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(54) Title: A COMBINED HEATING AND COOLING CIRCUIT

(57) Abstract: A combined heating and cooling circuit (1) comprises a heat source circuit (5) for supplying a heat load, and a heat sink circuit (6) for providing chilling. A refrigeration unit (2) sinks heat from the heat sink circuit (6), and waste heat from the refrigeration unit (2) is transferred to the heat source circuit (5). The waste heat from the refrigeration unit (2) is buffered through a first storage vessel (9) to the heat source circuit (5). Heat from the heat sink circuit (6) is sunk to the refrigeration unit (2) through a second storage vessel (18). First and second compensating circuits (32, 33) are provided for sinking heat from the first storage vessel (9) to a geothermal reservoir (35), and for transferring heat from the geothermal reservoir (35) to the second storage vessel (18), in order to balance the heat being sunk to the refrigeration unit (2) with the heat being drawn from the refrigeration unit (2), so that the heat source circuit (5) and the heat sink circuit (6) are operable independently of each other.
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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
"A combined heating and cooling circuit"

The present invention relates to a combined heating and cooling circuit and to a method for operating a combined heating and cooling circuit.

Combined heating and cooling circuits are known, and in general, such heating circuits comprise a refrigeration circuit wherein a cooling load is connected to the heat sinking input of the refrigeration circuit, and a heat load is connected to the waste heat output of the refrigeration circuit. In this way the refrigeration circuit provides cooling or chilling, and the waste heat from the refrigeration circuit is harnessed for space heating, or other heating. However, the problem with such combined heating and cooling circuits is that the heating side of the refrigeration circuit cannot be controlled independently of the cooling side, and vice versa. In other words, if a high chilling load is being catered for, the waste heat output will be high and vice versa. Various circuits have been proposed to overcome this problem, however, all such circuits tend to be relatively complex, and furthermore, the degree of independent control of the respective heating and cooling sides of the refrigeration circuit is limited.

There is therefore a need for a combined heating and cooling circuit which overcomes this problem.

The present invention is directed towards providing such a combined heating and cooling circuit and to a method for operating a combined heating and cooling circuit.

According to the invention there is provided a combined heating and cooling circuit comprising a heat source circuit for supplying a heat load, a heat sink circuit for sinking heat for supplying a cooling or chilling load, a refrigeration circuit having a heat sinking input and a waste heat output, a first buffer circuit for transferring and buffering heat from the waste heat output of the refrigeration circuit to the heat source circuit, a second buffer circuit for sinking and buffering heat from the heat sink circuit to the heat sinking input of the refrigeration circuit, and a compensating
circuit for communicating with a thermal mass at a datum temperature for selectively
sinking heat from the first buffer circuit to the thermal mass and transferring heat to
the second buffer circuit from the thermal mass for thermally balancing the heat
being sunk to the heat sinking input of the refrigeration circuit with the waste heat
being drawn from the waste heat output, so that the respective temperatures of the
heat source circuit and the heat sink circuit are controllable independently of each
other.

Preferably, the datum temperature of the thermal mass is at a temperature
intermediate the desired operating temperatures of the heat source circuit and the
heat sink circuit.

In one embodiment of the invention a control means is provided for controlling the
compensating circuit in response to the temperatures of the heat sink circuit and the
heat source circuit.

In another embodiment of the invention the first buffer circuit comprises a first
storage vessel for storing heat transfer medium, and a first primary heat transfer
means for transferring heat to the first storage vessel from the waste heat output of
the refrigeration circuit.

Preferably, the first primary heat transfer means comprises a first primary heat
transfer circuit, and a first primary circulating means located in the first primary heat
transfer circuit for circulating heat transfer medium between the first storage vessel
and the waste heat output of the refrigeration circuit for transferring heat from the
waste heat output of the refrigeration circuit to the first storage vessel.

Advantageously, the first buffer circuit comprises a first secondary heat transfer
circuit and a first secondary circulating means for circulating heat transfer medium
between the first storage vessel and the heat source circuit for transferring heat from
the first storage vessel to the heat source circuit.
In one embodiment of the invention the second buffer circuit comprises a second storage vessel for storing heat transfer medium, and a second primary heat transfer means for sinking heat from the second storage vessel to the heat sinking input of the refrigeration circuit.

Preferably, the second primary heat transfer means comprises a second primary heat transfer circuit and a second primary circulating means located in the second primary heat transfer circuit for circulating heat transfer medium between the second storage vessel and the heat sinking input of the refrigeration circuit for sinking heat from the second storage vessel to the heat sinking input of the refrigeration circuit.

Advantageously, the second buffer circuit comprises a second secondary heat transfer circuit and a second secondary circulating means for circulating heat transfer medium between the second storage vessel and the heat sink circuit for sinking heat from the heat sink circuit to the second storage vessel.

In one embodiment of the invention the compensating circuit comprises a first compensating circuit and a first compensating circulating means located in the first compensating circuit for circulating heat transfer medium between the first storage vessel and the thermal mass for sinking heat from the first storage vessel to the thermal mass when the chilling load demand on the heat sink circuit exceeds the heat load demand on the heat source circuit.

In another embodiment of the invention the compensating circuit comprises a second compensating circuit and a second compensating circulating means located in the second compensating circuit for circulating heat transfer medium between the second storage vessel and the thermal mass for transferring heat from the thermal mass to the second storage vessel when the heat load demand on the heat source circuit exceeds the chilling load demand on the heat sink circuit.

In one embodiment of the invention the first and second compensating circuits are interconnected by a valve means, the valve means being operable for preventing
circulation of heat transfer medium between the first and second compensating circuits when heat transfer medium is being circulated in one of the first and second compensating circuits.

In another embodiment of the invention the control means selectively operates the first and second compensating circulating means one at a time for selectively transferring heat between the corresponding one of the first and second storage vessels and the thermal mass in response to the temperature of the heat source and heat sink circuits.

In one embodiment of the invention the compensating circuit comprises a large earth-contact tubing array through which heat transfer medium is circulated for maintaining the temperature of the heat transfer medium in the tubing array at approximately the average annual earth temperature of the locality.

Preferably, the earth-contact tubing array is buried in the earth.

Alternatively, the compensating circuit comprises a heat exchanger through which heat transfer medium is circulated, the heat exchanger being located in a substantial body of water appropriately sized for maintaining heat transfer medium circulating in the heat exchanger at approximately the average annual temperature of the locality.

In one embodiment of the invention the thermal mass is a geothermal reservoir.

In one embodiment of the invention the compensating circuit is operable for transferring heat to the first storage vessel from the thermal mass for subsequent transfer to the heat source circuit for providing direct heat transfer from the thermal mass to the heat source circuit for supplying the heating demand on the heat source circuit.

In another embodiment of the invention the compensating circuit is operable for sinking heat from the second storage vessel to the thermal mass for in turn sinking
heat from the heat sink circuit to the second storage vessel for providing the chilling load on the heat sink circuit by sinking heat from the heat sink circuit to the thermal mass.

Additionally the invention provides a method for operating a combined heating and cooling circuit wherein the circuit comprises a heat source circuit for supplying a heat load, a heat sink circuit for sinking heat for supplying a cooling or chilling load, a refrigeration circuit having a heat sinking input and a waste heat output, a first buffer circuit for transferring and buffering heat from the waste heat output of the refrigeration circuit to the heat source circuit, a second buffer circuit for sinking and buffering heat from the heat sink circuit to the heat sinking input of the refrigeration circuit, and a compensating circuit for communicating with a thermal mass at a datum temperature for selectively sinking heat from the first buffer circuit to the thermal mass and transferring heat to the second buffer circuit from the thermal mass for thermal balancing the heat being sunk to the heat sinking input of the refrigeration circuit with the waste heat being drawn from the waste heat output, so that the respective temperatures of the heat source circuit and the heat sink circuit are controllable independently of each other, the method comprising the step of operating the compensating circuit for sinking heat from the first buffer circuit to the thermal mass when the cooling demand on the heat sink circuit relative to the heating demand on the heat source circuit causes the waste heat from the waste heat output of the refrigeration circuit to exceed the heat demand on the heat source circuit for controlling the heat output of the heat source circuit, and for transferring heat to the second buffer circuit from the thermal mass when the heating demand on the heat source circuit relative to the cooling demand on the heat sink circuit causes the heat being sunk to the heat sinking input of the refrigeration circuit to exceed the cooling demand of the heat sink circuit for controlling the heat sinking action of the heat sink circuit.

The advantages of the invention are many. A particularly important advantage of the invention is that it allows a refrigeration circuit to provide both heating and cooling simultaneously, while at the same time permitting simultaneous control of the heat...
output from the heat source circuit and heat sinking to the heat sink circuit independently of each other, without affecting the efficient operation of the refrigeration circuit. The provision of the thermal mass at a datum temperature, and the provision of the compensating circuit for communicating the first and second buffer circuits with the thermal mass permits independent control of the respective heat source circuit and heat sink circuit. The provision of the thermal mass as a geothermal reservoir provides a stable thermal mass, at a substantially constant temperature throughout the year. Additionally, the provision of the thermal mass as a geothermal reservoir permits any thermal imbalance in the refrigeration circuit to be readily easily compensated for by transferring heat to or sinking heat from the appropriate one of the first and second storage vessels from or to the geothermal reservoir. Additionally, the provision of the thermal mass as a geothermal reservoir allows the refrigeration circuit to operate at peak efficiency by minimising the thermodynamic lift. Indeed, in certain cases, the combined heating and cooling circuit can be operated with the refrigeration circuit shut down, in which case the compensating circuit is operated for transferring heat from the thermal mass to the first buffer circuit, for transfer to the heat source circuit for supplying the heating demand on the heat source circuit; and the compensating circuit is operated for sinking heat from the second buffer circuit to the thermal mass, for sinking heat from the heat sink circuit for supplying the chilling demand on the heat sink circuit.

The provision of the thermal mass as a geothermal reservoir provides a particularly efficient and cost-effective thermal mass, and the provision of the large earth-contact tubing array facilitates efficient transfer and sinking of heat between the thermal mass and the first and second storage vessels. The provision of the heat exchanger located in a reservoir comprising a large body of water also facilitates efficient transfer and sinking of heat between the thermal mass and the first and second storage vessels.

The invention will be more clearly understood from the following description of a preferred embodiment thereof, which is given by way of example only, with reference to the accompanying drawings, in which:
Fig. 1 is a circuit diagram of a combined heating and cooling circuit according to the invention, and

Fig. 2 is a circuit diagram of a portion of the circuit of Fig. 1.

Referring to the drawings, there is illustrated a combined heating and cooling circuit according to the invention indicated generally by the reference numeral 1, in which the heat output and the heat sinking of the combined heating and cooling circuit 1 are independently controllable relative to each other. The circuit 1 comprises a refrigeration unit 2 having a heat sinking input 3 for sinking heat into the refrigeration unit 2 for cooling and chilling, and a waste heat output 4 for discharging waste heat from the refrigeration unit 2. A heat source circuit 5 supplies a heat load, such as space heating or other such heat load. A heat sink circuit 6 is provided for sinking heat for providing cooling or chilling, for example, for providing cooling or chilling in an air conditioning unit or the like, or for chilling or cooling an area, such as, for example, a food storing area of a building or the like.

A first buffer circuit 7 for transferring and buffering heat from the waste heat output 4 of the refrigeration unit 2 to the heat source circuit 5 comprises a first storage vessel 9 for storing heated heat transfer medium from which heat is transferred to the heat source circuit 5. A first primary heat transfer means comprising a first primary heat transfer circuit 10 transfers waste heat from the waste heat output 4 of the refrigeration unit 2 through the heat transfer medium into the first storage vessel 9. A first primary circulating means provided by a first primary circulating pump 11 in the first primary heat transfer circuit 10 circulates heat transfer medium through the first primary heat transfer circuit 10 between the waste heat output 4 of the refrigeration unit 2 and the first storage vessel 9.

A first secondary heat transfer circuit 14 transfers heat through the heat transfer medium from the first storage vessel 9 to the heat source circuit 5. A first secondary circulating pump 15 located in the first secondary heat transfer circuit 14 circulates
the heat transfer medium through the first secondary heat transfer circuit 14 between the first storage vessel 9 and the heat source circuit 5. In this embodiment of the invention the heat transfer medium is water, and the first storage vessel 9 is a direct storage vessel so that the same heat transfer medium is circulated through the respective first primary and first secondary heat transfer circuits 10 and 14, respectively.

A second buffer circuit 17 for sinking and buffering heat from the heat sink circuit 6 to the heat sinking input 3 of the refrigeration unit 2 comprises a second storage vessel 18, which is a direct storage vessel and is similar to the first storage vessel 9. A second primary heat transfer means, namely, a second primary heat transfer circuit 19, and a second primary circulating means, namely, a second primary circulating pump 20 located in the second primary heat transfer circuit 19 circulates heat transfer medium between the second storage vessel 18 and the heat sinking input 3 of the refrigeration unit 2 for sinking heat from the second storage vessel 18 to the heat sinking input 3 of the refrigerator. In this embodiment of the invention heat exchange medium is the same heat exchange medium, which is used in the first storage vessel 9, as will be explained in more detail below. The second primary heat transfer circuit 19 and the second primary circulating pump 20 are similar to the first primary heat transfer circuit 10 and the first primary circulating pump 11, respectively.

A second secondary heat transfer means, namely, a second secondary heat transfer circuit 22 and a second secondary circulating means, namely, a second secondary circulating pump 23 located in the second secondary heat transfer circuit 22 circulates the heat transfer medium between the second storage vessel 18 and the heat sink circuit 6 for sinking heat from the heat sink circuit 6 to the second storage vessel 18. The second secondary heat transfer circuit 22 and the second secondary circulating pump 23 are similar to the first secondary heat transfer circuit 14 and first secondary circulating pump 15, respectively.

Returning to the refrigeration unit 2, and referring in particular to Fig. 2, the
refrigeration unit 2 comprises a conventional refrigeration circuit 25 having a hot coil 26 from which waste heat is delivered, and a cold coil 27 to which heat is sunk. A first heat exchanger 28 at the waste heat output 4 of the refrigeration unit 2 transfers waste heat from the hot coil 26 into the heat transfer medium circulating in the first primary heat transfer circuit 10. A second heat exchanger 29 in the heat sinking input 3 sinks heat from the heat transfer medium circulating in the second primary heat transfer circuit 19 to the cold coil 27. Accordingly, heat from the heat sink circuit 6 is sunk and buffered to the cold coil 27 of the refrigeration circuit 25 through the second secondary heat transfer circuit 22, the second storage vessel 18 and the second primary heat transfer circuit 19. Heat is transferred and buffered from the hot coil 26 of the refrigeration circuit 25 to the heat source circuit 5 through the first primary heat transfer circuit 10, the first storage vessel 9 and the first secondary heat transfer circuit 14. Accordingly, the circuit 1 acts as a combined heating and cooling circuit for simultaneously heating and cooling, the heat source circuit 5 providing the heating, and the heat sink circuit 6 providing the cooling.

However, in order that the heat source circuit 5 can operate independently of the heat sink circuit 6, and vice versa, without affecting the heat balance of the refrigeration unit 2, a compensating circuit 30 is provided. The compensating circuit 30 comprises first and second heat compensating circuits 32 and 33, respectively, which communicate the first and second storage vessels 9 and 18, respectively, with a thermal mass, which in this embodiment of the invention is provided by a geothermal reservoir 35, which will be described below. First and second compensating circulating means, namely, first and second compensating circulating pumps 38 and 39 located in the first and second compensating circuits 32 and 33, respectively, selectively circulate the heat exchange medium between the first and second storage vessels 9 and 18, and the geothermal reservoir 35. A valve means comprising first and second non-return valves 42 and 43 are located in the first and second compensating circuits 32 and 33, respectively, so that when only one of the first and second compensating circulating pumps 38 and 39 is operating, heat transfer medium is only circulated in the corresponding one of the first and second compensating circuits 32 and 33, and no circulation of the heat transfer medium
takes place in the other of the first and second compensating circuits 32 and 33, and
furthermore, there is no danger of heat transfer medium being drawn directly from
one of the first and second compensating circuits 32 and 33 to the other.

The geothermal reservoir 35 may be provided by an array of heat exchange tubes,
through which the heat exchange medium would be circulated by the first and
second compensating circuits 32 and 33. The array of heat exchange tubes would
be buried deep in the earth at a level where the temperature of the earth remains
substantially at the average annual temperature of the locality. In this way the
geothermal reservoir 35 would establish a datum temperature for the heat transfer
medium, similar to the average annual temperature which would lie between the
operating temperature at which heat is outputted from the heat source circuit 5 and
the operating temperature at which heat is sunk into the heat sink circuit 6.
Alternatively, the geothermal reservoir may be provided by a plate heat exchanger
located in a relatively large water reservoir. The heat transfer medium would be
circulated through the plate heat exchanger by the first and second compensating
circuits 32 and 33. The size of the water reservoir would be such that the water in
the reservoir would remain substantially at the average annual temperature of the
locality for similarly establishing a datum temperature for the heat transfer medium
similar to the average annual temperature.

In both cases the array of heat exchange tubes and the plate heat exchanger would
be sized in order to bring the temperature of the heat transfer medium to the datum
temperature prior to being returned to the first and second compensating circuits 32
and 33 from the array of heat exchange tubes or from the plate heat exchanger as
the case may be.

Accordingly, when the heat load being drawn from the heat source circuit is greater
than the cooling load being sunk by the heat sink circuit 6, heat from the geothermal
reservoir 35 is transferred to the second storage vessel 18 through the second
compensating circuit 33 for balancing the heat being sunk into the heat sinking input
3 of the refrigeration unit 2 with the heat being drawn from the waste heat output 4 of
the refrigeration unit 2, thereby permitting the heat load being supplied by the heat source circuit 5 to be greater than the chilling load being sunk by the heat sink circuit 6 so that the heat source circuit 5 and the heat sink circuit 6 can operate independently of each other. Alternatively, where the chilling load being sunk by the heat sink circuit 6 is greater than the heat load being supplied by the heat source circuit 5, heat is sunk from the first storage vessel 9 to the geothermal reservoir 35 through the first compensating circuit 32, thereby balancing the waste heat being outputted from the waste heat output 4 of the refrigeration unit 2 with the heat being sunk into the heat sinking input 3 of the refrigeration unit 2, thereby similarly permitting the heat sink circuit 6 and the heat source circuit 5 to be operated independently of each other.

An electronic control circuit 40 controls the operation of the first and second compensating circulating pumps 38 and 39, as well as the first primary and secondary circulating pumps 11 and 15 and the second primary and secondary circulating pumps 20 and 23, and also the refrigeration circuit 25 for controlling the operation of the circuit 1. Temperature sensors 45 located in the heat source circuit 5 and the heat sink circuit 6, as well as in the first and second storage vessels 9 and 18 and in the first and second heat exchangers 28 and 29 are read by the control circuit 40, which in turn operates the respective circulating pumps in response to the temperatures read.

An internal control circuit (not shown) in the refrigeration unit 2 controls the operation of the refrigeration circuit 25 by controlling either the temperature at the heat sinking input 3 to the refrigeration unit 2 or the temperature at the waste heat output 4 of the refrigeration unit 2. Such internal control circuits of refrigeration units will be well known to those skilled in the art. A means which is also not shown is provided in the internal control circuit for selecting the one of the input end 3 or the output end 4 of the refrigeration unit 2 at which the temperature is to be controlled. Additionally, the temperature at which the selected one of the input end 3 or the output end 4 of the refrigeration unit 2 is to be controlled is selectable. The electronic control circuit 40 communicates with the internal control circuit (not shown) of the refrigeration unit 2
for facilitating selection of the heat sinking input 3 or the waste heat output 4 of the refrigeration unit 2 at which the temperature is to be controlled, and also for facilitating selection of the temperature at which the selected one of the heat sinking input 3 or the waste heat output 4 is to be controlled. The desired one of the input and output ends of the refrigeration unit 2 at which the temperature is to be controlled, and also the desired temperature at which the selected one of the input and output end of the refrigeration unit 2 is to be controlled is programmed into the electronic control circuit 40 for in turn controlling the internal control circuit (not shown) of the refrigeration unit 2.

The operation of the circuit 1 by the control circuit 40 is as follows. Should the cooling demand on the heat sink circuit 6 relative to the heating demand on the heat source circuit 5 be such that the waste heat outputted to the hot coil 26 exceeds the demand for heat of the heat source circuit 5, in other words, the chilling load on the heat sink circuit 6 exceeds the heat load on the heat source circuit 5, the first compensating circulating pump 38 is activated for sinking heat from the first storage vessel 9 to the geothermal reservoir 35 for maintaining the operating temperature of the heat source circuit 5 at a desired pre-set temperature, while the cooling demand from the heat sink circuit 6 is being met. Additionally, in the event that the demand for heat from the heat source circuit 5 relative to the cooling load demand from the heat sink circuit 6 is such that the heat being sunk by the cold coil 27 is greater than the cooling demand of the heat sink circuit 6, the second compensating circulating pump 39 is operated for circulating heat transfer medium for transferring heat from the geothermal reservoir 35 to the second storage vessel 18, for maintaining the operating temperature of the heat sink circuit 6 at a desired pre-set temperature, while the heat source circuit 5 is satisfying the excess demand for heat.

Additionally, in the event that cooling is no longer required from the heat sink circuit 6 while heat is required from the heat source circuit 5, the second compensating circulating pump 39 is operated for transferring heat from the geothermal reservoir 35 to the second storage vessel 18 so that the heat source circuit 5 can be maintained at the desired pre-set operating temperature with no heat sinking effect.
being provided by the heat sink circuit 6. In the case where no heat is required from the heat source circuit 5, the first compensating circulating pump 38 is operated for sinking heat from the first storage vessel 9 to the geothermal reservoir 35 so that the heat sink circuit 6 can operate at the desired pre-set operating temperature with no heating effect being provided from the heat source circuit 5.

In certain cases, where the cooling load can be met by direct cooling from the geothermal reservoir 35, the refrigeration unit 2 may be deactivated when a heating load is not required. Sinking of heat from the heat sink circuit 6 would then be achieved by operating the second secondary circulating pump 23 and the second compensating circulating pump 39 for sinking heat from the heat sink circuit 6 through the second storage vessel 18 to the geothermal reservoir 35. Additionally, where the heating load can be met by direct transfer of heat from the geothermal reservoir 35, the refrigeration unit 2 may be deactivated when the heat sink circuit 6 is not required to provide chilling. Heat would then be transferred from the geothermal reservoir 35 through the first storage vessel 9 to the heat source circuit 5 by operating the first compensating circulating pump 38 and the first secondary circulating pump 15.

In cases where the heating demand on the heat source circuit 5 and the cooling demand on the heat sink circuit 6 could be simultaneously met by the geothermal reservoir 35, the first and second secondary circulating pumps 15 and 23 and the first and second compensating circulating pumps 38 and 39 would be operated for simultaneously transferring heat from the geothermal reservoir 35 to the heat source circuit 5 through the first storage vessel 9 and for sinking heat from the heat sink circuit 6 to the geothermal reservoir 35 through the second storage vessel 18.

In use, the desired pre-set temperatures at which the heat source circuit 5 and the heat sink circuit 6 are to operate are entered into the control circuit 40. Additionally, the one of the heat sinking input 3 and the waste heat output 4 at which the temperature of the refrigeration unit 2 is to be controlled is entered into the control circuit 40, as is the temperature at which the selected one of the heat sinking input 3
and the waste heat output 4 of the refrigeration unit 2 is to be controlled. Thereafter the control circuit 40 controls the operation of the combined heating and cooling circuit 1 as already described so that the respective operating temperatures of the heat source circuit 5 and heat sink circuit 6 are maintained at the respective pre-set temperatures, and as already described, the respective operating temperatures of the heat source and heat sink circuits 5 and 6 are thus controlled independently of each other, as are the heat output of the heat source circuit 5, and the heat sinking to the heat sink circuit 6.

While the first and second storage vessels 9 and 18 have been described as being direct storage vessels, the vessels could be indirect storage vessels, in which case, the heat transfer medium circulating in each of the first and second primary and secondary circulating circuits and the first and second compensating circuits would be different, or alternatively, in certain cases, the heat transfer medium circulating in some of the circulating circuits would be different to that circulating in others of the heat circulating circuits.
Claims

1. A combined heating and cooling circuit comprising a heat source circuit for supplying a heat load, a heat sink circuit for sinking heat for supplying a cooling or chilling load, a refrigeration circuit having a heat sinking input and a waste heat output, a first buffer circuit for transferring and buffering heat from the waste heat output of the refrigeration circuit to the heat source circuit, a second buffer circuit for sinking and buffering heat from the heat sink circuit to the heat sinking input of the refrigeration circuit, and a compensating circuit for communicating with a thermal mass at a datum temperature for selectively sinking heat from the first buffer circuit to the thermal mass and transferring heat to the second buffer circuit from the thermal mass for thermally balancing the heat being sunk to the heat sinking input of the refrigeration circuit with the waste heat being drawn from the waste heat output, so that the respective temperatures of the heat source circuit and the heat sink circuit are controllable independently of each other.

2. A combined heating and cooling circuit as claimed in Claim 1 characterised in that the datum temperature of the thermal mass is at a temperature intermediate the desired operating temperatures of the heat source circuit and the heat sink circuit.

3. A combined heating and cooling circuit as claimed in Claim 1 or 2 characterised in that a control means is provided for controlling the compensating circuit in response to the temperatures of the heat sink circuit and the heat source circuit.

4. A combined heating and cooling circuit as claimed in any preceding claim characterised in that the first buffer circuit comprises a first storage vessel for storing heat transfer medium, and a first primary heat transfer means for transferring heat to the first storage vessel from the waste heat output of the refrigeration circuit.

5. A combined heating and cooling circuit as claimed in Claim 4 characterised in that the first primary heat transfer means comprises a first primary heat transfer circuit, and a first primary circulating means located in the first primary heat transfer circuit.
circuit for circulating heat transfer medium between the first storage vessel and the waste heat output of the refrigeration circuit for transferring heat from the waste heat output of the refrigeration circuit to the first storage vessel.

6. A combined heating and cooling circuit as claimed in Claim 4 or 5 characterised in that the first buffer circuit comprises a first secondary heat transfer circuit and a first secondary circulating means for circulating heat transfer medium between the first storage vessel and the heat source circuit for transferring heat from the first storage vessel to the heat source circuit.

7. A combined heating and cooling circuit as claimed in any preceding claim characterised in that the second buffer circuit comprises a second storage vessel for storing heat transfer medium, and a second primary heat transfer means for sinking heat from the second storage vessel to the heat sinking input of the refrigeration circuit.

8. A combined heating and cooling circuit as claimed in Claim 7 characterised in that the second primary heat transfer means comprises a second primary heat transfer circuit and a second primary circulating means located in the second primary heat transfer circuit for circulating heat transfer medium between the second storage vessel and the heat sinking input of the refrigeration circuit for sinking heat from the second storage vessel to the heat sinking input of the refrigeration circuit.

9. A combined heating and cooling circuit as claimed in Claim 7 or 8 characterised in that the second buffer circuit comprises a second secondary heat transfer circuit and a second secondary circulating means for circulating heat transfer medium between the second storage vessel and the heat sink circuit for sinking heat from the heat sink circuit to the second storage vessel.

10. A combined heating and cooling circuit as claimed in any of Claims 4 to 9 characterised in that the compensating circuit comprises a first compensating circuit and a first compensating circulating means located in the first compensating circuit
for circulating heat transfer medium between the first storage vessel and the thermal mass for sinking heat from the first storage vessel to the thermal mass when the chilling load demand on the heat sink circuit exceeds the heat load demand on the heat source circuit.

11. A combined heating and cooling circuit as claimed in any of Claims 4 to 10 characterised in that the compensating circuit comprises a second compensating circuit and a second compensating circulating means located in the second compensating circuit for circulating heat transfer medium between the second storage vessel and the thermal mass for transferring heat from the thermal mass to the second storage vessel when the heat load demand on the heat source circuit exceeds the chilling load demand on the heat sink circuit.

12. A combined heating and cooling circuit as claimed in Claim 10 or 11 characterised in that the first and second compensating circuits are interconnected by a valve means, the valve means being operable for preventing circulation of heat transfer medium between the first and second compensating circuits when heat transfer medium is being circulated in one of the first and second compensating circuits.

13. A combined heating and cooling circuit as claimed in any of Claims 10 to 12 characterised in that the control means selectively operates the first and second compensating circulating means one at a time for selectively transferring heat between the corresponding one of the first and second storage vessels and the thermal mass in response to the temperature of the heat source and heat sink circuits.

14. A combined heating and cooling circuit as claimed in any preceding claim characterised in that the compensating circuit comprises a large earth-contact tubing array through which heat transfer medium is circulated for maintaining the temperature of the heat transfer medium in the tubing array at approximately the average annual earth temperature of the locality.
15. A combined heating and cooling circuit as claimed in Claim 14 characterised in that the earth-contact tubing array is buried in the earth.

16. A combined heating and cooling circuit as claimed in any preceding claim characterised in that the compensating circuit comprises a heat exchanger through which heat transfer medium is circulated, the heat exchanger being located in a substantial body of water appropriately sized for maintaining heat transfer medium circulating in the heat exchanger at approximately the average annual temperature of the locality.

17. A combined heating and cooling circuit as claimed in any preceding claim characterised in that the thermal mass is a geothermal reservoir.

18. A combined heating and cooling circuit as claimed in any preceding claim characterised in that the compensating circuit is operable for transferring heat to the first storage vessel from the thermal mass for subsequent transfer to the heat source circuit for providing direct heat transfer from the thermal mass to the heat source circuit for supplying the heating demand on the heat source circuit.

19. A combined heating and cooling circuit as claimed in any preceding claim characterised in that the compensating circuit is operable for sinking heat from the second storage vessel to the thermal mass for in turn sinking heat from the heat sink circuit to the second storage vessel for providing the chilling load on the heat sink circuit by sinking heat from the heat sink circuit to the thermal mass.

20. A method for operating a combined heating and cooling circuit wherein the circuit comprises a heat source circuit for supplying a heat load, a heat sink circuit for sinking heat for supplying a cooling or chilling load, a refrigeration circuit having a heat sinking input and a waste heat output, a first buffer circuit for transferring and buffering heat from the waste heat output of the refrigeration circuit to the heat source circuit, a second buffer circuit for sinking and buffering heat from the heat
sink circuit to the heat sinking input of the refrigeration circuit, and a compensating circuit for communicating with a thermal mass at a datum temperature for selectively sinking heat from the first buffer circuit to the thermal mass and transferring heat to the second buffer circuit from the thermal mass for thermal balancing the heat being sunk to the heat sinking input of the refrigeration circuit with the waste heat being drawn from the waste heat output, so that the respective temperatures of the heat source circuit and the heat sink circuit are controllable independently of each other, the method comprising the step of operating the compensating circuit for sinking heat from the first buffer circuit to the thermal mass when the cooling demand on the heat sink circuit relative to the heating demand on the heat source circuit causes the waste heat from the waste heat output of the refrigeration circuit to exceed the heat demand on the heat source circuit for controlling the heat output of the heat source circuit, and for transferring heat to the second buffer circuit from the thermal mass when the heating demand on the heat source circuit relative to the cooling demand on the heat sink circuit causes the heat being sunk to the heat sinking input of the refrigeration circuit to exceed the cooling demand of the heat sink circuit for controlling the heat sinking action of the heat sink circuit.
### INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

<table>
<thead>
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<th>IPC</th>
<th>F25B29/00</th>
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According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

<table>
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<tr>
<th>IPC</th>
<th>F25B F24D</th>
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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**Date of the actual completion of the international search**

2 June 2003

**Date of mailing of the international search report**

11/06/2003

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**Authorized officer**

De Graaf, J.D.
### INTERNATIONAL SEARCH REPORT

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