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(54) **Improvements relating to heating apparatus**

(57) The invention provides a heat exchange system wherein primary fluid (heated water) is circulated by means of a pump (34) through a heat exchanger (33) through which secondary fluid (water to be heated) is also circulated, and including sensing means (42, 47) for controlling the rate of heat supplied to the heat exchanger (33) via the primary fluid, characterised in that the sensing means (42, 47) comprises a temperature sensor means (42, 47) which is arranged to sense the rate of change of temperature of the primary and/or sec-

ondary fluid issuing from the heat exchanger (33). Preferably, there are two temperature sensors (42, 47) which respectively sense the rate of change of temperature of the secondary water and primary water such that in use, when a pre set rate of change of temperature in the secondary water is detected (showing that the secondary water is flowing), the pump (34) is switched on for the supply of hot primary water, and the rate of change of temperature of the primary water is used to control the pump (34) to control the temperature of the secondary water.

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Description

[0001] This invention relates to heating apparatus for the heating of a fluid (herein the secondary fluid) by means of another, hot fluid (the primary fluid) by heat exchange.

[0002] In the particular application in which we are interested, both fluids are water, but the invention is not to be considered as being limited to this medium, as other liquids could be used, and the liquids could be different and also gases or gas and liquid combinations could be used. As the main use of the invention is the control of the heating of secondary water by means of primary hot water, the further description given herein will be limited to this medium, but the wider application of the invention should be borne in mind.

[0003] A main application of heating of water by heat exchange is in the heating of domestic hot water which is used for washing purposes. This water is in fact referred to as secondary water in domestic water heating systems and the water which is used for space heating by way of central heating radiators, is referred to as primary water. The primary water is heated by means of a boiler or immersion heater.

[0004] Recently in the United Kingdom, the use of pressurised secondary hot water has been permitted, and this has led to the development of pressurised supply systems. One such system in which we are interested is known as "thermal storage", and in such a system, a body of water, supplied from the mains, is heated by the boiler or immersion heater and forms a thermal store. The heating takes place on the basis of supplying the heat to the store depending upon the residual heat stored, and not depending on instantaneous conditions of demand of the space heating and the hot water consumption. Thus, the boiler or immersion heater may be adding heat to the store in the evening or during the night when there is no demand from the space heating or for hot water, and equally, the boiler may not necessarily fire when the space heating is switched on (either manually or under thermostat control) or when someone in the house opens a hot water tap. Of course, if either space heating or the hot water demand continues, eventually the store heat supply capacity will reduce to such an extent that the boiler will fire adding heat to said store. It is possible to control the addition of heat so that it will take place during or mainly during off peak periods.

[0005] Although we are particularly interested in thermal storage installations, in general the present invention has particular application to any installation in which the primary water is circulated through a heat exchanger. In thermal storage applications, it is preferred that the heat exchanger is external to the storage tank which holds the store water. The secondary water also passes through this exchanger, but (usually) in the opposite direction from the primary water so that the primary water gives up its heat to the secondary water. In non thermal storage applications, the primary water is heated on de-

mand.

[0006] Conventionally, when there is a demand for secondary hot water, such as is caused by opening a tap, the cold water flows from the mains through the heat exchanger (to receive heat) and then issues from the tap. The supply of heat to the heat exchanger is by pumping hot primary water from the store through the heat exchanger and back to the store by means of a primary pump, the primary water giving up heat to the secondary water in the process.

[0007] The pump is caused to operate in that when the secondary water starts to flow, a flow switch in the pipe which carries the secondary water, is actuated, and this in turn starts the primary pump. The temperature of the secondary water issuing from the heat exchanger is monitored and this monitoring is used to control the operation of the primary pump, to ensure that the temperature of the secondary water does not become too great or too small.

[0008] The problem with such a system is that the flow switch, which is a reed switch, is a source of problems in that it can often stick and malfunction, causing poor functioning of the system. The switch development in effect has not kept pace with the development of the control systems of the heating system in general.

[0009] Also, being a mechanical component, the switch is an expensive item of the system.

[0010] A further disadvantage of the flow switch is that in general such switches have predetermined operating limits. Therefore, the flow switch will not actuate the primary pump if the flow of the secondary fluid is below a predetermined level, and henceforth heated secondary fluid will not be available. At secondary fluid flow rates greater than that detectable by the flow switch, the flow switch may be damaged and the resulting pressure loss may be unacceptable.

[0011] It is an object of the present invention to provide a controlled heating system in which the flow switch can be eliminated.

[0012] In accordance with the present invention there is provided a heat exchange system wherein the primary fluid is circulated by means of a pump through a heat exchanger through which secondary fluid is also circulated, and including sensing means for controlling the rate of heat supplied to the heat exchanger via the primary fluid, characterised in that the sensing means comprises a temperature sensor means which is arranged to sense the rate of change of temperature of the primary and/or secondary fluid issuing from the heat exchanger.

[0013] The temperature sensor means is preferably electronic in nature.

[0014] Preferably, the temperature sensor means is arranged to sense at least the rate of change of temperature of the secondary fluid issuing from the heat exchanger.

[0015] The sensing of the rate of change of the temperature of the secondary and/or the primary fluid may

be by measuring the temperature of the fluid at intervals, say half a second for example, and comparing each reading with the previous one or preferably two, in order to avoid the detecting of spurious temperature spikes

[0016] By sensing the rate of change, as opposed to the absolute temperature, the system can distinguish the condition which represents the flow of secondary and/or primary fluid, from other general operational conditions of the system.

[0017] Such an arrangement enables requirement of the prior art to provide a flow switch to be removed, by carrying out all the functions of the flow switch.

[0018] With prior art arrangements the simple removal of the flow switch would not provide the solution of the present invention in that in the prior art the flow switch is connected to the pump such that the pump will only operate when the flow switch is actuated. In the absence of the connection between a flow switch and the pump, other operational conditions of the apparatus can and do create situations where, by detecting only the absolute temperature of the issuing secondary water, the pump switches on spuriously.

[0019] Preferably, the temperature sensing means is adapted to sense the rate of change of temperature of both the secondary and primary fluid.

[0020] When the sensing system is set to detect the rate of change of temperature, then the temperature condition of the primary and secondary water can be accurately distinguished from the other conditions which might affect the absolute temperature of the secondary and/or primary fluid.

[0021] As stated the primary fluid and the secondary fluid are preferably the primary and secondary water of a domestic thermal storage water heating system.

[0022] The temperature sensor means of the secondary hot water may be arranged to detect the temperature of the hot secondary water issuing from the heat exchanger. The sensing control system provides that the temperature of the secondary water is being sensed at a frequency even if there is no water flow. As long as there is no rate of change of temperature of the secondary water, the pump is off. When a tap is opened and the secondary water starts to flow, its temperature will start to fall, and its rate of fall is detected. If that rate of fall is within operating limits, the pump is switched on and heat is supplied via the resulting flow of the primary water through the heat exchanger. The pump is controlled (regulated) in the preferred arrangement, by the rate of change of the temperature of the primary water, with the objective of keeping the issuing hot secondary water at a pre set temperature, for example 55°C. There is constant regulation. This regulation may comprise increasing or decreasing the speed of and/or stopping and starting the pump.

[0023] If for any reason, the sensor in the secondary side fails, such that no signals of temperature are fed back to the control system, the pump is stopped, showing a fault.

[0024] The control system also has a high temperature fails safe control, which is that if the temperature of the secondary water reaches a pre set high, for example 72°C, the pump is again switched off.

[0025] The temperature sensor means preferably also includes a temperature sensor in the primary side which repeatedly senses the temperature of the primary water issuing from the heat exchanger, at the same or at a different frequency as that used for the secondary sensor. The main function of the primary sensor is to regulate the pump, as described above, at a first rate of change of the temperature of the issuing primary water.

[0026] The primary sensor also serves to switch off the pump when the primary water temperature starts to rise at a certain, different rate, showing that the flow of secondary water has been terminated, for example by the closing of the tap. This sensor in normal operation will switch down the pump before the secondary sensor does so due to a high temperature in the secondary side.

The primary sensor is also arranged to switch off the pump should the issuing primary water reach a pre set maximum, for example 45°C, to avoid overheating for any cause. Additionally, the control system may be such that if the primary temperature sensor senses a low threshold temperature, for example 35°C, the primary pump is switched on regardless of what information is being supplied from the secondary sensor.

[0027] The two sensors therefore work in tandem, providing excellent control and enabling the elimination of the conventional flow switch.

[0028] It is possible to use only one sensor, on the primary or secondary, but such a system at present we feel would not have the same flexibility.

[0029] The invention in one main embodiment of thermal storage, and an embodiment where there is no thermal storage, will now be described, by way of example, with reference to the accompanying drawings, wherein:-

Fig. 1 is a circuit diagram of a thermal storage water heating apparatus according to a known configuration;

Fig. 2 is a circuit diagram of a thermal storage heating apparatus according to an embodiment of the invention;

Fig. 3 is a graph illustrating the characteristics of operation of the apparatus of Fig. 2. and

Fig. 4 is a circuit diagram of a water heating apparatus which is non thermal storage, to which the invention can also be applied.

[0030] Referring to Fig. 1, reference 10 indicates a thermal storage tank which contains a body of primary water which is heated by means of a boiler 12. To effect this heating, the water is circulated from the boiler through pipe 14 by means of the boiler pump 16. The

pump draws the water from the store 10 and delivers it to boiler 12. From the boiler 12, the heated water is returned to the store via the pipe 18. Heating of the water in the store is carried out under the control of a pair of store thermostats 20 and 22 of which 20 is a limiting thermostat and controls the maximum store temperature, whilst the thermostat 22 serves to control the temperature of the store accurately to 82°C, plus or minus 3°C. It will be seen that there is a manual reset and overheat cut out device 24 in line 18, which operates to cut out the boiler 12 should it overheat to the extent that the water in line 18 reaches a temperature in the region of 105°C. The device 24 can be used manually to reset the apparatus after the cut out.

[0031] The device 24 is linked to the thermostats 20 and 22 and also to the pump 16, so that the device 24 or the thermostat 20 or 22 by detecting an appropriate temperature can cause the pump 16 to stop.

[0032] Connected to the store 10 is a twenty litre expansion vessel 26 which serves to accommodate expansion of the water in the tank 10.

[0033] The apparatus illustrated is an integrated thermal storage system in that the water in the tank 10 serves to heat the dwelling in which the apparatus is located, and to supply the heat for the secondary water which is connected at the dwelling taps and showers.

[0034] For the heating circuit, the water in the tank 10 is circulated through pipe 28 via a central heating pump 30. The pipe is connected to the appropriate number of radiators 32.

[0035] For the heating of the secondary water, a plate heat exchanger 33 is used. A circulating pump 34 serves to pass water from the tank 10 through line 35 and to return it to the tank 10 via line 36. The secondary water is supplied from the mains via line 38 and it passes through the heat exchanger in contra flow to the primary water from the tank 10. The heated secondary water emerges on line 40, which contains a sensing thermister 42, and is delivered to the dwelling consumption points. The line 38 contains a flow switch 44 and electrical control lines 46 and 48 connect the sensor 42 and the flow switch 44 to a speed controller 49 which in turn controls the speed of the pump 34 via electrical control line 51.

[0036] Finally, the circuit may also include an integral or external clock and room thermostat; these items are indicated generally by the reference 50.

[0037] The basic operation of the circuit illustrated will now be described.

[0038] The boiler (or in an alternative arrangement electric immersion heaters), under thermostatic control, supplies heat to the store by circulating water from the boiler through the tank 10, in known manner. The heat is supplied depending upon the condition of the store 10, and not upon the instantaneous demand for space heating or hot water. The room thermostat and/or clock 50 dictates when the space heating circuit is operational, and the opening of a hot water dispensing point i.e. the opening of a tap, dictates when the heat exchanger

33 is operational.

[0039] The arrangement provides that there is control of the pump 34 when there is a demand for hot water at say a tap. This will be detected by the actuation of the flow switch 44, which causes starting of the pump 34 to circulate hot water through the heat exchanger 33. The pump speed control 49 controls the speed of the pump depending upon how much the temperature sensed by sensor 42 deviates from a predetermined level.

[0040] As indicated herein, the flow switch is a problem as regards effective functioning, and cost, and the present invention provides a means whereby, by the sensing of temperature rate of change, the flow switch need not be used.

[0041] The embodiment of the invention shown in Fig. 2 is an arrangement similar to Fig. 1, except that the flow switch has been eliminated. Similar reference numerals have been used to designate similar parts.

[0042] In the embodiment, the supply line 38 passes directly to the heat exchanger 33, and there is no flow switch as in the apparatus of Fig. 1. The sensor 42 is connected to controlling logic in the form of a microprocessor 43, and the sensor 42 is sensed at regular intervals, for example half a second whereby the rate of change temperature of the secondary water issuing from the heat exchanger on line 40 is constantly monitored. As explained herein, when the temperature at sensor 42 falls at a pre set rate, indicating the flow of secondary water, the pump 34 is started, for example by virtue of a signal from the microprocessor on line 45.

[0043] The control of the apparatus is by the microprocessor 43 in the manner explained herein, in that when the pump is running, its speed is controlled by a primary sensor 47 in the line 36, which is sensed at a frequency to detect the rate of change of the primary water issuing from the heat exchanger 33. Depending upon that rate of change, so the speed of the pump 34 is controlled by the processor 43 so as to maintain a pre set temperature of the water issuing from the taps, again as explained herein.

[0044] An operational condition of the apparatus is indicated by the graph of Fig.3. In the graph of Fig. 3 temperature detected by sensor 42 against time is indicated. In period 1 it is assumed that there is no demand for hot water, but that the water in pipe 40 at the sensor is still hot (the system is set up to ensure that the temperature of the water in the primary at sensor 47 is at a pre set minimum). With the passage of time, the temperature starts to drop with natural heat loss, and the temperature drifts downwards at a slow rate. Detection of this slow rate of change will not cause the pump 34 to start.

[0045] Period 2 however indicates that a tap has been turned on, and secondary water starts to flow out of line 40. The temperature of the water sensed by the sensor 42 starts to drop at a higher rate, and this is detected by the sensor 42, and/or the control logic, which in turn causes the pump to switch on to add heat to the sec-

ondary water, whose temperature will start to rise. The control of the pump speed to maintain a pre set temperature of the water issuing from the tap is under the detection of the rate of change of the temperature of the primary water by sensor 47. The flowing secondary water provides a temperature rate of change, and so by detecting this characteristic, the flow switch can be eliminated.

[0046] The sensors 42 and 47 in conjunction with the microprocessor also provide the additional control functions mentioned herein.

[0047] In the arrangement of Fig. 4, the boiler 100 supplies the heat to the primary water, which is circulated by the pump 101. The primary water is heated on demand, and is circulated by pump 101 either directly to the central heating radiators 102, or to the heat exchanger 104, when there is a demand at the tap (line 106). Normally the demand at the tap has priority, and normally a flow switch 108 detects when the demand is made. With the invention, the flow switch can be eliminated in the same manner as it is eliminated in the thermal storage embodiment, with the same effect. The same control system can be used.

[0048] It can be seen that by virtue of the invention the problem of providing a flow switch can be overcome and various methods can be adopted, whilst there is no sacrificing of the obtaining of effective control of the temperature of the secondary water to keep it at or within close limits of a preset required value.

Claims

1. A heat exchange system wherein primary fluid is circulated by means of a pump (34) through a heat exchanger (33) through which secondary fluid is also circulated, and including sensing means (42, 47) for controlling the rate of heat supplied to the heat exchanger (33) via the primary fluid, characterised in that the sensing means (42, 47) comprises a temperature sensor means (42, 47) which is arranged to sense the rate of change of temperature of the primary and/or secondary fluid issuing from the heat exchanger (33).
2. A system according to claim 1, wherein the temperature sensor means (42, 47) is electronic in nature.
3. A system according to claim 1 or 2, wherein the temperature sensor means (42, 47) is arranged to sense at least the rate of change of temperature of the secondary fluid issuing from the heat exchanger (33).
4. A system according to claim 1, 2 or 3, wherein the sensing of the rate of change of the temperature of the secondary and/or the primary fluid is by measuring the temperature of the fluid repeatedly at intervals, and comparing each reading with the previous one two readings.
5. A system according to any preceding claim, wherein the temperature sensing means (42, 47) is adapted to sense the rate of change of temperature of both the secondary and primary fluid.
6. A system according to claim 5, wherein the system is a domestic thermal storage water heating system.
7. A system according to any preceding claim, wherein the pump (34) is controlled (regulated) by the rate of change of the temperature of the primary water, with the objective of keeping the issuing hot secondary water at a pre set temperature, for example 55°C.
8. A system according to any preceding claim, including a high temperature fail safe control, which provides that if the temperature of the secondary water reaches a pre set high, for example 72°C, the pump (34) is switched off.
9. A system according to any preceding claim, wherein the temperature sensor means (42, 47) also serves to switch off the pump (34) when the primary water temperature starts to rise at a certain rate, different from that which is indicated during regulation, showing that the flow of secondary water has been terminated.
10. A system according to any preceding claim, wherein the sensor means (42, 47) is also arranged to switch off the pump (34) should the issuing primary water reach a pre set maximum, for example 45°C, to avoid overheating for any cause.
11. A system according to any preceding claim, wherein the sensor means (42, 47) is also arranged to switch the pump (34) on if the primary temperature sensor senses a low threshold temperature, for example 35°C, regardless of what information is being supplied from the sensor means (42, 47) in relation to the secondary water.
12. A system according to any of claims 1 to 5, wherein the system is one in which the primary water is heated instantaneously by a heat source.
13. A system according to claim 12, including a high temperature fail safe control, which provides that if the temperature of the secondary water reaches a pre set high, for example 72°C, the pump (34) and/or heat source is switched off.

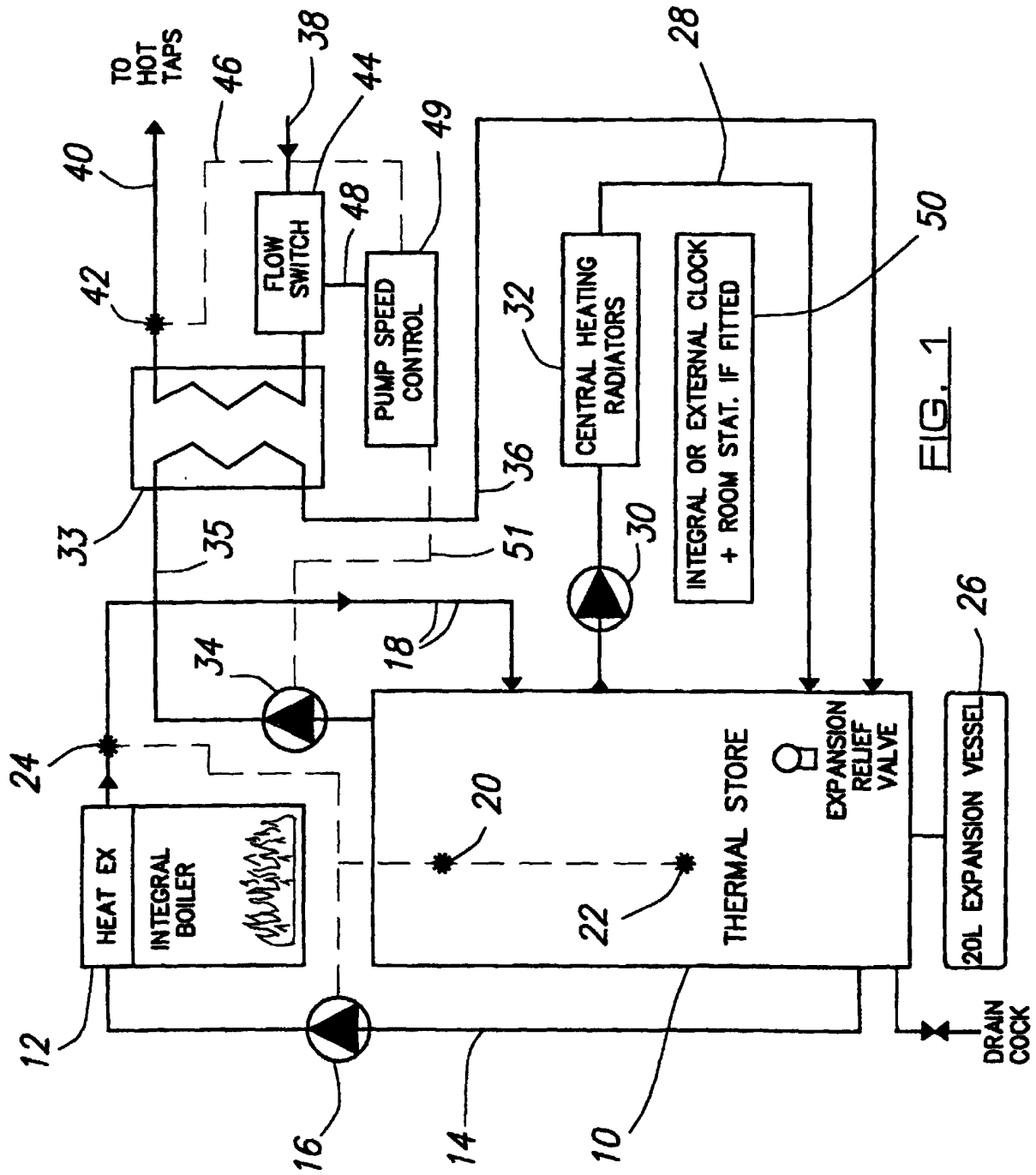


FIG. 1

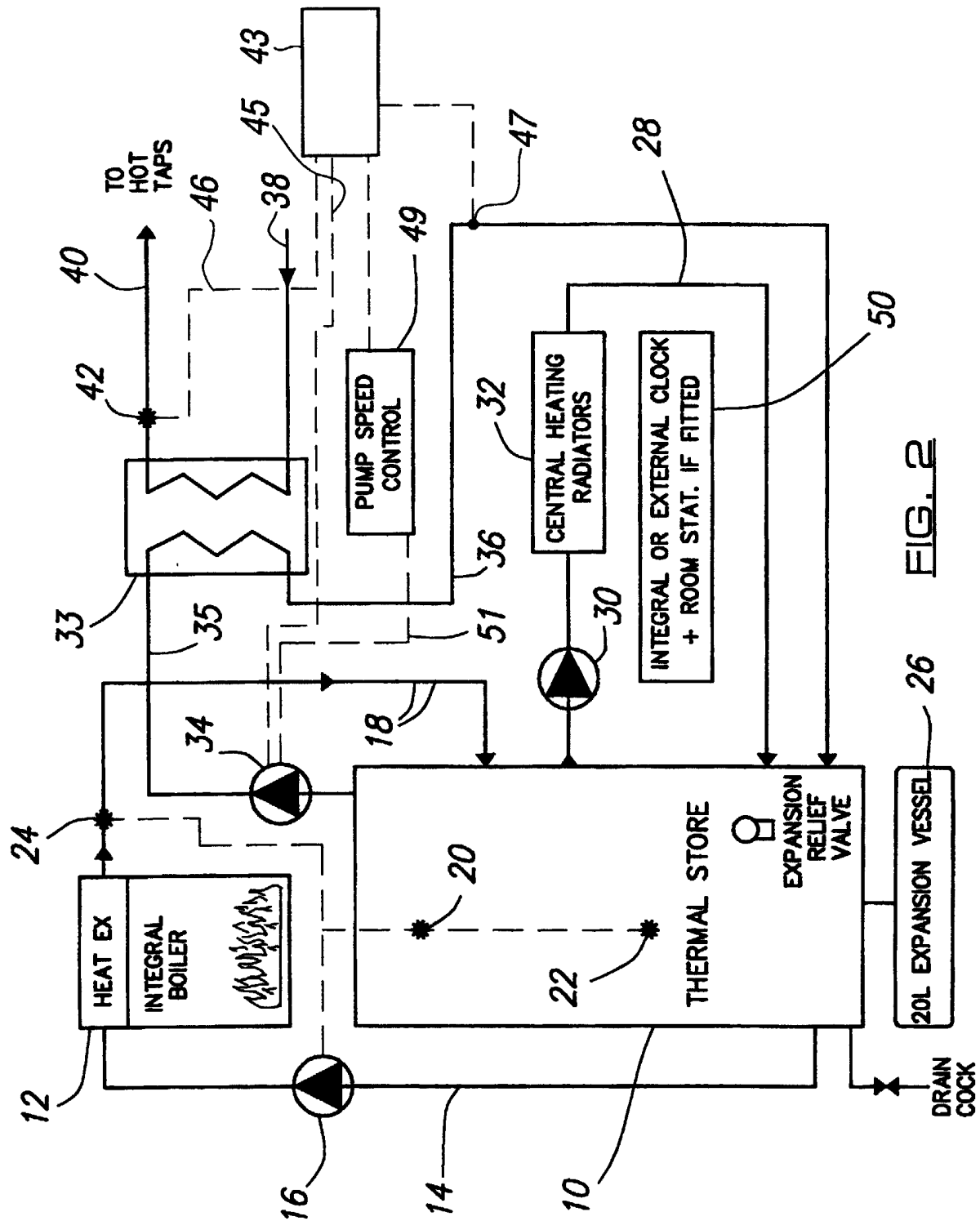


FIG. 2

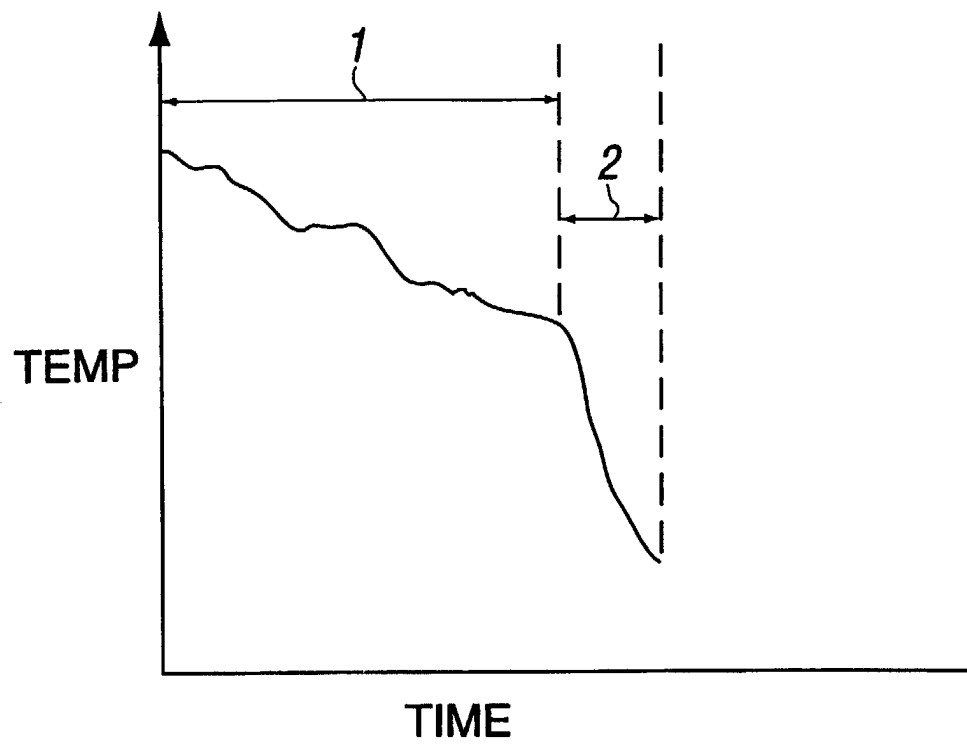


FIG. 3

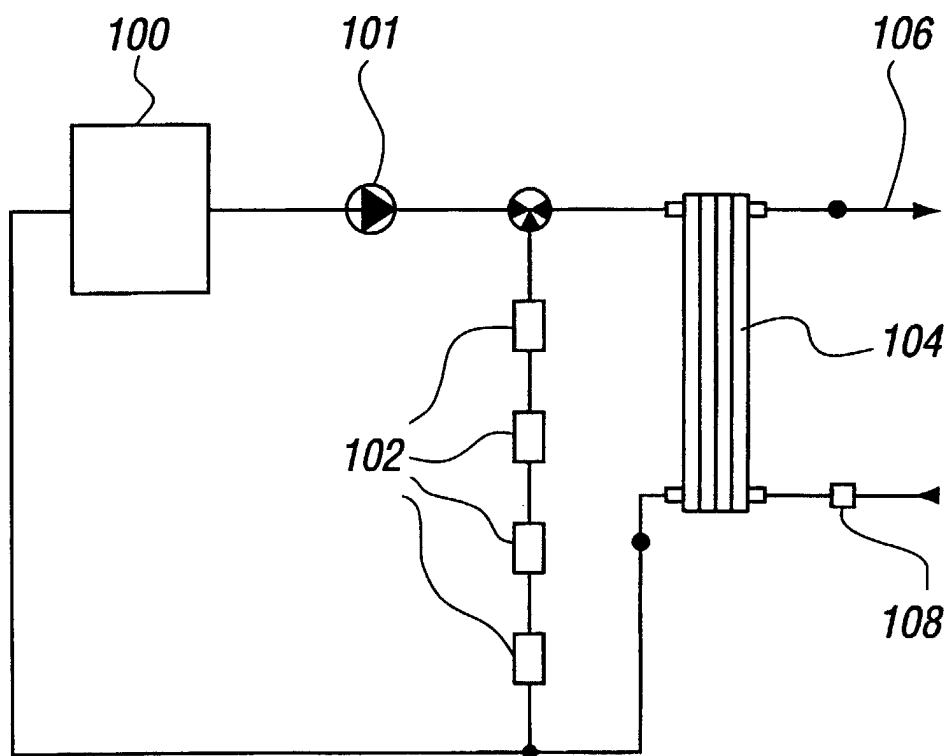


FIG. 4