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(54) Title: Improvements in and relating to heating and ventilating systems

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HEATING AND VENTILATING SYSTEMS USING SOLAR HEAT COLLECTORS

The present invention concerns improvements in and relating to heating and ventilating systems of the type using one or more solar panels as an energy source.

European Patent Specification No. EP 0 808 441 discloses an air heating and heat recovery ventilation system with one or more solar panels of the type which absorb and collect energy from the sun during daylight hours; an air handling unit for combining and distributing energy from different sources; a boiler which is interlinked to the system via the air handling unit; a control means which provides a means for co-ordinating and controlling all the components and functions of the system; and an air distribution system which allows for heat to be distributed throughout a house via a network of conduits. The energy processing unit includes an air handling unit which comprises an air-to-water heat exchanger and a fan for forcing the heated air from the solar panels through the heat exchanger, thereby transferring heat to the water in the domestic hot water supply system; and forcing warm air emerging from the heat exchanger to flow around the house.

International Patent Publication No. WO 2007/023480 discloses an improved air handling apparatus for use in an air heating and heat recovery ventilation system of the same type, i.e. using solar panels as an energy source.

A problem arises particularly when this type of heating and ventilation system is starting up, such as after a period of time during which no heat was drawn through the system. In such start-up situation, a huge surge of heat transfer fluid at a temperature in excess of 140°C, possibly even as high as 200°C, flows from the solar panels to the other parts of the system. Fluid at such a high temperature can cause serious damage to elements of the apparatus of the heating and ventilating system, such as the motor windings in the pump used for circulating fluid or the fan included in the air handling unit.

The present invention seeks to alleviate the problem of such heat surge associated with known heating and ventilating systems of the type referred to above.

Accordingly, the present invention provides a heating and ventilating system comprising one or more solar panels for absorbing and collecting energy from the sun during daylight hours and transferring the energy to fluid, a pump for pumping the fluid heated by the solar means through the system, an air handling unit for providing heated air and

distributing said air throughout a house or premises; a control means which provides a means for co-ordinating and controlling all the components and functions of the system; and an air distribution system which allows for heat to be distributed throughout a house via a network of conduits, wherein the air handling unit comprises a heat exchanger and means for forcing the heated fluid through the heat exchanger and means for forcing warm air emerging from the heat exchanger to flow around the house/premises, characterised in that the system includes a hot water storage tank for providing heated water to a hot water supply system, the hot water storage tank comprising a heat exchanger which is adapted to be supplied with heated fluid from the solar panels and wherein the hot water storage tank is configured to act as a thermal buffer so as to store energy which can be supplied to the air handling unit, when required, and in which the air distribution system is operable to function as a heat leak so as to prevent overheating of the solar panel means when there is insufficient hot water demand.

Thus, the present invention relates to a novel and complex relationship, combining high performance solar panels, including vacuum tube solar panels, used to heat water and ventilation air so as to maximise the efficiency of the solar panels.

Preferably, the heat exchanger is located in a lower portion of the hot water tank and advantageously, extends transversely across substantially the width of the tank. Ideally, the heat exchanger occupies substantially the lower half of the hot water storage tank. That is, the heat exchanger extends longitudinally along approximately the lower half of the hot water storage tank.

Conveniently, the system is configured to operate in a plurality of operating modes wherein

in a first operating mode, the solar panels deliver energy to the hot water storage tank only,

in a second operating mode, the solar panels deliver energy to the hot water storage tank and the air handling unit,

in a third operating mode, the solar panels deliver energy to the air handling unit only; and

in a fourth operating mode, the hot water storage tank delivers energy to the air handling unit only.

Preferably, the heating and ventilating system includes a plurality of motorised valves, the operation of which is controlled by the control means to provided the desired operating mode.

Advantageously, the motorised valves and associated piping are pre-assembled about the hot water storage tank.

Alternatively, the motorised valves and associated piping are pre-assembled onto a separate mounting board.

An advantage of the present invention is that the particular combination of the high performance solar panels, hot water storage tank and the air handling unit together with a complex arrangement of pipe work and control devices allows the solar panels deliver energy to the air handling unit while operating with the heat transfer fluid from the solar panels being at high temperatures. With the known heating and ventilating systems using solar panels, one would have to stop such systems delivering thermal fluid at temperatures in excess of 60°C because air at a temperature over 60°C is uncomfortable and in addition, operating with the heat transfer fluid at temperatures greater than 90°C may also affect the motor windings in either the circulating pump used to pump heat transfer fluid around the system, or in the fan in the air handling unit.

Another advantage of the present invention is that the lower half of the hot water storage tank is used as a thermal store to provide additional solar energy to the air handling unit (ventilation unit) at night. Supplying solar energy directly to the air handling unit ensures that the solar panels can work even with very low levels of solar irradiation or diffuse sun light without affecting the substantial amount of hot water available in the top section of the hot water tank or even the lower half of the tank. A similar situation arises when the hot water storage tank is at a temperature higher than that available from the solar panels but the solar panel temperature is still viable to deliver energy directly to the air handling unit.

A further advantage of the heating and ventilation system of the present invention lies in the flexibility of heating options available because of the multiple operating modes referred to above. This ensures that the solar panels operate at the lowest possible average temperature because the lower the operating temperature of the solar panels, the higher their efficiency.

The technical advantages of the present invention include:

1. The ability of the system to use solar energy to heat air as well as water increases the potential energy yield of the solar panels.
2. The hot water storage tank is used as a buffer tank to store solar energy to heat the ventilation air in the evening time when there is no solar energy available.
3. The ventilation system is used as a heat leak to prevent overheating of the solar panels when there is no hot water demand such as during a holiday period when the house is not occupied.
4. The solar panels can supply heat energy directly to the ventilation unit with the hot water storage tank out of the circuit.
5. The solar panels can supply heat energy directly to the hot water storage tank with the air handling unit out of the circuit.
6. The solar panels can supply heat energy to both the hot water storage tank and the air handling unit either in series or in parallel as determined by the control algorithm.
7. The ratio of thermal storage to surface area of solar panels can be reduced.
8. Using the hot water storage as a thermal buffer facilitates the operation of the solar panels at high fluid temperatures.
9. The performance of the solar panels is improved as the useful operating range of the solar panels is increased.

The usual, known design criteria when using high performance solar panels is to use circa 75 litres of water storage per square meter of solar panel to have sufficient daily storage capacity for peak summer time output. This design parameter limits the potential of the solar panels to deliver meaningful energy for winter use when there is a greater energy demand. However, by using the ventilation system as a night time heat leak for the thermal store, a ratio of 50 litres of water storage per square meter of solar panel could be used, a one third reduction in the size of hot water storage tank. This will help keep down the cost of water storage and more importantly, reduce the size of the hot water storage

tank as space is at a premium in new housing and therefore the size of the hot water storage tank can be an important consideration. But, most importantly for low energy housing, the increased surface area of solar panels available in the winter months is hugely beneficial. The consequence of this arrangement is that in a "no hot water load" situation such as when a house is not occupied, the system must be free to heat the ventilation air to the house to prevent overheating of the solar panels.

Depending on the sophistication the installation, a slightly less-complex arrangement can be employed which is still very beneficial but does not provide for the hot water storage tank to deliver energy to the air handling unit at night. (This operative mode is described below with reference to Figure 1).

The invention will now be described more particularly with reference to the accompanying drawings, in which are shown by way of example only, several different operating modes (embodiments) of the system of the present invention.

In the drawings:

Figure 1 is a schematic flow and circuit diagram showing the solar panels delivering energy to the hot water storage tank only;
Figure 2 is a schematic flow and circuit diagram showing the solar panels delivering energy to the hot water storage tank and the air handling unit;
Figure 3 is a schematic flow and circuit diagram showing the solar panels delivering energy to the air handling unit only;
Figure 4 is a schematic flow and circuit diagram showing the hot water storage tank delivering energy to the air handling unit only;
Figure 5 is a schematic side view of a hot water storage tank with some of the pipe work shown in a preferred arrangement, and
Figure 6 is a schematic diagram showing an alternative arrangement of the pipe work/valves.

Referring now to Figure 1, there is shown a schematic flow and circuit diagram illustrating the heating and ventilating system of the invention which is indicated generally by reference numeral 100. The system 100 includes solar panels 10, a hot water storage

tank 11. The hot water storage tank 11 includes a heat exchanger 120 provided in the lower section of the tank and a heat exchanger 121 provided in the upper section of the tank. The solar panels 10 provide energy to the heat exchanger 120 whereas the heat exchanger 121 is a heating coil provided with energy by either a boiler or an immersion heater (not shown). The system 100 also includes a controller 12 as well as an air handling unit 13 comprising two heat exchangers 14, 15.

The configuration of the indirect heat exchangers 120, 121 in the hot water storage tank 11 are designed to achieve the optimum balance between water storage for household use (e.g. showers) and energy supply to the air handling unit to temper the ventilation air. For this reason, the size and configuration of the solar heat exchanger 120 in the hot water storage tank is not that of the known, standard solar dual coil hot water storage tank. Instead of the coil being positioned as low as possible in the hot water storage tank as in the prior art, the lower heat exchanger 120 in the present improved heating and ventilation system is extended upwardly so that it traverses the lower half of the hot water storage tank, thus making the lower half of the tank available as a potential source of energy to the air handling unit and therefore to the dwelling house via the ventilation air, without affecting the hot water in the top half of the tank. However, when there is a draw on the hot water from the hot water storage tank, cold water is introduced to the bottom of the hot water storage tank. This reduces the store of energy available to the air handling unit 13 and therefore the ventilation air. The system 100 also includes a pump 20 for circulating heat transfer fluid through the heating and ventilation system; four motorised valves 21, 22, 23 and 24 operated by respective motors MV1, MV2, MV3 and MV4 which are controlled by the controller 12. The pump 20 is mounted in a vertical position. The system also includes a non-return valve 25 as well as two expansion vessels 30, 31, each of which has a capacity of 18L. Associated with the hot water storage tank 11 are a thermostatic mixing valve 112 as well as a feed line thermostat 110 on the feed line (pipeline 102) carrying heat transfer fluid into the hot water storage tank 11 and a return line thermostat 111 on the return line (pipeline 103) through which fluid flows out from the hot water storage tank 11. Also included in the system 100 are pipelines through which fluid may flow to and from the solar panels and electrical wiring leading to and from the controller 12 to the various elements of the system 100 as shown in Figures 1 to 4.

In a first operating mode of the system shown, the system is configured so that the solar panels 10 deliver energy to the hot water storage tank, only, as illustrated in Figure 1.

Solar energy is used to heat the solar panels 10 which in turn heats fluid in the solar panel housing (not shown). This heated fluid is drawn along the pipeline 101, in the direction of the arrows as shown in Figure 1. In the first operating mode in which energy is delivered to the hot water storage tank 11 only, the non-return valve 25 and the motorised valves 21 and 24 are all in the closed position. Therefore, all of the heat carried by the heat transfer fluid from the solar panels is led through the feed line 102 having the thermostat 110 provided thereon and passed through lower heat exchanger 120 in the hot water storage tank 11.

The heat is transferred to the water in the hot water storage tank 11 and cooler fluid is led through the return feed line 103 coming from the hot water storage tank 11 and is pumped back to the solar panels 10 in the return pipeline 103 with the non-return valve 25 in the closed position and the motorised valve 22 in the open position. The fluid passes the expansion vessels 30, 31 provided at this location in the pipelines so as to allow release of air from the expansion vessels by venting to atmosphere, if required. The fluid then flows by thermostat 42 which sends a signal to the controller 12 for control of the pump 20. The pipeline thermostat 42 is set at 90°C. Thus, if the pipeline thermostat 42 detects that the temperature of the fluid in the line is more than 90°C, a feedback control loop operates whereby a signal is sent to the controller 12, which in turn sends a signal to the pump 20 and then the pump 20 will be shut off and flow will cease so that no more heat is drawn into the system from the solar panels 10. If the temperature is less than 90°C, the fluid continues to be pumped along the pipeline and with the motorised valve 23 in an open position and motorised valve 24 in the closed position as shown, the fluid flows through the motorised valve 23 back to the solar panels 10.

Referring now to Figure 2, the heating and ventilating system 100 is shown operating in a second mode in which the solar panels deliver energy to both the hot water storage tank 11 and the air handling unit 13. Heat transfer fluid is pumped from the solar panels 10 along feed line 101 and since in this operating mode, the motorised valve 21 is closed, the heat transfer fluid flows into the hot water storage tank 11 along feed pipeline 102, passing by thermostat 110 and through the heat exchanger 120 in the lower half of the hot water storage tank. The heat energy from the heat transfer fluid is used to heat the water in the hot water storage tank 11. From the heat exchanger 120, the heat transfer fluid flows out from the hot water storage tank 11, past the return thermostat 111 on the

pipeline 103. The motorised valve 22 is closed but the non-return valve 25 is open and therefore the heat transfer fluid flows through non-return valve 25, and along pipeline 104 into the air handling unit comprising the air handling unit 13. In the air handling unit 13, the heat transfer fluid is used to heat air, by means of the heat exchangers 14, 15, which can be distributed throughout the house/premises.

Heat transfer fluid is pumped along the return line 105 from the air handling unit 13, passing the pipeline thermostat 41 which sends a signal to the controller for control of the motorised valve 21. The pipeline thermostat 41 is set at 50°. If the pipeline thermostat 41 detects that the temperature of the fluid along pipeline 105 is at a temperature higher than 50°C, then a signal will be sent from the thermostat 41 to the controller 12 which will result in the controller 12 sending a signal to the motor MV1, causing the motorized valve 21 to close (if the motorized valve 21 is not already closed in the configuration of the system in a particular operating mode).

Located along the pipeline 105 are two expansion vessels provided at this location in the pipelines so as to allow release of air from the expansion vessels by venting to atmosphere, if required. The fluid then flows past thermostat 42 which sends a signal to the controller 12 for control of the pump 20. The pipeline thermostat 42 is set at 90°C. Thus, if the pipeline thermostat 42 detects that the temperature of the fluid in the line is more than 90°C, then the pump will be shut off and flow will cease so that no more heat is drawn into the system from the solar panels 10. If the temperature is less than 90°C, the fluid continues to be pumped along the pipeline and with the motorised valve 23 in an open position and motorised valve 24 in the closed position as shown, the fluid flows through the motorised valve 23 back to the solar panels 10.

Having the system 100 operating in the mode illustrated in Figure 2 and as described above has the benefit of providing for the hot water storage tank 11 to deliver energy to the air handling unit 13, at night, to enable dissipation of excess heat in the system from the hot water storage tank.

Referring now to Figure 3, the heating and ventilating system 100 is shown operating in a third mode in which the solar panels deliver energy to the air handling unit only. Heat transfer fluid flows along feed pipeline 101 from the solar panels 10 and in this mode, the motorised valve 21 is in the open position, so that the heat transfer fluid flows in the

direction of the arrows through motorised valve 21 and along the pipeline 104 directly into the air handling unit 13.

Heat transfer fluid is pumped along the return pipeline 105 from the air handling unit 13 passing the pipeline thermostat 41 which sends a signal to the controller for control of the motorised valve 21 (feedback control loop). The pipeline thermostat 41 is set at 50°. If the pipeline thermostat 41 detects that the temperature of the fluid along pipeline 105 is at a temperature higher than 50°C, then a signal will be sent from the thermostat 41 to the controller 12 which will result in the controller 12 sending a signal to the motor MV1 and causes the motorised valve 21 to close so that heat transfer fluid cannot flow directly to the air handling unit 13 without having passed through the heat exchanger 120 in the hot water cylinder 11. If this happens and motorised valve 21 is closed, then the operating mode would be as shown in Figure 2.

Located along the pipeline 105 are two expansion vessels provided at this location in the pipelines so as to allow release of air from the expansion vessels by venting to atmosphere, if required. The fluid then flows past thermostat 42 which sends a signal to the controller 12 for control of the pump 20. The pipeline thermostat 42 is set at 90°C. Thus, if the pipeline thermostat 42 detects that the temperature of the fluid in the line is more than 90°C, then the pump will be shut off and flow will cease so that no more heat is drawn into the system from the solar panels 10. If the temperature is less than 90°C, the fluid continues to be pumped along the pipeline and with the motorised valve 23 in an open position and motorised valve 24 in the closed position as shown, the fluid flows through the motorised valve 23 back to the solar panels 10.

Referring now to Figure 4, the heating and ventilating system 100 is shown operating in a fourth mode in which energy is delivered from the hot water storage tank 11 to the air handling unit 13 only, i.e. no energy is drawn from the solar panels 10. Thus, in the present invention, the lower half of the hot water storage tank is used as a thermal store to provide stored solar energy to the air handling unit (ventilation unit), at night. Supplying solar energy directly to the air handling unit ensures that the solar panels can provide energy to the system even with very low levels of solar irradiation or diffuse sun light without affecting the substantial amount of hot water available in the top section of the hot water tank or even the lower half of the tank. A similar situation arises when the hot water

storage tank is at a temperature higher than that available from the solar panels but the solar panel temperature is still viable to deliver energy directly to the air handling unit.

In the fourth operating mode, all three motorised valves, 21, 22 and 23 are in the closed position but the motorised valve 24 is in the open position as shown. Warm heat transfer fluid flows out from the hot water storage tank 11 through pipeline 103, passing the line thermostat 111. The warm fluid flows in the direction of the arrows, into the air handling unit 13. Cooler fluid flows from the air handling unit 13 along the return pipeline 104 passing the thermostat 41, the expansion vessels 30, 31, the thermostat 42 and the pump 20. Since motorised valve 23 is closed and the motorized valve 24 is open, the fluid is returned in the direction of the arrows back to the hot water storage tank 11 and the loop is repeated.

Referring to Figure 5, a preferred embodiment of the piping/valves arrangement is shown whereby the piping and valves are assembled onto the hot water storage tank. However, the piping/valves arrangement can also be supplied on a pre-assembled board (not shown) for convenience, set up, for instance, as shown in Figure 6. As a further alternative, the arrangement of pipe work valves can also be assembled *in situ* to suit the confines of a particular installation.

With reference to the controller, there are a number of proprietary differential controllers available which are designed to support a multitude of arrangements and configuration of solar panels, heat stores and boilers but they do not provide the flexibility necessary to control the arrangement and multiplicity of operating modes described above. Hence, the controller 12 is especially adapted and configured to implement the specific control algorithms required to control the heating and ventilating system of the present invention. Thus, the heating and ventilating system of the invention provides an "intelligent" system which includes feedback control loops as indicated above, and multiple operating modes so as to maximise the efficiency of the solar panels.

The configuration of the pipe work, valves and thermostats connecting the solar panels, 10, the hot water storage tank 11 and the air handling unit 13 allows the high performance solar panels 10 to deliver the heat transfer fluid, which may be at a temperature as high as 140°C, at a more moderate and acceptable temperature of 60°C to the air handling unit 13. The control strategy is designed to limit the temperature of the heat transfer fluid to the

air handling unit. The hot water storage tank also acts as a solar thermal store allowing solar energy to be delivered to the house via the air handling unit 13 at a deferred time. This complex arrangement of pipe work and control devices facilitates the many modes of operation to ensure the maximum possible yield of solar energy.

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It will of course be understood that the invention is not limited to the specific details herein described, which are given by way of example only, and that various modifications and alterations are possible within the scope of the invention as defined in the appended claims.

CLAIMS:

1. A heating and ventilating system comprising one or more solar panel means for absorbing and collecting energy from the sun during daylight hours and transferring the energy to fluid, a pump for pumping the fluid through the system, an air handling unit for providing heated air and distributing said air throughout a house or premises; a control means which provides a means for co-ordinating and controlling all the components and functions of the system; and an air distribution system which allows heat to be distributed throughout a house via a network of conduits, wherein the air handling unit comprises a heat exchanger and means for forcing the heated fluid through the heat exchanger and means for forcing warm air emerging from the heat exchanger to flow around the house/premises, characterised in that the system includes a hot water storage tank for providing heated water to a hot water supply system, the hot water storage tank comprising a heat exchanger which is adapted to be supplied with heated fluid from the solar panel means and wherein the hot water storage tank is configured to act as a thermal buffer so as to store energy which can be supplied to the air handling unit, when required, and in which the air distribution system is operable to function as a heat leak so as to prevent overheating of the solar panel means when there is insufficient hot water demand.

2. A heating and ventilating system as claimed in Claim 1, in which the heat exchanger is located in a lower portion of the hot water tank.

3. A heating and ventilating system as claimed in Claim 2, in which the heat exchanger extends transversely across substantially the width of the tank.

4. A heating and ventilating system as claimed in Claim 2 or Claim 3, in which the heat exchanger occupies substantially the lower half of the hot water storage tank.

5. A heating and ventilating system as claimed in any one of the preceding claims, in which the heat exchanger extends longitudinally along approximately the lower half of the hot water storage tank.

6. A heating and ventilating system as claimed in any one of the preceding claims, in which the system is configured to operate in a plurality of operating modes wherein

in a first operating mode, the solar panel means delivers energy to the hot water storage tank only,

in a second operating mode, the solar panel means delivers energy to the hot water storage tank and the air handling unit,

in a third operating mode, the solar panels means delivers energy to the air handling unit only; and

in a fourth operating mode, the hot water storage tank delivers energy to the air handling unit only.

7. A heating and ventilating system as claimed in Claim 6, which includes a plurality of motorised valves, the operation of which is controlled by the control means to provide the desired operating mode.

8. A heating and ventilating system as claimed in Claim 7, in which the motorised valves and associated piping are pre-assembled about the hot water storage tank.

9. A heating and ventilating system as claimed in Claim 7, in which the motorised valves and associated piping are pre-assembled onto a separate mounting board.

10. A heating and ventilating system substantially as herein described with reference to and as shown in the accompanying drawings.

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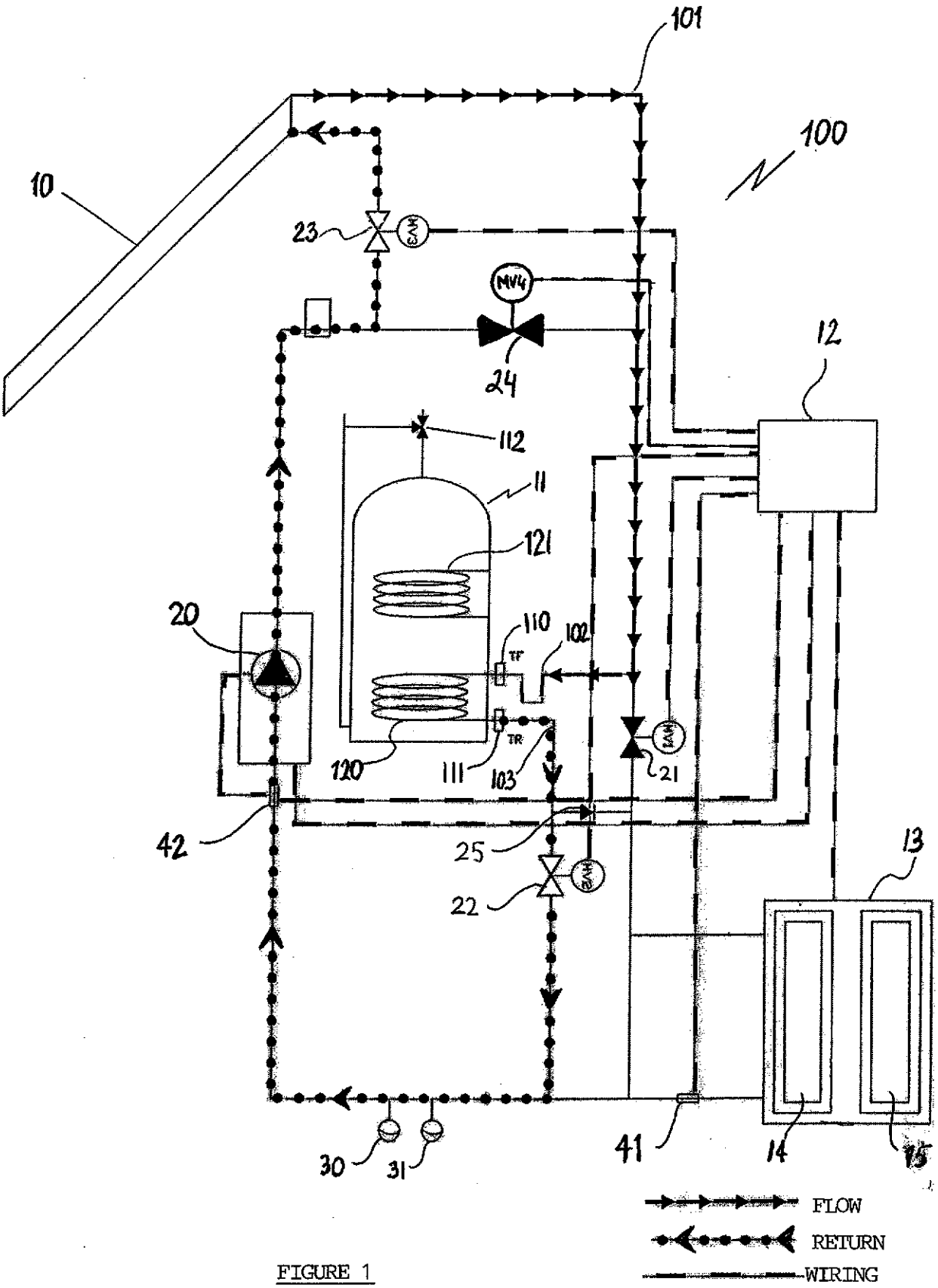

101
100
10
23
MV3
MV4
24
12
112
11
121
20
110
102
TP
TR
120
111
103
MV2
21
42
25
22
13
30
31
41
14
15
FLOW
RETURN
WIRING

FIGURE 1

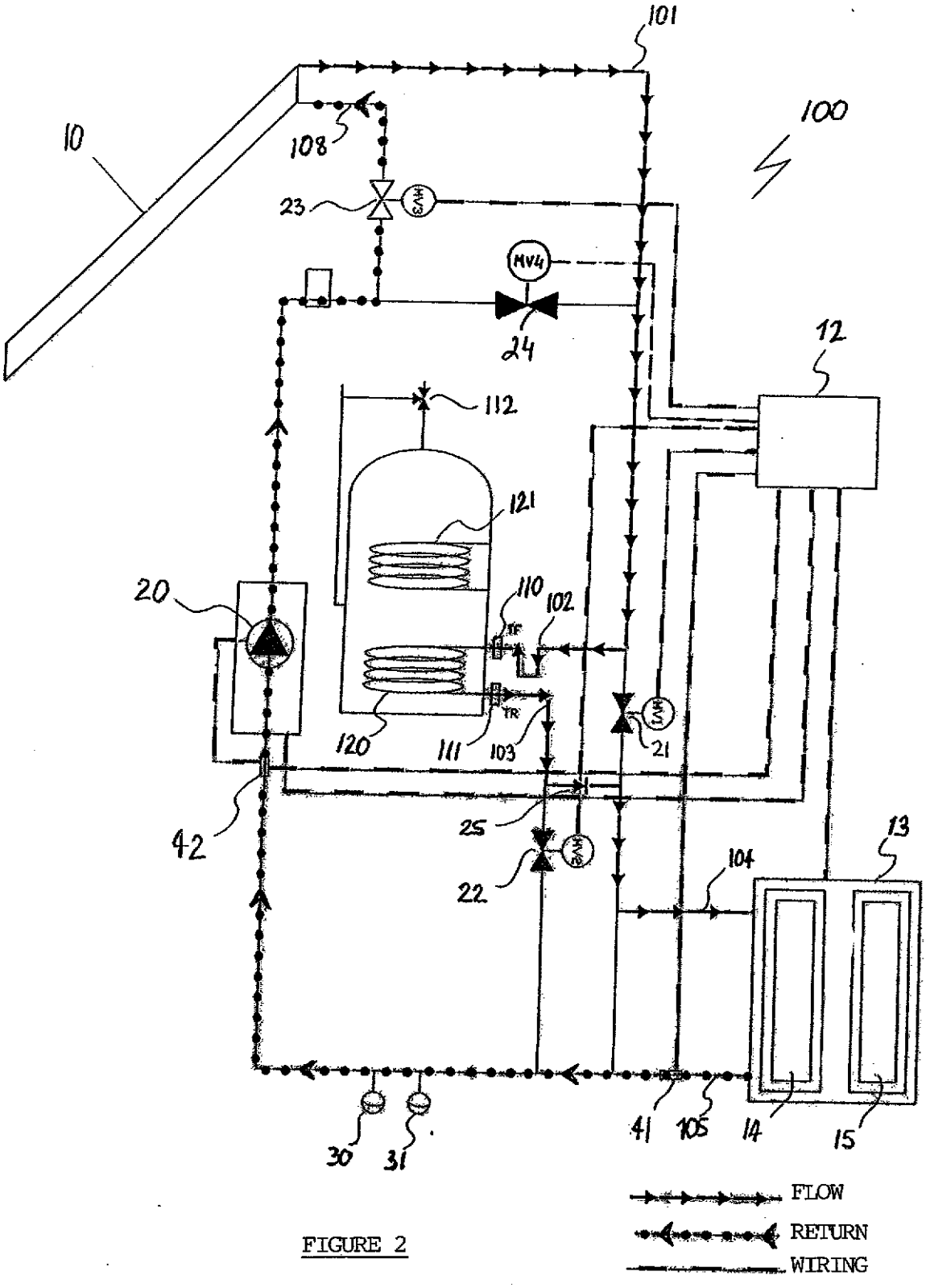

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MV3
MV4
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20
110
102
TP
TR
120
111
103
MV1
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MV2
22
104
13
30
31
41
105
14
15
FLOW
RETURN
WIRING

FIGURE 2

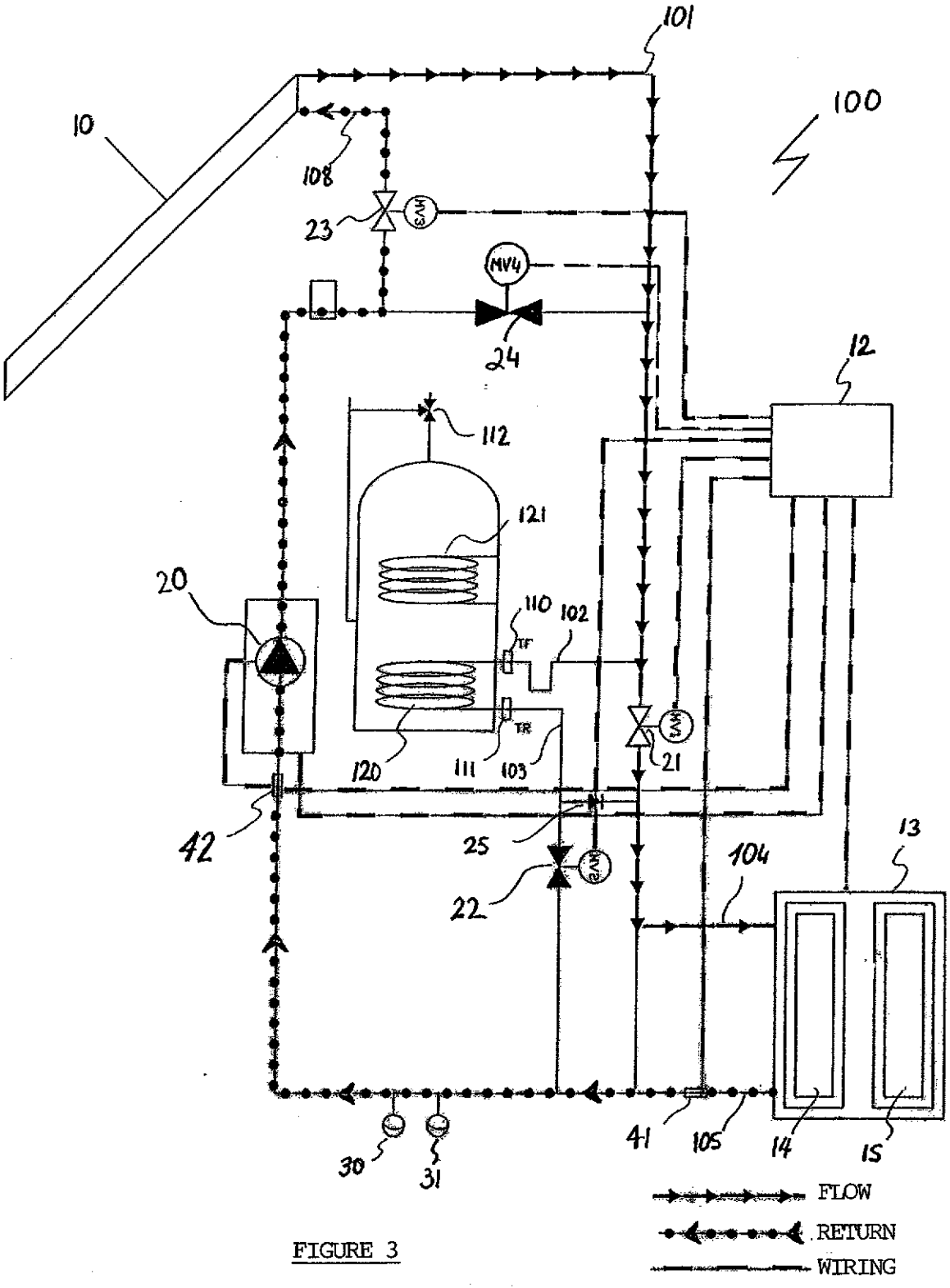

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100
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MV3
MV4
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20
110
102
TF
TR
120
111
103
MV1
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MV2
22
104
13
41
105
14
15
30
31
FLOW
RETURN
WIRING

FIGURE 3

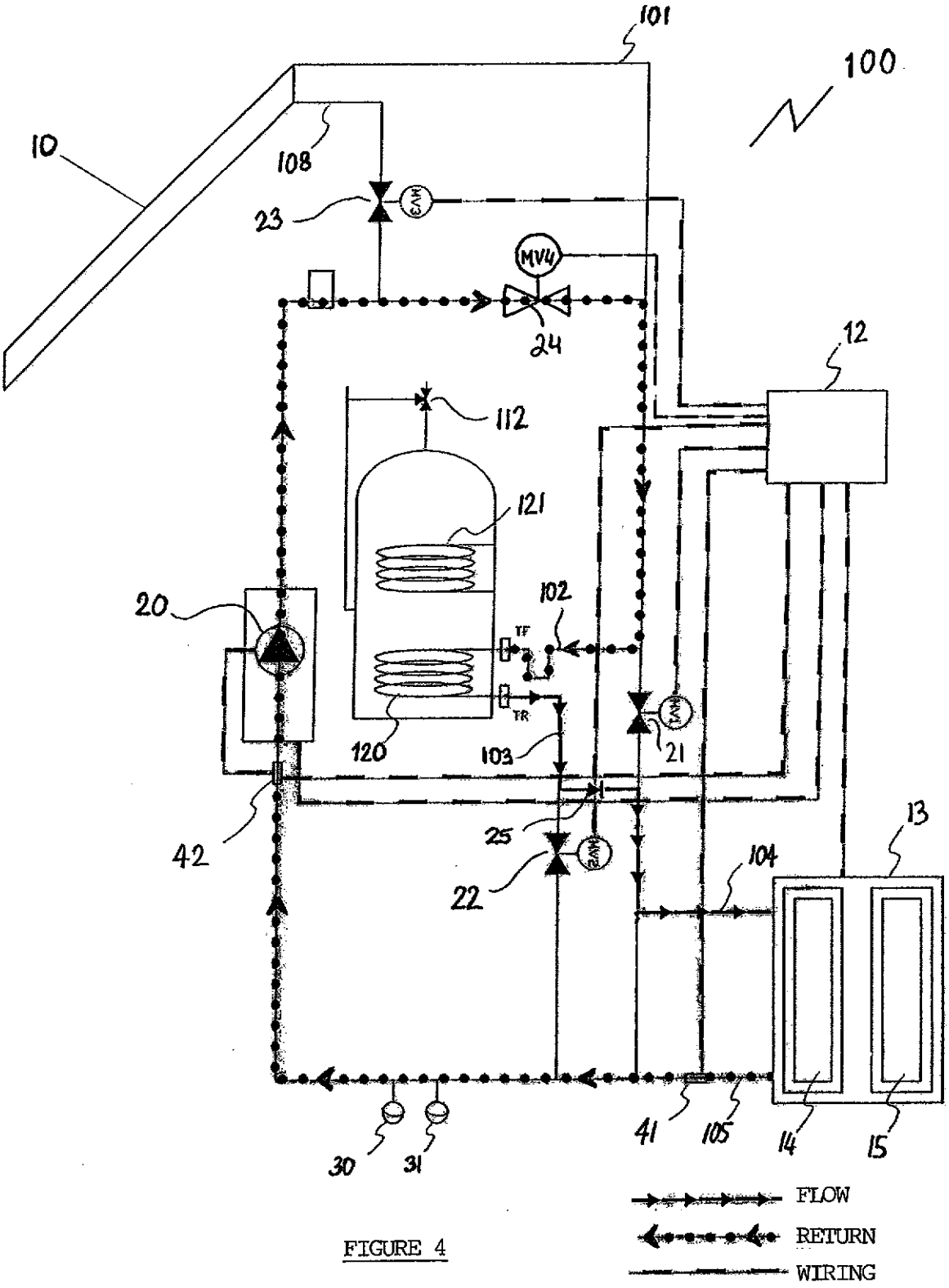

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MV3
MV4
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20
102
TF
TR
120
103
MV2
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25
22
13
104
41
105
14
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30
31
FLOW
RETURN
WIRING

FIGURE 4

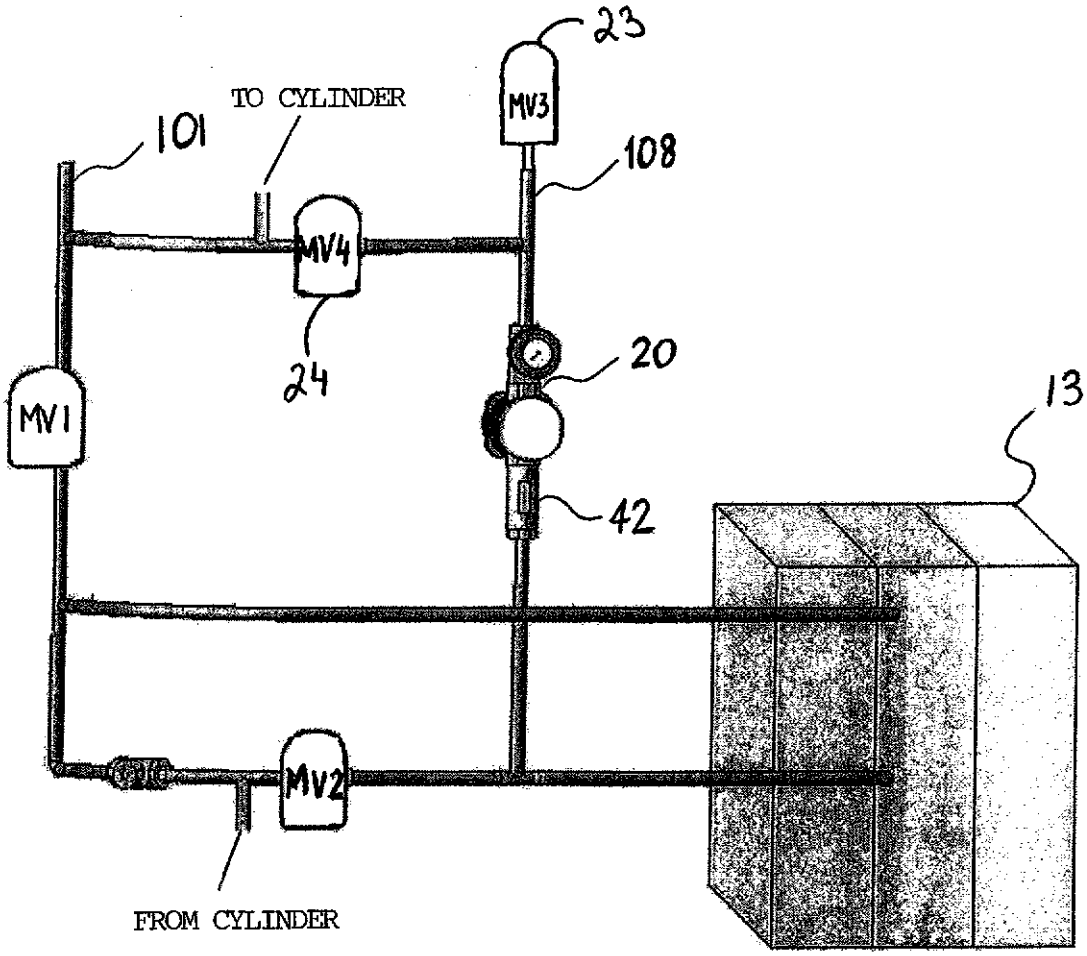

23
TO CYLINDER
MV3
101
108
MV4
24
20
MV1
13
42
MV2
FROM CYLINDER

FIGURE 5

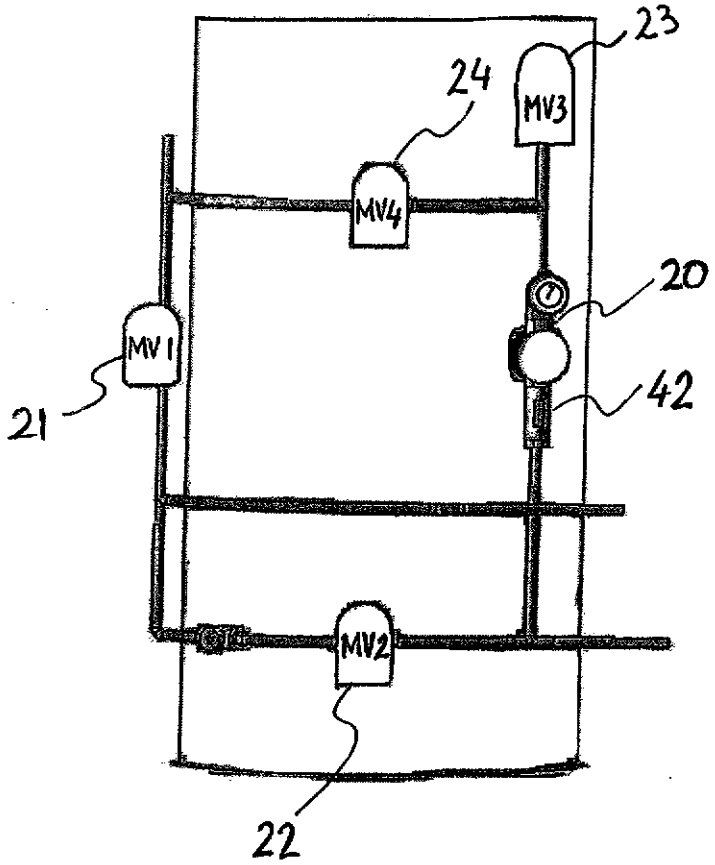


FIGURE 6