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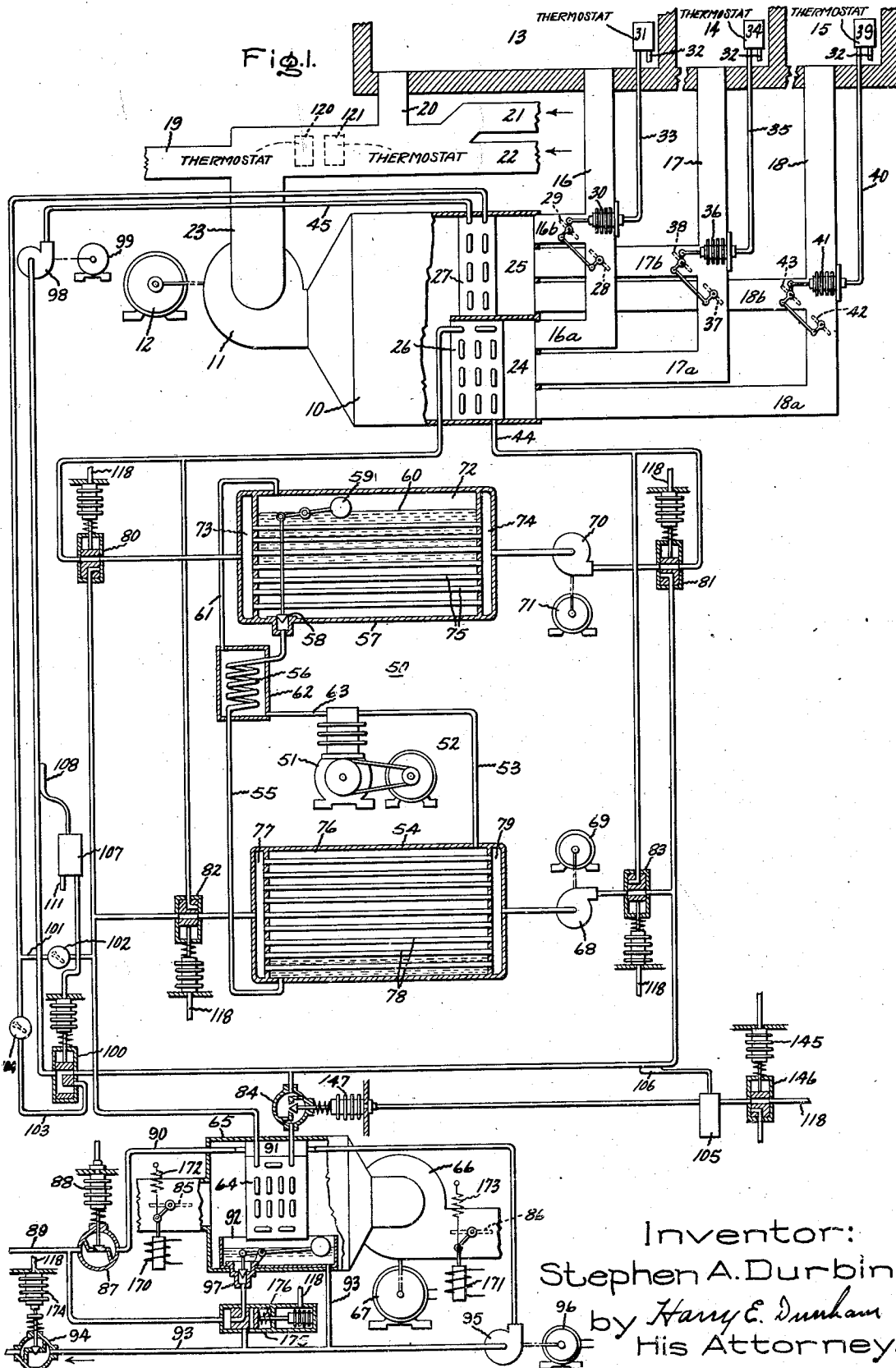
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2,292,335

AIR CONDITIONING APPARATUS

Filed Aug. 27, 1941

2 Sheets-Sheet 1



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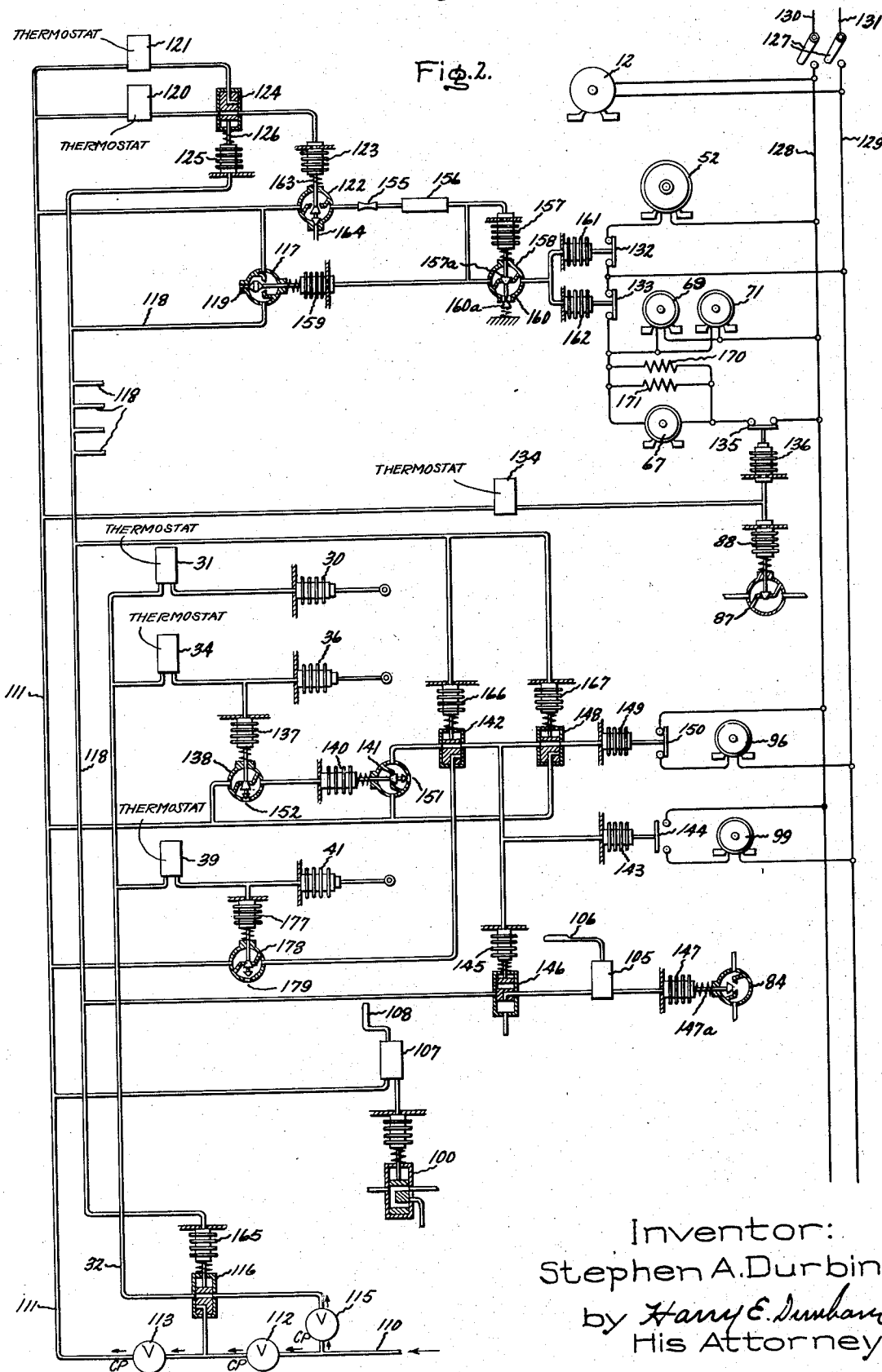
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,292,335

AIR CONDITIONING APPARATUS

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Application August 27, 1941, Serial No. 408,444

12 Claims. (Cl. 257—3)

My invention relates to air conditioning apparatus and particularly to such apparatus employing a reversible refrigerating machine or heat pump for both heating and cooling the air in one or more enclosures.

A reversible refrigerating machine may be employed for both heating and cooling by arranging it so that during the cooling season it pumps heat from the enclosure to be conditioned to the outdoor air or to some other heat dissipating medium, and so that during the heating season it pumps heat from the outdoor air or other medium to the air within the enclosure. The arrangement for reversing the machine may comprise suitable valves for reversing the refrigerant circuit of the machine so that the evaporator becomes a condenser and the condenser an evaporator, or the refrigerant circuit may be fixed and secondary fluid circuits provided so that the reversing operation may be accomplished without changing the main refrigerant circuit.

When the outdoor air, or any other fluid medium the temperature of which varies according to the season of the year, is employed as a source of heat and as a heat dissipating medium, it is obvious that the temperature of the medium varies in a direction opposite to the load demand of the machine. During the cooling season the greater the cooling load the higher is the temperature of the outdoor air and the less the differential of temperature between the outdoor air and the outdoor heat exchanger, and during the heating season the greater the demand for heating the lower is the temperature of the outdoor air and the less the differential of temperature between the outdoor heat exchanger and the outdoor air. It is, therefore, desirable to provide some arrangement for increasing the effectiveness of the heat exchange between the outdoor air and refrigerating machine to compensate for the increased load demand particularly when the temperature of the outdoor is near that of the outdoor heat exchange element.

During certain seasons of the year some rooms in a building may require a change of the air temperature opposite to that in other rooms thereof. For example, during the cooling season the sun may be shining on one side of the building so that rooms on that side require cooling while rooms on the shady side of the building may require heating, and during the heating season some rooms on the sunny side of the building may require cooling.

It is an object of my invention to provide an air conditioning apparatus including a heat pump

having an improved arrangement for supplying heat to the external heat absorbing element thereof.

Another object of my invention is to provide an air conditioning apparatus including a heat pump and having an improved arrangement for utilizing the outside air for the absorption and dissipation of heat.

Another object of my invention is to provide an apparatus for conditioning the air in a plurality of enclosures and including an improved arrangement for providing both heating and cooling capacity in accordance with the load demands of the several enclosures.

Another object of my invention is to provide an apparatus including a heat pump for conditioning the air in a plurality of enclosures and having an improved arrangement for changing the temperature of the air supplied to one or more of said enclosures in a direction opposite to that of the change of temperature of the air supplied to another of said enclosures.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of my invention reference may be had to the accompanying drawings in which Fig. 1 is a diagrammatic view of an air conditioning system embodying my invention and Fig. 2 is a diagrammatic view of the control for the air conditioning system shown in Fig. 1.

The air conditioning system shown in the drawings is arranged to condition the air for a plurality of rooms or other enclosures in a building. Desired quantities of fresh and return air are mixed and supplied to a conditioner housing which is divided into two air paths or chambers, each containing a heat exchange element, one the main heat transfer element and the other an auxiliary element. Ducts are provided so that air from each of the chambers is mixed and supplied to the separate rooms in proportions determined by thermostatic controls responsive to the temperatures of their respective rooms. A compression type refrigerating machine, including an evaporator and condenser is employed as a heat pump and is provided with a secondary circuit which may contain water, brine, or any other suitable medium for transferring heat between the evaporator and condenser elements of the refrigerating machine and the heat transfer

elements in the conditioner and an external heat transfer element over which outdoor air is circulated. During the cooling season the secondary circuit supplies cooling medium to the main heat transfer element of the conditioner and heating medium to the external heat transfer element. During the heating season the secondary circuit is reversed to supply heating medium to the main conditioner heat transfer element and cooling medium to the external heat transfer element.

The auxiliary heat transfer element is arranged to be connected to receive fluid from the secondary system to treat the air flowing through the auxiliary chamber and change its temperature in a direction opposite to that of the change of temperature of the air flowing through the main chamber. However, the auxiliary heat transfer element is normally inactive and is supplied with heat exchange medium only in the event that one or more of the enclosures to be conditioned requires a change of temperature opposite to that of the other enclosures. This arrangement makes it possible to heat one or more of the rooms during the cooling season and to cool one or more of the rooms during the heating season. During the cooling season, water is circulated over the outdoor heat transfer element to provide evaporative cooling. During the heating season, should the temperature of the outdoor air fall below a predetermined value the circulation of air over the outdoor heat transfer element is stopped and water from the city mains or other suitable source is circulated over the outdoor element to provide a source of heat at a suitable temperature.

Referring now to the drawings, the air conditioning system shown in Fig. 1 comprises a housing 10 through which air is circulated by a fan 11 driven by a motor 12 and is delivered to a plurality of rooms 13, 14 and 15 through suitable ducts 16, 17, and 18, respectively. Air is supplied to the housing 10 through a fresh air inlet duct 19 and through return air ducts 20, 21, and 22 connected to receive air from rooms 13, 14, and 15, respectively, the air from the ducts 19, 20, 21, and 22 being mixed and delivered to the fan 11 through an inlet connection 23. The housing 10 is divided into two chambers, a main conditioning chamber 24 and an auxiliary conditioning chamber 25, chambers 24 and 25 being arranged in parallel with respect to the air flow and being provided with extended surface heat transfer elements or coils 26 and 27, respectively. The duct 16 is provided with a branch 16a for receiving air from the chamber 24 and a branch 16b for receiving air from the chamber 25. Dampers 28 and 29 are provided in the duct 16a and 16b, respectively, to proportion the amounts of air from each of the chambers 24 and 25 which are to be admitted to the room 13 through the duct 16. The dampers 28 and 29 are linked together so that as one of the dampers moves toward its open position, the other moves toward its closed position. The dampers are positioned automatically by operation of an expansible bellows 30 under control of a thermostat 31 in the room 13. The thermostat 31 is of the pneumatic type and is arranged to receive compressed air through a supply line 32 and to deliver air under pressure to the bellows 30 through a connection 33, the pressure in the connection 33 being varied in accordance with the temperature of the air in enclosure 13. The ducts 17 and 18 are provided with branches 17a and 17b and

18a and 18b connected in the same manner as the branches of the duct 16. Rooms 14 and 15 may thus be supplied with air from either or both of the conditioning chambers 24 and 25. The room 14 is provided with a thermostat 34 of the same type as the thermostat 31 connected to receive compressed air from the supply line 32 and to deliver air under varying pressure through a connection 35 to a bellows 36 which controls dampers 37 and 38 corresponding to the dampers 28 and 29 controlled by the thermostat 31. Similarly the room 15 is provided with a thermostat 39 and arranged to receive air from the supply line 32 and deliver it through a connection 40 to bellows 41 which controls dampers 42 and 43 in the ducts 18a and 18b, respectively.

The main conditioning coil or heat transfer element 26 is connected to receive either heating or cooling medium from a supply line 44 and the auxiliary conditioning coil or heat transfer element 27 is normally inactive, but is arranged to receive either heating or cooling medium through a line 45 in a manner later to be described. Normally, therefore, the air flowing through the chamber 25 is at the temperature of the mixture delivered to the fan 11, whereas the air flowing through the chamber 24 is conditioned to heat the air during the heating season and to cool the air during the cooling season. It follows that the dampers 28, 37, and 42 should move to an open position on a demand for a decrease in room temperature during the cooling season and on a demand for an increase in room temperature during the heating season. In order that the pressure in the bellows 30, 36, and 41 may be decreased on a rise in temperature during the cooling season and on a fall in temperature during the heating season, the thermostat must be of a type which may be changed from winter to summer operation. This change-over may be effected in the thermostats illustrated by providing two available pressures of the compressed air to be delivered to the thermostat through the supply line 32 and by connecting the supply line to receive air at one pressure during the winter and at a different pressure during the summer. The details of the construction and operation of a thermostat of this type are disclosed in Patent No. 2,021,263 granted November 19, 1935, to Carl A. Otto.

In order to supply either heating or cooling medium to the heat transfer element, I provide a refrigerating machine 50 comprising a refrigerant compressor 51 driven by a motor 52 and arranged to deliver compressed gaseous refrigerant through a connection 53 to a condenser or heat dissipating element 54. Compressed gaseous refrigerant is cooled and liquefied in the condenser 54 and the liquid passes through a liquid line 55 and a heat exchange coil 56 to an evaporator or heat absorbing element 57 through a float controlled expansion valve 58. The valve 58 is operated by a float 59 to maintain substantially constant the level of liquid refrigerant in the evaporator as indicated at 60. Liquid refrigerant in the evaporator is vaporized by the absorption of heat and the vaporized refrigerant flows through a suction line 61 and a casing 62 about the heat exchange coil 56 back to the compressor 51 through a connection 63.

The refrigerating machine 50 is employed as a heat pump which is controlled selectively to pump heat from the outdoor air to the air in the chamber 24 or from the air in the chamber 24 to the outdoor air depending upon the season of the

year. In order to absorb heat from or dissipate heat to the outdoor air, an external heat transfer element or heat exchange coil 64 is housed in a duct or casing 65 through which outdoor air is circulated by operation of a fan 66 driven by an electric motor 67. In order to connect the evaporator and the condenser of the refrigerating machine to either of the heat exchange elements 26 and 64, I provide a secondary system for circulating a heat transfer medium such as brine or some other suitable non-freezing liquid through the heat exchanger coils and in heat exchange with the refrigerant in the condenser 54 and in the evaporator 57. The secondary system is arranged so that it provides, in effect, two closed circuits, one including the condenser 54 and the other including the evaporator 57. The condenser circuit includes a pump 68 driven by an electric motor 69 and is arranged to be connected to deliver liquid heated by the condenser to the element 26 during the heating season and to the element 64 during the cooling season. The evaporator circuit includes a pump 70 driven by an electric motor 71 and arranged to deliver liquid cooled by the evaporator to the element 26 during the cooling season and to the element 64 during the heating season.

The evaporator 57 comprises a main refrigerant chamber 72 and an inlet chamber 73 and an outlet chamber 74 connected by a plurality of parallel pipes 75 for circulating the brine or other heat transfer medium in heat exchange relation with the liquid refrigerant in the chamber 72. The condenser 54 is constructed in a manner similar to the evaporator 57 and comprises a main condensing chamber 76 where the compressed refrigerant is liquefied, and the brine is circulated through the condenser from an inlet header 77 through a plurality of parallel tubes 78 to an outlet header 79.

Suitable reversing valves 80, 81, 82, and 83 are provided to control the main connections of the secondary circulating system to determine the direction of heat transfer between the heat exchange elements 26 and 64. In the drawings the reversing valves are shown in their positions for the cooling season. During the cooling season the pump 70 circulates heat transfer liquid cooled by the evaporator through the upper port of the valve 81 to the heat exchange element 26 where the liquid absorbs heat from the air circulated through the chamber 24. The warmed liquid is returned to the evaporator through the upper port of the valve 80 and is again cooled by circulation through the pipes 75. The heat absorbed by the refrigerant within the evaporator is carried by the vaporized refrigerant to the compressor and is then conducted to the condenser with the compressed refrigerant. The compressed refrigerant is cooled and liquefied by heat exchange with the heat transfer liquid flowing through the tubes 78. The heat transfer liquid in the condenser tubes 78 is thus heated and is circulated by the pump 68 through the lower port of the valve 83 and through a normally open valve 84 to the heat exchange element 64 where it is available to heat the outdoor air passing through the casing 65. The heat transfer liquid returns from the element 64 to the condenser through the lower port of the valve 82.

During the heating season the positions of the reversing valves 80, 81, 82, and 83 are reversed by operation of a control which will be described later, and the heat transfer fluid is circulated through the lower ports of the valves 80 and 81

and through the upper ports of the valves 82 and 83. The pump 70 circulates liquid cooled by the evaporator 57 through the heat exchange element 64 to absorb heat from the outdoor air passing through the casing 65 and the pump 68 circulates heat transfer fluid heated by the condenser through the heat exchanger 26 so that the heat is supplied to the air flowing through the main conditioning chamber 24.

During the heating season when the outdoor temperature is well below freezing it will readily be understood that the required heating capacity of the machine is greater but since the differential of temperature between the heat exchanger and the outdoor air is small the transfer of heat is inefficient. I have provided an arrangement which under these conditions circulates water from the city water mains or other suitable source over the surface of the outdoor heat exchange coil 64; and in order to prevent freezing of water in the casing 65, dampers 85 and 86 are provided to shut off the circulation of the cold outdoor air through the casing 65. The arrangement for circulating water comprises a valve 87 actuated by a normally inactive bellows 88 which opens the valve only when the outdoor temperature is abnormally low, and controls the flow of water from the city mains or supply indicated at 89 through a pipe 90 to a spray-head 91 mounted over the heat exchange coil 64. The water, after being circulated over the heat exchanger coil, flows to a sump 92 at the bottom of the casing 65 and thence through a drain connection 93 to the drain through a valve 94 which is opened during the spraying operation.

For operation during the cooling season particularly when the outdoor temperature is high, I provide an arrangement for spraying water over the heat exchange coil 64 so that it operates as an evaporative cooler. The evaporative spraying arrangement utilizes the spray-head 91 and a pump 95 driven by an electric motor 96 which circulates water from the sump to the spray-head 91. The level of water in the sump is maintained substantially constant by operation of a float controlled valve 97. During the cooling season the valve 94 is kept closed so that water may be maintained at a desired level in the sump 92. The valve 87 is also closed so that city water is not circulated to the spray-head 91, however, make-up water is supplied to the sump from the source 89 by operation of the valve 97. By employing the pump 95 and continuous circulation of the water from the sump, it is possible to effect considerable economy in the use of the water over the cost of circulating city water over the coil 64 and wasting it to the drain.

The several rooms of a building may have widely varying heating and cooling loads and particularly during milder weather some rooms in the building may require heating, whereas others may require cooling. For example, the rooms on the sunny side of the building will be heated more than those on the shady side. Other conditions may arise where a large number of people in a room or some apparatus which operates at a high temperature may require that the room be cooled in order to obtain comfortable conditions during the heating season. In the apparatus shown in the drawings, I have provided an arrangement whereby one or more rooms may be supplied with air the temperature of which has been changed in a direction opposite to that of the main stream of conditioned air. Referring again to Fig. 1, the heat exchange element or coil

27 is connected in the secondary circuit in a by-pass around the coil 64 which includes a pump 98 driven by an electric motor 99. The by-pass circuit is thus arranged to receive heat transfer fluid from a portion of the secondary circuit such that it will change the temperature of the air flowing through the chamber 25 in a direction opposite to the change of temperature of the air flowing through the chamber 24. During normal operation of the air conditioning system, the ducts 16b, 17b and 18b are supplied with air at the temperature of the mixture of air in the casing 10 and the several sets of dampers supply air to the ducts 16, 17, and 18 at suitable temperatures which are attained by mixing air from the chamber 25 with air from the chamber 24. Should one of the sets of dampers move to a position in which all the air delivered to its main duct is taken from the chamber 25 this would be an indication that the change of temperature required in the corresponding room is opposite to that for which the main conditioning system is set to operate. In the system illustrated it is assumed that room 14 may require heating during the cooling season and that the room 15 may require cooling during the heating season.

With the apparatus set for the cooling season as shown in the drawings, should there be a demand for heating, as determined by the thermostat 34 in the room 14 which will then position its dampers to admit air only from duct 17b, the motor 99 will be energized to operate the pump 98. The pump 98 will deliver to the coil 27 heat transfer fluid which has been circulated from the condenser through the lower port of the valve 83, and then through a mixing valve 100 to the pump 98. Liquid after circulating through the heat exchanger 27 returns to the condenser circuit through a connection 101 provided with a check valve 102 to prevent reverse flow. A branch connection 103 provided with a check valve 104 is closed by the valve 100 in its lowermost position as shown. The heat exchanger coil 27 is thus connected in a by-pass in the secondary circuit of the condenser. The air circulated through the chamber 25 is now heated by the heat transfer coil 27 and heated air is delivered to the ducts 16b, 17b, and 18b, and the several dampers will adjust their positions accordingly, heated air now being available for delivery through the duct 17b to the room 14. Under this condition of operation the temperature of the water flowing through the condenser and consequently the temperature of the water flowing through the coil 27 is controlled by a reverse acting thermostat 105 having a thermal element 106 responsive to the temperature of the water delivered from the condenser by the pump 98. The thermostat 105 controls the valve 84 and thereby determines the proportion of the heat transfer liquid which is to pass through the outdoor heat exchange coil 64 to be cooled, the remainder of the fluid to be cooled passing through the heat exchanger coil 27 where its heat is absorbed by the air flowing through the auxiliary chamber 25. The thermostat 105 may be set to maintain any desired temperature, say 90° F.; when the temperature rises above this value, the valve is opened wider.

During the heating season should there be a demand for cooling in the room 15 as determined by the thermostat 39, the damper 42 being closed and the damper 43 being open, the motor 99 will be started to operate the pump 98 and deliver liquid cooled by the evaporator to

the heat transfer coil 27. The temperature of the water delivered to the pump 98 is controlled by the mixing valve 100. The valve 100 is actuated by a thermostat 107 having a thermal element or bulb 108 responsive to the temperature of the fluid delivered to the pump 98. The thermostat 107 is set to maintain the fluid delivered to the pump 98 at some suitable temperature such as 40° F., the control of the temperature being accomplished by mixing a portion of the liquid flowing directly from the pump 70 with another portion which has been warmed by the coil 27 and flows to the valve 100 through the connection 103. The check valve 104 is provided to prevent back flow through the conduit 103. The thermostat 107 maintains the valve 103 in its full open position as shown unless the temperature at the bulb or element 108 falls below 40° F.

The entire system is controlled automatically so that a changeover of the main conditioning system from heating to cooling, as well as the supply of heating or cooling fluid to the auxiliary heat exchange coil 27, will be accomplished in accordance with the load demands of the system as determined by suitable thermostats in the several rooms or other enclosures, in the outdoor air, and in the supply ducts. The manner in which the system operates and is controlled will now be explained with the assistance of the control diagram shown in Fig. 2.

The control system as shown in Fig. 2 is of the pneumatic type, the operating air at a suitable pressure, say 25 pounds per square inch, being supplied from a suitable source through a connection 110. Air at suitable pressure for the operation of the system is supplied through a main pressure supply line or conduit 111, pressure control valves 112 and 113 being provided to maintain a predetermined desired constant pressure such as 15 pounds per square inch in the conduit 111. The air line 32 which supplies air to the room thermostats is provided for changing the room thermostats from winter to summer operation, the change being effected by supplying air at either of two predetermined pressures determined by the control valve 112 and a control valve 115. The pressure maintained by the valve 112 may be 20 pounds per square inch for example and that maintained by the valve 115 may be 12 pounds per square inch. A valve 116 is provided to connect the line 32 selectively to receive air at either 12 or 20 pounds per square inch. The room thermostats 31, 34, and 39 as has already been stated are of the summer winter type; they are arranged to operate as cooling thermostats when the pressure in the line 32 is 12 pounds and as heating thermostats when the pressure is 20 pounds.

The changeover of the system as a whole from its setting for the cooling season to its setting for the heating season, and vice versa, is accomplished by operation of a valve or pneumatic relay 117 which is connected to receive pressure from the supply line 111. During the cooling season the supply line pressure of 15 pounds per square inch is applied directly to a heating-cooling or seasonal changeover line 118 by the valve 117 in its open position. When pressure prevails in the line 118 the several controls connected thereto are set in their positions for the cooling operation of the system. When the valve 117 moves to its closed position it connects the line 118 directly with the atmosphere through a port or orifice 119 and releases the

pressure on the control devices, thereby setting them in their positions for the heating operation of the system.

Thermostats 120 and 121 are arranged in the return duct to which air from the rooms is delivered by the ducts 20, 21, and 22. The thermostat 120 is placed in operation during the cooling season and the thermostat 121 is placed in operation during the heating season. The thermostats 120 and 121 are arranged to actuate a relay 122 by controlling the pressure in a bellows 123 of the relay. The thermostats are connected to the relay through a valve 124 which is actuated by a bellows 125 connected to receive pressure from the changeover line 118. During the cooling season there is pressure in the line 118 and the bellows 125 expands to move the plunger of valve 124 to its upper position thereby connecting the thermostat 120 to the bellows 123 through the lower port of the valve. When pressure is released from the line 118 to change the system over to its setting for the heating season the bellows 125 is collapsed by a spring 126 and the thermostat 121 is then connected to the bellows 123 through the upper or angle port of the valve.

When it is desired to place the system in operation a manual switch 127 is closed to connect electrical control lines 128 and 129 to electric power supply lines 130 and 131, respectively. The closing of switch 127 energizes the main blower motor 12 which is connected across the lines 128 and 129 and thereby starts the operation of the blower 11 to circulate air through the casing 10 and through the several ducts of the system. The compressor motor 52 and the pump motors 69 and 71 are also started provided normally closed switches 132 and 133 are in their closed positions and the outdoor fan motor 67 will also be started provided the outdoor temperature is above a predetermined value such as 20° F. as determined by a thermostat 134 which operates a switch 135 by means of a bellows 136. The water circulating pump 96 will also be started to spray water over the outdoor coil 64. When the several motors are running, the system is in operation for cooling and the thermostats 31, 34, and 39 will operate individually to position their corresponding dampers so that the desired predetermined temperatures are maintained in the rooms 13, 14, and 15. Under this condition of operation heat transfer fluid cooled by the evaporator is being supplied to the coil 26 to cool the air in the main conditioning chamber 24 and the air passing through the auxiliary chamber 25 is at the temperature of the mixture of air supplied to the blower 11.

It may happen that during the operation of the system the room 14 will become too cool for comfort. For example, this room may be on the shady side of the building and have relatively few sources of heat within it so that even air at the temperature of that supplied from the auxiliary chamber 25 will be too cold for the room 14. Under this condition the thermostat 34 will have operated so that the bellows 36 has expanded and moved the damper 37 to its completely closed position and the damper 38 to its completely open position. This position of the damper mechanism is an indication that room 14 requires heat and the increased pressure of air supplied by the thermostat 34 to the bellows 36 is also supplied to a bellows 137 of a relay 138; and when this pressure is sufficient to indicate a heating demand the relay 138 will open to admit air

under pressure from the line 111 and supply it to bellows 140 of a relay 141. This will actuate the relay 141 and supply air from the line 111 at a pressure controlled by the relay through the upper port of a valve 142 to a bellows 143. When the pressure in the bellows 143 reaches a predetermined value, the bellows will close a switch 144 and start the operation of the by-pass pump motor 99 to drive the pump 98 and circulate heated liquid through the coil 27. This will heat the air passing through the auxiliary chamber 25 and supply heated air to the duct 17b so that the room 14 may be maintained at its desired temperature. Pressure will also be supplied by the relay 141 to a bellows 145 and will actuate a valve 146 to connect the thermostat 105 to receive air under pressure from the line 118 through the upper port of the valve 146. The thermostat 105 then controls the valve 84 through a bellows 147 to maintain the temperature of the liquid supplied from the condenser at the desired value of 90° F. If the temperature falls below 90° the thermostat increases the pressure in the bellows 147 which expands against the pressure of a spring 147a and moves the valve toward its closed position. The relay 141 also supplies air under pressure through the upper port of a valve 148 to a bellows 149. The bellows 149 expands under pressure and opens a switch 150 to deenergize the motor 96 and stop the operation of the spray pump 95. This stops the evaporative cooling of the liquid in the coil 64 so that the desired higher temperature of the liquid may be maintained by operation of the thermostat 105.

The operation of the by-pass pump 99 to supply heated liquid to the coil 27 will be continued as long as the thermostat 34 maintains a sufficiently high pressure of the air in the bellows 137. When this pressure falls the positions of the several relays and operating bellows will be restored to their positions as shown in Fig. 2. The pressure in the bellows 143, 145, and 149 is released through a vent port 151 of the valve 141, and the pressure in the bellows 140 is released through a vent port 152 of the valve 138.

During the normal operation of the system in the cooling season the thermostat 120 maintains sufficient pressure in the bellows 123 to keep the relay valve 122 in its lower position so that air at 15 pounds pressure from the line 111 is delivered through a restrictor 155 and a receiver 156 to a bellows 157 of a relay 158 and also to a bellows 159 of the valve 117. The pressure in the bellows 157 and 159 maintains them in their expanded positions so that the relay valve 158 is closed and its lower chamber is in communication with the atmosphere through a port 160 and so that the valve 117 is open and its discharge port 119 is closed. When the relay 158 is in the position shown, bellows 161 and 162 which operate the switches 132 and 133, respectively, are in their collapsed positions and maintain the switches closed. The relay 158 includes a valve member 157a for controlling the rate of flow of air through the relay and a valve member 160a for controlling the discharge of air to the atmosphere. The valve 160a is pressed upwardly by a spring to close the opening 160 when the stem of valve 157a is moved upwardly by contraction of the bellows 157, the valve 160a being separate from the stem of the valve 157a so that the opening 160 is closed when the valve 157a starts to open and regulate the flow of air through the relay.

Should the temperature of the air returning

from the rooms and flowing over the thermostat 120 fall below a predetermined value, say 72° F., it would indicate that the system should be changed over from cooling to heating. At this temperature the pressure delivered by the thermostat 120 to the bellows 123 falls so that a spring 163 compresses the bellows and moves the relay to its upper position shutting off the connection between the receiver 156 and the pressure line 111 and also opening a discharge port 164 of the relay. The pressure in the receiver 156 will now gradually fall because of the discharge of air through the restrictor 155 to the atmosphere through the port 164. As the air pressure falls from 15 pounds to say 8 pounds per square inch the bellows 157 will gradually contract and operate the relay 158 so that the port 160 is closed and the pressure will build up slowly in the bellows 161 and 162 to 7 pounds per square inch. As the pressure builds up, the bellows 161 will first expand to open switch 132 and stop the compressor motor 52, and then the bellows 162 will expand to open the switch 133 and stop the liquid pump motors 68 and 71. As the air pressure continues to fall from 8 pounds per square inch, the bellows 159 will contract until, say at 7½ pounds per square inch, it will shut off the connection between the lines 118 and 111 and will exhaust the line 118 to the atmosphere through the exhaust port 119 of the relay 117. The pressure in the seasonal changeover line 118 will then fall to zero and the system will be changed over from its cooling setting to its heating setting. The bellows 125 will contract to change the valve 124 so that the heating thermostat 121 takes over control by being connected to the bellows 123 through the upper port of the valve. The three-way valves 80, 81, 82, and 83 are provided with individual bellows each connected to the line 118 so that when the pressure in the line 118 falls to zero as the air from the receiver 156 is completely exhausted through the port 164, the bellows contract and the valves move to the opposite positions from those in which they are shown in Fig. 1, and connect the secondary fluid circuits in their heating positions.

The valve 116 is also moved to its upper position by the contraction of an operating bellows 165 and the line 32 is thereby connected through the lower port of the valve 116 so that its pressure is changed from 12 to 20 pounds per square inch which changes the thermostats 31, 34 and 39 to their winter or heating positions. The valves 142 and 148 are moved to their upper positions since their corresponding bellows 166 and 167, respectively, are connected with the line 118 and contract on release of pressure.

Since the air in the chamber 25 is heated the damper mechanisms controlled by the several room thermostats must necessarily be adjusted by their thermostats in accordance with the change in temperature of the air in the auxiliary chamber. The changeover having been effected, the pressure in the bellows 161 and 162 will fall to zero and the switches 132 and 133 will be closed in sequence. The bellows 123 will remain contracted and the relay 122 in its upper position until the thermostat 121 indicates that the temperature has risen to a predetermined value, say 75° F., and that there should be a changeover from heating to cooling operation.

The system, when in its heating setting, will operate to supply hot fluid to the heat transfer coil 26 and heat the air passing through the main conditioning chamber 24 and thermostats

31, 34 and 39, and operate their corresponding damper mechanisms to supply air at the required temperatures to these several enclosures. Should the outdoor temperature fall below 20° F. so that the transfer of heat from the outdoor air to the heat exchange coil 64 is inefficient, the thermostat 134, which is responsive to the outdoor temperature, will operate to decrease the pressure in the bellows 136 and open the switch 135 thereby discontinuing operation of the motor 67 and also deenergizing two solenoids 170 and 171. These solenoids indicated in Fig. 1 in their energized positions, operate the dampers 85 and 86, respectively, and when deenergized allow springs 172 and 173 to close the dampers. The operation of the switch 135 thus stops the blower 66 and shuts off the circulation of outdoor air through the casing 65. The decrease in air pressure caused by the thermostat 134 also allows the bellows 88 to contract and open the valve 87 and admit city water to the spray head 91. In this connection it should be stated that the contraction of the bellows 167 has operated the valve 148 to connect the bellows 149 directly to the air pressure line 111 so that the switch 150 is maintained open throughout the heating operation and the spray pump 95 cannot be operated. City water will be delivered from the supply 89 through the valve 87 and conduit 90 to the spray head 91 and the coil 64 then absorbs heat from the city water which is cooled and flows to the sump 82 from which it is drained through connection 93 and valve 94. The valve 94 has a bellows 174 connected to the seasonal changeover line 118 which contracts to open the valve when the pressure in the seasonal changeover line is zero as during the heating operation. When the pressure in the line 118 falls to zero a valve 175 connected between the water supply 89 and the float operated valve 97 is moved to its closed position by operation of a spring 176 so that no water is admitted to the sump 82 through the valve 97 during the heating season.

As long as the temperature of the outdoor air remains at 20° F., or lower, the valve 87 will continue to supply water to the spray head 91 so that the heat for the operation of the system is supplied from the city water mains. As soon as the temperature rises above 20° F. the valve 87 will be closed to shut off the supply of water to the spray head and the bellows 136 will expand to again open the dampers 85 and 86 and start the operation of the outdoor blower motor 67.

If during the heating season the temperature in the room 15 should increase above a predetermined value, as determined by the thermostat 39, such that the damper 42 is completely closed and the damper 43 completely opened, this is an indication that cooling is required in room 15. A continuation of the increased pressure of the air delivered by the thermostat 39 will cause a bellows 177 of a relay 178 to expand thereby admitting air from the pressure line 111 through the lower port of the valve 142 to the bellows 143 and 145. The resulting expansion of the bellows 143 closes the switch 144 and starts the operation of the by-pass pump 98. The motor 99 will drive the pump 98 and circulate cooled liquid through the coil 27 to provide cooling capacity to reduce the temperature of the air supplied to the room 15. Since the air passing through the chamber 25 is now cooled, all the damper mechanisms will readjust their positions to maintain the desired temperatures in the sev-

eral rooms. The temperature of the liquid circulated through the by-pass secondary system by operation of the pump 98 will be controlled by the thermostat 107 which actuates the mixing valve 100. The thermostat 105 does not operate, since the expansion of the bellows 145 merely operates the valve 146 to connect the thermostat with the seasonal changeover line, which during the heating season carries no pressure; consequently the valve 84 remains in its open position. Whenever the pressure delivered by the thermostat 39 to the bellows 177, falls below the value at which the relay 178 was operated, the bellows 177 will contract and the pressure will be released from the bellows 143 and 144 through a discharge orifice 179 of the relay.

The operation of the system to provide heating will continue throughout the heating season until such time that the return duct thermostat 121 supplies pressure to the bellows 123 of the relay 122 at a value indicating that the temperature has risen to such a value that cooling is required. When this occurs, the plunger of relay 122 will move to its lower position and connect the receiver 156 to the pressure supply line 111 through the restrictor 155. As the pressure builds up bellows 159 will expand to shut off the discharge orifice 119 and supply pressure to the seasonal changeover line 118, and as the pressure continues to rise the bellows 161 and 162 will expand to open the switches 132 and 133 in sequence and deenergize the compressor motor 52 and the pump motors 68 and 71, as well as the outdoor fan motor 67. As the pressure continues to rise the bellows 157 will expand and actuate the relay 158 to open the discharge orifice 160 thereby releasing the pressure from the bellows 161 and 162 and again starting the motors 52, 67, 69, and 71. Since the seasonal changeover line is now under pressure the system is operated on its cooling cycle the several controls being again in their positions as shown on the drawings.

During the operation of the system as above described the control will automatically select the most desirable operating setting, so that the system will supply heat transfer liquid either heated or cooled depending upon the load demand of the greater number of rooms, and those rooms which are apt to have a conditioning load in a direction opposite to that normal during the season, may be supplied with air the temperature of which has been changed in a direction opposite to that of the main air supply.

While I have described and illustrated my invention in connection with a particular type of air conditioning system, other applications will readily be apparent to those skilled in the art. I do not, therefore, desire my invention to be limited to the particular construction shown and described, and I intend in the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for heating and cooling the air in a plurality of enclosures comprising a refrigerating machine, means providing two air circulating paths, means for circulating air through said paths and into said enclosures, said means being so arranged that each of said enclosures may receive air from both said paths, a heat transfer element arranged in one of said paths, means for selectively connecting said element to receive heating or cooling medium from said

refrigerating machine, a heat transfer element in the other of said paths, and means dependent upon a condition of the air in at least one of said enclosures for connecting said last mentioned heat transfer element to receive from said refrigerating machine heating or cooling medium of the opposite temperature characteristic from that selected to be supplied to said first mentioned heat transfer element.

2. Apparatus for conditioning the air in a plurality of enclosures comprising means including two chambers and a plurality of ducts for conducting air from both of said chambers to each of said enclosures, separate means associated with each of said enclosures for proportioning the relative amounts of air from each of said chambers which are conducted to the corresponding ones of said enclosures, means for selectively raising or lowering the temperature of the air passing through one of said chambers, means for selectively raising or lowering the temperature of the air passing through the other of said chambers, said last mentioned means being normally inactive, and means dependent upon the setting of at least one of said proportioning means to conduct air to its corresponding enclosure solely from said other chamber for rendering said normally inactive means effective to change the temperature of the air passing through said other chamber in a direction opposite to that of the change in temperature of the air passing through said one chamber.

3. Apparatus for conditioning the air in a plurality of enclosures comprising a refrigerating machine for supplying heat transfer medium for heating and for cooling, means including two chambers and a plurality of ducts for conducting air from both of said chambers to each of said enclosures, individual means for proportioning the relative amounts of air from each of said chambers which are conducted to each of said enclosures, a heat transfer element arranged in one of said chambers and connected to receive heat transfer medium from said refrigerating machine for selectively raising or lowering the temperature of the air circulated through one of said chambers, a normally inactive heat transfer element arranged in the other of said chambers, and means dependent upon the positioning of at least one of said individual proportioning means to conduct air solely from said other of said chambers to the corresponding one or ones of said enclosures for connecting said normally inactive heat transfer element to receive heat transfer medium from said refrigerating machine for changing the temperature of the air circulated through said other chamber in a direction opposite to that of the change in temperature of the air circulated through said one chamber.

4. Apparatus for conditioning the air in a plurality of enclosures comprising means for supplying air to each of said enclosures, said means including a main duct and an auxiliary duct for each enclosure, damper means associated with each enclosure for proportioning the relative amounts of air to be conducted through the main duct and the auxiliary duct to the enclosure, means for raising or lowering the temperature of the air passing through said main ducts, means for raising or lowering the temperature of the air passing through said auxiliary ducts, said last mentioned means being normally inactive, and means dependent upon the setting of at least one of said damper means to conduct air

solely from its corresponding auxiliary duct for rendering said normally inactive means effective to change the temperature of the air passing through said auxiliary ducts in a direction opposite to that of the change in temperature of the air passing through said main ducts.

5. Apparatus for conditioning the air in a plurality of enclosures comprising two chambers and a plurality of ducts for connecting both of said chambers to each of said enclosures, means including proportioning dampers associated with each of said enclosures for determining the amount of air to be conducted from each of said chambers to the corresponding ones of said enclosures, means for raising or lowering the temperature of the air passing through one of said chambers, means for raising or lowering the temperature of the air passing through the other of said chambers, and means dependent upon the positioning of at least one of said dampers to conduct air solely from said other chamber to the corresponding one of said enclosures for rendering said normally inactive means effective to change the temperature of the air passing through said other chamber in a direction opposite to that of the change in temperature of the air passing through said one chamber.

6. Apparatus for conditioning the air in a plurality of enclosures comprising means including two chambers and a plurality of ducts for conducting air from both of said chambers to each of said enclosures, separate means associated with each of said enclosures for proportioning the relative amounts of air from each of said chambers to be conducted to the corresponding ones of said enclosures, means for raising or lowering the temperature of the air passing through one of said chambers, means for raising or lowering the temperature of the air passing through the other of said chambers, said last mentioned means being normally inactive, means operative during the cooling season and dependent upon a setting of at least one of said proportioning means to conduct air to its corresponding enclosure solely from said other chamber for rendering said normally inactive means effective to heat the air passing through said other chamber, and means operative during the heating season and dependent upon the setting of a different one of said proportioning means to conduct air to its corresponding enclosure solely from said other chamber for rendering said normally inactive means effective to cool the air passing through said other chamber.

7. Apparatus for conditioning the air within an enclosure comprising a refrigerating machine having a heat absorbing means and a heat dissipating means, means for utilizing said heat dissipating means to heat the air in the enclosure, means for circulating outside air in heat exchange relation with said heat absorbing means to supply heat to said refrigerating machine, normally inactive means for conducting water in heat exchange relation with said heat absorbing means to supply heat to said refrigerating machine, and means dependent upon a predetermined low temperature of the outside air for preventing the circulation of outside air in heat exchange relation with said heat absorbing means and for rendering said normally inactive means effective to conduct water in heat exchange relation with said heat absorbing means to supply heat to said refrigerating machine.

8. Apparatus for conditioning the air within an enclosure comprising a refrigerating machine

having a heat absorbing means and a heat dissipating means, means for utilizing said heat dissipating means to heat the air in the enclosure, said heat absorbing means including an extended heat transfer surface arranged externally of the enclosure, means including a housing surrounding said extended surface and a blower for circulating outside air over said surface, normally inactive means for circulating water over said extended surface to supply heat to said refrigerating machine, damper means operative to a closed position for preventing the admission of outside air to said housing, and means dependent upon a predetermined low temperature of the outside air for stopping the operation of said blower and for positioning said damper means to prevent the admission of outside air to said housing and for rendering said normally inactive means effective to circulate water over said extended surface.

9. Apparatus for conditioning the air within an enclosure comprising a reversible refrigerating machine having a first heat transfer means for heating or cooling the air within the enclosure and a second heat transfer means for absorbing heat from and for dissipating heat to the outside air, selectively operable means for connecting said refrigerating machine for heating or for cooling the air in the enclosure, means for circulating outside air over said second heat transfer means, a spray-head for directing water over the surface of said second heat transfer means, means dependent upon the connection of said refrigerating machine to cool the air in said enclosure for collecting water circulated over said second heat transfer means and for recirculating the water to said spray-head whereby said second heat transfer means operates as an evaporative cooler, normally inactive means for connecting said spray-head to a source of water supply, means for enclosing said second heat transfer means to prevent the circulation of outside air thereover, and means dependent upon a predetermined low temperature of the outside air when said refrigerating machine is connected to heat the air in the enclosure for actuating said normally inactive means and for actuating said means for enclosing said second heat transfer means whereby heat for said refrigerating machine is supplied from the source of water.

10. A system for conditioning the air in a plurality of enclosures comprising a casing having two chambers therein, means for withdrawing air from said enclosures and for supplying the withdrawn air to said casing, a main conditioning coil in one of said chambers, a normally inactive auxiliary conditioning coil in the other of said chambers, means for supplying air to each of said enclosures from both of said chambers, individual temperature responsive means for each of said enclosures for proportioning the amounts of air supplied thereto from each of said chambers, means including a reversible refrigerating machine for supplying heating and cooling medium to said coils, means dependent upon the temperature of the air from said enclosures supplied to said casing for selectively operating said refrigerating machine to supply heating or cooling medium to said main conditioning coil, and means dependent upon the temperature of the air in at least one of said enclosures for supplying to said auxiliary coil heating or cooling medium for changing the temperature of the air circulated through said other chamber in a direction opposite to the change effected by

said main coil in the temperature of the air circulated through said one chamber.

11. Apparatus for conditioning the air within an enclosure comprising a reversible refrigerating machine having a first heat transfer means for heating or cooling the air within the enclosure and a second heat transfer means for absorbing heat from and for dissipating heat to the outside air, selectively operable means for connecting said refrigerating machine for heating or for cooling the air in the enclosure, means for circulating outside air over said second heat transfer means, a spray-head for directing water over the surface of said second heat transfer means, means dependent upon the connection of said refrigerating machine to cool the air in said enclosure for collecting water circulated over said second heat transfer means and for recirculating the water to said spray-head whereby said second heat transfer means operates as an evaporative cooler, normally inactive means for connecting said spray-head to a source of water supply, and means dependent upon a predetermined low temperature of the outside air when said refrigerating machine is connected to heat the air in the enclosure for actuating said normally inactive means whereby heat for said refrigerating machine is supplied from the source of water.

12. Apparatus for conditioning the air in a plurality of enclosures comprising a refrigerating machine for supplying heat transfer medium for heating and for cooling, means including two chambers and a plurality of ducts for conducting

air from both of said chambers to each of said enclosures, individual means for proportioning the relative amounts of air from each of said chambers which are conducted to each of said enclosures, said refrigerating machine comprising a compressor and a condenser and an evaporator, a first heat transfer element in one of said chambers, a second heat transfer element arranged externally of said chambers, means for circulating a heat transfer fluid over said second heat transfer element for absorbing and for dissipating heat externally of said chambers, a first fluid circuit including said first element, a second fluid circuit including said second element, means for selectively connecting said evaporator and said condenser in heat exchange relation with said fluid circuits whereby the condenser is in heat exchange relation with said first circuit when said evaporator is in heat exchange relation with said second circuit and vice versa, a third heat transfer element in the other of said chambers, normally inactive means including a third fluid circuit by-passing a portion of said second circuit for supplying heat transfer fluid to said third element which has a heat characteristic opposite to that of the fluid supplied to said first element, and means dependent upon the positioning of at least one of said individual proportioning means to conduct air solely from said other of said chambers through the corresponding one or ones of said enclosures for rendering active said normally inactive means to supply heat transfer fluid to said third element.

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