

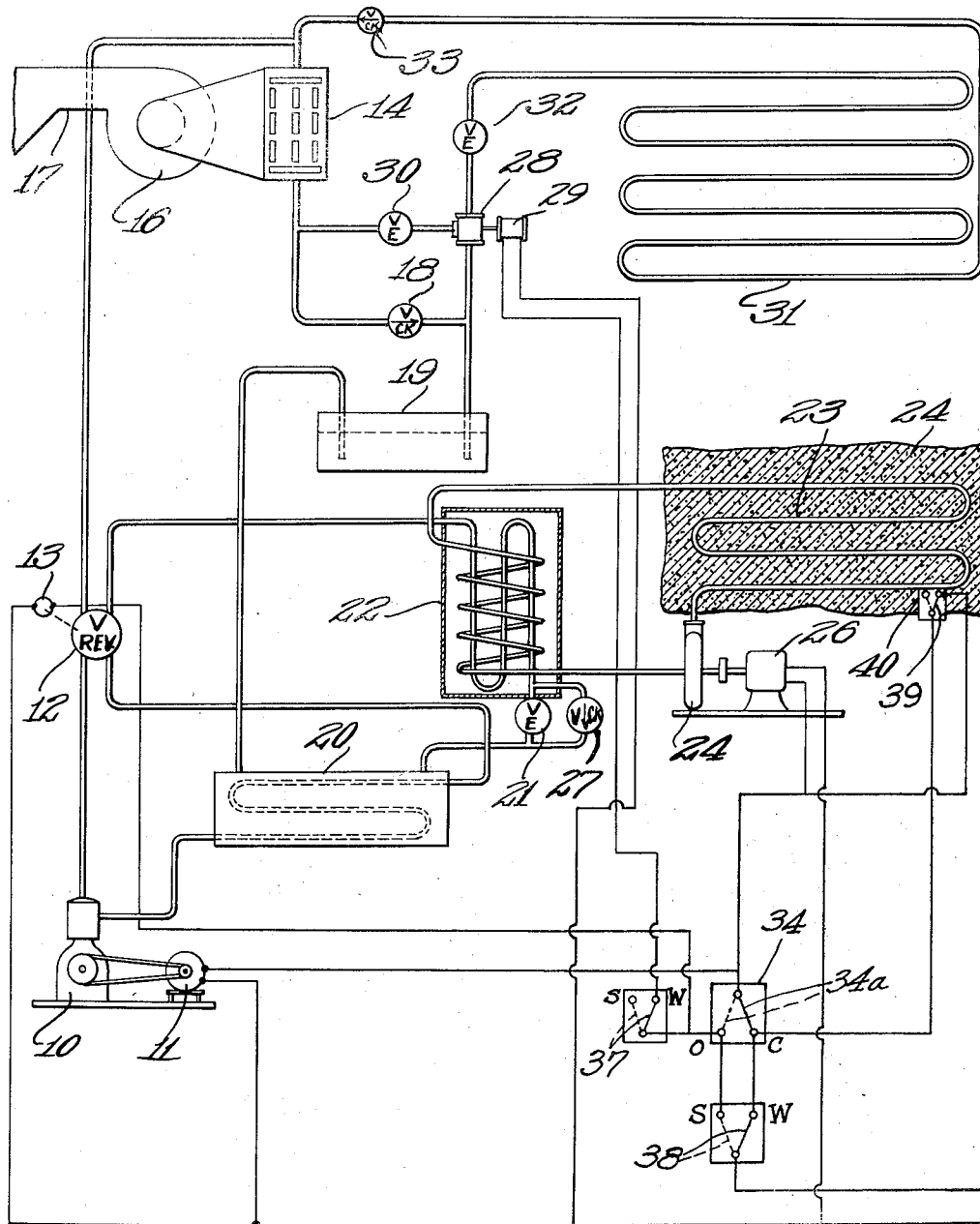
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AIR CONDITIONING SYSTEM

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This invention relates generally to heat pump apparatus and more particularly relates to a heat pump apparatus of the type having a subterranean reservoir of thermal energy and having reversing controls to selectively recharge the subterranean reservoir with thermal energy absorbed from the atmosphere.

Although the use of heat pump apparatus of the type having earth coils running beneath the surface of the earth and comprising a subterranean reservoir is well known, one of the particular problems which has been presented in utilizing the heat pump apparatus for temperature conditioning of closed spaces has resided in the depletion of available thermal energy in the subterranean reservoir under abnormal operating conditions such as might occur, for example, if a prolonged season of particularly cold weather is encountered. The ultimate potential of the earth as a heat source, of course, is large, however, since the rate of heat flow through the earth is very slow, one way of coping with this phenomenon is to provide an extensive earth coil which will enlarge the scope of the subterranean reservoir. Such provision is undesirable in situations where limited space requirements and low equipment cost must be considered.

In accordance with the general principles of the present invention, the subterranean reservoir of a heat pump apparatus is selectively replenished with atmospheric thermal energy by selectively reversing the refrigeration cycle of the heat pump apparatus and expanding the reversely flowing liquefied refrigerant through a secondary evaporator comprising an atmospheric heat absorber.

Control means are provided to effect the recharging of the subterranean reservoir only when the heat pump apparatus is not required to supply thermal energy for temperature conditioning. Control means are further provided to stop the reverse operation of the heat pump apparatus after the quantity of available thermal energy in the subterranean reservoir has reached an optimum level.

It is an object of the present invention, therefore, to provide a heat pump apparatus wherein a subterranean reservoir may be selectively recharged by reversely cycling the heat pump apparatus and replenishing the subterranean reservoir with atmospheric thermal energy.

Another object of the present invention is to provide a heat pump apparatus having a subterranean reservoir of thermal energy which is particularly compact insofar as space requirements are concerned and which may conveniently comprise structural components which are commercially available at economical cost.

Another object of the present invention is to provide a heat pump apparatus for a temperature conditioning system which is efficient in operation despite the existence of severe climatic conditions.

Many other advantages, features and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description that follows and the accompanying sheet of drawings in which a preferred form of our in-

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vention is diagrammatically illustrated by way of preferred example only. It is believed that the steps of the novel methods practiced in accordance with the disclosure of this invention will be most readily understood from a description of the apparatus provided.

On the drawings:

The single figure of the drawings shows in diagrammatic form a heat pump apparatus incorporating the principles of our invention.

As shown on the drawings:

The heat pump apparatus illustrated diagrammatically on the single figure of the drawing includes the usual components of a reverse cycle refrigeration apparatus. There is shown a compressor 10 driven by a motor 11 which pressurizes a supply of a suitable refrigerant such as dichloro difluoro methane, the refrigerant leaving the compressor in a pressurized gaseous state. The refrigerant then passes through a reversing valve 12 actuated by a motor 13 and releases thermal energy in a condenser 14. The condenser 14 conveniently comprises a temperature conditioner for a heating system serving an enclosed space. Accordingly, suitable means for applying the thermal energy released at the condenser 14 may be provided, for example, a blower 16 discharging temperature conditioned air into a duct system 17. A hot water system, of course, would employ a pump to circulate the heated water.

After leaving the condenser 14, the refrigerant passes through a check valve 18 and having been transformed into a liquefied state is received in a receiver 19.

The liquefied refrigerant is further cooled in a heat exchanger 20 and then passes through an expansion valve 21. Upon being expanded into gaseous state through the expansion valve 21 and in an evaporator 22, the refrigerant again passes through the reversing valve 12, through the heat exchanger 20 and back to the compressor 10.

It will be appreciated that the refrigerant absorbs thermal energy at the evaporator 22 in the usual manner. In order to supply thermal energy to the evaporator 22, an earth coil 23 is submerged beneath the surface of the ground 24, thereby to form a subterranean reservoir of thermal energy. The earth coil 23 is charged with a suitable heat exchange medium such as a fluid customarily employed in a refrigeration brine system. In order to circulate the fluid medium through the earth coil 23, a pump 24 powered by a motor 26 is employed so that the fluid medium will flow between the subterranean reservoir and the evaporator 22.

The cycle thus far described provides satisfactory temperature conditioning during winter months when it is necessary to provide heat for an enclosure being temperature conditioned.

The structure provided is also suited to temperature condition the enclosure in the summer months when it is desirable to reduce the temperature in the enclosure being temperature conditioned. Under such requirements of operation, the pressurized gaseous refrigerant passes from the compressor 10 through the reversing valve 12 and through the evaporator 22, which in this instance, operates as a condenser. The thermal energy released by the refrigerant in changing to liquid form in the evaporator 22, or condenser, is dissipated to the subterranean reservoir by the earth coil 23.

The liquefied refrigerant then passes through a check valve 27, through the heat exchanger 20, and thence through the receiver 19.

A control valve 28 actuated by a motor 29 is suitably positioned to direct the refrigerant through an expansion valve 30, thereupon heat is absorbed at the condenser 14, which in this instance, acts as an evaporator. It will be appreciated that with this mode of operation,

the blower 16 will provide cooled air to the duct system 17.

The refrigerant then passes through the reversing valve 12 and through the heat exchanger 20 prior to its return to the compressor 10.

In employing the heat pump apparatus described for temperature conditioning an enclosure exposed to prolonged periods of exceptionally cold weather, a considerable depletion of the available thermal energy in the subterranean reservoir will be experienced because the rate of heat flow from areas remote from the earth coil 23 will not be rapid enough to replenish the quantity of extracted thermal energy. Although it would be possible to counter this phenomenon by extending the length of the earth coil 23 so as to expand the thermal energy potential of the subterranean reservoir, such provision is limited by the amount of available space and the expense necessary to provide a subterranean reservoir of larger size.

According to the principles of the present invention, thermal energy from the atmosphere is employed to selectively recharge the subterranean reservoir whenever the heat pump apparatus is not required to deliver thermal energy to the enclosure being temperature conditioned.

To accomplish this end, a second evaporator 31 is provided which preferably consists of an atmospheric heat absorber, for example, an air coil, which is controlled by the valve 28. Thus, upon selectively reversing the flow of refrigerant so that the operation of the heat pump apparatus corresponds generally to "summer" operation, the reversely flowing liquefied refrigerant will pass through the valve 28 and will be expanded by an expansion valve 32 so as to absorb heat from the atmosphere in the second evaporator 31 whereupon the refrigerant will pass through the check valve 33 and will be returned to the compressor 10 through the reversing valve 12 and the heat exchanger 20. The valve 28 is preferably arranged to cooperate with the check valve 18 to by-pass the condenser 14, sometimes operable as an evaporator, so that temperature conditioning of the enclosure during the replenishing or recharging operation will be unaffected.

It will be apparent that under the conditions last described, the thermal energy from the atmosphere will be released at the evaporator 22, operable in this instance as a condenser, so that the thermal energy may be furnished to the ground 24 surrounding the coil 23.

Although it would be possible to initiate all of the aforescribed operating conditions by manually operating the valves 12 and 28 in order to reverse the operation of the heat pump apparatus and cut in the second evaporator 31, the present invention further contemplates the automatic regulation of the apparatus through the provision of a suitable control circuit.

There is provided at 34 a thermostatic control device which responds to variations from a reference temperature. Preferably, the thermostatic control device 34 is arranged to respond to variations from a reference temperature selected to correspond with the desired temperature to be maintained in the enclosure being temperature conditioned.

A selector switch 37 and a selector switch 38 are provided which may be moved between a "summer" position and a "winter" position indicated by "S" and "W," respectively.

In "winter" operation, a demand for heat will close a switch 34a of the thermostatic device 34 to position "C" whereupon motor 11 will be energized as will motor 26. As soon as the desired temperature is obtained in the enclosure being temperature conditioned, the switch 34a, is moved to "O" position. If switch 39 is in closed position the reversing valve 12 and the valve 28 will be actuated.

The condenser 14, sometimes operative as an evaporator,

is by-passed and the reversely flowing liquefied refrigerant is expanded through the second evaporator 31. Unless otherwise controlled, this operation would continue until such a time as a demand for heat would again operate to reverse the operation of the heat pump apparatus. It will be apparent, however, that it would not always be practical to continuously recharge the subterranean reservoir, for example, if a prolonged period of mild weather was encountered, a practical limit of thermal energy storage in the subterranean reservoir would be attained. Thus, a thermal sensing element is indicated at 40 which responds to the temperature of the fluid medium flowing through the coil 23, thereby indicating the quantity of thermal energy available in the subterranean reservoir and serves to actuate the switch 39 to open position whereupon the entire system will be deenergized.

The arrangement thus provided effects the automatic recharging of the subterranean reservoir with thermal energy extracted from the atmosphere whenever operating conditions are opportune.

It will be understood that positioning of the selector switches 37 and 38 for "summer" operation will effect the necessary reversal of operation.

It is contemplated that those versed in the art may suggest various minor structural modifications to the preferred embodiment herein described by way of illustrative example only, however, it should be clearly understood that we wish to embody within the scope of this application all such modifications that reasonably and properly come within the scope of our contribution to the art.

We claim as our invention:

1. Apparatus for temperature conditioning an enclosure, comprising, a compressor to pressurize a gaseous refrigerant, a temperature conditioner for an enclosure comprising a condenser to liquefy said gaseous refrigerant, thereby to yield thermal energy for heating the enclosure, an expansion valve to expand the liquefied refrigerant, an evaporator to receive the expanded refrigerant, means to supply thermal energy from an earth reservoir beneath the surface of the ground to said evaporator, a thermostat responsive to variations in temperature in the enclosure and being in control of said apparatus, a reversing valve means actuated by said thermostat to reverse the direction of flow of refrigerant, whereby the pressurized gaseous refrigerant is liquefied in the evaporator and the earth reservoir is recharged with thermal energy, a second evaporator comprising an atmospheric heat absorber and circulating means including a valve actuated by said thermostat and arranged to selectively by-pass the reversely flowing refrigerant around said temperature conditioner and through said second evaporator to absorb atmospheric thermal energy for recharging the earth reservoir whenever the temperature in the enclosure is at a predetermined reference level, said reversing valve means and said valve of said circulating means being concurrently actuated by said thermostat, and a control means responsive to variations in the thermal energy potential of said reservoir in parallel with said thermostat for conditioning said thermostat to actuate said valve means and said valve whenever recharging of the reservoir is required.

2. In a heat pump apparatus of the type having a condenser forming an air temperature conditioner and an evaporator arranged to extract thermal energy from a thermal reservoir, the improvement whereby the thermal reservoir may be selectively recharged with atmospheric thermal energy, comprising, reversing means to selectively reverse the flow of refrigerant through the evaporator, a second evaporator comprising an atmospheric heat absorber, by-pass means to selectively by-pass the reversely flowing refrigerant around the condenser and through the second evaporator, and a thermostat responsive to variations from a reference temperature,

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said reversing means comprising a reversing valve controlled by said thermostat and arranged in said heat pump apparatus to control the flow of refrigerant in selected direction, said by-pass means including a valve controlled by said thermostat selectively controlling the flow of refrigerant through the condenser and said second evaporator, said thermostat actuating both of said valves concurrently during the heating cycle of the apparatus, and control means responsive to variations in the thermal energy potential of said reservoir in parallel with said thermostat to condition said thermostat for actuation of said valves whenever recharging of the reservoir is required.

3. A temperature conditioning system for an enclosure, comprising conduit means for providing a closed fluid circuit, a compressor in said circuit for compressing and driving a gaseous refrigerant through said circuit, liquifying means at one point in said circuit to yield thermal energy for heating the enclosure, expanding means at a second point in said circuit for absorbing thermal energy, a thermal reservoir, means connecting said expanding means in thermal transfer relation with said reservoir at said second point in said circuit, a second expanding means comprising an atmospheric heat absorber, flow controlling means in said circuit to temporarily relatively reverse the flow of refrigerant in said circuit whenever there is temporarily no need for heating the enclosure whereby gaseous refrigerant will be liquefied at said second

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point to dissipate thermal energy to said thermal reservoir and to concurrently by-pass the reversely flowing liquefied refrigerant at said one point in said circuit around said liquifying means and through said atmospheric heat absorber to re-charge the thermal reservoir with atmospheric thermal energy without affecting the temperature of the enclosure.

4. A temperature conditioning system as defined in claim 3, and thermostatic control means regulating said flow controlling means in response to temperature variations in the enclosure.

5. A temperature conditioning system as defined in claim 4, said thermostatic control means being constructed to stop said compressor in response to attainment of a predetermined level of thermal energy in said thermal reservoir.

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