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(54) **Controlling water heating**

(57) A boiler 10 with a thermostat 12 heats water for a tank 14 with thermostat(s) 34, 36. If the boiler cycles on and off without reaching the temperature set by the tank thermostat(s) – for instance due to a faulty thermostat 12 or a fault in the boiler 10 – a processor 38 resets the tank thermostat(s) 34, 36 to a level which the boiler is able to reach. In this way inefficient cycling of the boiler is avoided.

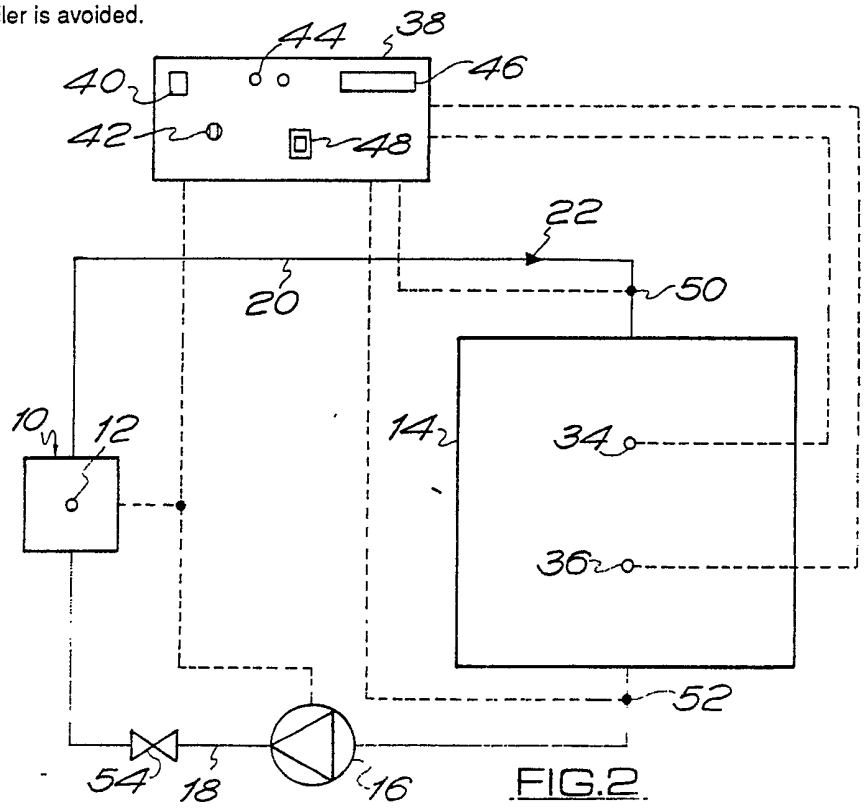

FIG.2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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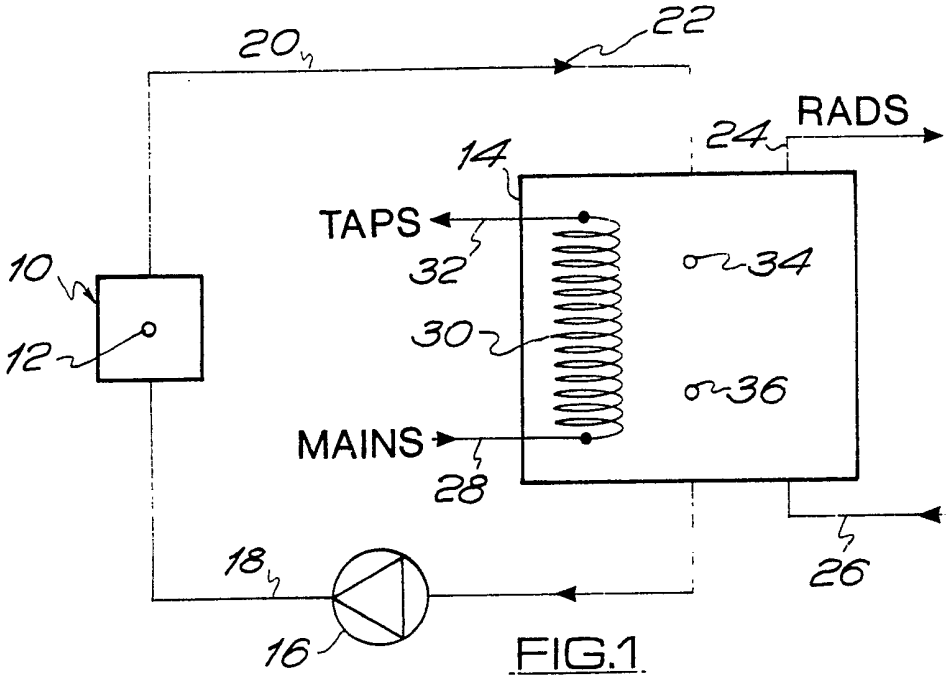
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FIG.1

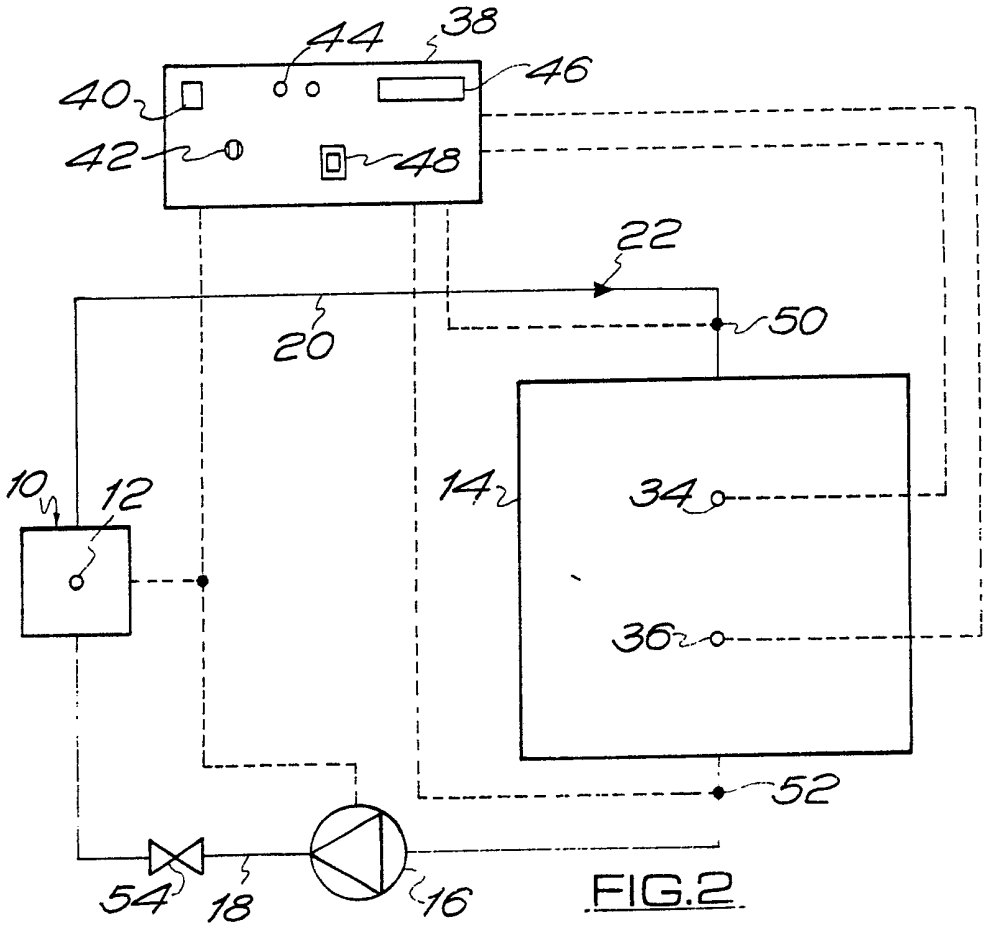
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FIG.2

Charging Controls for Energy Stores

This invention relates to a control system for controlling the "charging" of a thermal store. In this context, a thermal store comprises a body of liquid, typically water, contained in a tank or like vessel, and "charging" of the store comprises the application of heat to that body of liquid.

It is often required to provide for the heating of water in a domestic hot water tank, and specific areas of application are described in our patents as follows:-

GB Patent No. 2156099
GB Patent No. 2153503
GB Patent No. 2153504
GB Patent No. 2160957
GB Patent No. 2174483

In the thermal store heating arrangements described in the above patents, the difficulty arises in connection with the control of the charging of the thermal store in order to maintain an optimum temperature therein or more particularly the optimum temperature is not achieved.

In practise, what happens is that the small boilers which are available for heating water in a thermal store by circulating the water through the boiler, are not sufficiently accurately set during manufacture such that although the boiler thermostat may have a rating of say 82°C, in fact the thermostat may be such that the boiler would not achieve a temperature of that level. For example although the boiler had a rating on the thermostat of say 82°C, in practise it could be as low as 75°C or even less.

It is usual to provide that the store has a thermostat, and typically the store thermostat would be set in relation to the rated boiler thermostat temperature. Thus if the boiler thermostat is rated at 82°C, then the thermal store thermostat may be rated for example in the order of 70°C. If in fact the boiler cannot achieve 82°C by virtue of the inefficient manufacture and setting of the boiler, then clearly the store temperature of 70°C may never be achieved, and the boiler would be functioning continuously. In such circumstances the customer may complain and then the engineer would have to adopt manual setting techniques to vary things such as the flow rate the boiler thermostat and the store thermostat to achieve optimum conditions. Such fine tuning requires the presence of qualified personnel on site for a considerable period of time.

The present invention provides a control system for obviating or mitigating this disadvantage, and in accordance with the invention in its most general aspect, a control system for a thermal store which is charged by a boiler having a boiler thermostat, and which is under the control of store thermostat means, comprises a control processor which upon detection of failure of the boiler to produce an expected output automatically adjusts the setting of the thermostat means of the store to optimise the boiler capability as related to the charging of the store.

In a preferred case, the thermostat means of the store comprises at least two thermostats disposed at upper and lower levels within the store, and both store thermostats are automatically adjusted depending upon the boiler output should it be that the boiler fails to meet its rating.

The processor is preferably such that if the boiler fails to meet its rating by more than a predetermined amount, then

there will be warning indication means to the extent that the boiler should be adjusted or replaced.

By this means, when a boiler with a particular maximum rating as supplied by the manufacturer is not capable of meeting that rating, then the store thermostats can be automatically adjusted to ensure that the store is charged to the maximum capability of the boiler depending upon its actual rating as opposed to its manufacturer's rating, and unnecessary cycling of the boiler in its attempts to charge the store can be avoided.

The processor can provide various other functions as will be better explained with reference to the embodiment of the invention which is described hereinafter.

The accompanying drawings illustrate diagrammatically two control systems, the control system in Fig. 1 being the conventional control system as is used for example in the thermal store systems as described in the said patents, and Fig. 2 illustrating a thermal store charging control system according to the present invention.

Referring to the drawings, in Fig. 1 a conventional thermal store heating system is shown. The system comprises a boiler 10 provided with a boiler thermostat 12 and water is circulated from the thermal store tank 14 by means of a pump 16 which circulates the water from the tank 14 through the coupling lines 18, 20 through the boiler 10 and in the direction of circulation as indicated by arrows 22. By this means, heat is added to the tank 14, and it will be observed that the hot water enters at the top of the tank and flows downwardly towards the bottom of the tank. Heat is extracted from the tank 14 by the circulation of the water in the tank through a circuit 24 which typically is for domestic heating

and includes room radiators. The return flow from the radiators of the relatively cold water is indicated by reference 26.

Additionally, cold mains water for providing the supply of hot water to the domestic taps and other outlets is supplied through input line 28 and it then passes through a heat exchanger 30 (illustrated diagrammatically) inside the tank 14, and the heated water is discharged from outlet 32.

When such a system is in operation in a domestic dwelling it can be appreciated that it is necessary to maintain thermostatic control on the operation of the boiler and the pump 16 to ensure that the water in the tank 14 is charged in an optimum manner. In the example illustrated, the control is achieved by means of two tank thermostats 34 and 36 which respectively are located nearer the top and the bottom of the tank 14, and therefore are referred to as the top thermostat 34 and the bottom thermostat 36.

When an installer installs such a system, he has to set the thermostats 34 and 36 for optimum operation so that the system does not require constant attention. To do this he sets the thermostats 34 and 36 at particular temperatures having regard to the maximum rating of the boiler 10. The boilers 10 typically are by British standards rated to provide a certain temperature of water in the output line 20, and typically that temperature is 82^{o}C. However, the control and manufacture of boilers and their thermostats is such that it is not unusual for the maximum rating of the boiler 10 to deviate substantially in a downwards direction from the maximum rated figure of for example 82^{o}C. Clearly, if the thermostats 34 and 36 are set at designed temperatures related to an assumed output of 82^{o}C from the boiler 10, and that output is not achieved, then spurious results can take

place. Thus, assume that the thermostat 36 which operates to cease charging by the boiler when the temperature of the water adjacent the thermostat 36 reaches a predetermined "charging terminates" temperature, has a designed temperature of 70°C. In the normal course of events when the water in the vicinity of thermostat 36 reaches 70°C, the boiler is shut down regardless of the setting of the boiler thermostat 12. The thermostat 34 is a "boiler on" thermostat insofar as when the water in the vicinity of thermostat 34 drops to the thermostat design temperature, the boiler is switched on regardless of the condition of the boiler thermostat 12. Thermostat 34 only switches the boiler on, and thermostat 36 only switches the boiler off. A typical design temperature for thermostat 34 may be of the order of 70°C.

If, because of inefficiency of manufacture of the boiler or its thermostat, the boiler has a maximum rating of say 75°C it will be appreciated that the water in the tank 14 can never be greater than 75°C, and in fact probably can never be greater than something less than 70° - 75°C due to losses in the lines 18 and 20. This being the case, the thermostat 36 will be unlikely to reach its design temperature and therefore thermostat 36 will never exercise any control by way of shutting down boiler 10. When the boiler has commenced supplying heat therefore, it will continue to operate in heating the water in the store 14 by switching on and off as it reaches its effective maximum output temperature of 75°C.

Equipment operating under such conditions has a number of disadvantages. Firstly, the heat in the thermal store 14 will never reach what is expected and although this to some extent may not be detected by virtue of the radiators being of a larger size on the space heating side, and the water being of an acceptable temperature on the domestic tap side,

nevertheless a user may notice that the boiler is continuously switching on and off in order to maintain even the reduced quantity of heat in the thermal store. This is an inefficient method of heating the thermal store and such inefficiency will reflect in the energy bills which the consumer has to pay.

To make the system of Fig. 1 operate more economically manual adjustment of the various controls is necessary. This manual adjustment can in fact be a lengthy procedure, as the optimum conditions will depend not only upon the adjustment of the settings of the thermostats 34 and 36, but also the adjustment of the flow rate across the boiler and the optimum condition can only effectively be achieved if qualified personnel spend considerable time on site fine tuning the various controls.

The same fine tuning control is required even if instead of using two sensors 34 and 36 in the thermal store, a single thermostatic sensor is used.

The arrangement of Fig. 2 shows a system for obviating the abovementioned disadvantages which largely occur when a boiler has an effective output rating (maximum boiler thermostat setting) which is less than its expected design rating (setting). The control system adopted in Fig. 2 is to heat the store as efficiently as possible under the above circumstances, but if the boiler output is so far below its design setting, then obviously the boiler thermostat (or even the boiler) must be adjusted or replaced.

In Fig. 2, the same reference numerals as used in Fig. 1 have been employed and further description of the referenced parts of which a description has already been given shall not be made. Also, the space heating circuit and secondary tap

water circuit have not been illustrated in the interests of clarity.

The control system shown in Fig. 2 comprises a microprocessor 38 which is provided with an on/off switch 40, one or more set buttons 42, warning or signalling devices 44, which may be used to indicate alarm or extreme conditions, a device 46 for inputting and monitoring data and a control switch 48 which has a manual position and an automatic position. The processor 38 which of course will be coupled to suitable electrical supply is for monitoring the thermostats 34 and 36 and flow sensors 50 and 52 and on the basis of such monitoring to control the operation of the store and the boiler in the way described hereinafter.

The processor 38 is programmed to effect the controls as described hereinafter.

It is assumed that the design rated temperature of the boiler is 82°C and that the design rated temperatures of the thermostats 34 and 36 are 68°C and 70°C respectively, but it is to be stressed that these temperatures and indeed the other temperatures given herein are by way of example only, and any appropriate design temperatures may be involved. It is useful however for the explanation of the operation of the system shown in Fig. 2 to indicate specific temperatures.

In order to effect operation of the system, the switch 40 is first of all moved to the on position and secondly the design temperatures for the thermostats 34 and 36 are inputted by means of the device 46. At this time there may also be inputted by the device 46 safety margin temperature ranges A and B the function of which will be described hereinafter, and typically A and B may be a temperature range of 3°C each. As an alternative, the safety margin temperature ranges A and

B may be previously programmed into the processor 38 so that in the operation of the system the processor will automatically take these ranges into account.

The switch 48 is set to manual. If the system is starting from cold, the boiler 10 will switch on in view of the fact that the temperature of the water therein will be considerably lower than the switch on temperature of the boiler thermostat 12 which may, at least from the boiler design operating temperature, be in the order of 75°C. Pump 16 is also operated, and commencement of the heating of the water in the tank 14 takes place. The water gradually heats up to the set design temperature of the thermostat 34 (in the order of 68°C) but as the boiler 10 will be already in operation, the heating of the water to 70°C has no effect as regards sensor 34 because the function of sensor 34 is only to switch on the boiler if necessary. It should be mentioned here that the temperature of the water in the store 14, because the hot water is introduced at the top of the store, will be graded from a higher value at the top of the store to a lower value at the bottom of the store. If the water in the vicinity of sensor 34 is therefore at the order of 70°C, then the temperature in the vicinity of thermostat 36 will be less than 70°C.

One way of measuring the store temperature with a "low" boiler thermostat is to raise the flow through the boiler thereby reducing the difference between the temperature of the flow and the return which enables the setting of the bottom thermostat to be raised.

These factors can be monitored at the micro-processor 38 which is one of the major benefits of the system.

As heating progresses, if the boiler begins to cycle i.e.

switch off and on on its boiler thermostat before the water in the vicinity of thermostat 36 reaches the design temperature e.g. 70°C, then some operational difficulty is indicated. Experience has shown that this difficulty is probably due to the fact that the boiler 10 is not in fact giving out water at the design rated temperature but is giving out water at a lower temperature than the design rated temperature. This may mean that the boiler thermostat 12 has been poorly set or it may be a fault in the boiler itself but, regardless of the reason, should this event take place, the person setting the system then presses set button 42 immediately before or after the boiler switches off so that the processor 38 can sense the maximum achievable boiler output temperature. The processor 38 now acts to reset the operational temperature of the sensor 36 to a value equal to the temperature sensed by the flow return sensor 52 minus the safety margin value A. The temperature of the water sensor 52 is taken because the temperature of the water at sensor 36 must always be at least equal to or greater than the temperature of the water at sensor 52 and by deducting the safety margin A, typically 3°C, it is assured that the sensor 36 is arranged to operate at a temperature lower than the maximum store temperature which can be achieved by the boiler 10 and therefore the sensor 36 will effect control of the boiler and will prevent it from cycling during the heating of the store 14.

Equally, the processor 38 is set to examine the design temperature of thermostat 34, and if the new and reset design temperature for thermostat 36 minus the safety margin B is greater than the original design temperature for sensor 34, then there is no adjustment of the design temperature of thermostat 34. If however the new design temperature for thermostat 36 less the safety margin B is less than the originally set design temperature for thermostat 34 then

thermostat 34 is set at a new design temperature equal to the new design temperature for thermostat 36 less the safety margin B.

By this means, the settings of the thermostats 34 and 36 are reduced to match the actual capability of the boiler thereby to optimise the boiler output.

If on the other hand as the store 14 is heating up the original design temperature for thermostat 36 is reached by the water in the vicinity of thermostat 36 before the boiler starts cycling on its own thermostat, then the rating of the boiler is satisfactory and no automatic adjustment of the sensors 34 and 36 need take place.

When the sensors have been reset, or when it is shown that it is not necessary to reset them, the switch 48 is moved to the automatic position which disables the set button 42 to prevent accidental resetting.

The signal lights 44 can be used to indicate the correct functioning of the controls at the end of any subsequent store charge. The processor can be used for monitoring the continuing operation of the control system and if for example due to a drift in boiler thermostat setting, an out of range function is indicated, for example by the indicating devices 44, the system can be reset as above described. The monitoring facility 46 can be used for fault finding.

The capability of the microprocessor 38 depends upon its capacity. A microprocessor of greater capacity therefore providing a more powerful controller could be arranged to monitor and store temperatures over a charge period and recognise out of range operation and automatically reset the controller. Major faults that could not be rectified by

resetting would be indicated by an alarm signal. A major fault would be if the actual boiler thermostat setting were so far from the design thermostat setting as to make the system unworkable.

The control system according to the embodiment described provides a means by which thermal energy store charging controls are set instantaneously taking into account temperatures in the charging boiler/boilers and in the thermal store/stores. The controls can also take into account desired design parameters and the controls may comprise a charge controller incorporating electronic and/or electric circuits. The control device may also incorporate signalling devices showing correct operation. Furthermore the controller may monitor and store circuit temperatures, compare same with design parameters and automatically reset the control system and/or operate an alarm if monitored values are outside predetermined levels. The controller may further incorporate a means for inputting data, a means for displaying data and it may also incorporate a boiler pump overrun timer as disclosed in our co-pending Patent Application No. 8811553.0.

With this type of control, sensor 34 can become sensor 50 and/or sensor 36 can become sensor 52.

Finally the controller may incorporate a boiler circuit and/or a heating system clock control.

CLAIMS

1. A control system for a thermal store which is charged by a boiler having a boiler thermostat, and which is under the control of store thermostat means, comprising a control processor which upon detection of failure of the boiler to produce an expected output automatically adjusts the setting of the thermostat means of the store to optimise the boiler capability as related to the charging of the store.

2. A control system according to Claim 1, wherein the thermostat means of the store comprises at least two thermostats disposed at upper and lower levels within the store, and both store thermostats are automatically adjusted depending upon the boiler output should it be that the boiler fails to meet its rating.

3. A control system according to Claim 2, wherein the upper level thermostat controls the switching on of the boiler only, and the lower level thermostat controls the switching off of the boiler only, and the store is heated by hot water circulated from the boiler into the upper end of the store and the return to the boiler is from the lower end of the store.

4. A control system according to any one of Claims 1 to 3, wherein the processor includes a warning indication means to indicate a condition when the boiler fails to meet its rating by more than a predetermined amount.

5. A control system according to any preceding claim, wherein the processor includes an on/off switch.

6. A control system according to any one of the preceding claims, wherein the processor has a setting means which is

actuated when it is desired to set the boiler thermostat and the store thermostat means.

7. A control system according to Claim 6, wherein the processor includes a disabiling means for disabiling the setting means when the boiler thermostat and store thermostat means have been set to the required values.

8. A control system according to any preceding claim, including temperature sensors in the flowpath between the boiler and the store for sensing the temperatures of the water flowing into the store and flowing out of the store.

9. A control system according to Claim 8, wherein the processor is set to adjust the temperature of the store thermostat means dependent upon the temperatures detected by said flow sensors.

10. A control system substantially as hereinbefore described with reference to Fig. 2 of the accompanying drawings.

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