

WATER HEATER

FIELD OF INVENTION

The present invention is applicable to liquid fluid heaters which are heated electrically, tanks therefor, and methods of maintaining and/or providing
5 the fluid at a predetermined temperature. The present invention has particular application to water heaters, and more particularly water heaters that are designed to provide water substantially at or near boiling point.

BACKGROUND

Water heaters of the boiling water type generally have water heated
10 within a storage tank. It is considered that boiling water heaters have had difficulty in rapidly heating the stored water from an initial ambient temperature, when the heater is first turned "on", and also upon filling of the tank with relatively cool water particularly after hot water is drawn from the storage tank. If a relatively small heating element is used for the heating of the water in the
15 storage tank, the water will heat slowly and will thus provide a relative degree of control over the heating of the water. If on the other hand, a relatively large heating element is used to heat the water, the water will heat relatively quickly as is desirable by a user of the water heater, but the degree of control over the water temperature is greatly reduced. There has thus been a difficulty
20 associated with water heaters of the storage type in heating to and maintaining water within the storage tank at or near boiling point, i.e. 100 °C.

Yet a further difficulty exists in that the heating of water beyond boiling point is considered undesirable, not least of which for the reason of safety of users, so that the action of the water boiling does not cause boiling water to be
25 vented or splashed out of the water heater and onto a user, but also for the reason that the heating of water beyond its boiling point is not considered energy efficient.

SUMMARY OF INVENTION

The present application seeks to address these difficulties by providing a
30 number of inventions.

One invention is predicated on the provision of at least a portion of the water inlet conduit being in thermal contact with at least a portion of the steam

condenser. It has been found that the arrangement of the proximity of the water inlet conduit to the condenser facilitates the cooling of the condenser by the passage of water through the water inlet during filling of the tank and thus aids in the reduction of heat emitted from the water heater and further reduces the amount of energy used by the water heater to maintain the heated water at or near boiling point. Preferably the inlet conduit and condenser are metal pipes.

The proximity of the inlet water conduit to the condenser further enables the condenser arrangement to have one end thereof left open to atmosphere. It has been found that the heat transfer between inlet water conduit and the condenser enables steam and/or water vapour given off from the heated water in the water storage tank to be condensed.

It has also been advantageously found that the provision of the condenser being open to atmosphere at one end, together with the provision of an aperture between the condenser and water inlet, enables the water in the water inlet to "bleed out" of the water inlet proximate the condenser by the ingress of atmosphere (air) into the water inlet via the aperture.

Another invention results from the placement of the temperature sensing device so as to be directly exposed or squirted by water when the water is flowing through the water inlet conduit. This squirt has been found to relatively rapidly cool the temperature sensing device to below the trigger temperature, and therefore enhance the sensitivity of the temperature sensor to steam given off by the heating of the water.

Yet another invention is resultant from the reduction of mass of material heated by the already heated water in the storage tank during a maintenance cycle. This serves to allow the temperature sensor to remain above its trigger temperature for a relatively longer period of time. This facilitates a reduction in energy losses and therefore enable relatively extended cycle times in the operation of the water heater. Significantly, the mass is reduced by the reduction or draining of water, that would otherwise be situated in the inlet conduit proximate the condenser tube.

Another invention is considered to reside in the provision of an electronic sensing element in or near the condenser arrangement. The sensing element is

preferably a sensor bulb or temperature sensing element, but may also be another suitable type of element, for example a moisture sensing element. A temperature sensor and its control circuit may advantageously be designed to operatively trigger heating of the water in the storage tank when the element
5 registers heat within the range of 40 to 90 °C. Preferably the trigger temperature is set at or near 75°C.

Still another invention is the provision of an electronic temperature sensing element within a metal sensor bulb, and which is placed proximate the condenser arrangement. The sensor bulb is preferably designed to cool as a
10 result of being splashed by the water flowing through the aperture in the water inlet, but not to cool to the extent that the water in the heater is over boiled before the temperature sensor again rises above its trigger temperature.

Another invention is also provided in the insulation of the temperature sensing element from the condenser conduit. This insulation serves to enable
15 the temperature sensor to be more responsive to heating by the passage of steam. The insulation also reduces conduction losses to the condenser tube.

PREFERRED EMBODIMENT

A preferred embodiment of the present invention will now be described with reference to the accompanying drawings, where:

20 Figure 1 illustrates a schematic view of a water heater in accordance with the various inventions disclosed;

Figure 2 illustrates a schematic view of the logic circuitry utilised in accordance with the present invention disclosed;

Figure 3 illustrates a more detailed view of the condenser and water inlet
25 conduit arrangements; and

Figure 4 illustrates, in section, the thermistor sensor bulb.

With reference to Figure 1, a water heater is shown having a storage tank 1 in which there is provided a heating element 2 and a vent 3. Coupled to the vent 3 is a condenser arrangement 4 and provided within or near the condenser
30 4 is a temperature sensor 5.

The water heater also has a supply of water 6 coupled, in operation, to a valve 7 which communicates with a cold water inlet 8 for filling and refilling of

the storage tank with water. The water inlet 8 communicates between valve 7 and at least partially along condenser 4. The water inlet is connected to one end of the storage tank to enable the entry of water to the storage tank. In the embodiment shown, the water inlet communicates with the bottom of the storage tank and preferably below the tap fitting 9 which is used as an outlet for heated water from the storage tank.

The provision of the water supply near one end or near a bottom end of the tank enables cool water to be placed in the storage tank without substantially affecting or with little effect on the temperature of the water proximate the tap fitting or water outlet 9.

It has been found that water heated in a storage tank comprises several thermal layers of water, each layer having a slightly different temperature. By the provision of the water inlet at the bottom of the tank, the coolest water can be provided near the bottom of the tank and proximate the heating element, and the temperature of the heated water proximate the water outlet can be provided at a desirable temperature, e.g. 99.9 to 100° C.

Also coupled to the tank vent 3 is a condenser arrangement 4. The condenser arrangement is provided preferably in the form of a copper tube of a predetermined length selected in accordance with the amount of heat to be dissipated or absorbed by the condenser.

It is almost impossible to boil water without some excess steam or overboiling being produced. In the fill/heat function, the condenser tube could be much shorter and still work very well, but, in the maintenance cycle, a longer condenser tube is required.

In the maintenance cycle, the condenser tube is not water cooled and the water in the cooling tube is drained out. Any excess steam that passes the sensor bulb has to be condensed inside the condenser tube. If there is insufficient mass (that is copper tube), steam could exit the condenser.

Calculation of the mass needed to condense the excess steam in the maintenance cycle, given the heat produced by a 2.4 kW heating element as used in a test water heater over 2.5 seconds and heat loss of the condenser tube, is described below:

For example, given in a most preferred form:

1. Total power 2.4kW @ 240v
2. Energy used in the maintenance cycle : 2.5 seconds ON = 5.68 BTU
3. Energy used per hour: Heater OFF TIME 2.5 minutes in an ambient temperature of 20°C is:

2.5 minutes = 24 cycles per hour

24 cycles x 5.68 BTU = 136.32 BTU per hour, thus

136.32 BTU = 40 watts per hour.

This is the energy that the condenser must contend with.

- 10 The condenser arrangement is thermally coupled to the water inlet 8 which is also preferably provided in the form of a copper tube which may be soldered or brazed to the condenser tube. Other arrangements are possible within the scope of the present invention. The condenser serves to condense steam given off by the water heated within the storage tank. The condenser is
- 15 preferably inclined to allow condensed water to gravitate back to the storage tank by the ingress of air from vent 10, via condenser 4 and aperture 16 when the water in valve 7 is shut off. One end of the condenser 4 is also preferably coupled to vent 10 which is open to the atmosphere, and preferably the space within a cover (not shown) over the water tank. Vent 10 is also coupled to a vent
- 20 11 in the event that water overflows in an error situation.

There is also provided a level sensing arrangement 12 which comprises a conduit fluidly coupled to the storage tank in which sensor 15 is provided so as to monitor or detect the predetermined upper water level of the storage tank and sensor 13 is provided to monitor the lower level of water in the tank. The

25 lower level is preferably determined with reference to the height of the heating element in the storage tank. It is preferred that the heating element is covered at least partially with water before heating of water within the tank commences. The water level can, however, be set to any particular predetermined height dependent on the placement of sensors 13 and 15. Further any type of level

30 sensing can be used, but in this embodiment electrodes are used. Coupling 14 is a reference potential coupling to the level sensing conduit, and sensors 15 and 13 are coupled to their respective logic inputs 204, 205 as illustrated in

Figure 2. In the embodiment shown, the water is used to complete the circuit electrically between the grounded sensing conduit 14 and the respective level sensor 13 or 15.

Operation of the Water Heater

5 Initial fill of storage tank from empty:

In operation of the tank, cool water passes via valve 7 and water inlet 8 from the water supply to the bottom of the tank. The logic circuitry illustrated in Figure 2, when first filling the tank from an empty position, senses for water to activate sensor 13. In this case, this indicates that the tank water is above the
10 heating element. The sensor 13 may be placed any where to sense water level, but is preferably placed in water level tube 12 outside the storage tank.

Logic Control From Initial Fill:

The activation of sensor 13 as described above then signals the logic circuitry to close water inlet valve 7 and switch on the power control via heat
15 control 201 to power the heating element 2. Heating of the water then commences. Note that in the initial fill of cold water, the condenser tube and thermistor serve no purpose until heating of the water commences.

As the water approaches 100°C, steam is generated. The steam rises via vent 3, passing sensor bulb 5. Any steam that is not absorbed by the sensor
20 bulb 5 will be condensed on the inside of the condenser tube 4 (having been cooled by the passage on inlet water) and run back into the storage tank. When the thermistor 5 reaches its trigger temperature of preferably 75°C, the heater element is switched off and the inlet water valve is energized allowing cold water to splash into the condenser tube 4 through aperture 16. This splash is in
25 the form of a small injection of water flowing over the end of the sensor bulb 5. Most of the inlet water, however, is directed to the bottom of the storage tank. The amount of cold water that enters the storage tank is predetermined and calculated to minimize storage tank water temperature drop. Too much cold
30 water would drop the temperature of the water in the tank to an unacceptable level. The method preferably used to maintain the water temperature at close to boiling while adding small amounts of cold water is as follows:

This method has been achieved by firstly fitting restrictors to the water valve allowing only two litres of water per minute to pass through the valve. This has made the control of the water entering the storage tank much easier. The method has mainly been achieved by allowing a small amount of cold water to
 5 be injected, some of which is splashed over the end of the sensor bulb. The water inlet valve is open for approximately 1.5 sec/2 sec. This time is calculated on the time it takes for the thermistor temperature to drop below its trigger temperature of 75°C and also includes an inbuilt delay circuit. After this small amount of cold water has entered the storage tank, the water inlet valve will
 10 close and the heating element will be re-energized. The water will again start to boil. This function will repeat itself until the water comes into contact with sensor 15. The tank is then considered full.

The amount of cold water that can enter the storage tank at any one time while in the fill/heat function is disclosed below:

- 15 i) Power consumption 240v / 2400 w 10 AMP - all models
 ii) Maintenance cycle time
 Heater on 2 to 3 seconds
 Heater off 2 to 3 minutes
 20 iii) Calculating the amount of cold water entering the storage tank while in the fill/heat function.

The maximum amount of water that the inlet valve can deliver is two litres per minute with supply pressure being between 2-10 bar

$$\frac{2000 \text{ ML}}{60 \text{ SEC}} = 33.3 \text{ ML/sec}$$

- 25 Time the inlet valve is open 1.5 (min) to 2 (max) sec.

$$33.3 \text{ ML} \times 1.5 \text{ sec} = 49.95 \text{ ML min}$$

$$33.3 \text{ ML} \times 2 \text{ sec} = 66.6 \text{ ML max}$$

4 cups per 1 litre of water

$$\frac{1000 \text{ ML}}{4 \text{ cups}} = 250 \text{ ML}$$

- 30 4 cups

$$\frac{250 \text{ ML per cup}}{49.95 \text{ ML}} = 5 \text{ squirt cycles per litre}$$

$$49.95 \text{ ML}$$

So if one cup of boiling water is drawn, five injections of cold water are made to the storage tank ($1/5$ of a cup at a time) to refill the tank.

Logic Control Circuit for Fill and Heat Function

When the thermistor reaches its trigger temperature, the thermistor sensing circuit 202 signals the logic circuit. The logic circuit signals the power control to switch off the heating element. At the same time the water valve circuit is signalled to turn on and after approximately 2 to 3 seconds. The heating element will be switched on and the water valve will be switched off.

Another invention also is considered to reside in having the sensor bulb or thermistor sensor or be heated by steam temperature rather than water temperature. The temperature sensor preferably includes a sensor bulb in which there is provided an electronic thermistor. The sensor is preferably placed in or near the condenser tube so as to be heated by the passage of steam or to sense steam temperature.

There is preferably provided during the filling of the tank, a correlation between water in and heater off, and vice versa. There is also preferably provided a correlation between water valve off and partial draining of the water inlet conduit proximate the condenser tube.

It is preferable that the filling of the tank occurs in a cyclic nature, that is, a relatively small quantity of water is placed in the tank and heated and then a further quantity of water is placed in the tank and again heated. It is found that this process enables the drawing of heated water from tap 9 as soon as the water has passed the level of tap 9. This is considered desirable for a user when the water heater unit of the present invention is first turned on, so that heated water can be drawn within a relatively short period of time.

The cyclic filling and heating process is also preferably used when water is drawn from the tank by a user, the tank is to be topped-up and the water in the tank is again to be heated to the desired temperature.

Between condenser 4 and water inlet 8 there is provided an aperture 16. This is also illustrated in more detail in figure 3. When the water valve 7 is activated to allow water into the storage tank, a dribble or splash of water passes through aperture 16 and directly on to sensor 5. This serves to relatively

immediately cool the temperature sensor 5 from its temperature at or above its trigger temperature of 75°C, to a lower temperature, so that the temperature thermistor can again be heated by the passage of steam to the condenser as a result of water heating as described above. Once the filling and heating cycle 5 has resulted in water being heated to what is indicated as the maximum water level, the water heater goes into a maintenance cycle.

In this maintenance cycle, the operation of the water heater serves to maintain the temperature of water in the storage tank substantially at or near the desirable temperature, for example 100° C.

10 In a maintenance cycle, the water in the storage tank being heated up to 100°C gives off steam and this steam is vented through vent 3 passed sensor 5 and is condensed in condenser arrangement 4. It is found in practice that little if any steam is vented out of vent 10.

When the water heater goes into the maintenance cycle, the condenser 15 tube will get relatively hot. This is utilized to hold the thermistor above its set temperature of 75°C for a predetermined time of at least two minutes, after which time, the water will be reheated again. The "on" time is calculated at 2 to 3 seconds and the "off" time is calculated at 2 to 3 minutes. The performance of a unit so configured has been found to be very energy efficient.

20 A further innovation is resultant from the reduction of mass of material heated by the steam rising from the already heated water in the storage tank during a maintenance cycle. This reduction of mass serves to reduce energy losses and therefore enable relatively extended cycle times in the operation of the water heater.

25 In a preferred form, the total mass of material thermally coupled to the condenser arrangement is reduced. Significantly, the mass is reduced by the reduction or draining of water, that would otherwise be situated in the inlet conduit, from the inlet water conduit.

This reduction or draining serves to reduce the mass to which heat can 30 be lost or dissipated from or around the temperature sensor resulting in the temperature sensor being kept at a higher temperature, above the heater trigger temperature. As heat is lost from or around the temperature sensor, the

temperature sensor will also lose heat and this results in the sensor falling below the trigger temperature, causing heating of the water in the tank.

Figure 3 shows a closer representation of the condenser arrangement 4 and water inlet 8 together with the aperture 16 and temperature sensor 5. It can be seen that the placement of the temperature sensor 5 within the condenser tube 4 is isolated from the extremities of the condenser tube 4 by way of insulation means preferably silicon grommet 17. A closer view of the thermistor is provided in Figure 4 where the electronic thermistor is indicated as 18 with leads 19, 20 coupled to the NTC circuitry 202. There is provided a relatively small mass 21 which is proximate the sensing part of the thermistor and the thermistor 18 is provided a heat transfer compound of suitable quality 22. Preferably the sensor bulb 23 is made of brass or a thermally conductive material of suitable quality. The parts of the sensor bulb 23 other than 21 can be made more massive, if required, to retain latent heat.

The insulation of the sensor bulb is operationally more efficient. If the sensor bulb was to come into contact with the condenser tube, the reaction time of the thermistor would be slowed down dramatically causing over boiling of the water. Also in the maintenance cycle, the off time would allow the water in the storage tank to fall well below 99°C especially in a hot ambient environment, due to the lack of thermistor sensitivity. Too much cold water may also enter the storage tank.

The size of the aperture provided at 16 is preferably a 1/8" diameter hole placed approximate the mass 21 of the thermistor sensor bulb 23. The aperture between the water inlet and condenser tubes has been positioned and drilled to a size so as to only allow a relatively small amount of inlet water to dribble onto the very end of the sensor bulb. This allows the thermistor to drop below its trigger temperature of 75°C relatively quickly. The bulk of the sensor bulb, however, may retain its latent heat for the next boil cycle. This retention of latent heat serves to reduce over boiling events.

It has been found that by allowing too much cold water to run over the sensor bulb, a relatively large amount of stream energy is needed to reheat the bulb, resulting in over boiling of the water in the storage tank.

Operation of the Electronic Power Control Board

The lower level sensor 13 communicates with the power control circuits. When the storage tank is empty, the heating element preferably cannot be energised until water touches the lower sensor 13.

- 5 When power is first applied to the water heater after installation, the water inlet valve is energised and the storage tank will fill with water, preferably covering the heating element. When the water comes into contact with the lower sensor 13, the water valve will be switched off. The heating element will then be energised and heating of the water will commence.
- 10 The thermistor circuit communicates with the heater power control circuit and the water inlet valve circuit.

IN THE MAINTENANCE CYCLE

- When the thermistor is above its trigger temperature, the heating element will be OFF, and when the thermistor is below its trigger temperature, the
- 15 heating element will be switched ON.

IN THE FILL AND HEAT CYCLE

- When the water level is low (below 15) and the thermistor is above its trigger temperature, the heating element will be switched OFF, and the water inlet valve will be switched ON, a small injection of cool water will run over the
- 20 sensor bulb, but most of the water will be directed to the bottom of the storage tank. The thermistor will relatively quickly drop below its trigger temperature, and then the water inlet valve will be switched OFF and the heating element will be switched ON. When the water boils, steam will be given off, and this in turn will cause the thermistor to again go above its trigger temperature. This cycle
- 25 will repeat until the storage tank is full.

The top level sensor 15 communicates with the water inlet valve circuit only. When water comes into contact with the sensor 15, no more water can enter the storage tank until contact with the sensor 15 is broken, for example by the drawing of water from outlet 9.

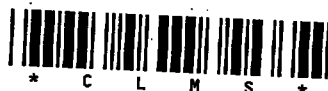
THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A liquid fluid heater comprising:
 - a fluid inlet conduit, through which incoming fluid is adapted to pass; and
 - a condenser conduit, adapted to condense vapour from fluid which has been heated, the inlet conduit and the condenser conduit being in thermal contact with each other over at least a portion of their length.
2. A fluid heater as claimed in claim 1, wherein the inlet conduit and the condenser conduit are arranged substantially parallel over the portion of thermal contact.
3. A fluid heater as claimed in claim 1 or 2, wherein the inlet conduit and the condenser conduit are each a length of pipe.
4. A fluid heater as claimed in claim 1, 2 or 3 wherein the inlet conduit and the condenser conduit are arranged substantially co-axial over the portion of thermal contact.
5. A fluid heater as claimed in any one of claims 1 to 4, wherein the condenser tube is inclined relative to horizontal.
6. A fluid heater as claimed in any one of claims 1 to 5, wherein the fluid heater is a water heater.
7. A fluid heater as claimed in any one of claims 1 to 6, wherein the condenser conduit is vented to atmosphere.



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8. A fluid heater as claimed in any one of claims 1 to 7, further comprising an aperture provided between the inlet conduit and the condenser conduit, the aperture being of a size that enables a relatively small amount of incoming fluid to be squirted into the condenser conduit when fluid flows through the inlet conduit.

9. A fluid heater as claimed in any one of claims 1 to 8, further comprising a thermistor, the thermistor being positioned in the condenser conduit so as to enable the small amount of fluid from the inlet conduit to pass over at least a portion of the thermistor, and being adapted to sense the temperature of heated fluid in the condenser conduit.

10. A fluid heater as claimed in any one of claims 1 to 9, wherein the thermistor is at least partially covered by a metal case, the case being in thermal contact with the thermistor.

11. A water heater, comprising in combination:

- a water storage tank;
- a water heating element for cyclically heating water in the tank;
- a water storage tank outlet positioned above the heating element;
- a water inlet conduit for providing inlet water to a bottom portion of the tank; and
- a water inlet control means for providing inlet water cyclically and in relatively small amounts in between heating element cycles.

12. A water heater comprising, in combination:

- a water inlet conduit for passing inlet water to the heater and a condenser conduit;
- the condenser conduit being vented to atmosphere; and
- an aperture providing fluid communication between the inlet conduit and the condenser conduit, and for enabling the inlet water to drain from the inlet conduit proximate the condenser conduit.

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13. A method of substantially maintaining heated water in a water heater at a predetermined temperature, the method comprising the step of cyclically applying energy to the heated water.

14. A method as claimed in claim 11, wherein energy is applied to the heated water for less than 1 minute, and energy is not applied to the heated water for less than 10 minutes.

15. A water heater as herein described.



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