

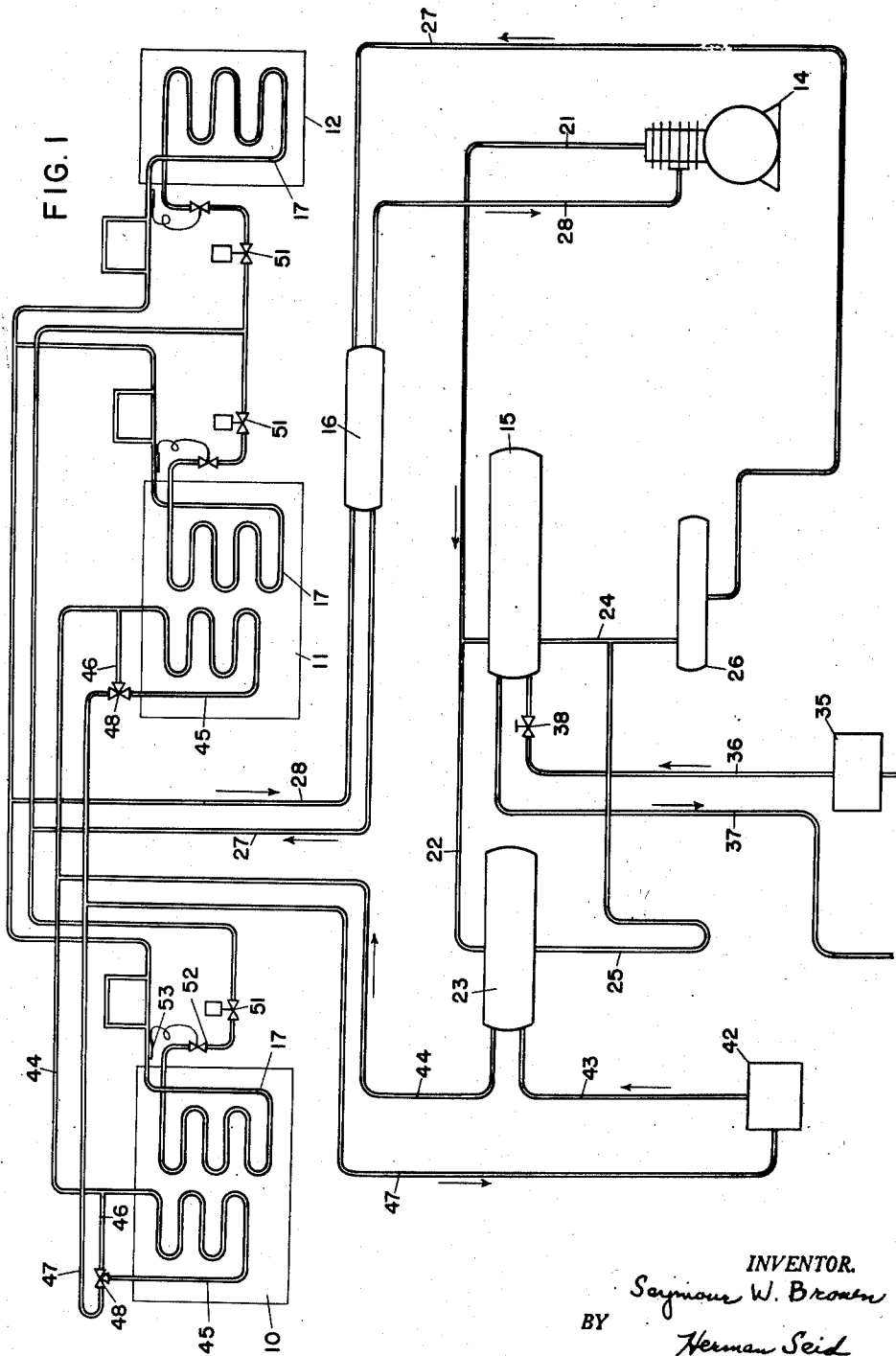
April 2, 1957

S. W. BROWN
METHOD AND APPARATUS FOR HEATING AND
COOLING A COMPARTMENTED ENCLOSURE

2,787,128

Filed Nov. 28, 1952

4 Sheets-Sheet 1



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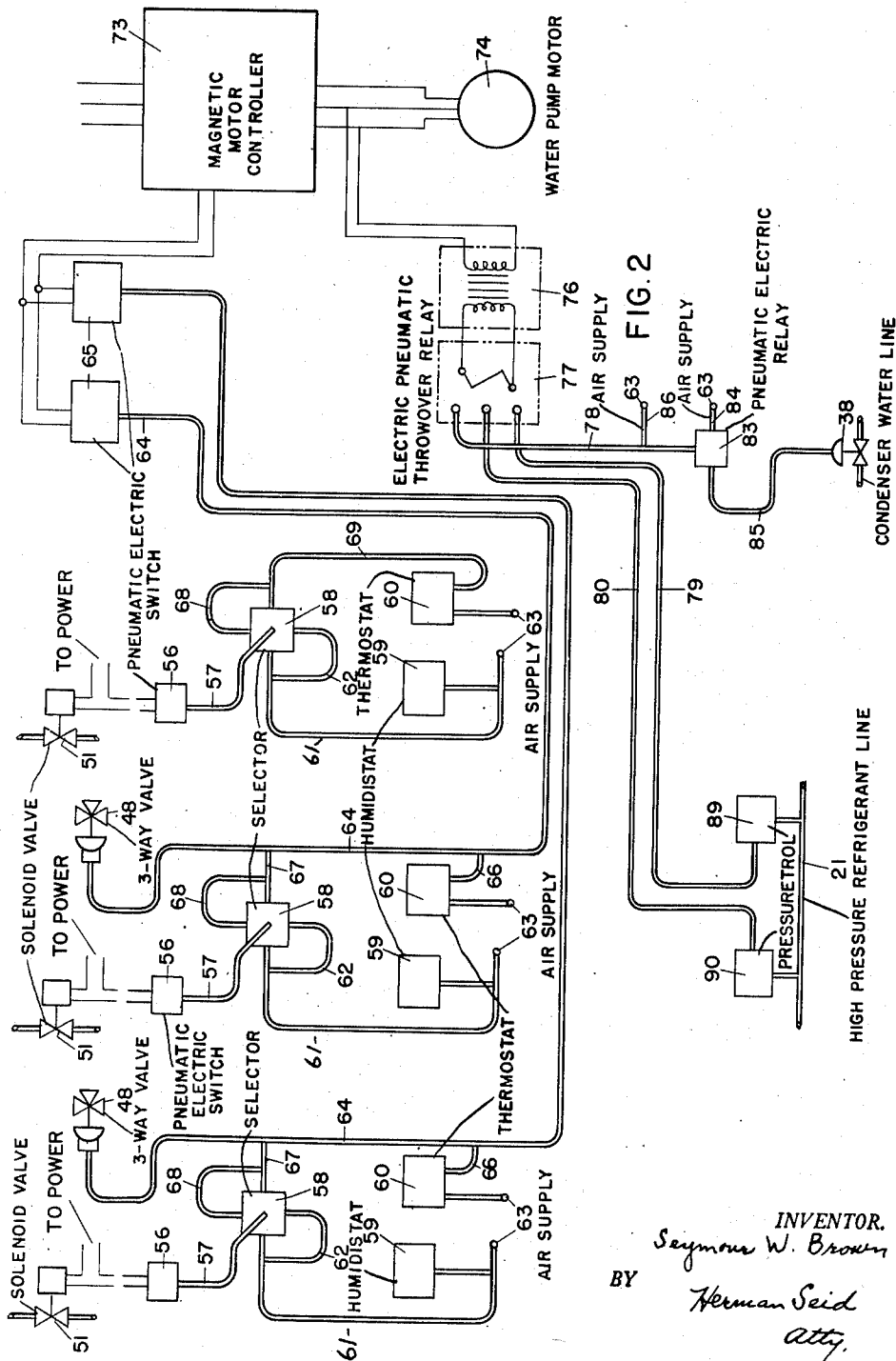
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FIG. 3

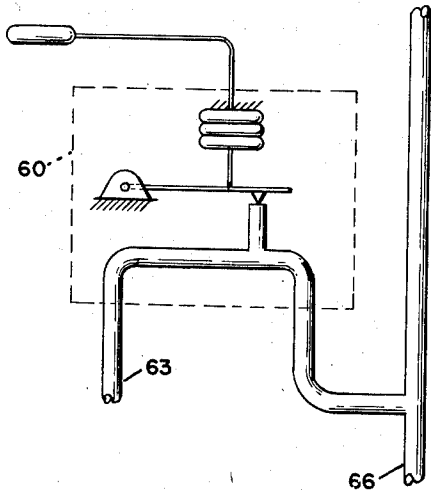


FIG. 4

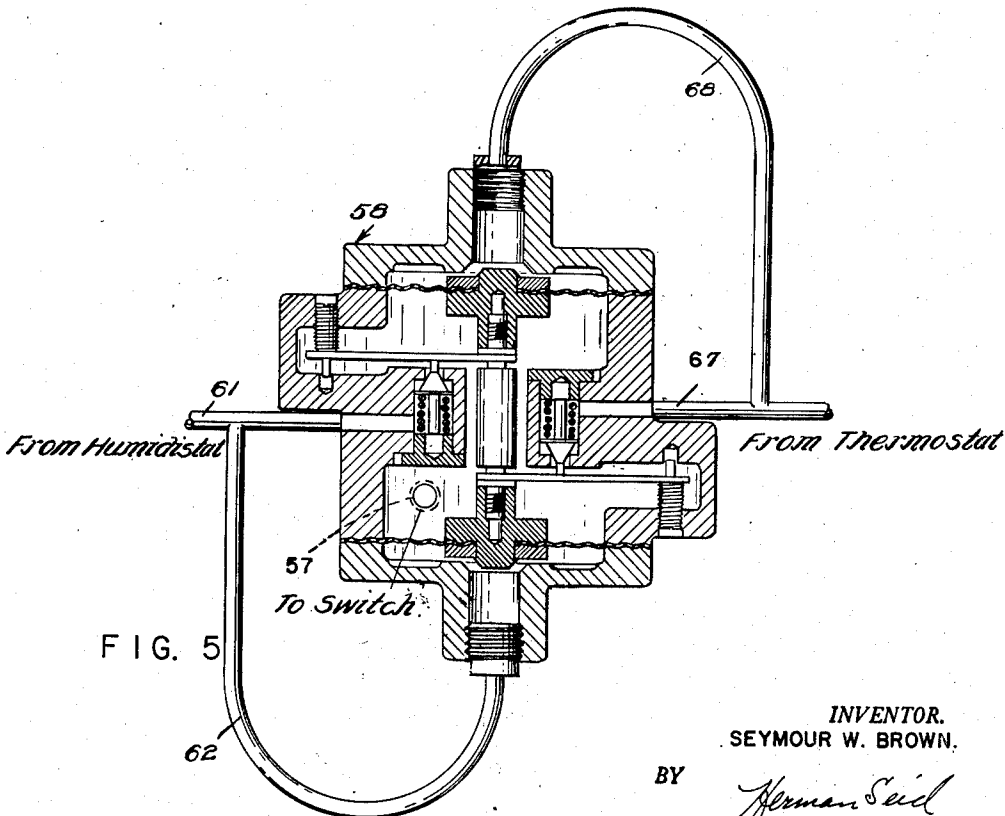
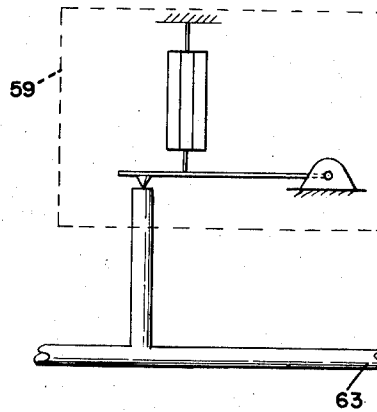


FIG. 5

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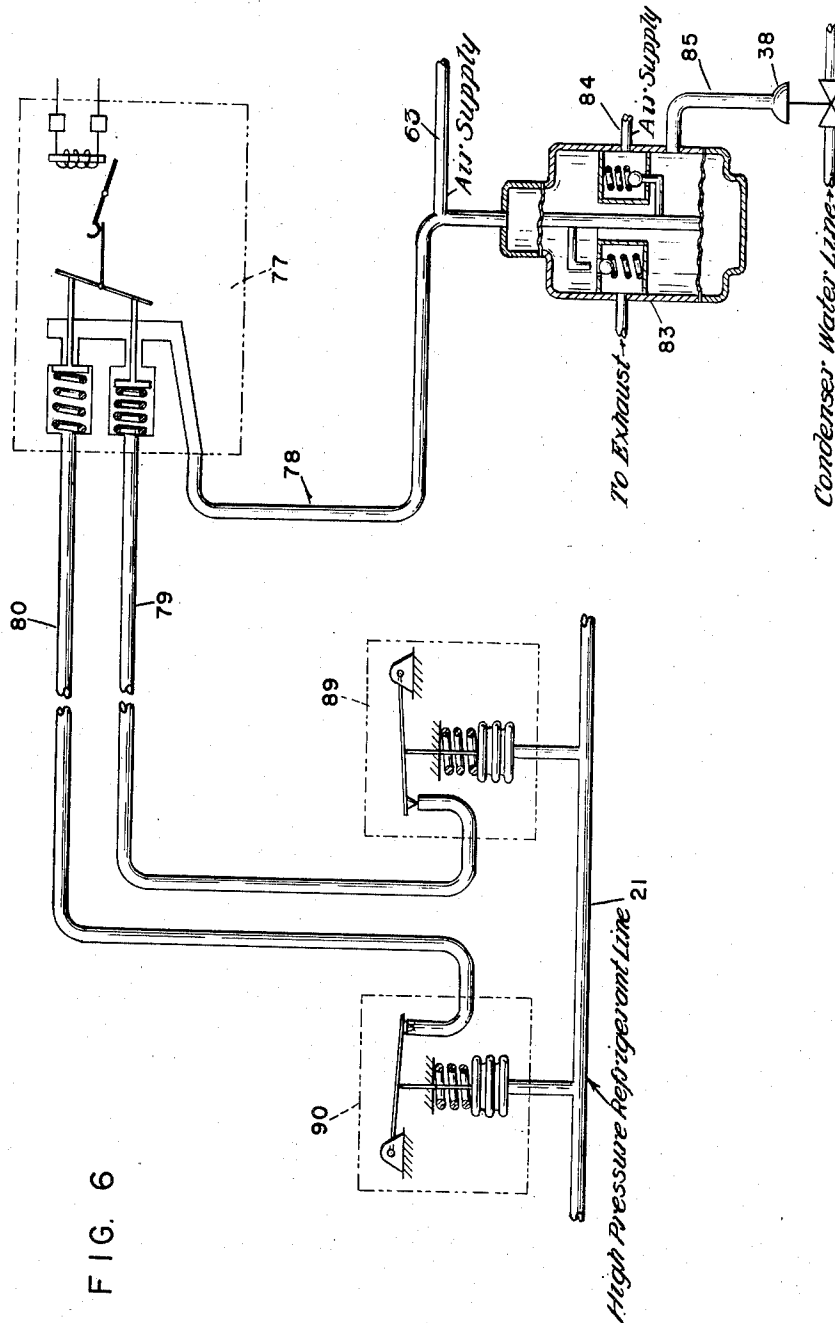
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4 Sheets-Sheet 4



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METHOD AND APPARATUS FOR HEATING AND COOLING A COMPARTMENTED ENCLOSURE

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Application November 28, 1952, Serial No. 323,117

10 Claims. (Cl. 62—3)

This invention relates to a method and apparatus for heating and cooling an enclosure divided into a plurality of compartments and particularly to heating and cooling ships, especially submarines.

The chief object of the present invention is to provide an enclosure divided into compartments in which each compartment is conditioned separately from a central conditioning station.

An object of the present invention is to provide an air conditioning system for an enclosure containing a plurality of compartments, the conditioning system including a hot water pump which starts automatically upon a demand for heat in any compartment to supply heated water to the compartment to satisfy the demand; and means to reduce the quantity of the water supplied to the condenser of the air conditioning system simultaneously with the actuation of the hot water pump.

Another object of the invention is to provide an air conditioning system particularly adaptable for ships such as submarines in which one or more compartments require cooling at all times.

Still another object is to provide a refrigeration system which maintains a low compressor discharge pressure during cooling, and when heating is required in any compartment of the enclosure, it may be utilized to maintain a high compressor discharge pressure to provide the required source of heat.

A further object is to provide a heat exchanger with less surface than is normally required to heat water that is circulated as a heat source.

This invention relates to a heating and cooling system for an enclosure containing a plurality of compartments, comprising in combination, a refrigeration system including a compressor, a condenser, and an evaporator to serve as a cooling source for one of the compartments of the enclosure, a heater, a water pump for circulating water through the heater to at least one of the compartments to serve as a heating source, a line connecting the compressor and the condenser, a second line leading to the heater and being connected to said first line, a third line connecting the heater and the condenser to the evaporator, means for supplying water to the condenser, and means responsive to a change in the condition of one of the compartments to reduce the flow of water through the condenser to cause a portion of the hot gaseous refrigerant to pass through the heater in heat exchange relation with the water passing through the heater.

This invention further relates to a method for conditioning an enclosure containing a plurality of compartments which consists of the steps of supplying refrigerant from a refrigeration system as a cooling medium to each compartment, reducing the supply of water to the condenser of the refrigeration system when the temperature in any of the compartments decreases below a predetermined point, supplying water to a heater in parallel with the condenser and in heat exchange relation with the hot gaseous refrigerant when the condenser water supply is reduced, and passing water from the heater to the compartment in which the temperature has decreased below the predetermined point.

The attached drawings illustrate a preferred embodiment of my invention in which

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Figure 1 is a diagrammatic view of the conditioning system of the present invention;

Figure 2 is a diagrammatic view of the arrangement of the control system of the present invention; and

Figure 3 is a diagrammatic view of a thermostat shown in Figure 2;

Figure 4 is a diagrammatic view of a humidistat shown in Figure 2;

Figure 5 is an elevational view, in section, of a selector switch sensing air pressure in lines containing either a thermostat or a humidistat; and

Figure 6 is a diagrammatic view of a portion of the pneumatic control system showing the regulation of the valve governing the supply of cooling water to the condenser.

Referring to the drawings and particularly to Figure 1, there is disclosed three compartments, 10, 11 and 12. These compartments are shown in a single enclosure, which may be a submarine, for example. It will be understood that the number of compartments may be increased or decreased accordingly.

A refrigeration system is shown and this system is employed to provide heating, cooling, and dehumidification of each of the compartments depending upon the requirements of each compartment. This refrigeration system includes a compressor 14, a condenser 15, a heat exchanger 16 and an evaporator or cooling coil 17 disposed in each of the compartments 10, 11, and 12. The discharge line 21 of the compressor leads to the condenser 15. A second refrigerant line 22 extends from discharge line 21 to a heater 23. Refrigerant lines 24 and 25 lead, respectively, from condenser 15 and heater 23 to receiver 26. The receiver 26 is in communication with heat exchanger 16 by refrigerant line 27. After passing through the heat exchanger 16, the line 27 leads to each of the evaporators 17. A suction line 28 leads from the evaporators through the heat exchanger to the compressor 14.

The condenser 15 is supplied with water by means of water pump 35. On a submarine or other similar water vessel, this water is preferably sea water. The pump 35 is connected to the condenser 15 by means of line 36. After passing through the condenser 15, the water exits by line 37 which may lead to an overboard discharge. It is understood that if this were a land installation, the water could be recirculated through a cooling tower, for example. A valve 38 is shown in line 36 to regulate the quantity of water entering the condenser 15. If desired, the condenser may be air cooled rather than water cooled.

Water is circulated through the heater 23 by means of a water pump 42. This pump circulates water through line 43 to the heater 23 and then through line 44 to heating coils 45 disposed in compartments 10 and 11. A bypass line 46 leads from the supply line 44 to the return line 47. A three-way valve 48 is disposed at the connection of bypass line 46 with return line 47 and the heating coil 45 to regulate the amount of water that bypasses the heating coil 45 in order to maintain the desired temperature. The return line 47 leads to pump 42. Thus, a closed hot water circulating system is provided.

Refrigerant is supplied to each of the cooling coils 17 from the line 27. In the portion of the line 27 leading to each cooling coil or evaporator 17, there is disposed a solenoid valve 51. Between the solenoid valve 51 and the evaporator 17 there is placed an expansion valve 52 which is connected to a thermostatic bulb 53 located in the suction line 28 adjacent the evaporator 17. If desired, other types of expansion means could be employed.

Referring more particularly to Figure 2, each solenoid valve 51 is shown electrically connected to a pneumatic-electric relay switch 56, of the conventional type wherein

a supply of air is utilized to control mechanism designed to make or break a circuit. An air pressure line 57 leads from the switch 56 to selector relay 58, of the well known type wherein compressed air under the influence of either one of a plurality of regulating devices, is forwarded by the selector relay to an instrument such as a switch or valve, for example, to serve as an actuating agent therefor. A common valve of this general kind includes two separate diaphragms arranged to form three vertically spaced chambers. Air under the influence of one regulating instrument (temperature responsive) is introduced into the top chamber and air under the influence of another regulating instrument (humidity responsive) is introduced into the bottom chamber. Air from each source is also introduced into separate valved openings in the middle chamber which has communication with a line connected to the instrument to be supplied with the air. An unbalance between the pressures exerted by the two air streams on the diaphragms causes a mechanical linkage to open the line to either of the air streams so that the air delivered to the device is governed by the instrument regulating the admitted air stream. Disposed in each of the compartments 10, 11 and 12 is a humidistat 59, of the well known kind wherein air supplied to an instrument of the pneumatic-electric type is regulated by an instrument arranged to vent supply air under certain predetermined humidity conditions and a thermostat 60, of the well known kind wherein air supplied to an instrument of the pneumatic-electric type is regulated by an instrument arranged to vent supply air under certain predetermined temperature conditions. An air pressure line 61 leads from the humidistat 59 to the selector relay 58. A bypass air pressure line 62 extends from line 61 to the selector relay 58 as shown in Figure 2. Thus air pressure line 61 is also in communication with the main compressed air line 63. A regulator is employed to reduce the air pressure from the main compressed air line to about 15 pounds in the various air pressure lines shown on Figure 2.

An air pressure line 64 provides communication between the three-way valve 48 and a pneumatic-electric relay switch 65 similar to the switch 56. A branch air pressure line 66 leads from the thermostat 60 to the line 64. Air pressure line 67 leads from the selector relay 58 to line 64 so that thermostat 60 is in communication with the selector relay 58. A bypass air pressure line 68 extends from line 67 to the selector relay 58 as shown in Figure 2.

The controls for compartments 10 and 11, where there are both heating and cooling coils, are exactly the same. However, in compartment 12 the control system is connected slightly different since there is no air pressure line leading to a pneumatic electric relay switch 65 because there is no heating coil in this compartment. Therefore, thermostat 60 is connected to selector relay 58 by a direct air pressure line 69.

The pneumatic electric relay switches 65 are connected in parallel and are electrically connected to magnetic controller or motor starter 73. This controller or starter 73 is connected to a pump motor 74. This pump motor 74 operates water pump 42.

This magnetic controller 73 is also electrically connected to a transformer 76 which is connected to electro-pneumatic throwover relay 77 of the well known type wherein a mechanical linkage, actuated by an energized coil, opens one valve to permit communication between an air supply line and the line containing the valve while closing a second valve to prevent air flow from the supply line to a second line containing the closed valve and normally in communication with the supply line. Leading from the throwover relay 77 are three air pressure lines 78, 79 and 80.

Air pressure line 78 is in communication with condenser water regulating valve relay 83, of the type similar to member 58 wherein compressed air under the in-

fluence of one or more regulating instruments acts as an operating medium. This relay is also in communication with the main compressed air line 63 by means of branch line 84. The relay 83 is also in communication with the condenser water valve 38 by means of the branch line 85. Between the relay 83 and relay 77, the line 78 has a branch line 86 that is in communication with the main compressed air line 63. Both lines 84 and 86 have restrictors therein to limit the air volume passing to the controls.

The line 79 leads from the relay 77 to a pressuretrol 89 of the conventional kind wherein mechanism under the influence of a pressure condition within a conduit or vessel (in this case the discharge line) acts to vent compressed air acting as an actuating medium under certain prescribed conditions. This pressuretrol is in communication with the compressor discharge line 21. The line 80 leads from the relay 77 to a second pressuretrol 90 of a type similar to member 89, which is also in communication with the discharge line 21.

Considering the operation of the present invention during the cooling and dehumidification cycle, the compressor 14 supplies refrigerant to the condenser 15 from which it flows to the receiver 26 and then to heat exchanger 16. After passing through heat exchanger 16, the refrigerant passes through each expansion valve 52 to each evaporator 17 provided the solenoid valve 51 for the particular evaporator is open. The thermal expansion valves are set to remain open as long as the temperature of the refrigerant at the point of attachment of the thermostatic bulb 53 at the leaving end of the evaporator is a predetermined amount above the corresponding saturation temperature. This regulation provides the cooling coils with a maximum amount of refrigerant while preventing liquid refrigerant from surging back to the compressor.

Upon an increase in the compartment temperature above the control setting, the thermostat 60 increases air pressure in the branch lines 64 and 67. This increased pressure will act through selector relay 58 and line 57 to cause switch 56 to close its contacts. The closing of the contacts of switch 56 energizes the refrigerant solenoid valve 51 for the cooling coil in the particular compartment. This results in the valve 51 opening so that refrigerant may flow through the evaporator in the compartment while its temperature is above the desired level. If the humidity should increase, the humidistat 59 will act in a similar manner through selector relay 58 and pneumatic-electric relay switch 56 to energize the refrigerant solenoid valve 51 in the particular compartment.

If either the temperature or humidity of the compartment falls below the control setting, the selector relay 58 will permit the solenoid valve 51 to continue to remain energized. This is accomplished by the selector relay 58 communicating the relay switch 56 with the control whose condition is still above the control setting for the compartment. In particular, the instrument (thermostat 60 or humidistat 59) affected will partially vent the air pressure from its branch line. However, the selector relay 58 acts so that the instrument (thermostat 60 or humidistat 59) with the highest branch air pressure will be given control of the relay switch 56. Thus, the relay switch 56 will be energized whenever the compartment thermostat 60 calls for cooling or the humidity exceeds the setting of the humidistat 59.

If both the temperature and the humidity of a particular compartment fall below the control setting, the solenoid valve 51 will be de-energized to prevent any further reduction in temperature or humidity since this will prevent the flow of refrigerant through the evaporator or cooling coil 17. This occurs by the fact that the air pressure in the branch lines of thermostat 60 and humidistat 59 is reduced. This reduced air pressure causes the contacts of the relay switch 56 to open and thus de-energize the solenoid valve 51.

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It will be understood that compartment 12 will always require cooling so that the refrigeration system will be in continuous operation. For example, on a submarine this could be the pump room. It is essential that some heat source be provided so that the refrigeration system will be required to do some cooling at all times. If this condition does not exist, the refrigeration system will cease to operate of its own accord.

During the cooling cycle, the flow of condenser water through the condenser 15 is controlled by the pressuretrol 89. This pressuretrol is disposed in the discharge line 21 so as to maintain a desired low discharge pressure. This pressuretrol 89 controls the discharge pressure by regulating the flow of condenser water. The pressuretrol 89, during the cooling cycle, is in communication with the condenser regulating valve 38 by means of the throw-over relay 77.

If the temperature of any compartment should fall below the desired temperature, the thermostat 60 in the particular compartment will act through air pressure line 64 to energize the pneumatic electric relay switch 65. When the temperature in a particular compartment falls below the desired temperature, the thermostat in that compartment vents air from its branch line. This drops the air pressure in line 64 and closes the contacts in one of the relay switches 65. Since all of the switches 65 are connected in parallel with the magnetic controller or motor starter 73, which actuates the water pump motor 74, the energizing of any of the switches 65 will result in the pump motor 74 being started. The magnetic controller or motor starter 73 has an electrical interlock therein whereby the throwover relay 77 is energized. The energization of the relay 77 results in the transfer of air pressure from the pressuretrol 89 to the pressuretrol 90. This will cause the discharge pressure of the system to be increased and this is accomplished by partially closing the condenser water regulating valve 38. This increase in pressure will raise the refrigerant condensing pressure to a temperature range suitable for heating the hot water passing through heater 23 with the compressor discharge gas. Since the condenser pressure has increased, the hot refrigerant gas will now be partially condensed in the hot water heater 23.

Since the thermostat 60 also controls the three-way hot water mixing valves 48, the starting of the hot water pump motor 74 will result in the opening of the three-way valves 48 in those compartments requiring heating. The hot water will flow through the coils 45 in the compartments requiring heating but will be bypassed around those coils in the compartments which do not require heating. The amount that the three-way hot water mixing valves 48 will open is dependent upon the difference between the compartment temperature and the thermostat setting; the valve opening wider upon an increase in the temperature difference. Upon a rise in temperature, the three-way mixing valves 48 will gradually close to the coil 45 and open to the bypass 46. When the last mixing valve is closed, the thermostat in this compartment will cause the relay switch 65 to be de-energized. This will result in a de-energizing of the magnetic controller 73 and thus stop the motor 74 which drives the pump 42.

When the magnetic controller 73 is de-energized, it will cause the throwover relay 77 to transfer the regulation of the discharge pressure from the pressuretrol 90 back to the pressuretrol 89. This will result in lowering the discharge pressure so that the refrigeration system will return to its normal cooling cycle. This also causes all of the refrigerant to flow through the condenser 15 since no water is flowing through heater 23.

It will be understood that in any specific compartment, the heating coil and the cooling coil may be in operation at the same time. This will exist when the humidistat 59 calls for a lowering of the humidity and the thermostat 60 calls for heating.

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While only one refrigeration system has been disclosed, it will be understood that a number of such systems may be employed if such are required. If desired, suitable electric heaters or other similar means may be employed to provide a source of heat if the refrigeration system is shut down.

It will be seen that I have devised a conditioning system wherein my refrigeration system will run on the same cycle at all times. All that is needed is a heat source so that some cooling will always be accomplished by one of the evaporators or cooling coils 17.

My device permits the cooling of some compartments and the heating of other compartments at the same time in an enclosure from a single refrigeration system.

It will be understood that the cooling could be performed by an indirect system if desired. If such a system were used, three-way valves could be employed to control the amount of fluid flowing through the coil rather than the solenoid valve and the expansion valve. It also will be understood that other type of control systems could be employed. It is important, however, that the results accomplished be the same.

While I have described a preferred embodiment of my invention, it will be understood that my invention is not limited thereto since it may be otherwise embodied within the scope of the following claims.

I claim:

1. In a heating and cooling system for an enclosure containing a plurality of compartments, the combination of a refrigeration system including a compressor, a condenser, and an evaporator to serve as a cooling source for one of the compartments of the enclosure, a heater, means for circulating fluid through the heater to at least one of the compartments to serve as a heating source, a line connecting the compressor and the condenser, a second line leading to the heater and being connected to the first line, a third line connecting the heater and the condenser to the evaporator, means for supplying cooling medium to the condenser, and means responsive to a change in the condition of one of the compartments to reduce the flow of cooling medium through the condenser to cause a portion of the hot gaseous refrigerant to pass through the heater in heat exchange relation with the fluid passing through the heater.
2. In a heating and cooling system for an enclosure containing a plurality of compartments, the combination of a refrigeration system including a compressor, a condenser, and an evaporator in each compartment of the enclosure to serve as a cooling source, a heater, means including a water pump for circulating water through the heater to at least one of the compartments to serve as a heat source, a line connecting the compressor and the condenser, a second line connecting the compressor to the heater and extending from the first line, a third line connecting the heater and the condenser to the evaporators, a fourth line for supplying water to the condenser, a valve in the condenser water supply line to regulate the flow of water through the condenser, control means in at least one of the compartments, said control means in response to a decrease in temperature actuating the water pump and moving said valve to a partially closed position to reduce the flow of condenser water resulting in a portion of the hot gaseous refrigerant flowing through the heater to heat the water therein.
3. A system for conditioning an enclosure containing a plurality of compartments including in combination a refrigeration system having a condenser, a compressor, an evaporator in each compartment to serve as a cooling source, a heater, a line connecting the compressor to the condenser, a second line connecting the compressor to the heater and extending from the first line, a third line connecting the condenser and the heater to the evaporators, a water pump to circulate water to be heated through the heater, a heating coil in at least one of the compartments, a closed system for circulating the water

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from the hot water pump to the heater to the heating coil and back to the hot water pump, means for supplying cooling medium to the condenser, means to control the amount of cooling medium flowing through the condenser, said control means being responsive to a change in temperature in any of the compartments containing a heating coil.

4. A system for conditioning an enclosure containing a plurality of compartments including in combination a refrigeration system having a condenser, a compressor, an evaporator in each compartment to serve as a cooling source, a heater, a pump, a heating coil in at least one of the compartments, a closed system for circulating hot water from the pump to the heater to the heating coil and back to the pump, a refrigerant line connecting the compressor and the condenser, a second refrigerant line connecting the compressor and the heater and extending from the first line, a third refrigerant line connecting the heater and the condenser to the evaporators, means for supplying a cooling medium to the condenser, means for regulating the flow of cooling medium, said regulating means being responsive to the condition of any of the compartments containing a heating coil to regulate the flow of cooling medium to the condenser and to regulate the amount of heating of the hot water.

5. A system for conditioning an enclosure containing a plurality of compartments including in combination a refrigeration system having a condenser, a compressor, an evaporator to serve as a cooling source in each compartment, a heater, a pump, a heating coil in at least one of the compartments, a closed system for circulating hot water from the pump to the heater to the heating coil and back to the pump, a refrigerant line connecting the compressor and the condenser, a second refrigerant line connecting the compressor and the heater and extending from the first line, a third refrigerant line connecting the heater and the condenser to the evaporators, means for supplying a cooling medium to the condenser, means for regulating the flow of cooling medium, said regulating means being responsive to the discharge pressure of the compressor, a thermostat disposed in each compartment containing a heating coil to respond to a change of the temperature therein, said thermostat actuating the pump when the compartment temperature decreases to a predetermined temperature, the actuation of the pump resulting in the discharge pressure of the compressor being raised, and means responsive to a change in the discharge pressure to reduce the flow of cooling medium so that more hot gaseous refrigerant passes through the heater causing an increase in the temperature of the water passing through the heater in heat exchange relation with the refrigerant.

6. A system for conditioning an enclosure containing a plurality of compartments including in combination a refrigeration system having a condenser, a compressor, an evaporator in each compartment to serve as a cooling source, a heater, a pump, a heating coil in at least one of the compartments, a closed system for circulating hot water from the pump to the heater to the heating coil and back to the pump, a refrigerant line connecting the compressor and the condenser, a second refrigerant line connecting the compressor and the heater and extending from the first line, a third refrigerant line connecting the heater and the condenser to the evaporators, means for supplying a cooling medium to the condenser, means for regulating the flow of cooling medium, said regulating means being responsive to the discharge pressure of the compressor, a starter for the pump, an electric switch connected to the starter, a thermostat in each compartment containing a heating coil connected to the starter switch, said thermostat being adapted to actuate the pump through the switch and the starter when the temperature drops to a predetermined point, a selector relay connected to the starter and being adapted to change

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the discharge pressure of the compressor, the actuation of the starter resulting in an increase in the discharge pressure to reduce the flow of the cooling medium to the condenser so that more hot gaseous refrigerant passes through the heater in heat exchange relation with the water to increase the temperature of the water.

7. A system for conditioning a submarine containing a plurality of compartments including in combination a refrigeration system having a compressor, a condenser, and an evaporator in each compartment to serve as a cooling source, an expansion means for each evaporator, each expansion means being responsive to the temperature and humidity of its compartment, a heater, a refrigerant line leading from the compressor to the condenser, a second refrigerant line leading from the first line to the heater, a third line leading from the heater and the condenser to the evaporators, a heating coil in at least one of the compartments, at least one of the compartments containing only an evaporator, a pump for circulating water from the heater to the heating coil to the pump and back to the heater, means for supplying water to the condenser, means for regulating the flow of the condenser water in response to a change in temperature in any compartment containing a heating coil, and said pump being adapted to circulate water through the heater when the condenser water flow is reduced.

8. A system for conditioning a water vessel containing a plurality of compartments including in combination a refrigeration system having a compressor, a condenser, and an evaporator for each compartment to serve as a cooling source, a heater connected in parallel with the condenser for refrigerant flow, a water pump, a heating coil in at least one of the compartments, a closed system for circulating water from the pump to the heater to the heating coil and back to the pump, means for supplying water to the condenser, means for regulating the flow of condenser water in response to a change in temperature in any compartment containing a heating coil, said pump being adapted to start circulation of the water in the closed system when the flow of condenser water is reduced.

9. In a method for conditioning an enclosure containing a plurality of compartments consisting of the steps of supplying refrigerant from a refrigeration system as a cooling medium to each compartment, reducing the supply water to the condenser of the refrigeration system when the temperature in any of the compartments decrease below a predetermined point, supplying water to a heater in parallel with the condenser and in heat exchange relation with the hot gaseous refrigerant when the condenser water supply is reduced, and passing water from the heater to the compartment in which the temperature has decreased below the predetermined point.

10. A method for conditioning an enclosure containing a plurality of compartments which consist of cooling each compartment by passing therethrough refrigerant from a refrigeration system, reducing the flow of water through the condenser of the refrigeration system when the temperature of any of the compartments decreases below a predetermined point to cause a portion of the hot gaseous refrigerant to pass through a heater in parallel with the condenser, passing water through the heater in heat exchange relation with the portion of the refrigerant, and passing the water from the heater to the compartment in which the temperature has decreased below the predetermined point when the flow of condenser water is reduced.

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