(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 092 864**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 83200524.3

(22) Date of filing: 13.04.83

(51) Int. Cl.³: F 24 D 17/00
F 24 D 19/10

(30) Priority: 15.04.82 IT 2074582
22.12.82 IT 2491482

(43) Date of publication of application:
02.11.83 Bulletin 83/44

(84) Designated Contracting States:
DE FR GB IT

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DE FR GB

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(54) Improvements in heat pump systems for hot water production.

(57) The hot water production system, in particular for domestic use, comprises: a water container connected to a cold water inlet (3) and hot water outlet (5); a water circuit connected to the container in which a circulation pump is disposed; and a heat pump, the condenser of which is in heat transfer relationship with said water circuit. In the water circuit (4) there is disposed a heat exchanger (7) heated by the condenser (8). Temperature control means (TA) are provided, which control the circulation pump (6) and heat pump (9). A temperature-controlled valve (14) controls the amount of water flowing from the water circuit to the container (1).

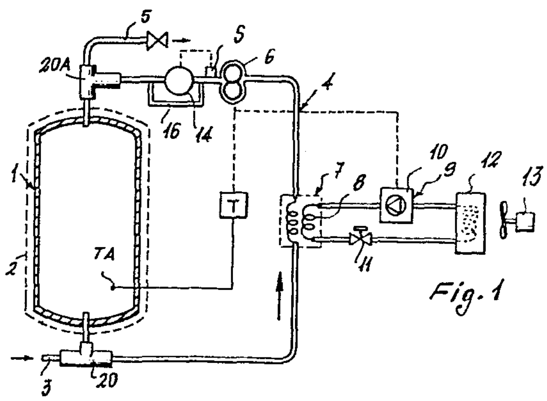

Fig. 1

EP 0 092 864 A2

"Improvements in heat pump systems for hot water production"

This invention relates to a hot water production system, particularly for domestic use, comprising: a water container, possibly with an electric heating element, and provided with a cold water inlet and a hot water outlet; a water circuit connected to the container and comprising a heat exchanger and a circulation pump; the system further comprising a heat pump, the condenser of which forms part of the heat exchanger.

In systems of this type, and specifically in those in which the insulated container is a normal electrical hot water production appliance, known as a water heater, and provided with a bottom cold water inlet and a top hot water outlet, there is a drawback in the fact that when the user item draws off water, the water from the electric water heater mixes with the insufficiently heated water from the heat pump, so that the user item receives a mixture at a temperature lower than the presumed temperature, i.e. lower than that indicated for example on the thermometer of the electric water heater. This is due to the fact that the thermal power given up to the water by the heat pump is too low. This drawback could be overcome by using heat pumps of greater power, but this would obviously result in greater overall size cost of purchase.

The object of the present invention is therefore to provide a system of the specified type which obviates the aforesaid drawback by using a heat pump which is not over-sized, together with an electric water heater of conventinal type, which may already be installed in the user's premises, and without having to make actual modifications to the water heater.

This and further objects which will be more apparent from the detailed description given hereinafter are attained according to the invention by a system of the indicated type, characterized essentially in that the water circuit comprises, an automatically operated valve which is controlled by a sensor which senses the temperature in the circuit.

The use of the above automatically controlled valve ensurer that only water of a certain temperature can flow into the upper part of the container.

According to a further embodiment of the invention the automatically controlled valve is a two position valve which in neither of its two positions does prevent passage of water from the pump to the container.

Various methods can be used for obtaining water passage independently of the valve position. The most simple consists of using a valve having no shut-off position. Thus, the valve could have a maximum opening position and a minimum opening position, or alternatively be provided with a passage in its valve element. A further simple method consists of using a valve having a total closure position and a total opening position, and being associated with a conduit or channel of small cross-section disposed in parallel to that controlled by the valve itself.

A further advantageous embodiment of the system according to the invention is characterized in that the water circuit comprises in parallel with the container and heat-exchanger a return line controlled by the valve.

The valve used is of the modulating type, in the sense that the diversion of water towards the return line depends on the temperature of the water fed by the circulation pump.

By this means, the water is kept circulating by the circulation pump through the heat exchanger, which can also act as an accumulator, so that the water heats up in less time, and the temperature-controlled valve returns a fraction (depending on the temperature) of the pump throughput to the heat exchanger, the remaining fraction of the throughput passing to the user item or to the container.

The invention will be more apparent from the detailed description of preferred embodiments given by way of non-limiting example and illustrated on the accompanying drawing, in which:

Figure 1 is a diagrammatic illustration of the system according to the invention;

Figures 2 and 3 are axial diagrammatic sections through two different embodiments of the valve used in the system of Figure 1.

Figure 3 is a diagrammtic view of a system according to the invention which comprises in parallel with the heat exchanger and the container a return duct, and

Figure 4 is a partial view of the system with a different type of heat exchanger.

In Figure 1, reference numeral 1 indicates a container covered with an insulating layer 2 to prevent heat-loss from the contained water towards the outside. The container can be any known hot water cylinder provided internally with an electric heater element associated with a thermal protector (not shown). Lowerly, the container is connected hydraulically by a normal T connector 20 both to the cold water inlet 3 and to a water heating circuit indicated overall by 4. Upperly, the container 1 is hydraulically connected by a normal T connector 20A to said circuit 4, and to an outlet pipe 5 which feeds the hot water to the user point, for example the shower of an apartment.

The water circuit 4 comprises an electrically operated circulation pump 6 and a heat exchanger 7. The entire circuit 4 and thus also the heat exchanger 7 are suitably heat-insulated. A thermostat T, which controls the electric motors of the circulation pump 6 and of the compressor 10 forming part of a heat pump 9, senses the temperature of the water in the container 1 by means of its sensor TA. In order to heat the water circulating through the circuit 4, the heat exchanger is associated with the condenser 8 of the heat pump 9, which in the normal manner comprises the said compressor 10, the condenser 8, the expansion device 11 (for example a thermostatic valve) and the evaporator 12, which as shown can be arranged in an airflow generated by a fan 13. Alternatively, a cooling liquid fed by a pump can be brought into contact with the evaporator 12. The fan 13 can also be controlled by the thermostat T. The thermostat T can also be located at a point in the water circuit 4. A valve 14 is disposed in the water circuit between the circulation pump 6 and connector 20A, and can assume two positions, namely a complete shut-off, i.e. closed position, and an open position. The valve can be of the thermostatic type, i.e. to open and close in accordance with the expansion and contraction of a component which "senses" the water temperature. This "sensor" is shown separately and indicated by S in Figure 1. The valve can alternatively be of the electro-magnetic type and open when the temperature sensed by the sensor S has caused electrical circuit of the valve to be made. In parallel with the valve 14 there is a conduit 16 which, independently of the position of the valve, conveys a predetermined fraction of the delivery of the pump 6 to the container 1.

The cross-section of the conduit 16 is a fraction of the passage cross-section of the valve 14. The valve 14 can also be constructed as shown diagrammatically in Figures 2 and 3. With these valves there is no need to provide a conduit 16 in parallel with the valve. In this respect, in Figure 2, the body 20 of the valve 14A is provided with a channel 16A disposed in parallel to the passage 21 which itself can be shut off by the valve element 22, which is controlled by the inductor 23. This latter is supplied by an electrical source when the relative supply circuit is made by means of the thermal sensor S. Instead of the channel 16, the valve element 22B of the valve 14B (Figure 3) can be provided with a passage aperture 16B, which remains open when the valve element is in its shut-off position.

Assuming that the described system has just been connected to the cold water inlet, the container 1 and line 4 will be full of cold water at mains temperature, for example 12^{O}C, the thermostat T will start the compressor 10, the circulation pump 6 and possibly the fan 13, and the valve 14 will be in its shut-off position, so that only a small fraction of the water fed by the pump 6 passes through the conduit 16.

As the conduit 16 has a cross-section which is less than the passage cross-section of the valve, the water throughput circulating through the circuit 4 is less than that which would circulate with the valve open. The water circulates more slowly through the circuit 4 than when the valve is open, and thus attains a higher temperature at the upstream side of the valve 14 after a given time. When the water reaches a given temperature a t the sensor S, the valve 14 opens, and is traversed by a higher throughput of water, which is fed into the container 1. This hot water is replaced by the cold water, which is withdrawn from the bottom of the container. The result is that the valve 14 again closes, the water throughput reduces, the water temperature increases at S, and the valve 14 opens when the threshold value is reached at S. This cycle is repeated until all the water has attained the operating temperature of the thermostat T, which then switches off the circulation pump 6, the compressor 10 and possibly the fan 13.

If the user now withdraws hot water through the pipe 5, this becomes replaced by cold water taken from the main 3. This causes the operation of the thermostat T and the closure of the valve 14, so that a reduced water throughput reaches the connector 20A. The valve 14 reopens and closes in accordance with the temperature of the water at the sensor S in the manner described heretofore, and this continues, even after hot water ceases to be withdrawn, until the water has reached the threshold temperature of the thermostat T.

The operation of the modified embodiments of Figures 2 and 3 is apparent from the aforegoing description, and requires no further clarification.

Figure 3 shows a system of the same type as the system shown in Figure 1, and therefor in both Figures the same reference numerals denote corresponding parts. The difference between the two systems is that the system according to Figure 3 comprises a return duct 16. The temperature-controlled valve 14 of known type is disposed between the circulation pump 6 and the connector 20A, and divides the water throughput fed by the circulation pump 6 between the return line 16 and the pipe 17 leading to the T connector 20A, in accordance with the temperature sensed by a sensor S. Specifically, the sensor S can be disposed either upstream or downstream of the valve 14 and senses the water temperature. The signal representing the temperature sensed by the sensor S can be amplified and used for controlling a motor, not shown, which operates the valve 14 and controls the water flow to the line 16 and pipe 17. Alternatively, the temperature signal can control the valve by means of a linkage. For example, when the water temperature sensed by the sensor S is equal to the mains temperature (approximately 12^{O}C), the valve in question directs the entire throughput of the pump 6 towards the return line 16 and through the T connector 18 of the heat exchanger 7. The unidirectional valve 15 between the connectors 18 and 20 prevents circulation in the opposite direction to the arrow X. As the water temperature increases, an increasing fraction of the water is made to flow to the pipe 17 and from this to the user item through the pipe 5, or to the container 1. An equal fraction of cold water is drawn through the unidirectional valve 15. As the temperature increases still further, the entire pump throughput is directed towards the pipe 17. The circulation ceases completely when the cut-out temperature of the thermostat T is reached, thus stopping the pump 6 and the compressor 10.

Assuming that the described system has just been connected to the water main, the container 1 and heat-exchanger 7 will be full of cold water at mains temperature, e.g. 12^{O}C, and the thermostat T will have cut in to operate the compressor 10, the fan 13 (if this latter is not already operating) and the circulation pump 6. The valve 14 will be in a position such as to direct the entire throughput of the pump 6 towards the return line 16. Consequently, only the water circulating through the heat-exchanger 7 will be heated by the heat pump 9. When this water reaches a certain temperature (and assuming the user does not require hot water), the valve 14 enables a fraction of the pump throughput (this fraction increasing with temperature) to be fed to the container 1, and cold water from this latter enters the heat-exchanger 7 as replacement. By this means, the temperature in this latter decreases in spite of the fact that the heat pump 9 continues to provide heat.

This reduction reduces the water fraction which enters the pipe 17 and consequently the container 1. Because of this, the temperature and thus the fraction entering the pipe 17 increase. This procedure is repeated automatically until all the water in the container 1 and accumulator has reached the cut-out temperature of the thermostat T, which then stops the pump 6 and compressor 10.

If at this point the user draws hot water from the pipe 5, this water is replaced by cold water from the water main 3. This causes the thermostat T to operate, and start the circulation pump 6 and compressor 10, which causes the water to heat up. As the temperature at the sensor S reduces, the valve 14 reduces the water fraction directed to the pipe 17,whereas it increases that recirculated through the heatexchanger 7, which thus heats up. The sensor S senses the change, and a larger water quantity is fed to the pipe 17. When water draw-off ceases, the system heats the water in the container 1 as heretofore described, until the cut-out temperature of the thermostat T is reached.

Figure 4 shows an embodiment which from the conceptual aspect is equivalent to the preceding. The only difference is that the heat-exchanger 7 is replaced by a conventional circulation-type heat-exchanger 7A.

It is interesting to note that the water circuit 4 and heat pump can be connected to a container 1 (normally used for heating the water by means of an electric heating element) by simple T connectors, the installation of which is easy and rapid. This represents a considerable economical and practical advantage for the installation of a heat pump on the premises of a user already provided with a conventional water heater.

CLAIMS

1. A hot water production system, particularly for domestic use, comprising a water container, possibly with an electric heating element, and provided with a cold water inlet and a hot water outlet; a water circuit connected to the container and comprising a heat exchanger and a circulation pump; the system further comprising a heat pump, the condenser of which forms part of the heat exchanger, characterized in that the water circuit includes an automatically operated valve (14) which is controlled by a sensor (S) which senses the temperature of the water in the circuit.

2. A system as claimed in claim 1, characterized in that the automatically operated valve (14) is a two-position valve which in neither of its two positions does prevent passage of water from the pump (6) to the container (1).

3. A system as claimed in claim 2, characterized in that the valve (14) is a shut-off valve, but in parallel therewith there is present a conduit (16) having a cross-section less than the passage cross-section of the valve (14).

4. A system as claimed in claim 2, characterized in that the valve (14B) has an open position and a position in which the relative passage is throttled.

5. A system as claimed in claim 2, characterized in that the valve (14A) possesses a body (20) in which there is provided a channel (16A) straddling the valve shut-off member (22), and having a cross-section less than the passage cross-section (21) of said valve.

6. A system as claimed in claim 1, characterized in that the water circuit (4) comprises, in parallel with the container (1) and heat exchanger (7, 7A), a return line (16) controlled by the valve (14).

7. A system as claimed in claim 6 characterized in that a unidirectional valve 15 is connected between the return line (16) and water main (3) in such a manner as to allow passage from this latter to the former.

8. A system as claimed in one or more of the preceding claims, characterized in that the container (1) is a conventioanl water heater

comprising an electric heating element, and to which the water circuit is preferably connected by means of simple T connectors (20A).

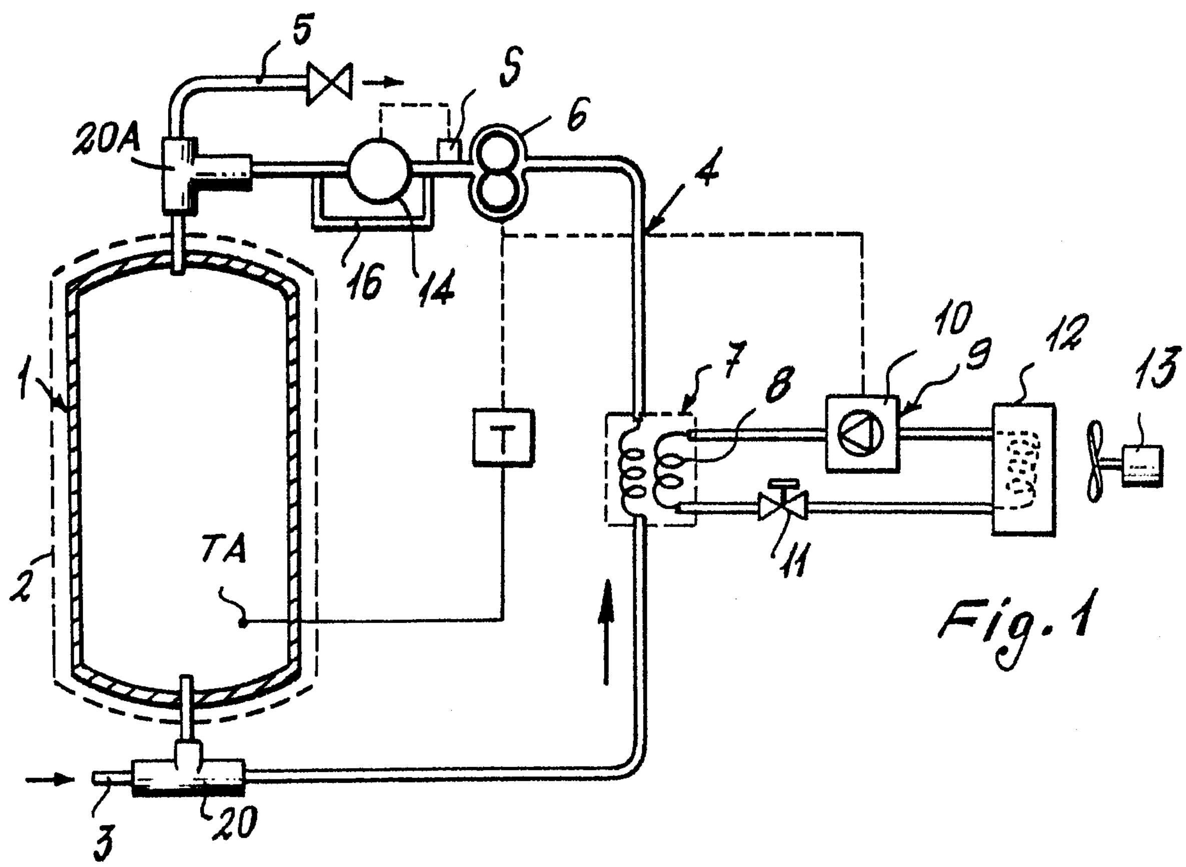

Fig. 1

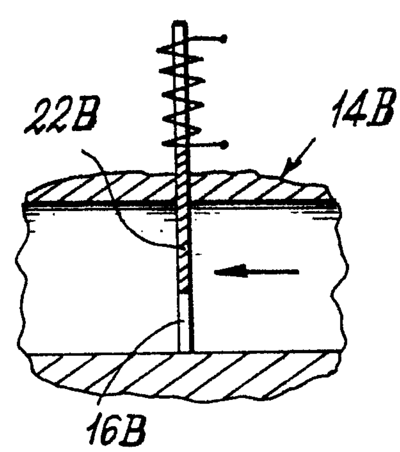

Fig. 3

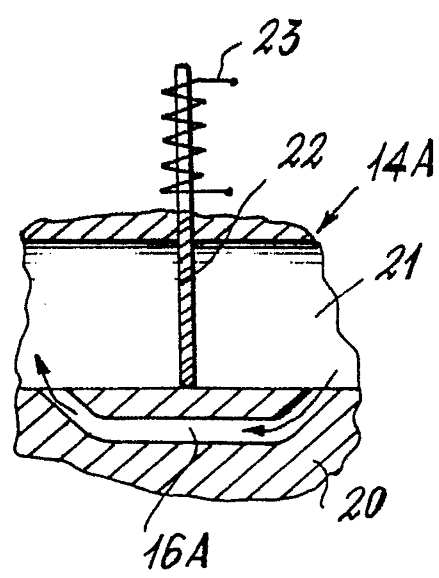

Fig. 2

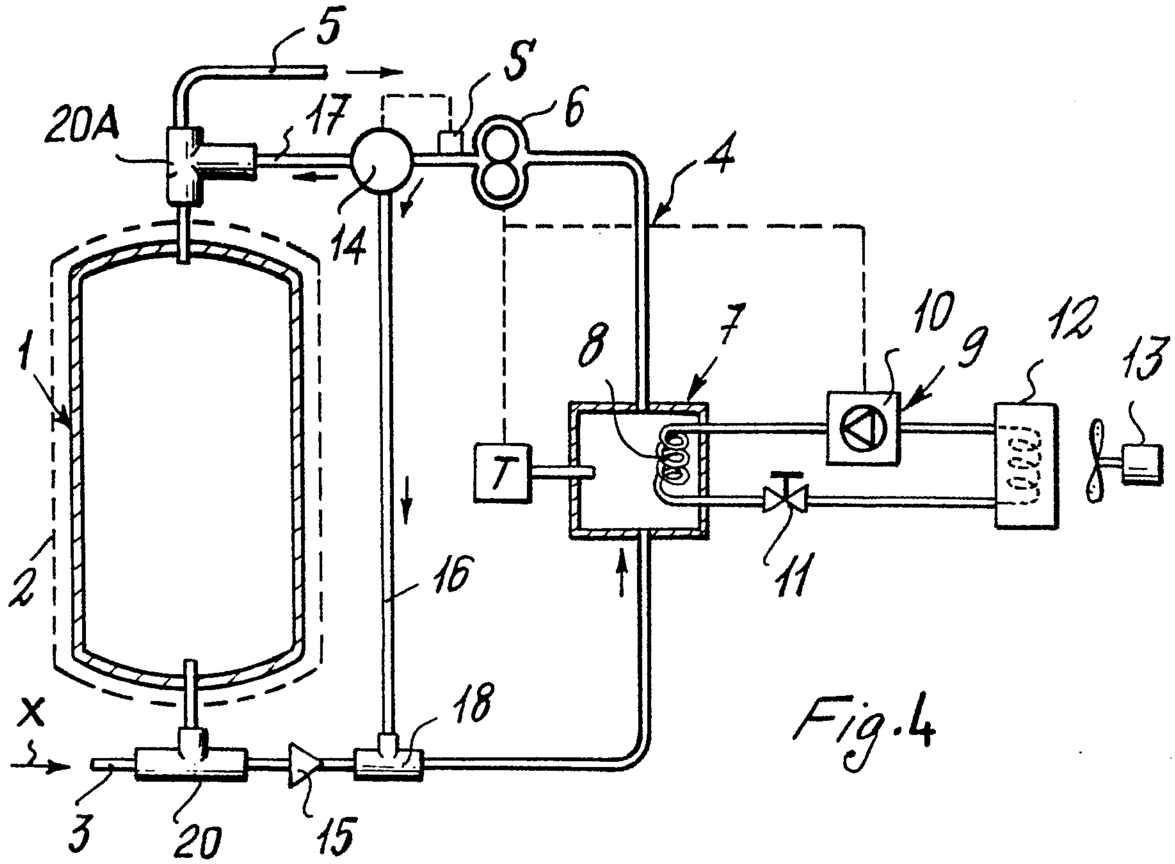

Fig.4

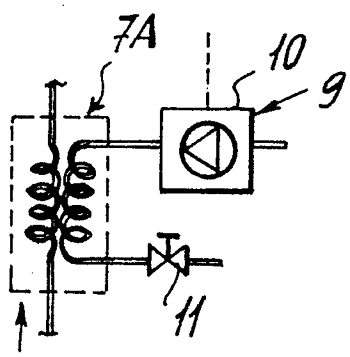

Fig.5