiments the heat diffuser plate may even be omitted. The Applicant has recognised that a benefit of more than one sheathed electrical heating element is that the heating elements can have a different electrical resistance. This can be exploited for purposes other than heating.

10 This is considered novel and inventive in its own right, and thus when viewed from a fourth aspect, the present invention provides a heater assembly for a flow heater, comprising

a liquid flow tube;

15 a first sheathed electrical heating element arranged in good thermal contact with the liquid flow tube and comprising a first pair of electrical terminations;

a second sheathed electrical heating element arranged in good thermal contact with the first sheathed electrical heating element and comprising a second pair of electrical terminations;

20 wherein the second sheathed electrical heating element is connected electrically in series with the first sheathed electrical heating element by an electrical connection between one of the first pair of electrical terminations and one of the second pair of electrical terminations;

25 wherein the first sheathed electrical heating element has a first resistance and the second sheathed electrical heating element has a second resistance different to the first resistance.

The Applicant has recognised that connecting a second element, having a different resistance, in series with the first element means that an electrical component outside the heater assembly can be connected in parallel with the second element and run at a different voltage and power to the flow heater. For example, the second element of the heater assembly may be used to power another electrical component such as a pump in a liquid heating appliance. Yet again, such arrangements can avoid the need for complicated control electronics.

In some preferred embodiments the second resistance is lower than the first resistance. For example, a heater assembly running on the UK mains AC electrical supply at 240 V may have the first resistance set at 19 ohm and the second resistance set at 1 ohm, giving a power of 2-3 kW for the heater assembly and below 1 kW for another electrical component connected across the second element.

Various embodiments extend to a flow heater comprising such a heater assembly and an electrical component connected in parallel with the second sheathed electrical heating element. The electrical component may be a lower power component such as a mechanical pump, a timer, a visible/audible indicator, a user interface, etc.. Various embodiments further extend to a liquid heating appliance comprising such a flow heater, and optionally any of the other features described hereinabove.

In some preferred embodiments the electrical component comprises a pump for conveying liquid to be heated through the liquid flow tube. The pump may be driven by an electrical motor. For example, the pump may be a DC pump running at 12 V while the heater assembly may be connected to the mains AC electrical supply at 240 V. Of course a rectifier may be included in the circuit connecting the pump to the heater assembly if one component is DC while the other is AC.

As is mentioned above, the first and second sheathed electrical heating elements may be stacked on top of one another in any order. The second sheathed electrical heating element being arranged in good thermal contact with the first sheathed electrical heating element includes embodiments wherein a heat diffuser plate is sandwiched between the first and second elements. However this may not be particularly important if the second sheathed electrical heating element has a much lower resistance and therefore only contributes a fraction of the overall heating power of the assembly. In preferred embodiments, a heat diffuser plate is arranged in good thermal contact with a bottom of the first heating element and the second heating element is arranged in good thermal contact with a top of the first heating element. The first and second heating elements may have flat surfaces in contact with one another. The first and second heating elements may be bonded together.

It will be understood that a sheathed electrical heating element, also known as a tubular element, is a heating element comprising an electrical resistance heating wire embedded in insulating e.g. magnesium oxide powder inside a metallic tubular casing. The resistance heating wire may be coiled. The resistance heating wire
5 may be formed of NiCr or NiCrAl alloy. The metallic tubular casing may be formed of stainless steel (e.g. Incoloy alloy), copper or aluminium. A stainless steel or copper casing is used for elements that are immersed directly in water. In any of the aspects or embodiments described above, the casing is formed of aluminium for its superior heat conductivity properties. The liquid flow tube may be stainless steel
10 or also made of aluminium or aluminium alloy. In addition, or alternatively, the heat diffuser plate is preferably made of aluminium or aluminium alloy. The entire heater assembly is ideally bonded together, e.g. using standard brazing techniques.

In any of the aspects or embodiments described above, the flow heater is arranged
15 to heat liquids to temperatures up to, and potentially including, boiling. A liquid heating appliance comprising such a flow heater preferably does not have a separate boil pool, for example of the type disclosed in WO2010/106349, so as to avoid the extra expense involved. A liquid heating appliance according to various embodiments disclosed herein may include a steam separator arranged in the flow
20 path between the exit of the flow heater and the outlet for dispensing heated liquid. A suitable steam separator may, for example, comprise a device arranged to vent steam from the flow path before the heated liquid reaches the outlet. This helps to reduce a back pressure to the flow heater resulting from steam generation and means that liquid heated close to boiling is dispensed without the sputtering effects
25 of entrapped steam vapour. The embodiments described herein may find use in domestic countertop liquid heating appliances, for example hot water dispensers and beverage makers.

Some embodiments of the present invention will now be described, by way of
30 example only, and with reference to the accompanying drawings, in which:
Figure 1 is a perspective view of a liquid heating appliance according to one or more embodiments of the present invention;
Figure 2 is a cutaway perspective view of the liquid heating appliance showing the reservoir and pump more clearly;

Figure 3 is a side cross-sectional view of the liquid heating appliance showing the maximum fill level of the reservoir;

Figure 4 is a top perspective view of the heater assembly seen in the embodiment of Figures 1 to 3;

5 Figure 5 is a bottom perspective view of the heater assembly seen in the embodiment of Figures 1 to 3;

Figure 6 is a schematic power supply circuit diagram for the liquid heating appliance of Figs. 1 to 5 and heater assembly of Figs. 4 to 5;

10 Figure 7 is a bottom perspective view of another heater assembly according to an alternative embodiment of a liquid heating appliance; and

Figure 8 is a schematic power supply circuit diagram for the liquid heating appliance and heater assembly of Fig. 7.

15 There is generally seen in Figures 1 to 3 a liquid heating appliance 2 for providing heated liquid on demand. A top cover of the appliance 2 has been omitted to expose the main working parts. The appliance 2 comprises a flow heater 4, a liquid reservoir 6, a pump 8, and an outlet 10 for dispensing heated liquid, for example into a cup or carafe (not shown) placed on the tray 12. The reservoir 6 takes the form of a removable water tank that fills a vertical space at the back of the

20 appliance 2, as is shown in Fig. 2. The reservoir 6 may be filled with liquid (e.g. water) up to a maximum fill level 14. As is seen most clearly from Fig. 3, the maximum fill level 14 is below the level of the flow heater 4. In this embodiment, the flow heater 4 comprises a heater assembly made up of a liquid flow tube 16, a sheathed electrical heating element 18 and a heat diffuser plate 20. The flow heater

25 4 has an entrance 4a at one end of the liquid flow tube 16 and an exit 4b at the other end for liquid being conveyed through the flow heater 4 by the pump 8. For the sake of clarity, there has been omitted from Figs. 1 to 3 the flexible tubing that connects to the entrance 4a and exit 4b. The flow heater 4 is described in more detail below, with reference to Figs. 4 and 5.

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A bi-directional flow path is defined in the appliance 2 from the liquid reservoir 6 to the outlet 10. With reference to Fig. 2 in particular, the flow path runs from a reservoir outlet 6b that is connected to the pump 8 (e.g. by a connecting tube, not shown), passing through the pump 8 and its outlet 8b, along a connecting tube (not

35 shown) to pass through an optional restrictor valve 22 having an inlet 22a and outlet

22b, along tubing (not shown) to the entrance 4a of the flow heater 4, through the flow heater 4 to its exit 4b and along further tubing (not shown) that connects to an outlet pipe 24 and outlet 10. The flow path is bi-directional because liquid can flow freely in either direction. The pump 8 is an impeller pump that allows liquid to flow therethrough in either direction. The outlet pipe 24 directs heated liquid through a steam separator 25 before it exits the appliance through the dispensing outlet 10. As is seen from the cross-sectional view of Fig. 3, the steam separator 25 provides a double-walled passage so that steam can be vented through an outer passage separately from the heated liquid that passes through an inner passage to the dispensing outlet 10.

From Fig. 3 it can be seen that the entrance 4a at one end of the liquid flow tube 16 is higher than the maximum fill level 14 of the reservoir 6. This means that, when the pump 8 is not running, any liquid remaining inside the liquid flow tube 16 will run back through the entrance 4a and along the flow path to the reservoir outlet 6b. It can also be seen that the flow heater 4 is not horizontal but instead mounted at an incline in the appliance 2. The inclined arrangement of the flow heater 4 means that it has an apex 26 that is higher than the entrance 4a, and also higher than the exit 4b. Any residual liquid in the liquid flow tube 16 will therefore tend to flow from the apex 26 down to the entrance 4a and/or exit 4b when the pump 8 is not operating. The exit 4b at the other end of the liquid flow tube 16 is also higher than the maximum fill level 14 of the reservoir 6 so as to avoid stagnation.

The optional restrictor valve 22 is useful for controlling the flow rate of liquid through the flow heater 4 and hence the temperature attained by the heated liquid. The restrictor valve 22 may be a pressure-compensating constant flow valve of the type that provides a uniform flow rate to the flow heater 4 regardless of upstream variations in pressure. This is known from WO2012/114092, the contents of which are hereby incorporated by reference. Such a restrictor valve 22 may be employed if it is desirable for the appliance 2 to dispense heated liquid in a more repeatable manner.

In a preferred embodiment the optional restrictor valve 22 is a user-adjustable restrictor valve. It can be seen from Figs. 1 and 2 that such a valve 22 may include a knob 28 for manual adjustment by a user. Turning the knob 28 changes the flow

resistance of the restrictor valve 22 and hence the flow rate of liquid conveyed to and through the flow heater 4. This is equivalent to a user adjusting the temperature of the heated liquid that is dispensed. It will be appreciated that such a user-adjustable restrictor valve 22 provides a convenient way for a user to control the liquid temperature without needing any electronic (e.g. microprocessor-based) controller in the appliance 2.

A further feature of the appliance 2 is the ability to delay operation of the pump 8 to allow for pre-heating of the flow heater 4, again without the use of any electronic (e.g. microprocessor-based) controller. This is achieved by the flow heater 4 including a thermomechanical switch, in this embodiment a bimetallic actuator 30, mounted in good thermal contact with the heater assembly of the flow heater 4. There is also seen in Fig. 1 a thermomechanical control 32 mounted to the underside of the flow heater 4. These features will now be described further with reference to Figs. 4 and 5.

From Figs. 4 and 5 it can be seen more clearly that the flow heater 4 comprises a heater assembly 15 made up of a liquid flow tube 16, a sheathed electrical heating element 18 and a heat diffuser plate 20. The heat diffuser plate 20 is arranged on a bottom side of the sheathed electrical heating element 18 and the liquid flow tube 16 is arranged on a top side of the sheathed electrical heating element 18. The heater assembly 15 is a horseshoe arrangement that is more compact than prior flow heaters, and can be made using standard manufacturing techniques as known for the underfloor heaters of kettles. In this horseshoe arrangement, the liquid flow tube 16 and the sheathed electrical heating element 18 are arcuate, for example extending around an angular range of at least 270°, and the generally circular diffuser plate 20 spans the horseshoe arrangement. The liquid flow tube 16, sheathed electrical heating element 18 and heat diffuser plate 20 are bonded together in close thermal contact. The heater assembly 15 is therefore very efficient at reaching a substantially uniform temperature.

The Applicant has recognised that the uniform heat distribution of such a flow heater 4 may be exploited when it is desired to sense the temperature of the heater assembly and use the sensed temperature to delay operation of a pump that is conveying liquid through the flow heater 4 in use. As seen in Fig. 4, the bimetallic

actuator 30 is mounted in good thermal contact with the heat diffuser plate 20. The bimetallic actuator 30 can be arranged in a power supply circuit to the pump 8, as seen in Fig. 6, as a normally open switch. The actuator 30 operates, and closes the switch, only once it reaches a predetermined temperature. Although Figs. 1 to 4
5 show the bimetallic actuator 30 mounted on the top face of the heat diffuser plate 20, it could instead be mounted on the bottom face. In other embodiments the bimetallic actuator 30 could instead be mounted in good thermal contact with the liquid flow tube 16 and/or the sheathed electrical heating element 18. The exact position of the bimetallic actuator 30 is not expected to be critical as the heater
10 assembly 15 of the flow heater 4 is expected to quickly reach a uniform temperature during use.

It is seen most clearly from Fig. 5 that a thermomechanical control 32 is mounted on the bottom face of the heat diffuser plate 20. The control 32 is conveniently
15 accommodated within the footprint of the horseshoe arrangement of the heater assembly 15. One of the Applicant's standard U-series controls may be employed. The control 32 includes a pair of bimetallic overheat detectors that respond to the temperature of the flow heater 4. The control 32 is connected to the power supply circuit for the flow heater 4 so as to interrupt power to the flow heater 4 in the event
20 of an overheat condition being detected. The control 32 may also provide a manual on/off function. Such features are well known, see for example WO95/34187, the contents of which are hereby incorporated by reference.

Fig. 6 provides a schematic overview of the power supply circuit 40 connecting the
25 flow heater 4 to the mains AC electrical supply. The control 32 is electrically connected in series with the flow heater 4. The pump 8 and bimetallic actuator 30 are electrically connected in parallel with the flow heater 4. There is a power supply to the pump 8 only when the bimetallic actuator 30 operates to close the switch in the parallel branch of the circuit. This means that operation of the pump 8 can be
30 delayed after the flow heater 4 is energised. In this embodiment the pump 8 runs on the mains AC supply voltage.

In the embodiment described so far, the flow heater 4 comprises a single sheathed electrical heating element 18, but more than one sheathed electrical heating
35 element may optionally be provided. An alternative embodiment is seen in Fig. 7.

There is shown a heater assembly 15' for an alternative flow heater 4', comprising a second sheathed electrical heating element 38 mounted in good thermal contact with the bottom face of the heat diffuser plate 20, adjacent to the control 32. Of course the second sheathed electrical heating element 38 could be mounted in any suitable location in the heater assembly 15', for example on the top face of the heat diffuser plate 20 next to the main element 18. In this embodiment the second sheathed electrical heating element 38 is not present in the heater assembly 15' so much for an additional heating effect but to conveniently provide a different (e.g. lower) power to another component, in particular the pump 8 that conveys liquid through the flow heater 4'. Although not shown in Fig. 7, one of the electrical terminations (so-called "cold tails") 18a, 18b of the first heating element 18 is electrically connected to one of the electrical terminations (so-called "cold tails") 38a, 38b of the second heating element 38, for example by a metallic bridge or conductive wire, so that the first and second elements 18, 38 are electrically connected in series. This will be understood with reference to Fig. 8.

Other than the addition of the second sheathed electrical heating element 38 and associated modifications to the power supply circuit, described below with reference to Fig. 8, the alternative heater assembly 15' and its associated flow heater 4' has the same features as previously described. In particular, although not visible in Fig. 7, there is a bimetallic actuator 30 mounted on the top face of the heat diffuser plate 20.

Fig. 8 provides a schematic overview of the power supply circuit 50 connecting the flow heater 4' to the mains AC electrical supply. The control 32 is electrically connected in series with the flow heater 4'. The flow heater 4' now includes a first, higher power e.g. 19 ohm element 18 and a second, lower power e.g. 1 ohm element 38 connected in series. The pump 58 and bimetallic actuator 30 are electrically connected in parallel with the lower power element 38. There is a power supply to the pump 58 only when the bimetallic actuator 30 operates to close the switch in the parallel branch of the circuit. This means that operation of the pump 58 can be delayed after the flow heater 4' is energised. In this embodiment the pump 58 runs on a DC voltage (e.g. 12 V) that is lower than the mains supply voltage. A rectifying and smoothing circuit 52 is provided across the lower power

element 38, as is well known in the art, to convert the mains AC electrical supply to a DC voltage across the pump 58.

5 Operation of the appliance 2 will now be described. The reservoir 6 is pre-filled with liquid up to the maximum fill level 14 before commencing a heating and dispensing cycle. A user may select a desired temperature for the liquid to be heated to, using the knob 28 to adjust the restrictor valve 22. A user will turn on the appliance using an on/off switch coupled to the control 32. Power is then supplied to the flow heater 4, 4' and the heating element(s) is/are energised. If the flow heater 4, 4' is already
10 warm enough then the pump 8, 58 may start to operate at the same time, pumping liquid from the reservoir 6 to the flow heater 4, 4'. However, if the bimetallic actuator 30 senses that the starting temperature of the flow heater 4, 4' is too low then there will be delayed operation of the pump 8, 58 after energising the heating element(s) of the flow heater 4, 4'. Power is only supplied to the pump 8, 58 after a
15 certain period of preheating for the flow heater 4, 4'. Liquid that is pumped to the flow heater 4, 4' must first pass through the restrictor valve 22 and this determines the flow rate through the heater 4, 4'. The faster the flow rate, the lower the temperature to which the liquid is heated. The heated liquid that exits the flow heater 4, 4' is passed to the outlet 10 to be dispensed into a cup or carafe placed
20 on the tray 12. The liquid is heated on demand and dispensed only a few seconds after the pump starts to operate. The appliance may include a timer or other means for metering a preset volume of liquid, or the user may simply operate the on/off switch once the desired amount of heated liquid has been dispensed.

25 As the pump 8, 58 is connected electrically in parallel with a heating element of the flow heater 4, 4', the pump 8, 58 is de-energised at the same time as the flow heater 4, 4'. The appliance does not provide for the pump to continue conveying liquid through the flow heater 4, 4' and take up any residual heat. Nor does the appliance provide for the flow heater 4, 4' to continue heating to evaporate any
30 residual volume of liquid after the pump has stopped operating. Although the appliance benefits from a simple non-electronic control arrangement, this means there is a volume of liquid in the flow path downstream of the pump that has not yet been heated and dispensed when the appliance is turned off. This is dealt with by the position of the flow heater 4, 4' having its entrance 4a higher than the maximum
35 fill level 14 of the reservoir 6 and the incline of the flow heater 4, 4'. The flow heater

4, 4' is therefore arranged to self-drain and the undispensed liquid runs back along the flow path, through the pump 8, 58, to the reservoir 6.

Claims

1. A liquid heating appliance for providing heated liquid on demand,
comprising:
 - 5 a flow heater having an entrance and an exit;
 - a liquid reservoir having a maximum liquid fill level;
 - a pump for conveying liquid from the reservoir through the flow heater;
 - an outlet for dispensing heated liquid from the exit of the flow heater;
 - a bi-directional flow path from the liquid reservoir to the outlet, the bi-
 - 10 directional flow path passing through the pump and the flow heater;
 - wherein at least the entrance of the flow heater is higher than the maximum liquid fill level of the reservoir.
2. A liquid heating appliance according to claim 1, wherein the flow heater
15 comprises a liquid flow tube extending upwards to an apex that is higher than the entrance.
3. A liquid heating appliance according to claim 1 or 2, wherein the exit of the
flow heater is higher than the maximum liquid fill level of the reservoir.
20
4. A liquid heating appliance according to any preceding claim, wherein the
liquid flow tube has an arcuate shape extending between the entrance and exit.
5. A liquid heating appliance according to any preceding claim, wherein the bi-
25 directional flow path comprises a restrictor valve, preferably arranged between the pump and the flow heater.
6. A liquid heating appliance according to any preceding claim, further
comprising a user-adjustable restrictor valve arranged to adjust the flow rate of
30 liquid through the flow heater.
7. A liquid heating appliance for providing heated liquid on demand,
comprising:
 - a flow heater;
 - 35 a liquid reservoir;

a pump for conveying liquid from the reservoir through the flow heater;
an outlet for dispensing heated liquid from the flow heater; and
a user-adjustable restrictor valve arranged to adjust the flow rate of liquid
through the flow heater.

5

8. A liquid heating appliance according to claim 6 or 7, wherein the user-adjustable restrictor valve is arranged between the pump and the flow heater.

9. A liquid heating appliance according to any preceding claim, further
10 comprising means for delaying operation of the pump to convey liquid from the reservoir through the flow heater after energising the flow heater.

10. A liquid heating appliance according to claim 9, wherein the means for
delaying operation of the pump provides a variable delay depending on the actual
15 or expected temperature of the flow heater at the time of use.

11. A liquid heating appliance according to claim 9 or 10, wherein the means for
delaying operation of the pump comprises a thermomechanical switch, such as a
bimetallic actuator, arranged in thermal contact with the flow heater.

20

12. A liquid heating appliance according to any preceding claim, wherein the
flow heater comprises a heater assembly comprising:

a liquid flow tube;

a sheathed electrical heating element arranged in good thermal contact with
25 the liquid flow tube; and

a heat diffuser plate arranged in good thermal contact with the heating
element.

13. A liquid heating appliance according to claim 12, further comprising a
30 bimetallic actuator mounted in good thermal contact with the heater assembly to sense the temperature of the flow heater.

14. A flow heater comprising:
a heater assembly comprising:

35 a liquid flow tube;

a sheathed electrical heating element arranged in good thermal contact with the liquid flow tube; and

a heat diffuser plate arranged in good thermal contact with the heating element;

5 a pump operable to convey liquid through the liquid flow tube; and

a bimetallic actuator mounted in good thermal contact with the heater assembly to sense the temperature of the heater assembly;

wherein the sensed temperature of the heater assembly is used to delay operation of the pump after energising the sheathed electrical heating element.

10

15. A flow heater according to claim 14, wherein the delay is varied depending on the sensed temperature of the heater assembly.

16. A flow heater according to claim 14 or 15, further comprising a thermomechanical control mounted to the heater assembly.

15

17. A flow heater according to any of claims 14-16, wherein the heat diffuser plate is arranged on a bottom side of the sheathed electrical heating element and the liquid flow tube is arranged on a top side of the sheathed electrical heating element.

20

18. A flow heater according to any of claims 14-17, wherein the liquid flow tube and the sheathed electrical heating element are arcuate, extending in a horseshoe arrangement, and the heat diffuser plate spans the horseshoe arrangement.

25

19. A liquid heating appliance for providing heated liquid on demand, comprising a flow heater according to any of claims 14-18.

20. A liquid heating appliance according to claim 12 or 13, further comprising a thermomechanical control mounted to the heater assembly.

30

21. A liquid heating appliance according to claim 12, 13 or 20, wherein the heat diffuser plate is arranged on a bottom side of the sheathed electrical heating element and the liquid flow tube is arranged on a top side of the sheathed electrical heating element.

35

22. A liquid heating appliance according to any of claims 12-13 or 20-21,
wherein the liquid flow tube and the sheathed electrical heating element are
arcuate, extending in a horseshoe arrangement, and the heat diffuser plate spans
the horseshoe arrangement.

23. A liquid heating appliance according to any of claims 12-13 or 20-22,
wherein the heater assembly comprises more than one sheathed electrical heating
element.

24. A flow heater according to any of claims 14-18, wherein the heater
assembly comprises more than one sheathed electrical heating element.

25. A heater assembly for a flow heater, comprising
a liquid flow tube;
a first sheathed electrical heating element arranged in good thermal contact
with the liquid flow tube and comprising a first pair of electrical terminations;
a second sheathed electrical heating element arranged in good thermal
contact with the first sheathed electrical heating element and comprising a second
pair of electrical terminations;
wherein the second sheathed electrical heating element is connected
electrically in series with the first sheathed electrical heating element by an
electrical connection between one of the first pair of electrical terminations and one
of the second pair of electrical terminations;
wherein the first sheathed electrical heating element has a first resistance
and the second sheathed electrical heating element has a second resistance
different to the first resistance.

26. A heater assembly according to claim 25, wherein the second resistance is
lower than the first resistance.

27. A flow heater comprising the heater assembly of claim 25 or 26 and an
electrical component connected in parallel with the second sheathed electrical
heating element.

28. A flow heater according to claim 26, wherein the electrical component comprises a pump for conveying liquid to be heated through the liquid flow tube.

5 29. A liquid heating appliance for providing heated liquid on demand, comprising a heater assembly according to claim 25 or 26 or a flow heater according to claim 27 or 28.



Application No: GB1716398.1 **Examiner:** Andrew Isgrove
Claims searched: 1-6, 8-13 when dependant on 1-6, and 20-23 when dependant on 12 or 13 **Date of search:** 27 February 2018

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X,Y	X: 1-4 Y: 7, 8, 12, 13, 20-23	WO2013/057506 A1 (STRIX) figs 6 & 7
X	1 & 3	WO2007/046702 A2 (BRAVILOR et al) fig 1
X	1 & 3	CN201488238 U (MIDEA HOLDING) WPI Abstract Accession No. 2010-G64626, figs 1 & 3
X	1 & 3	WO2013/045507 A1 (NESTEC) fig 1
Y	7 & 8	WO2014/195842 A2 (HEATEX) fig 1
Y	12, 13, 20-23	WO2009/081159 A2 (STRIX et al) fig 2
A	-	JP2000170682 A (SANKYO et al) figs 1, 3 & 6

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

Worldwide search of patent documents classified in the following areas of the IPC



A47J; F24H; H05B

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, Patent Fulltext

International Classification:

Subclass	Subgroup	Valid From
A47J	0031/54	01/01/2006
A47J	0027/21	01/01/2006
F24H	0001/10	01/01/2006
H05B	0001/02	01/01/2006
H05B	0003/40	01/01/2006



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Further Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	WO2006/127108 A2 (SUNBEAM PRODUCTS) fig 5 paragraph [0031]
A	-	JP2009142648 A (ZOJIRUSHI) WPI Abstract Accession No. 2009-K96001, fig 1
A	-	WO2011/077135 A2 (STRIX et al) fig 12 item 57
A	-	US4000396 A (ABEL) fig 2

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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F24H	0001/10	01/01/2006



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H05B	0001/02	01/01/2006
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Patents Act 1977 Further Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	7 & 8	WO2014/195842 A2 (HEATEX) fig 1
X	7	US5964143 A (DRISCOLL et al) fig 1, 1b & 5
X	7	WO2007/014891 A1 (SAECO et al) fig 1
X	12, 13, 20-23	WO2009/081159 A2 (STRIX et al) fig 2
X	12, 13, 20-23	WO2009/081156 A1 (STRIX et al) figures 9-12
X	12, 13, 20, 23	GB2493719 A (STRIX) figs 6 & 7

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F24H	0001/10	01/01/2006
H05B	0001/02	01/01/2006
H05B	0003/40	01/01/2006