

FLUID TEMPERATURE MODIFICATION APPARATUS

Field of the Invention

5 This invention relates to a fluid temperature modification apparatus. In a preferred embodiment the invention may be arranged to deliver hot water from a hot water supply tap without a user having to wait for cold water to be flushed out of a hot water supply line.

Background of the Invention

10 Plumbing and fluid conduit based systems have been developed to allow fluid to be distributed to various points inside a structure. These systems can be used to distribute a range of fluids from a supply reservoir or a connection to a utility supply network. In a variety of instances the temperature of these fluids may need to be adjusted before they can be
15 used in a desired application.

Central fluid heating or cooling systems plumbed into supply lines can adjust the temperature of a fluid prior to delivery. However these systems will leave sections of supply line between outlet ports and the temperature
20 treatment system holding fluid, and the fluid within ultimately ends up at the ambient environmental temperature. The fluid within these sections of supply line will need to be flushed out before fluid at a desirable temperature is available at an outlet.

25 This approach will result in the fluid at ambient temperature being wasted, with wastage accumulating to significant volumes both over time and within supply networks having multiple fluid outlets serviced by a single temperature treatment system.

30 For example, in houses and apartment blocks hot water can be delivered to multiple outlet taps from a central tank of heated water. Water users who turn on hot water delivery taps will typically have to run the tap for 5-40 seconds to flush out water at the ambient temperature. The entire volume of

water trapped in the plumbing between the tap and central hot water tank will need to be flushed out and is generally allowed to run down a drain.

5 This wastage of water is a concern to both householders and water supply utilities. Furthermore, householders find it inconvenient to have to wait for cold water to be flushed out of a tap before they have hot water delivered.

10 To combat this problem it would be possible to install additional heating or cooling systems adjacent to an outlet port or tap. However, in these buildings electrical energy is generally delivered by alternating current ("AC"). These AC systems generally run at either 230V at 50Hz or 110-120V at 60Hz. Having AC power supplied to electrical components in the vicinity of fluids such as water can create safety issues, and these problems are normally addressed by using a transformer isolated power converter to
15 provide galvanic isolation and convert the available AC power into a direct current supply.

20 Although transformer isolated technology and associated circuitry can allow AC or DC current to be supplied safely the vicinity of a fluid outlet tap, the internal construction of the transformer places significant restrictions on how quickly energising current can be supplied to an associated heating coil. In particular, transformers are not able to supply a high enough energising current quickly enough for users wishing to have immediate access to hot water.

25 A similar situation is applicable with heating or cooling systems powered by existing electrical battery technology. The relatively high internal resistance of existing batteries limits their capacity to supply instantaneous high power, with the internal resistance of the battery also increasing as it is discharged.
30 Additionally, battery lifetime will be limited by the requirement for repeated high power discharge cycles.

It would therefore be of advantage to have an improved fluid temperature modification apparatus which addressed any or all of the above issues, or at
35 least provided the public with an alternative choice. In particular it would be of advantage to have an apparatus which could modify the temperature of fluid stored in the supply line prior to the fluid reaching the delivery outlet

from a central temperature treatment system. An additional advantage would be the ease of installation of such a device, enabling plumbers to retrofit into existing fluid supply lines. It would also be of advantage in domestic applications to have an apparatus which could almost instantly
5 deliver hot water from a hot water tap without a user having to wait for cold water to be flushed out of a hot water supply line.

Disclosure of the Invention

10 According to one aspect of the present invention there is provided a fluid temperature modification apparatus which includes

at least one temperature modification element associated with a fluid conduit, said temperature modification element being located adjacent
15 to an outlet of said fluid conduit, and
at least one energy storage capacitor, and
at least one trigger switch which when operated connects one or more energy storage capacitors to a temperature modification element,

20 wherein the operation of a trigger switch at least partially discharges at least one energy storage capacitor to energise a temperature modification element which modifies the temperature of fluid in the conduit adjacent to the outlet port of the conduit.

25 According to a further aspect of the present invention there is provided a fluid temperature modification apparatus substantially as described above wherein a trigger switch is associated with a bank of energy storage capacitors and a temperature modification element.

30 According to a further aspect of the present invention there is provided a fluid temperature modification apparatus substantially as described above which includes a plurality of trigger switches, two or more of said trigger switches each being connected to a separate bank of energy storage capacitors.

35 According to yet another aspect of the present invention there is provided a fluid temperature modification apparatus substantially as described above

which includes a plurality of temperature modification elements, with one of a plurality of trigger switches being associated with each temperature modification element.

- 5 According to a further aspect of the present invention there is provided a fluid temperature modification apparatus substantially as described above wherein said at least one temperature modification element is energised by a transformer isolated power converter and associated electronic sub-
10 systems providing a supply of direct current (DC) electrical energy from an alternating current (AC) source.

- According to another aspect of the present invention there is provided a fluid temperature modification apparatus substantially as described above which includes an activation sensor adapted to issue a signal which indicates when
15 the outlet of the conduit has been opened.

Preferably an activation sensor can be formed from a flow rate sensor.

- 20 According to a further aspect of the present invention there is provided a fluid temperature modification apparatus substantially as described above which includes a controller arranged to receive said indicative activation signal from the activation sensor and to issue at least one control signal to at least one trigger switch to operate said trigger switch or switches based on the received activation signal.

- 25 According to a yet further aspect of the present invention there is provided a fluid temperature modification apparatus substantially as described above which also includes an inlet temperature sensor arranged to provide a signal indicative of the temperature of fluid entering the fluid conduit, and
30 a controller arranged to receive said indicative temperature signal from an inlet temperature sensor and to issue at least one control signal to at least one trigger switch to operate said trigger switch or switches

- 35 According to yet another aspect of the present invention there is provided a fluid temperature modification apparatus substantially as described above which also includes

an inlet temperature sensor arranged to measure the stored fluid temperature, and

an output temperature sensor arranged to provide a signal indicative of the temperature of fluid leaving a fluid conduit outlet, and

5 a controller arranged to receive said indicative temperature signal from the temperature sensors and to issue at least one control signal to at least one trigger switch to operate said trigger switch or switches based on at least in part the received indicative temperature signals.

10 Preferably the controller is arranged to issue at least one control signal to operate said trigger switch or switches based on a combination of an indication of conduit fluid flow rate provided by an activation sensor and the received indicative temperature signals received from the inlet and outlet temperature sensors.

15 The present invention is arranged to provide a temperature modification apparatus used in conjunction with a fluid conduit. The invention is to be located adjacent to an outlet of this fluid conduit and is to be used to modify the temperature of fluid stored in the supply conduit to facilitate prompt
20 delivery of fluid at or near a desired temperature.

Those skilled in the art will appreciate that conduits have a significantly greater length than diameter and are usually closed by a terminating valve or similar component. The conduits with which the present invention are
25 employed will therefore immediately allow for the delivery of fluids once a user has made a demand for these fluids.

In a preferred embodiment the invention may be used in a domestic hot water heating application. In this application the fluid to be modified is water
30 at ambient temperatures which is located in a section of plumbing conduit which runs between a central hot water supply system and an outlet hot water tap. In such embodiments the invention includes at least one temperature modification element located in contact or association with a section of plumbing conduit which extends from a wall or similar structure
35 and which terminates in a hot water outlet such as a hot water tap.

In other embodiments the invention may be used to heat or cool other types of fluids in a variety of applications. For example in alternate applications the invention may be used to heat raw material fluids which are employed in a production process and are delivered via conduit from a main reservoir. In yet other embodiments the invention may – for example – be used to cool beverages delivered via supply lines in public bars.

Reference throughout this specification will in the main be made to the invention being used to heat water in a domestic hot water supply application. However those skilled in the art will obviously appreciate that the invention may be used in other applications and reference to the above should in no way be seen as limiting.

The invention includes at least one temperature modification element which – when energised – is arranged to heat or cool fluid contained within a conduit. As referenced above, in a preferred embodiment a temperature modification element may be arranged to heat water in a section of conduit adjacent to a hot water tap.

In such preferred embodiments a temperature modification element may be formed by an electrically energised heating coil sited inside a conduit and in direct contact with water or other fluid to be heated. A heating coil can be supplied with an electrical current so that the coils electrical resistance will result in the heating of water in the conduit.

In other embodiments however a temperature modification element may be arranged to cool fluid within a conduit. For example, in one alternative embodiment the invention may implement temperature modification elements in the form of thermo-electronic cooling devices which incorporate at least one Peltier junction.

Reference throughout this specification will however be made to a temperature modification element being formed from a heating coil, although those skilled in the art will appreciate that other components may be employed in various alternative embodiments.

In a preferred embodiment the invention includes a plurality of temperature modification elements. Each temperature modification element may be energised by at least one capacitor, and in preferable embodiments energised by a bank of capacitors.

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In some embodiments a temperature modification element may be energised by two or more banks of capacitors. For example, in one potential embodiment the invention may include a fast discharge capacitor bank and a high storage capacitor bank, each of the fast discharge and high storage capacitor banks being connected to a separate trigger switch.

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Preferably in such embodiments the trigger switch connected to the fast discharge capacitor bank is closed to energise a temperature modification element once the opening of the outlet of the conduit has been detected. In such embodiments the trigger switch connected to the high storage capacitor bank can be closed to energise a temperature modification element after the at least partial depletion of the fast discharge capacitor bank.

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In yet other embodiments a temperature modification element may be energised by a transformer isolated power converter and associated electronic sub-systems providing a supply of DC electrical energy from an AC source. In such embodiments the trigger switch can be closed to energise a temperature modification element at substantially the same time as said one or more energy storage capacitors are used to energise a temperature modification element.

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Reference throughout this specification has also been made to the invention employing a transformer isolated power converter and associated electronic sub-systems in various roles in a number of embodiments. Those skilled in the art will appreciate that this component may take a range of forms from a traditional large stand-alone transformer through to small integral high frequency ferrite or similar components which can perform in the same function.

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Furthermore, in one particular embodiment the invention may be implemented by a combination of three separate heating coils - each energised respectively by a fast discharge capacitor bank, a high storage

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capacity capacitor bank, and a transformer isolated power converter providing a supply of DC electrical energy from an AC source.

5 The invention employs at least one energy storage capacitor which is at least partially discharged to energise at least one temperature modification element.

10 In a preferred embodiment the invention may employ large capacitors provided by electrical double layer capacitors. These EDL or electrical double layer capacitors are also known as super capacitors, ultra-capacitors, pseudo capacitors or cap-batteries.

15 EDL capacitors have a high capacitance giving these components and their associated circuitry high relative time constants. Due to the nature of their construction and size, EDL capacitors have relatively large energy storage capacity and can be discharged at a high rate of power.

20 Reference throughout this specification will also be made to the invention employing large capacitors formed from or provided by EDL capacitors. However those skilled in the art will appreciate that the present invention may also be implemented through other forms of suitable capacitors.

25 According to one aspect of the invention there is provided a trigger switch used to connect a temperature modification element to a source of energy such as a capacitor bank, or a DC current supply provided by a transformer isolated power converter. Trigger switches associated with either or both of an energy source or temperature modification element can allow a variety of energy supply configurations to be developed.

30 For example in embodiments where the invention is used to implement a fast discharge capacitor bank and a high-capacity capacitor bank, the fast discharge bank can be discharged to a heating coil as soon as the opening of the conduit outlet is confirmed. A temperature sensor provided by the invention can determine whether the fluid leaving the outlet has been heated
35 enough. After a threshold time since opening of the outlet, if the fluid leaving the outlet requires further heating a trigger switch associated with a high-capacity capacitor bank may be activated.

As indicated above in various embodiments the invention may provide a temperature modification element energised by an AC or DC supply derived from a transformer isolated power converter. The temperature modification element energised by the power converter may also be connected to a trigger switch. The energisation of this temperature modification element can then be triggered at the same time as the outlet opens and in parallel with the temperature modification element energised by a fast discharge capacitor bank or high-capacity capacitor bank.

In a variety of embodiments a trigger switch may be deployed or located within a fluid conduit and adjacent to a temperature modification element. This arrangement of the invention also allows any waste heat generated by the operation of the switch to be delivered to fluid present in the conduit. In a number of such embodiments trigger switches may be implemented using solid state transistor or similar semiconductor based switches which can be submerged in the fluid held by a conduit and still function effectively.

Preferably in embodiments where the invention provides a temperature modification element energised by a DC supply derived from a transformer isolated power converter, these same energy supply connections can be used to recharge the capacitor or capacitors used by the invention. In some embodiments of the invention at least one temperature modification element may be energised by a battery providing a supply of DC electrical energy. Batteries can provide an alternative source of electrical energy which can complement the energy discharge characteristics of the capacitors used with the invention.

Preferably in such embodiments the trigger switch associated with the battery is closed to energise a temperature modification element at substantially the same time as said one or more energy storage capacitors are used to energise a temperature modification element. This approach caters for the limited power capability of battery systems, allowing capacitors to energise a temperature modification element immediately, with a battery providing a further energy source prior to the capacitors being fully discharged.

In some embodiments the trigger switch associated with a battery can be closed in a periodic or repeating fashion to establish a duty cycle for the battery connection in some circumstances. For example in some cases a pulse width modulation connection scheme may be employed in conjunction with a battery trigger switch to vary the heating or cooling contribution provided by the battery. The effective duty cycle of this triggering signal may for example be modified depending on the predicted energy demands currently being placed on the invention.

In a preferred embodiment the invention may include a capacitor recharge circuit configured to recharge one or more at least partially discharged capacitor banks at the same time as one or more charged capacitor banks are being discharged. This capacitor recharge circuit can therefore allow different members of the same bank of capacitors to be recharged while other members of an alternative charged bank are being discharged.

In a preferred embodiment the invention may also include a controller. This controller may be implemented through any appropriate programmable device, but in a preferred embodiment may be provided by a programmable microprocessor.

The controller may be connected to at least one temperature sensor – referred to as an outlet temperature sensor – which is capable of providing an indication of the temperature of fluid leaving the outlet of the conduit. In additional embodiments the controller may be connected to a further temperature sensor – referred to as an inlet temperature sensor – which is capable of providing an indication of the temperature of fluid stored in a supply conduit.

In a further preferred embodiment the invention may also incorporate an activation sensor capable of confirming that the outlet of the conduit has been opened. For example, in one embodiment this activation sensor may be formed by a fluid pressure or flow sensor capable of signalling to the controller that the outlet has been opened.

In a preferred embodiment an activation sensor may be implemented by a flow rate sensor arranged to measure or indicate the rate at which fluid is

moving through the conduit associated with the invention. In addition to detecting when the conduit has been opened, these flow rate measurements – in combination with a measurement of inlet and outlet fluid temperature – may be used to calculate the energy demand currently required of the invention.

The controller may also be programmed to issue activation signals to trigger switches. The controller may be programmed to monitor the performance of the invention and modify the connections of the trigger switches accordingly. As indicated above in some embodiments the controller may be able to calculate or estimate the energy demands currently required of the invention. The controller may control the selection of particular trigger switches and the activation times for these trigger switches based on these energy demands.

In addition in some embodiments this controller may also use the signals or information provided by an outlet and/or inlet temperature sensor(s) to modify the behaviour of the invention. In particular the temperature of water provided by the outlet may be monitored by the controller for safety reasons to ensure that the temperature of the water supplied does not exceed a safe temperature value.

In yet other instances the temperature reading provided by an inlet temperature sensor can give an indication of the temperature of fluid travelling through the conduit and towards the remaining components of the invention. If the temperature sensed by the inlet temperature sensor meet that required from the operation of the invention, the invention may be deactivated.

Those skilled in the art will also appreciate that a controller provided in conjunction with the invention may also receive input signals from sensors other than just flow rate or temperature sensors. Depending on the application in which the invention is employed additional sensor input derived control parameters may be considered by the controller in determining a switching program for the invention's trigger switch or switches.

The present invention may therefore provide many potential advantages over the prior art, or in the least providing the public with an alternative choice.

- 5 The invention may be used to almost immediately raise or lower the temperature of a fluid leaving a conduit.

10 In a preferred embodiment this is achieved by activating a set of heating coils powered by a combination of large capacitor banks and an AC or DC current supply from a transformer isolated power converter or a derived DC power supply. The discharge characteristics of the capacitors used can rapidly supply significant energy to a heating coil by suitably adjusting the heating coil characteristics combined with capacitor bank characteristics.

- 15 Different configurations of capacitor banks may also be employed in situations where heating or cooling needs to be conducted over longer periods of time. In these instances a high-capacity capacitor bank may be used to energise a heating coil after a fast discharge capacitor bank has been significantly discharged.

20 In various embodiments the controller may allow for the independent automatic operation and intelligent control of the temperature modification apparatus provided. Manual user inputs are not required to adjust the activation and behaviour of the invention for it to function effectively and efficiently. The invention can also perform to promptly heat or cool fluids where the energy demands placed on it vary significantly and unpredictably. For example, in the case of domestic hot water supply applications the invention can perform effectively irrespective of whether hot water is required for a 10 second period, or for the duration of a shower. In
25 30 embodiments where multiple trigger switches and energy sources are provided the controller may determine and execute a switching program which allows for the prompt and preferably immediate delivery of fluids at the correct temperature.

- 35 In addition in embodiments where inlet temperature values are sensed a controller provided with the invention may disable its operation if it determines that fluid at the correct temperature is currently being delivered

through the conduit involved. In embodiments where the temperature of fluid provided at the outlet of the conduit is monitored, the operation of the invention may also be disabled if the sensed temperature is outside of a safe operational range.

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Brief description of the drawing

Additional and further aspects of the present invention will be apparent to the reader from the following descriptive embodiment with reference to the accompanying drawing in which:

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- Figures 1a and 1b provide a representative sketch of a fluid temperature modification apparatus 1 as provided in a preferred embodiment, and
- Figure 2 shows the steps executed within a switching control algorithm executed by the controller used in accordance with a further embodiment of the invention.

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Further aspects of the invention will become apparent from the following description of the invention which is given by way of example only of a particular embodiment.

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Best modes for carrying out the invention

Figures 1a and 1b provide a representative sketch of a fluid temperature modification apparatus 1 as provided in a preferred embodiment. Figure 1a shows the elements of the invention associated with a conduit, and figure 1b illustrates the inputs and outputs of a controller as used in the embodiment shown.

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The apparatus 1 includes three temperature modification elements implemented by heating coils 2.

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These heating coils are located in the interior of a conduit, which is provided in this embodiment by a domestic hot water supply line 3.

The hot water supply line 3 is supplied with hot water originating from a boiler tank 4. The boiler tank 4 is centrally located within the building housing the apparatus and is arranged to feed a large number of hot water supply lines.

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Without the operation of the invention hot water could not be rapidly delivered to a user operating a hot water outlet tap 5 connected to the hot water supply line 3. The user of the tap 5 will need to wait for the hot water from the boiler 4 to flush out the intervening ambient temperature water currently held in the hot water line 3.

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Each of the heating coils 2 are connected to an energy supply system in the form of either a fast discharge large capacitor bank 6, a high-capacity large capacitor bank 7, or a transformer isolated power converter 8. In other embodiments the AC powered isolation transformer may alternatively be provided by, or combined with a battery based energy supply system.

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In this embodiment the fast discharge bank 6 will have an energy storage capacity lower than the high capacity bank 7, but will take much less time to recharge back to a full charge.

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Each of the fast discharge 6, high-capacity 7 or transformer isolated power converter 8 energy sources are connected to its own dedicated heating coil 2.

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Interrupting the connection of the energy source of each heating coil 2 is a trigger switch 9. The operation of the trigger switch is controlled by a microprocessor 13 (as shown in figure 1b) provided with inlet and outlet fluid temperature readings from inlet and outlet temperature sensors 10, which are sited in combination with a fluid pressure/ flow sensor 11. These sensors can detect whether the hot water tap 5 has been opened from a measured flow rate value, the temperature of the water leaving the hot water tap, and the temperature of the water travelling from a remote hot water supply tank.

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The controller is also capable of sending a similar form of control signal to recharging connections 12 made between the capacitor banks 6, 7 and the

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isolation transformer 8. These connections are used to recharge each capacitor bank from the AC power source associated with the transformer isolated power converter 8 in periods with low demand for hot water.

- 5 The temperature and pressure/flow sensors 10, 11 provide performance information to the controller which can adjust the connections made by each capacitor bank trigger switch 9a or inductor trigger switch 9b. The controller can implement various combinations of capacitor bank and transformer energy supply connections to raise the outlet water temperature above a threshold temperature in the minimum period of time required to achieve this.

For example, after a period of low demand for hot water, the first use of the invention will result in hot water being present in the conduit, where this water has a temperature above or near a threshold temperature. Subsequent openings of the tap in the short term will only need this water to be heated slightly.

In this environment of increased frequency of demand the fast capacitor bank will re-charge quickly in the periods available between tap openings. The high capacity bank may not need to be connected to its heating coil in these circumstances, allowing it to recharge un-interrupted from the transformer isolated power converter 8.

- 25 The input information provided to the controller can also be used to modify the behaviour of the invention in a number of additional way. For example in the embodiment shown, if a signal provided by the flow sensor indicated the fluid flow rate has dropped to zero with the hot water tap being closed, all the trigger switches 9a, 9a, 9b can be opened by the controller.
- 30 Furthermore, if the inlet temperature sensor 11 indicates that hot water from the hot water supply tank has now reached the hot water tap, again all the trigger switches 9a, 9a, 9b can be opened by the controller.

The tables below summarise the key variables that the electronic control unit or controller used in the embodiment of figure 1 independently assesses to quantify the energy to be delivered. Table 1 and 2 are specific to the

prompt delivery of hot water to taps in domestic households, while Table 3 considers energy requirements in alternative applications.

Table 1: Key dependencies

Variable	Notes
Required outlet temperature	Likely to be fixed between 40°C and 55°C
Inlet temperature	Dependent on season (i.e. could be 1°C in winter vs. 18°C in summer in New Zealand)
Flow rate	Variable across households; however, likely to be between 5 and 8L/min
Volume to be heated	Dependent on length of pipe run between main water heater and outlet; however, likely to be between 2 and 4L

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Table 2: Potential use cases within the domestic delayed hot water application

	Req. Outlet Temp. (°C)	Inlet Temp (°C)	Flow Rate (L/min)	Volume (L)	Power (kW)	Energy Required (Wh)
Scenario 1	40	18	5	2	7.5	50
Scenario 2	55	1	8	4	30	250

Table 3: Potential future water heating applications

Application	Req. Outlet Temp. (°C)	Inlet Temp (°C)	Flow Rate (L/min)	Volume (L)	Power (kW)	Energy Required (Wh)
Alternative to gas califont	45	10	6	10	14.5	400
Alternative to under-sink tank	45	10	6	25	14.5	1000
Alternative to boiling tank	100	10	6	25	37.5	2600
Alternative to	45	10	6	120	14.5	4850

gas / electric main water heating system						
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As indicated above Table 2 illustrates how the inlet water temperature and measured water flow rate is assessed to determine the energy required to deliver hot water promptly in this application. This determination of specific on-demand energy expenditure is used as an input parameter to a switching control algorithm executed by the controller.

Figure 2 shows the steps executed within a switching control algorithm executed by the controller used in accordance with a further embodiment of the invention. In this embodiment the invention is provided with an equivalent implementation to the embodiment discussed with respect to figures 1a, 1b, other than being provided with an additional energy source in the form of a battery.

At step A of this algorithm a test is made of the measured flow rate of water travelling through a hot water supply conduit. If no water flow is detected the controller deems that the hot water tap terminating the conduit is closed, causing the algorithm to wait until water flow is detected.

Step B is executed once water flows is detected to test whether the temperature of water sensed by a water inlet temperature sensor is less than a target temperature to be delivered. If the temperature of the water in the conduit is at or higher than the target temperature the algorithm loops back to step A. Step C is executed if the inlet water temperature is below the target temperature.

At step C the controller closes the trigger switch of a fast discharge capacitor bank and closes the trigger switch of the transformer isolated power converter. The controller then waits for a period of five seconds before moving on to step D.

At step D the controller again tests for water flow in the conduit, at step E tests the inlet water temperature, and at step F tests the outlet water

temperature. If there is no water flowing in the conduit, if the inlet water temperature is up to the target temperature, or if the outlet water temperature is up to the target temperature then step G is executed. At step G all open trigger switches are closed and the algorithm loops back to step A.

If none of these conditions are met then step H is executed. At step H the trigger switch of the fast discharge capacitor bank is opened and this capacitor bank is connected to a recharge circuit. Also at step H the trigger switch of a high-capacity capacitor bank is closed, and the trigger switch of a battery based energy supply is activated with a low duty cycle pulse width modulated trigger signal. The controller then waits for a period of five seconds before executing step I.

At step I the controller again tests for water flow in the conduit, at step J tests the inlet water temperature, and at step K tests the outlet water temperature. If there is no water flowing in the conduit, if the inlet water temperature is up to the target temperature, or if the outlet water temperature is up to the target temperature then step L is executed. At step L all open trigger switches are closed and the algorithm loops back to step A.

If none of these conditions are met then step M is executed. At step M the trigger switch of the battery based energy supply is activated with a high duty cycle pulse width modulated trigger signal. The controller then waits for a period of five seconds before executing step N.

At step N the controller again tests for water flow in the conduit, at step O tests the inlet water temperature, and at step P tests the outlet water temperature. If there is no water flowing in the conduit, if the inlet water temperature is up to the target temperature, or if the outlet water temperature is up to the target temperature then step Q is executed. At step Q all open trigger switches are closed and the algorithm loops back to step A.

If none of these conditions are met then step R is executed. At step R the trigger switch of high-capacity capacitor bank is opened and this capacitor bank is connected to a recharge circuit. The battery is then connected

continuously, and the outlet temperature is tested until it reaches the target temperature. Once this occurs the closed battery and transformer isolated power converter trigger switches are opened, the battery is connected to a recharging circuit, and the algorithm loops back to step A.

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In the preceding description and the following claims the word "comprise" or equivalent variations thereof is used in an inclusive sense to specify the presence of the stated feature or features. This term does not preclude the presence or addition of further features in various embodiments.

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It is to be understood that the present invention is not limited to the embodiments described herein and further and additional embodiments within the spirit and scope of the invention will be apparent to the skilled reader from the examples illustrated with reference to the drawings. In particular, the invention may reside in any combination of features described herein, or may reside in alternative embodiments or combinations of these features with known equivalents to given features. Modifications and variations of the example embodiments of the invention discussed above will be apparent to those skilled in the art and may be made without departure of the scope of the invention as defined in the appended claims.

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What we claim is:

1. A fluid temperature modification apparatus which includes
at least one temperature modification element associated with a fluid
5 conduit, said temperature modification element being located adjacent to an
outlet of said fluid conduit, and
at least one energy storage capacitor, and
at least one trigger switch which when operated connects one or more
energy storage capacitors to a temperature modification element,
10 wherein the operation of a trigger switch at least partially discharges at least
one energy storage capacitor to energise a temperature modification
element which modifies the temperature of fluid in the conduit adjacent to
the outlet port of the conduit.
- 15 2. A fluid temperature modification apparatus as claimed in claim 1
wherein a trigger switch is associated with a bank of energy storage
capacitors and a temperature modification element.
3. A fluid temperature modification apparatus as claimed in claim 1 which
20 includes a plurality of trigger switches, two or more of said trigger switches
each being connected to a separate bank of energy storage capacitors.
4. A fluid temperature modification apparatus as claimed in claim 1 which
includes a plurality of temperature modification elements, with one of a
25 plurality of trigger switches being associated with each temperature
modification element.
5. A fluid temperature modification apparatus as claimed in claim 1 which
includes an activation sensor adapted to issue a signal which indicates when
30 the outlet of the conduit has been opened.
6. A fluid temperature modification apparatus as claimed in claim 5 which
includes an activation sensor formed from a flow rate sensor.
- 35 7. A fluid temperature modification apparatus as claimed in claim 5 which
includes a controller arranged to receive said indicative activation signal
from the activation sensor and to issue at least one control signal to at least

one trigger switch to operate said trigger switch or switches based on the received activation signal.

8. A fluid temperature modification apparatus as claimed in claim 7 which includes an inlet temperature sensor arranged to provide to the controller a signal indicative of the temperature of fluid leaving a fluid conduit.

9. A fluid temperature modification apparatus as claimed in claim 8 which includes an outlet temperature sensor arranged to provide to the controller a signal indicative of the temperature of fluid present in the conduit.

10. A fluid temperature modification apparatus as claimed in claim 9 wherein the controller is arranged to issue at least one control signal to at least one trigger switch to operate said trigger switch or switches based on at least in part the received indicative temperature signals.

11. A fluid temperature modification apparatus as claimed in claim 10 wherein the controller is arranged to issue at least one control signal to operate said trigger switch or switches based on a combination of an indication of conduit fluid flow rate provided by an activation sensor and the received indicative temperature signals received from the inlet and outlet temperature sensors.

12. A fluid temperature modification apparatus as claimed in claim 1 wherein said at least one temperature modification element is located in contact with a section of water plumbing conduit which terminates in a hot water outlet.

13. A fluid temperature modification apparatus as claimed in claim 12 wherein the water plumbing conduit terminates in a hot water outlet tap.

14. A fluid temperature modification apparatus as claimed in claim 1 wherein a temperature modification element is formed by an electrically energised heating coil sited inside a conduit.

15. A fluid temperature modification apparatus as claimed in claim 1 wherein a temperature modification element is formed a thermo-electronic cooling device which incorporates at least one Peltier junction.

5 17. A fluid temperature modification apparatus as claimed in claim 1 which includes a capacitor recharge circuit configured to recharge one or more at least partially discharged capacitors banks at the same time as one or more charged capacitor banks are being discharged.

10 18. A fluid temperature modification apparatus as claimed in claim 1 wherein a temperature modification element is energised by two or more banks of capacitors.

15 19. A fluid temperature modification apparatus as claimed in claim 1 which includes a fast discharge capacitor bank and a high storage capacitor bank, each of the fast discharge and high storage capacitor banks being connected to a separate trigger switch.

20 20. A fluid temperature modification apparatus as claimed in claim 19 wherein the trigger switch connected to the fast discharge capacitor bank is closed to energise a temperature modification element once the opening of the outlet of the conduit has been detected.

25 21. A fluid temperature modification apparatus as claimed in claim 20 wherein the trigger switch connected to the high storage capacitor bank is closed to energise a temperature modification element after the at least partial depletion of the fast discharge capacitor bank.

30 22. A fluid temperature modification apparatus as claimed in claim 1 wherein an energy storage capacitor is provided by electrical double layer capacitor

35 23. A fluid temperature modification apparatus as claimed in claim 1 wherein a trigger switch is implemented using a solid state semiconductor switch submerged in the fluid held by a conduit.

24. A fluid temperature modification apparatus as claimed in claim 1 wherein said at least one temperature modification element is energised by a transformer isolated power converter and associated electronic sub-systems providing a supply of DC electrical energy from an AC source.

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25. A fluid temperature modification apparatus as claimed in claim 24 wherein DC electrical energy supplied by the transformer isolated power converter is used to re-charge the one or more energy storage capacitors.

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26. A fluid temperature modification apparatus as claimed in claim 24 wherein the trigger switch associated with the transformer isolated power converter is closed to energise a temperature modification element at substantially the same time as said one or more energy storage capacitors are used to energise a temperature modification element.

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27. A fluid temperature modification apparatus as claimed in claim 1 wherein said at least one temperature modification element is energised by a battery providing a supply of DC electrical energy.

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28. A fluid temperature modification apparatus as claimed in claim 27 wherein the trigger switch associated with the battery is closed to energise a temperature modification element at substantially the same time as said one or more energy storage capacitors are used to energise a temperature modification element.

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