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(54) Improvements in water heating and space heating apparatus and methods.

(57) Water heating apparatus includes a heat store in the form of a tank (12) for containing a volume of water, heaters for heating the water in the tank, and a heat exchanger located in an upper portion of the tank having a cold water inlet (28) and a hot water outlet (30) for feeding a hot water supply (32). The heat exchanger (26) and the heaters (16, 14) are arranged to encourage convection currents around the heat exchanger (26).

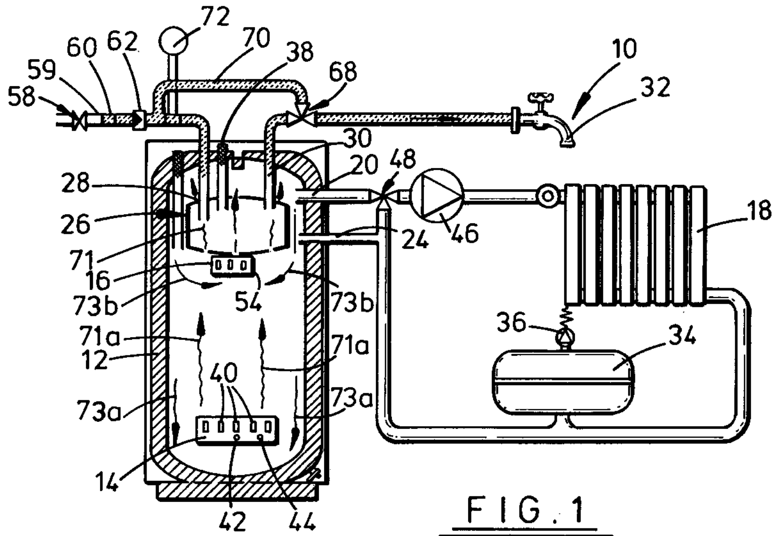

FIG. 1

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This invention relates to improvements in apparatus and methods for water heating and space heating. In particular, but not exclusively, the invention relates to an improved water and space heating system in which electric elements are used as a primary heat source.

One of the most popular forms of space heating for domestic and commercial applications is wet heating systems in which hot water is circulated from a boiler through radiators and the like located throughout the space to be heated. At present, the majority of these systems are gas, oil or solid fuel fired. The heated water from the boiler also provides the heat source for the hot water supply, the heated water being carried from the boiler and passed through a coil located within a hot water heating and storage tank.

In many situations it is not possible or is inconvenient to utilise a gas, oil or solid fuel fired boiler and in these situations electricity may be used to provide space and water heating. Electrical space heating may be provided using radiant element heaters, though these are generally considered to be expensive to run. Many homes are provided with "storage heaters" which draw low tariff power, usually during the night and early morning, to heat material which then gives off heat during the day. Such heaters suffer from the disadvantage that they are less controllable than other systems and cannot be used to produce instantaneous heat in, for example, a rarely used room where the heater has not had the opportunity to warm up during the previous low tariff period. Also, electric storage heaters tend to be heavy and bulky. Electric water heating typically takes the form of one or more electrical heating elements located in a water tank. Again, heating water using such elements is considered to be relatively expensive when compared with other fuels.

It is one object of the present invention to provide an improved water and space heating system, of the type described in GB-A-2 253 268, which is suited for heating using an intermittent supply of energy, such as low tariff electricity, to provide a steady supply of heat for heating water and for space heating.

In one embodiment of the present invention a water heating and space heating system includes a heat store in the form of a tank containing a relatively large volume of water, electrical heating elements for heating the water in the tank, a wet space heating system including a plurality of radiators in fluid communication with the tank through tank outlet and return ports, and a heat exchanger located in an upper portion of the tank and having a cold water inlet and a hot water outlet for feeding a hot water supply. Two sets of electrical heating elements are provided, one set in an upper portion of the tank and another set in a lower portion of the tank. Both sets of elements may be utilised to heat the entire volume of water, while the upper set of elements may be utilised alone during periods of low demand. The upper elements are located relative to the heat exchanger to provide direct heating of the heat exchanger and to ensure effective circulation of the heated water in the tank around the heat exchanger. This ensures effective heat transfer from the heated water in the tank to the water which provides the hot water supply. The lower elements ensure that the entire volume of water is heated. During normal operation the upper elements will switch off at a lower temperature than the lower elements. The maximum temperature of the store is therefore governed by the setting of the lower element temperature sensor.

The system is particularly suited for utilising low tariff electricity made available to the consumer outside peak demand periods which typically occur around morning and evening meal times. During the period when low tariff electricity is available the volume of water in the tank, which is highly insulated, is heated to a relatively high temperature by the elements. Water for space heating is drawn from the tank and mixed with return water from the space heating system to bring the water temperature to around 80°C before being pumped through the radiators. The consumable hot water available from the heat exchanger is mixed with cold water to reduce the water temperature to around 55°C before being supplied to the hot taps.

In accordance with one aspect of the present invention there is provided water heating apparatus including:

heat store means in the form of a tank for containing a volume of water;

heating means for heating the water in the tank; and

heat exchange means located in an upper portion of the tank having a cold water inlet and a hot water outlet for feeding a hot water supply;

the heat exchange means and the heating means being arranged to encourage convection currents around said heat exchange means.

This arrangement overcomes a disadvantage of the arrangement disclosed in applicant's co-pending patent application GB-A-2 253 268, and other conventional heat stores, in which stratification of liquid may occur, reducing the effectiveness of the heat transfer to the water in the heat exchanger.

The apparatus may form part of a space heating system including at least one heat radiating means, such as a radiator in fluid communication with the tank through tank outlet and return ports. Preferably, the return port is arranged such that relatively cool returning water flows into a region between an outer surface of the heat exchange means and an inner surface of the tank surface, to encourage the creation of a downwardly directed convection currents in this region.

Preferably also, the heating means includes a first heating element located in a lower portion of the tank and a second heating element located in an upper portion of the tank. The second heating element may provide a major proportion of heating effect initially serving as a direct acting heater, heating the top of the tank and thus providing rapid heating of the heat exchanger. The first element serves to build up heat in the remainder of the store and bring the tank to its maximum temperature.

Preferably also, the heat exchange means defines one or more passages therethrough for accommodating upwardly directed convection currents, spacing being provided between an outer surface of the heat exchange means and an inner surface of the tank wall for accommodating downwardly directed convection currents. Most preferably, the upper second heating element is located directly below the heat exchange means for providing a hot water plume which passes upwards through the passages in the heat exchange means.

The tank may be vented or, alternatively, may be sealed for maintaining the pressure of the volume of water at or above atmospheric pressure, to permit the water to be heated to temperatures above 100°C without boiling. Further, if desired, the heat exchanger may contain water at above ambient pressure.

In accordance with a further aspect of the present invention there is provided a method of heating a store of water for use in heating comprising the steps:

providing a volume of water contained in a tank to form a heat store;

providing a heat exchanger in an upper portion of the tank; and

heating the water in the tank in such a manner to heat at least said upper portion and to encourage the creation of convection currents around the heat exchanger, to provide for more effective heat transfer thereto and to provide a hot water supply.

Preferably, the water in the tank is heated at two separate locations, one in a lower portion of the tank and the other in an upper portion of the tank.

If the store of water is to be used to provide heat for space heating, the method includes the further step of utilising the volume of water as a source of hot water for a wet space heating system.

According to another aspect of the present invention there is provided fluid heating apparatus comprising:

heat store means in the form of a tank for containing a volume of fluid;

heating means for heating the fluid in the tank; and

heat exchange means located in an upper portion of the tank having a fluid inlet and an outlet for feeding a hot fluid supply;

the heat exchange means and the heating means being arranged to encourage convection currents around said heat exchange means.

These and other aspects of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic representation of a water heating and space heating system in accordance with one embodiment of the present invention;

Figures 2a and 2b are sectional and plan views respectively of a heat exchanger of the system of Figure 1; and

Figures 3 and 4 are schematic representations of water heating and space heating system in accordance with further embodiments of the present invention.

Reference is first made to Figure 1 of the drawings, which illustrates a water heating and space heating system 10 in accordance with one embodiment of the present invention.

The system includes a heat store in the form of a well insulated tank 12 containing a relatively large volume of water. For domestic applications a 120 - 600 litre tank may be utilised. The water is heated by means of two electrical heating element units 14, 16. The tank 12 provides the source of hot water for a space heating system represented in Figure 1 by a single radiator 18 which communicates with the tank 12 through a tank outlet port 20 and a return port 24. A heat exchanger 26, typically of 20 - 40 litres capacity, is provided in an upper portion of the tank 12 and is connected in line with a cold water inlet 28 and a hot water outlet 30 which feeds the hot water supply, represented in Figure 1 by a hot tap 32.

In this example, the tank 12 and space heating system are sealed and contain water at a pressure of around 0.5 bar. Minor variations in pressure are accommodated by a pressure vessel 34 which includes a pressure gauge from which the pressure of the system may be read and also includes a safety valve 36 which can release pressure should some element of the system fail resulting in the water pressure rising above a predetermined safe level, for example 3 bar. A relief valve 38 is also provided on the tank 12, the valves 36, 38 also being provided with tundishes (not shown) with suitable drains to carry off any water which escapes through the valves. The pressurization of the tank 12 and space heating system allows the water in the tank 12 to be heated to a relatively high temperature, typically around 110°C, without boiling.

The system 10 is intended to rely primarily on low tariff electricity which is available during off-peak periods. In this example, the lower heating unit 14 includes heating elements 40 of a combined rating of 3 kW and is provided with a thermostat 42 set at 110°C, and a high limit thermostat 44 set at 115°C, and which must be manually re-set. The upper heating unit 16 includes heating elements 54 of a combined rating of 9kW.

When heating is required in the building provided with the system 10 a pump 46 draws water from the tank outlet port 20 and into the space heating circuit. Before passing into the circuit the hot water passes through a mixer valve 48 where the hot water (up to 110°C) is mixed with return water from the radiators (typically at around 60°C), the valve 48 including a temperature sensor and flow control such that the water supplied to the radiators 18 is around 80°C. The remainder of the return water passes through the return port 24 into the tank 12 adjacent the heat exchanger 26. As will be described, the inflow of relatively cold water of this point improves the operation of the heat exchanger 26.

The system is intended to use the minimum amount (if any) of high tariff electricity by utilising the store of heat created during low tariff periods. The water is heated to 110°C and during the peak period the water temperature is permitted to fall to around 80°C, the fall in temperature being accommodated by varying the proportion of return water mixed with the heating system supply at the mixer valve 48. The heat store will typically be sized such that the anticipated demand from the system may be met from the stored heat, though if the temperature of the water in the tank should fall below a predetermined temperature, one of the heating units 16 may be switched on.

The supply of cold water for the heat exchanger 26 comes directly from the mains supply via a stop cock 58, a filter 59 and pressure valve 60, set at, for example, 3 bar, and also a non return valve 62 which prevents inadvertent contamination of the mains supply. The cold water inlet 28 is in the form of a tube which extends into one side of the heat exchanger 26, as illustrated more clearly in Figure 2a and 2b of the drawings. The inlet has a chamfered end to throw the incoming cold water onto the outer wall of the heat exchanger. Thus, the outer wall of the heat exchanger will tend to be cooler than the other walls.

The heat exchanger 26 is cylindrical in form and has various parallel tubes 63 extending between the upper and lower walls 64, 66 to facilitate circulation of heating water. As can be seen in Fig. 2b the heat exchanger 26 has a larger central tube 65 surrounded by smaller diameter tubes 63 and the ends 26a,26b of the cylinder are domed for mechanical strength. The hot water outlet 30 is located on the other side of the heat exchanger 26 adjacent the upper wall 64. The heated water is then passed through a mixer valve 68 where the hot water is mixed with cold water, supplied through a by-pass pipe 70, in controlled proportion to bring the water temperature down to the desired level for supply to the taps, typically 55°C.

The effective operation of the store relies on the circulation of the heated water in the tank around the heat exchanger as will be explained.

Circulation of water within the tank 12 tends to follow a general pattern with different operating modes (central heating on/off, electricity on/off) causing variations in the circulation rates around the tank. The primary convection currents present in the tank 12 illustrated by arrows 71, 73 as in Figures 1 and 2. The main objective of the circulation is to ensure that the temperature of the whole of the heated section of the tank moves up and down uniformly. Stratification is deliberately avoided to ensure that all parts of the heat exchanger 26 are in contact with hot water, giving the maximum domestic hot water performance.

In addition, if the central heating water falls below the temperature of the water in the heat exchanger 26, due perhaps to low hot water load but high heating load, the lack of stratification ensures that the whole of the heat exchanger 26 contributes to transferring heat back into the central heating water.

When the heating elements 14, 16 switch on, a plume of hot water 71 rises off the elements towards the base of the heat exchanger 26. The vertical tubes 63 running through the heat exchanger 26 allow the plume to pass through to the top of the tank 12, enhancing the heat transfer to the heat exchanger 26. With no central heating water flow, some of the plume separates and passes up the outer surface of the heat exchanger 26. The cooler water 73 displaced by the hot plume at the top of the boiler passes down the inner surface of the tank 12.

If the boiler is on the 'winter' setting (both upper and lower heating elements 16, 14 on), the plume 71a extends from the lower element 14 all the way to the top of the tank 12 and circulation takes in the whole volume of the tank 12. The upper 9kW elements 16 provide direct heating, heating the upper portion of the tank and giving a very rapid heat up of the domestic hot water heat exchanger 26. The main heating store is only utilised when the electricity supply is off and therefore the lower (3kW) rated heating elements 14 have the whole of the low tariff 'on' period to heat up the rest of the store and bring the whole tank to its maximum temperature; the supply will typically be available for a minimum of four hours, allowing the 3 kW element 14 sufficient time to raise the temperature of the lower portion of the tank 12.

If the boiler is on 'summer' setting (upper elements 16 only), the plume 71, 73b extends from the upper elements 16 upwards and the circulation only takes in the upper volume of the tank 12. Cooler water circulating downwards mixes with the cooler water just below the upper heating elements 16 causing a slight rise in temperature in the volume below the elements 16 (up to 45°C as opposed to 90°C in the upper heated volume), reducing the heat emission from the tank 12 in the lower section.

When the central heating pump 46 switches on, the circulation is only modified slightly. The cold return 24 from the central heating enters the tank 12 opposite the side of the heat exchanger 26. This avoids the possibility of the cold flow affecting the upper heating element temperature sensors by deflecting the water away from the elements, but more importantly produces a cold water area, relatively high up in the tank 12 and around the periphery of heat exchanger 26. This enhances the internal circulation within the tank, preventing stratification.

The effect of having the elements 14, 16 off is to make the central plume less well defined, but the flow patterns remain essentially the same. With no central heating demand, the driving head is provided by the cooling effect of the outside surfaces of the outer tank. Where there is central heating demand, the cold return from the radiators enhances the effect as described above.

Expansion of the water within the heat exchanger 26 and associated pipe work is accommodated by means of an expansion vessel 72.

It is preferred that the tank 12 and heat exchanger 26 are fabricated from a suitable grade of mild steel, though other materials, such as the traditional copper and stainless steel, may also be used. The capacities of the tank and heat exchanger and the rating of the heating elements may be selected depending on the application of the system and the lengths of the periods when low tariff power is available.

Reference is now made to Figure 3 of the drawings which shows a further embodiment of the present invention. The system of Figure 3 is substantially similar to the first described embodiment as shown in Figure 1, similar elements of the system of Figure 3 being identified with the same reference numbers prefixed with 1. In the embodiment of Figure 3 the tank 112 and the radiators 118 are not sealed and the tank 112 is provided with a vent 80. Water supply to the tank 112 is provided from a feed tank 82 which is mounted above the tank 112 to provide a head, the feed pipe 84 entering the tank 112 and an inlet 86 at a lower portion of the tank 112.

This system will typically operate at a lower temperature than the first described embodiment, the water in the tank 112 being heated to around 95°C by heating unit 114, 116 during low tariff periods, the upper elements switching off at 88 - 92°C, while the lower element switches off at 95°C.

Figure 4 of the drawings illustrates a still further embodiment of the present invention. This embodiment is similar to that illustrated in Figure 3, with the modification that the cold water input to the heat exchanger 126 is supplied from a feed tank 200, providing sufficient head (typically 1m) for operation of the mixing valve. Also, the hot water supply is vented via an overflow pipe 202, leading to the feed tank 200.

From the above description it will be evident that these embodiments of the invention provide systems which allow consumers to obtain the electricity required for heating and hot water during low tariff periods. This is also advantageous to electricity generators and suppliers as the variations in demand for electricity between peak periods and off-peak periods will be reduced.

It will be clear to those of skill in the art that the above described embodiments are merely exemplary of the present invention and that various modifications and improvements may be made without departing from the scope of the invention: for example, a system may be provided which will only provide a supply of hot tap water, or a supply of hot water for space heating; and the capacity rating and operating temperatures of the system may vary widely, depending on application. The cylindrical shape of the heat exchanger is for ease of manufacture and the heat exchanger could be cubical as could the outer tank. The heat exchanger could have a plurality of smaller parallel tubes instead of a single larger central tube with smaller peripheral tubes, as long as there are vertical pathways to provide circulation around and through the heat exchanger. Also, the apparatus could be used to heat fluids other than water such as oil, brine and any chemically suitable fluid.

Claims

1. Water heating apparatus including:

heat store means in the form of a tank (12) for containing a volume of water;

heating means (14, 16) for heating the water in the tank (12); and

heat exchange means (26) located in an upper portion of the tank having a cold water inlet (28) and a hot water outlet (30) for feeding a hot water supply (32), the heat exchange means (26) and the heating means (16) being arranged to encourage convection currents around said heat exchange means (26).

2. The apparatus of claim 1, in which the apparatus forms part of a space heating system including at least one heat radiating means (18) in fluid communication with a tank (12) through tank outlet and return ports (20, 24).

3. The apparatus of claim 2, in which the return port (24) is arranged to return water into a region between an outer surface of the heat exchange means (26) and an inner surface of the tank (12).

4. The apparatus of claims 1, 2 or 3 in which the heating means includes a first heating element (14) located in the lower portion of the tank (12) and a second heating element (16) located in an upper portion of the tank.

5. The apparatus of claim 4 in which the second heating element (16) provides a major proportion of the heating effect.

6. The apparatus of any one of preceding claims in which the heat exchange means (26) defines one or more passages (63) therethrough for accommodating upwardly directed convection currents (71), spacing being provided between an outer surface of the heat exchange means (26) and an inner surface of the tank (12) for accommodating downwardly directed convection currents (73).

7. The apparatus of claim 5 or claim 6 in which the second heating element (16) is located directly below the heat exchange means (26) for providing a hot water plume which passes upwards through the passages (63) in the heat exchange means (26).

8. A method of heating a store of water for use in heating comprising the steps:

providing a volume of water contained in a tank to form a heat store;

providing a heat exchanger in an upper portion of the tank; and

heating the water in the tank in such a manner to heat at least said upper portion and to encourage the creation of convection currents around the heat exchanger, to provide for more effective heat transfer thereto and to provide a hot water supply.

9. The method of claim 8 in which the water in the tank is heated at two separate locations, one in a lower portion of the tank and the other in an upper portion of the tank, the water being heated in such a manner that the upper portion of the tank is heated at a different rate than the lower portion of the tank.

10. The method of claim 8 wherein the water in the upper portion of the tank is heated at a faster rate than the lower portion of the tank.

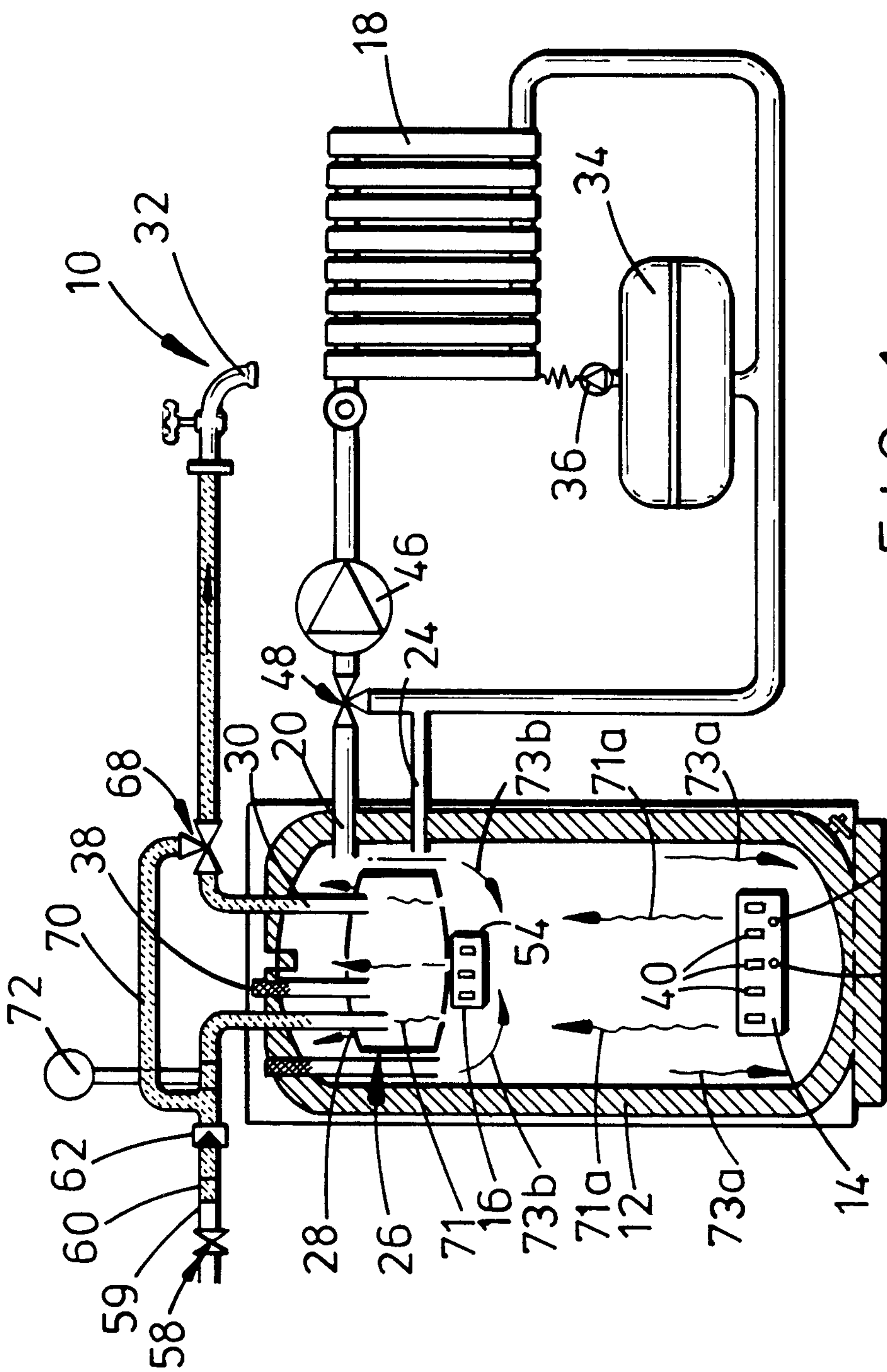
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FIG. 1

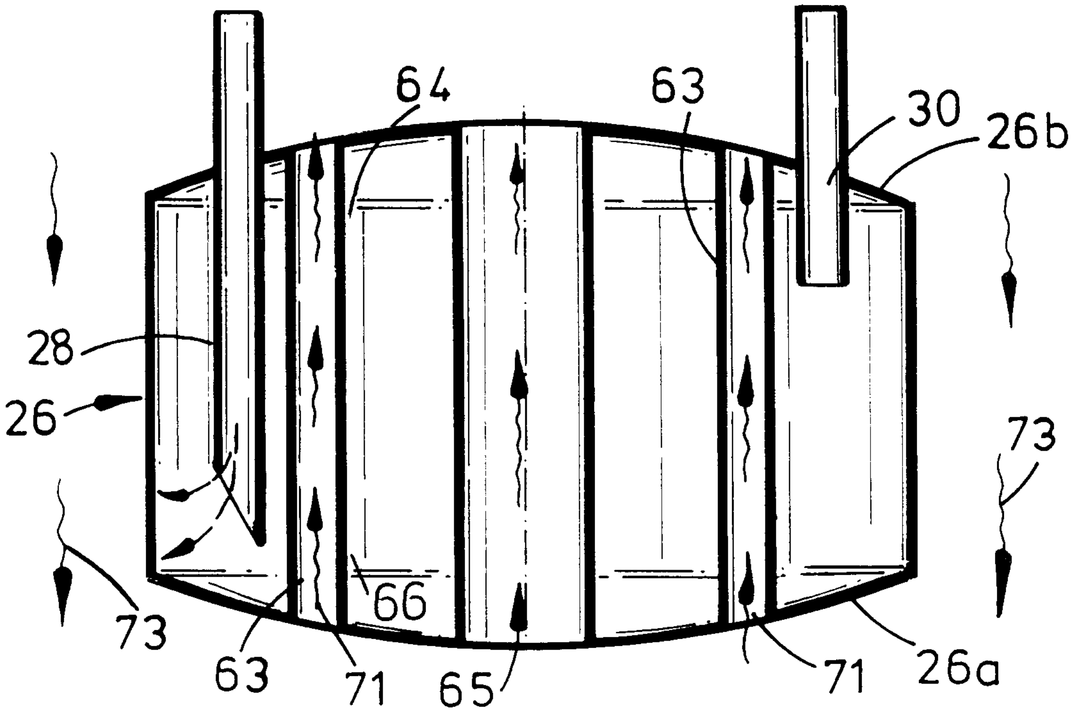

FIG. 2a

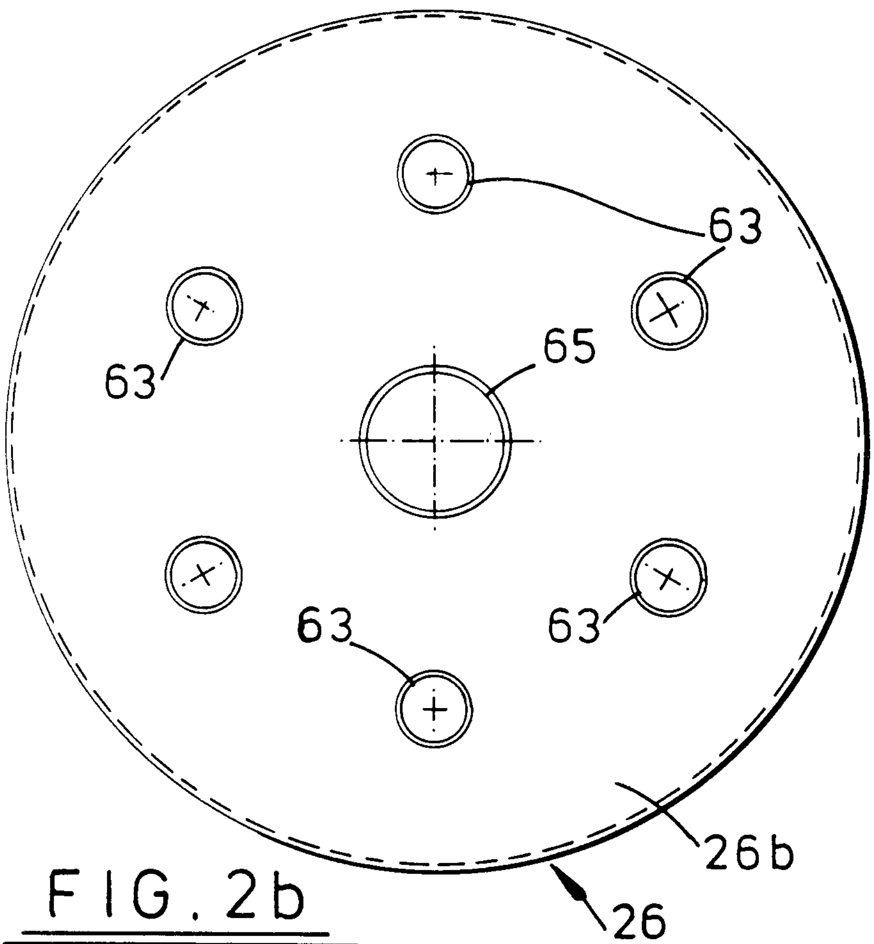

FIG. 2b

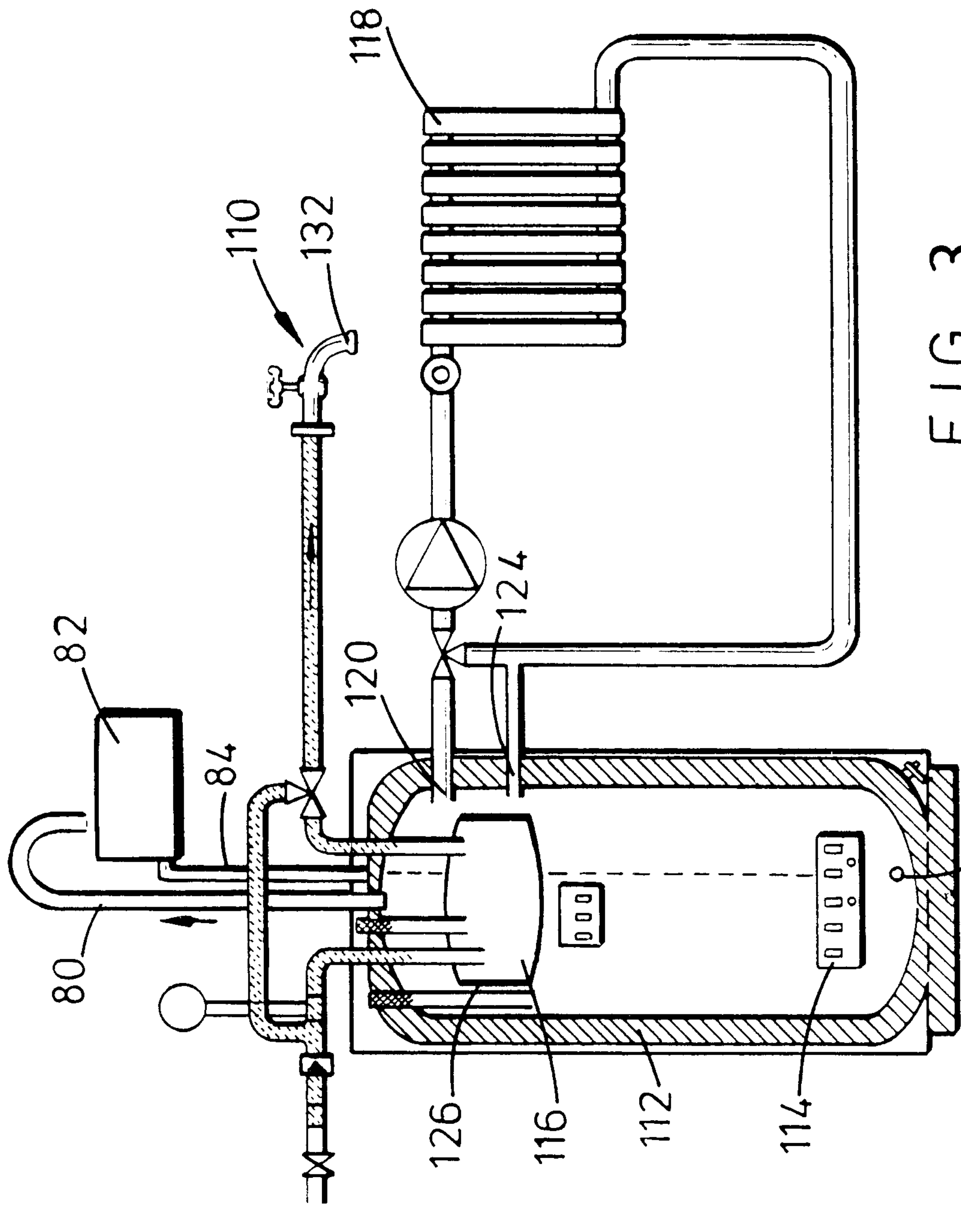

FIG. 3

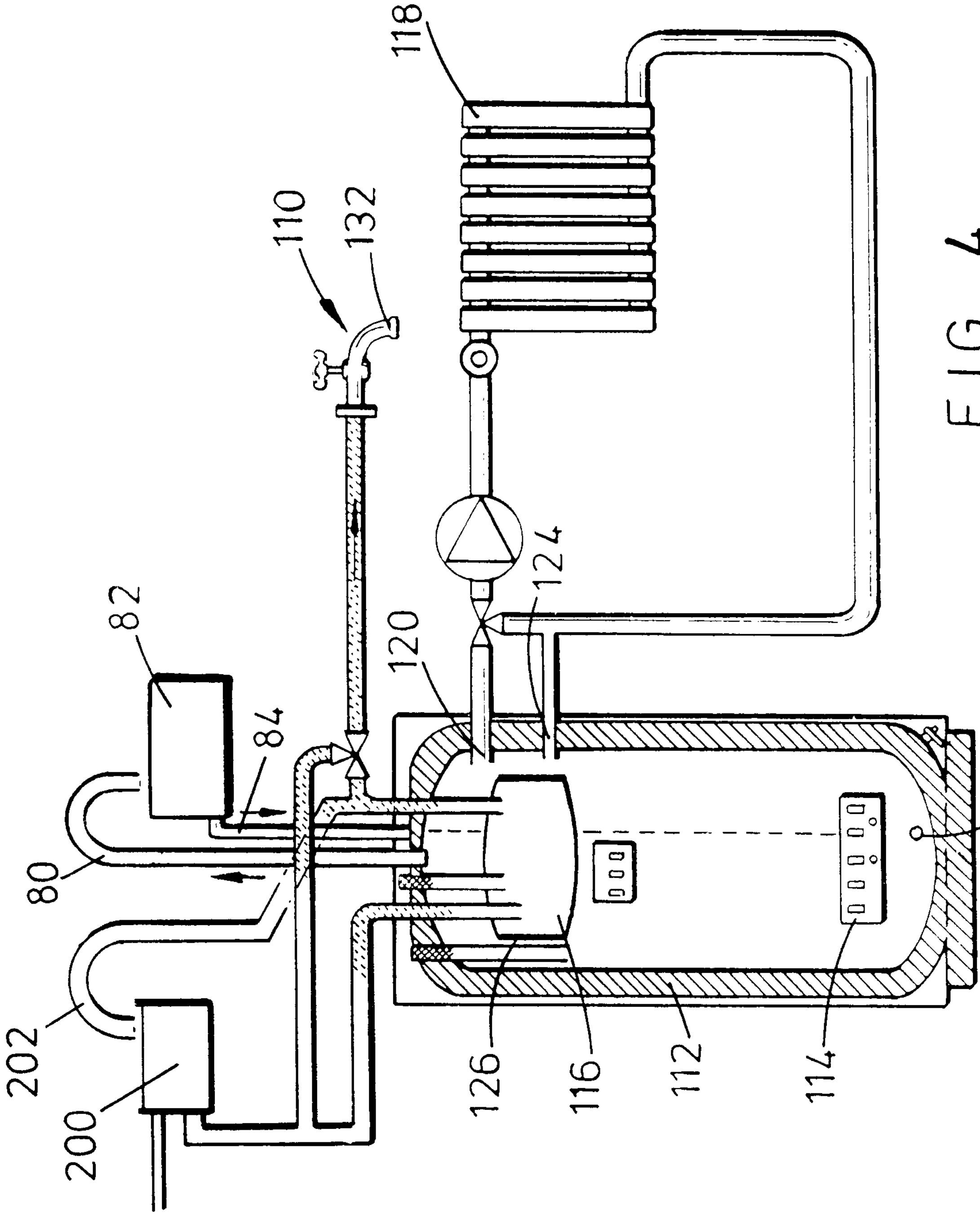

FIG. 4

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 30 9841

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X,D	GB-A-2 253 268 (HEPBURN) * the whole document * ---	1-10	F24D11/00
A	GB-A-2 131 526 (WHITE) * the whole document * -----	5,9,10	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
F24D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 April 1994	Van Gestel, H

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
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