Nov. 19, 1940. L. A. PHILIPP 2,222,237

AIR CONDITIONING SYSTEM

Filed Nov. 8, 1933 2 Sheets-Sheet 1

Fig. 1.

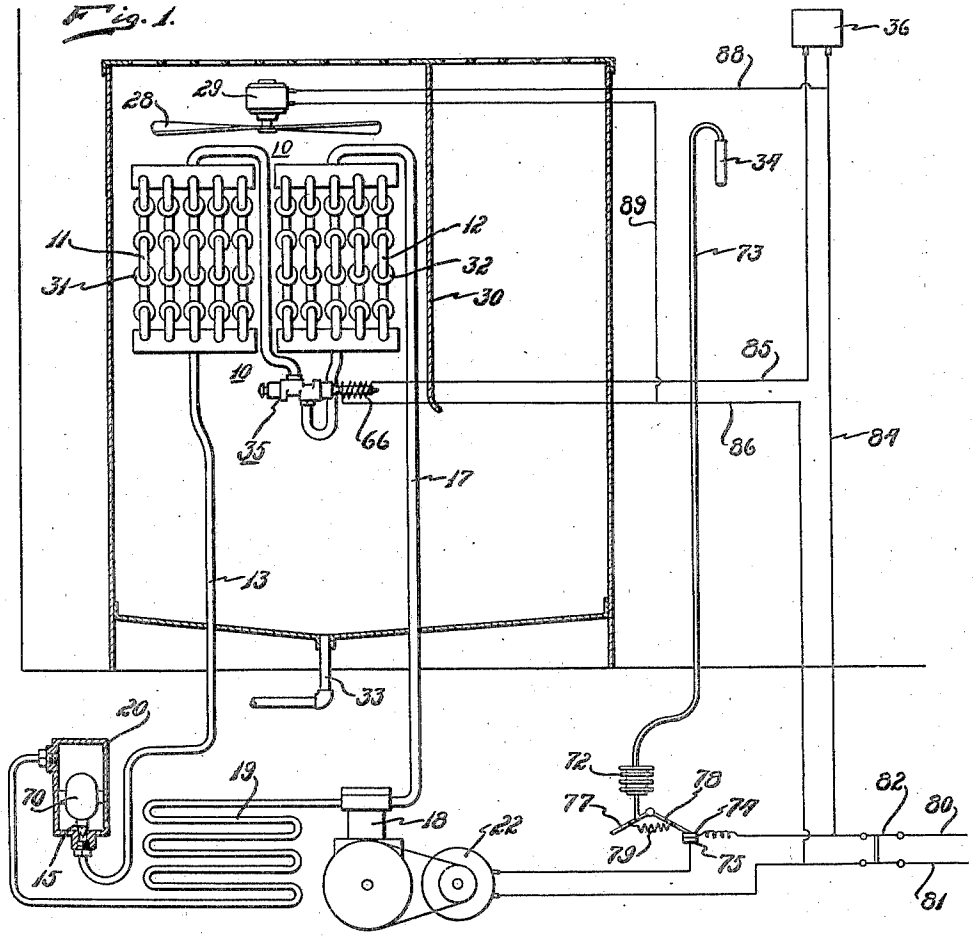
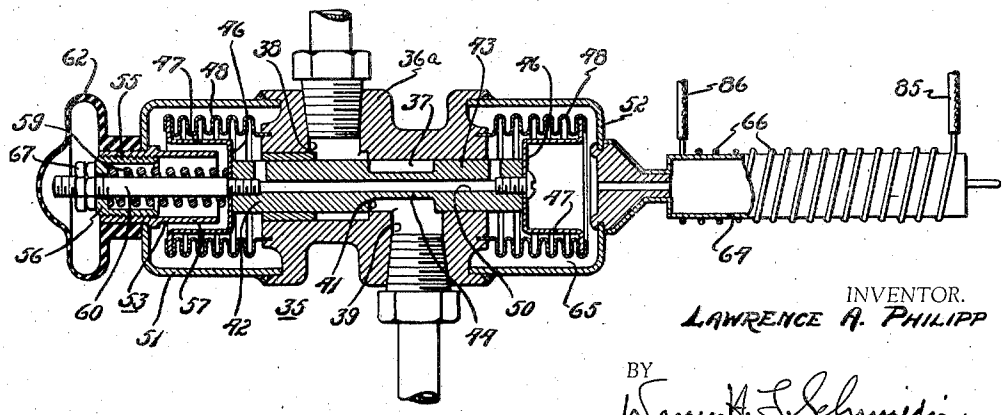


Fig. 2.



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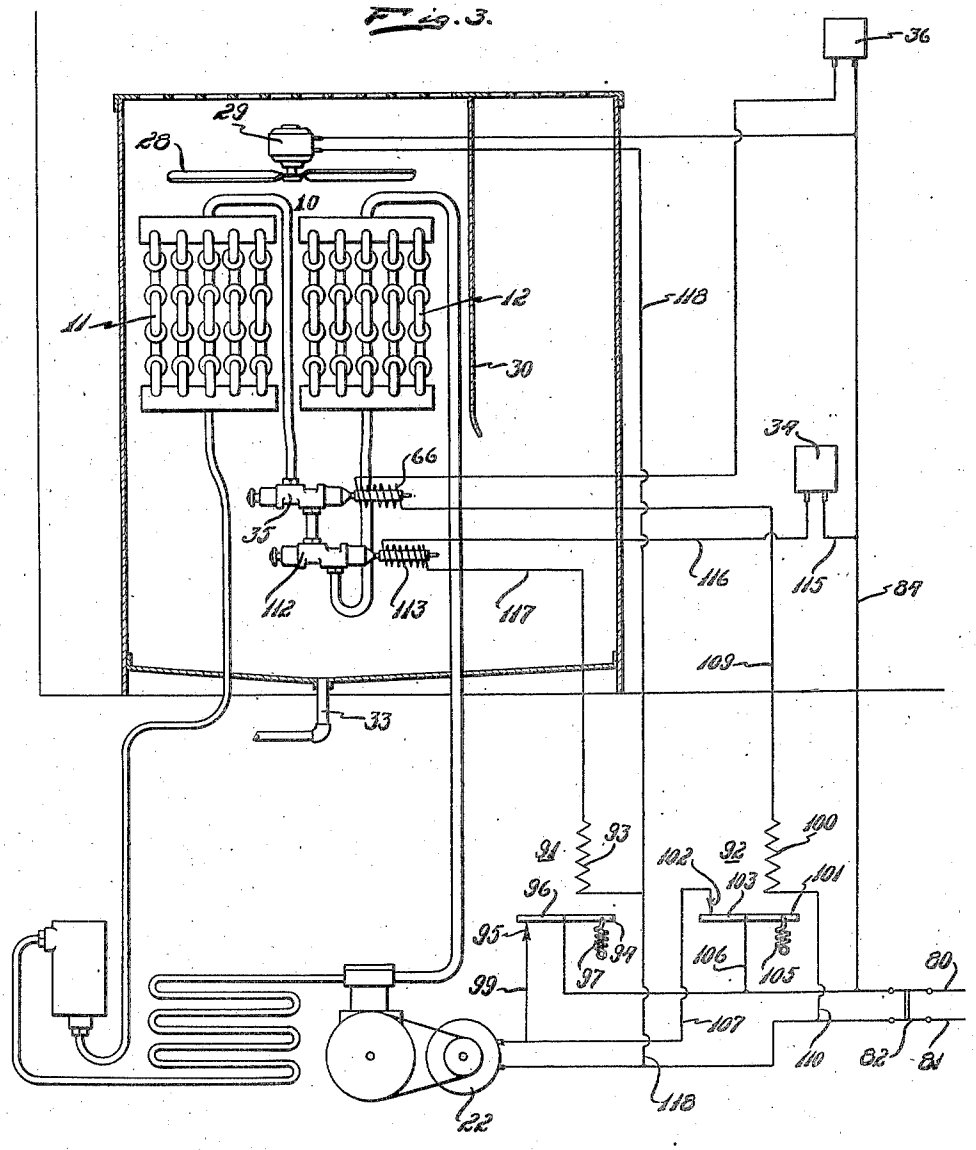
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Fig. 3.



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AIR CONDITIONING SYSTEM

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11 Claims. (Cl. 62—6)

The present invention relates to the art of conditioning air and more particularly to the method of and apparatus for cooling and dehumidifying air.

One of the objects of the present invention is to provide an improved method of and apparatus for conditioning air, utilizing two heat absorbing sections in which a refrigerating medium is circulated first through one of the sections and then the other and varying the flow from one of the sections to the other in accordance with the condition of the air to be conditioned.

Another object of the invention is to control the flow of refrigerating medium from one of the heat absorbing sections to the other in accordance with variations of the relative humidity and/or the temperature of the air to be conditioned.

Other and further objects and advantages will be apparent from the following disclosure, reference being had to the accompanying drawings wherein preferred forms of embodiments of the present invention are clearly shown.

In the drawings:

Fig. 1 illustrates diagrammatically one form of the air conditioning system applied for cooling a room;

Fig. 2 is a longitudinal cross sectional view of an automatic throttle valve used in the system; and

Fig. 3 illustrates diagrammatically another embodiment of the invention.

My invention contemplates the use of a heat absorber of any suitable type having at least two heat absorbing surfaces. Both of these surfaces are utilized under normal or low humidity conditions for removing principally sensible heat from the air and one of these surfaces is utilized also and particularly when the air to be conditioned is high in relative humidity, for cooling the air to below its dew point in order to cause precipitation and thereby remove a large part of the moisture from the air.

In the present embodiment an evaporator 10 of a mechanical refrigerator is employed as a heat absorber and the two heat absorbing surfaces of the heat absorber are provided by dividing the evaporator into two sections or portions 11 and 12. The flow of refrigerant by a feed pipe 13 to the evaporator 10 is controlled by an expansion valve 15 and gaseous refrigerant is withdrawn from the evaporator through a low pressure or suction pipe 17. The heat dissipator is herein shown as comprising a reciprocating type compressor 18, a condenser 19 and a liquid receiver 20. Gaseous refrigerant withdrawn from the sections 11 and 12 passes through the suction pipe 17 into the low pressure side of the compressor 18 wherein it is compressed and flows into the condenser 19. It is liquefied in the condenser by being cooled and from the condenser the liquefied refrigerant flows into the receiver 20 and then conducted through the expansion valve 15 to refrigerant feed pipe 13. The compressor is driven by a motor 22 which is controlled by a switch 23. It is to be understood that the capacity of the machine is such as to provide sufficient refrigeration under abnormal high temperature and humidity conditions or both, of the air to be conditioned and that the refrigerating effect is varied in accordance with the conditions of the air to be conditioned.

The air conditioner herein illustrated is the type for cooling a room 24 such as an office or a living room in the home and the evaporator 10 is disposed in a cabinet 25 having an air inlet 26 and an air outlet 27. The air is forced through the cabinet and about the evaporator 10 by a fan 28 driven by an electric motor 29. A partition 30 extends downwardly from the top of the cabinet 25 and from the front to the rear for directing air. The sections 11 and 12 of the evaporator are arranged side by side and approximately one-half of the air circulated passes about section 11 and the other half about section 12. Section 12 has approximately as much heat absorbing surface as section 11. In order to increase the heat absorbing surfaces of sections 11 and 12, fins 31 and 32 are attached to these sections. Water collected on the evaporator drips to the floor of the cabinet 25 and is conducted out of the cabinet through a drain pipe 33. Preferably the heat dissipator is disposed outside of the room to be conditioned but in case it is desirable to have this machine in the room, the condenser and compressor are cooled by water so that the heat is carried out of the room in the water.

The primary or principal purpose of section 11 is to remove sensible heat from all of the air passing thereover and although section 12 will remove sensible heat from the air passing thereover, its function at times, particularly when the relative humidity of the air to be conditioned is high, is to remove latent heat from the air by lowering the temperature of such air to below its dew point. It will be appreciated that the air in the room is subjected to different conditions due to changes in the temperature and humidity of the air outside the room and due to the direct addi-

tion of heat and moisture to the air within the room.

In order to maintain the air in the room between predetermined high and low temperature limits, a thermostat 34 is provided for controlling the operation of the heat dissipator. This thermostat is preferably disposed so as to respond to the mean temperature of the air in the room and controls the motor switch 23 by opening the same when the temperature of the air in the room attains a predetermined low value and closes the same when the temperature of the air attains a predetermined high value. Thus the temperature of the air in the room is maintained between certain limits by controlling the operation of the heat dissipator.

Not only is it desirable to control the temperature of the air in the room, but, it is also desirable to control the relative humidity of the air. When the relative humidity is high, the temperature of part of the air, as it passes through the cabinet 25, is decreased to below its dew point to cause precipitation of the moisture out of the air. The section 12 of the evaporator 10 is used for this purpose, it being designed and controlled to maintain at times a temperature much lower than that of the section 11. Since the relative humidity varies independently of variations in temperature, it is necessary to remove varying proportions of moisture from the air while maintaining the temperature of the air between the predetermined fixed high and low temperature limits. In other words it is necessary at times to provide a low temperature to remove sufficient moisture and it is also necessary that the mean temperature of the air in the room should not be lowered below a predetermined limit. To provide these proper refrigerating conditions, I vary the amount of heat absorbed by different portions of the evaporator 10 by increasing and decreasing the temperature differential between these portions. These portions in the present disclosure are sections 11 and 12. When the relative humidity of the air to be conditioned is relatively high, the section 12 is arranged to operate at a low temperature and the section 11 at a relatively high temperature. The temperature of the section 12 at this time will be low enough to cool a portion of the air to below its dew point and the amount of heat units removed by both sections is sufficient only to maintain the temperature of the air in the room between its predetermined fixed high and low temperature limits.

The relative amount of heat units absorbed by sections 11 and 12 is controlled by a valve 35 which valve is controlled by a humidostat 36. Valve 35 includes a main body 36a forming a cylinder 37. The cylinder is provided with an inlet 38 which is connected with the outlet of section 11 and is provided with an outlet 39 which connects with the inlet of section 12. A pressure balanced piston 41 is disposed in the cylinder and is provided with two heads 42 and 43 which are connected with one another by a neck 44. The bottoms 46 of metal cups 47 are sealed to the opposite ends of the piston 41 and the lips of the cups are sealed to ends of metal bellows 48. The opposite ends of the bellows 48 are sealed to the opposite ends of the main body 36a. By this construction the ends of the cylinder 37 are sealed. The interiors of the bellows 48 are interconnected through the passage 50 in the piston 41 whereby the pressures within the bellows are equal. Cups 51 and 52 are sealed with the opposite ends of body 36a and inclose the bellows 48. A sleeve 53 is sealed with the cup 51 and is provided with an outwardly extending end 55 which is internally threaded to receive a fitting 56 and is provided with an end 57 which extends within a cup 47. A coil spring 59 is disposed between the end of fitting 56 and the bottom of cup 47 and normally urges the piston 41 to the right. A bolt 60 is attached to the end of piston 41 and extends through the fitting 56. Nuts 67 are threaded on the end of bolt 60 which are arranged to engage the end of fitting 56 for limiting the right hand movement of piston 41. A rubber end cover 62 is carried by the sleeve end 55 to prevent moisture ladened air from entering cup 47.

A volatile fluid containing bulb 64 is secured to the cup 52 and connected with the chamber 65 formed thereby so that the pressure on the exterior of bellows 48 is the same as the pressure in the bulb. An electrically operated heater 66 surrounds the bellows and is controlled by the humidostat 36. It will be observed, that when the pressure in chamber 65, acting on bellows 48, is sufficient to overcome the resistance offered by spring 59, the piston 41 will be moved to the left.

The piston 41 is shown in its right hand position in which position only a restricted flow of refrigerant can flow about the right hand end of head 42. The size of this passage can be regulated by adjusting the nuts 67. When the heater 66 is energized, the pressure of the volatile fluid in bulb 64 and chamber 65 is increased sufficiently to move the piston 41 to the left to enlarge the passage at the right hand end of head 42 whereby an increased flow of refrigerant is permitted from section 11 to section 12.

The operation of the compressor 18 causes gaseous refrigerant to be withdrawn from the evaporator 10. The liquid refrigerant under high pressure is delivered to the liquid receiver 20. A float 70 within receiver 20 controls the expansion valve 15 by permitting the same to escape into feed pipe 13 at the rate liquid refrigerant is delivered to the receiver. Refrigerant will continue to flow through the evaporator 10 until the temperature of the air to be conditioned is reduced to a predetermined minimum at which time the thermostat 34 will operate the snap switch 23 to interrupt the motor circuit. The compressor 18 will remain inactive until the temperature of the air is raised to a predetermined maximum at which time the thermostat will close switch 23 to establish the motor circuit. The snap switch 23 includes a metal bellows 72 which is connected with the bulb 34 by a tube and this system contains a volatile fluid which causes expansion and contraction of bellows 72 in accordance with increase and decrease in temperature within room 24. The bellows 72 is arranged to move a movable contact 74 into and out of contact with a stationary contact 75 through a series of levers 77 and 78 and a spring 79. Contacts 74 and 75 are connected to the mains 80 and 81 which are controlled by a line switch 82. The humidostat 36 and the heater 66 are connected to the mains as follows: main 80, wire 84, humidostat 36, wire 85, heater 66, wire 86 and main 81. The fan motor 29 is connected as follows: main 80, wires 84 and 88, motor 29, wires 89 and 86 and main 81.

When the relative humidity is low, the humidostat 36 causes heater 66 to be connected whereby the flow of refrigerant from section 11 of the evaporator 10 to section 12 is unrestricted. Therefore, at this time, both sections 11 and 12

will operate at the same temperature or substantially so. Both sections then operate to remove primarily sensible heat from the air. If however, the relative humidity increases to a predetermined maximum, the humidostat 36 will operate to discontinue the flow of current to heater 66 and in that event, the valve 35 will operate to restrict the flow of refrigerant from section 11 to section 12. By restricting the flow at this point, the pressure in the section 12 will be decreased and the pressure in section 11 will be increased which in effect provides a colder temperature in section 12 and a warmer temperature in section 11. The air passing over section 12 will be cooled, by this relatively cold section to considerably below its dew point so as to cause precipitation and a consequent removal of more moisture from the air. Subject to the control of the refrigerating system by the thermostat 34, the system will continue to operate with the sections 11 and 12 at materially different temperatures until the relative humidity of the room is lowered to the minimum humidity adjustment of humidostat 36 at which time the heater 66 will be energized again to remove the restriction offered by valve 35 and then the sections will again operate under equal pressures.

Thus it will be seen that I have provided an air conditioning system which maintains the air to be conditioned between predetermined limits by controlling the amount of refrigerating medium flowing therethrough and I have provided an air conditioning system which removes moisture from the air, when desirable, by varying the temperature differential between sections of a heat absorber by varying the flow of refrigerant medium from one of the sections to the other. In this manner it is not necessary to reduce the temperature of all of the air circulating through the conditioner, which method would at times necessitate the cooling of the air below its desired minimum, but by increasing the temperature of one of the sections, at the time the other is lowered to a value sufficient to remove moisture, the mean temperature of the air leaving the conditioner is no lower than when the sections are operating to remove primarily only sensible heat from the air.

In the form of the invention shown in Fig. 3; the motor circuit is not only controlled by the thermostat 34 but also by the humidostat 36. The circuit to the motor is controlled by two switches 91 and 92 which are connected in parallel. Switch 91 includes a magnet coil 93, an armature 94, contacts 95 and 96. A spring 97 tends to hold the contacts 95 and 96 apart. When the coil 93 is deenergized to complete a circuit to the motor as follows: main 30, contacts 96 and 95, wire 99, motor 22 and main 31. Switch 92 includes a magnet coil 100, an armature 101, contacts 102 and 103. A spring 105 holds the contacts 102 and 103 together when the coil 100 is deenergized and when the coil 100 is deenergized a circuit to the motor 22 is made as follows: main 30, wire 106, contacts 103 and 102, wire 107, motor 22 and main 31. Therefore if coil 93 is energized or if coil 100 is deenergized, a circuit is completed to the motor.

The humidostat, in addition to controlling the heater coil 66, controls the magnet coil 100. The circuit for the heater 66 and coil 100 includes main 30, wire 34, humidostat 36, wire 35, heater 66, wire 109, coil 100, wire 110 and main 31. When the relative humidity is at or below a predetermined minimum, the humidostat causes a circuit to be completed through heater 66 and coil 100 whereby the flow of refrigerant through valve 35 is unrestricted and the motor controlling contacts 102 and 103 are separated. If however, the relative humidity is too high, the humidostat will operate to cause the circuit to heater coil 66 and magnet coil 100 to be interrupted whereby valve 35 will restrict the flow of refrigerant from section 11 and will permit contact 103 to engage contact 102 to complete the motor circuit. Thus the refrigerating apparatus is controlled directly by the humidity of the air to be conditioned.

The thermostat 34, in addition to controlling the motor circuit, also controls the flow of refrigerant from section 11 of the evaporator to section 12. A valve 112, similar to valve 35 is interposed between valve 35 and section 12. It includes a heating coil 113 which, when deenergized, restricts the flow of refrigerant through the valve 112. The heating coil 113 is connected in series with magnet coil 93 and is controlled by thermostat 34 through the following circuit: main 30, wire 34 and 115, thermostat 34, wire 116, heating coil 113, wire 117, magnet coil 93, wire 118 and main 31. If the temperature of the air to be conditioned is at or below a predetermined minimum, the thermostat 34 is in a condition in which the circuit through coils 113 and 93 is interrupted whereby the flow of refrigerant through valve 112 is restricted and motor contacts 95 and 96 are separated. If the temperature of the air increases to above a certain degree, the thermostat 34 closes the circuit through coils 113 and 93 to remove the restriction of valve 112 and causes the motor contacts 95 and 96 to engage one another. The motor 22 will then operate the compressor 18 causing the temperature of the evaporator to lower until the air in the room is decreased to a predetermined minimum. The flow of refrigerant from section 11 to section 12 will not be restricted if the humidity of the air is at or below a predetermined minimum but if, the relative humidity of the air increases above such minimum, the humidostat will operate to break the circuit through heating coil 66 and magnet coil 100 to cause the valve 35 to restrict the flow therethrough and close the contacts 102 and 103. The evaporator sections 11 and 12 will then operate at different temperatures until the relative humidity is lowered to the desired predetermined minimum although the thermostat 34 has operated to break contacts 95 and 96. If thermostat 34 has so operated, valve 112 will further restrict the flow of refrigerant from section 11 to section 12 so as to cause a wider differential in temperature between these sections and a consequent greater precipitation of moisture with a slow decreasing of the mean temperature of the air leaving the cabinet.

When the relative humidity of the air is below, for example 50%, and the air requires cooling, the sections 11 and 12 operate at the same temperature or substantially so. The valves 35 and 112 can be adjusted so that when the relative humidity of the air is too high and the temperature of the air is too high, valve 35 will maintain, for example, the suction temperature of the refrigerant in evaporator at 60° F. and that in section 12 at 38° F. and when the temperature of the air is at its desired minimum and the relative humidity is still too high, the combined restrictions of valves 35 and 112 will maintain, for example, a suction temperature of the refrigerant in section 11 at 70° F. and that in section 12 at 34° F.

Thus it will be understood that this system functions differently under three different conditions of the air. When the humidity is substantially proper, sections 11 and 12 operate at substantially the same temperature. When the humidity of the air is relatively high and when the air should also be cooled, valve 35 will cause the section 11 to be increased and the section 12 to be decreased in temperature. And when the air is reduced to the desired low temperature but the humidity is still too high for comfort, the valve 112 causes a further increase in differential between sections 11 and 12 to cause a removal of a relatively large amount of moisture from the air.

Under certain conditions, it will be desirable to cause some precipitation of moisture at the sections 11 and 12 when the valves 35 and 112 are open, and it is to be understood that when said section or portion 11 is referred to as functioning to remove principally sensible heat, such terms are used merely to define the main functional purpose of the section as distinguished from the main functional purpose of section or portion 12 at the time valves are closed.

While the forms of embodiments of the present invention as herein disclosed constitute preferred forms, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

I claim:

1. The process of cooling and dehumidifying air which comprises causing the air which is to be conditioned to circulate in heat exchange relation with a portion of an evaporator of a mechanical refrigerator, and in heat exchange relation with another portion of the evaporator, causing refrigerating medium to flow first through the first mentioned portion of the evaporator and then through the second mentioned portion, controlling the heat exchange between the air and the evaporator in accordance with the temperature and relative humidity of the air to be conditioned, and while the refrigerating medium flows through the evaporator, varying the flow of refrigerating medium from the first to the second mentioned portions of the evaporator in accordance with the change in the relative humidity and temperature of the air to be conditioned.

2. An air conditioning system comprising in combination, a refrigerating system including an evaporator, said evaporator including a first portion and a second portion connected with the first portion for receiving refrigerant therefrom, and means intermediate said portions for controlling the flow of refrigerant from the first to said second mentioned portions of the evaporator in response to changes in the relative humidity of the air to be conditioned.

3. An air conditioning system comprising in combination, a refrigerating system including an evaporator, said evaporator including a first portion and a second portion connected with the first portion for receiving refrigerant therefrom, means for controlling the heat exchange between the air and the evaporator in response to the temperature of the air to be conditioned, and means intermediate said portions for controlling the flow of refrigerant from the first to said second mentioned portions of the evaporator in response to changes in the relative humidity of the air to be conditioned.

4. The process of cooling and dehumidifying air which comprises causing the air which is to be conditioned to circulate in heat exchange relation with a portion of an evaporator of a mechanical refrigerator, and in heat exchange relation with another portion of the evaporator, causing refrigerating medium to flow first through the first mentioned portion of the evaporator and then through the second mentioned portion, controlling the heat exchange between the air and the evaporator in accordance with the temperature of the air to be conditioned, and while the refrigerating medium flows through the evaporator, controlling the flow of refrigerating medium from the first mentioned portion to the second mentioned portion in accordance with changes in relative humidity and temperature of the air to be conditioned.

5. The process of cooling and dehumidifying air which comprises causing the air which is to be conditioned to circulate in heat exchange relation with a portion of an evaporator of a mechanical refrigerator, and in heat exchange relation with another portion of the evaporator, causing refrigerating medium to flow first through the first mentioned portion of the evaporator and then through the second mentioned portion, controlling the heat exchange between the air and the evaporator in accordance with the temperature of the air to be conditioned, and while refrigerating medium flows through the evaporator, varying the flow of refrigerating medium from the first mentioned portion of the evaporator to the second mentioned portion in accordance with the changes in the relative humidity of the air to be conditioned.

6. An air conditioning system comprising in combination, a refrigerating system including an evaporator, said evaporator including a portion, and including a second portion connected with the first portion for receiving refrigerant therefrom, means responsive to the relative humidity and the temperature of the air to be conditioned for controlling the heat exchange between the air and the evaporator, and means intermediate said portions for controlling the flow of refrigerant from the first to said second mentioned portions of the evaporator in response to changes in the relative humidity of the air to be conditioned.

7. An air conditioning system comprising in combination, a refrigerating system including an evaporator, said evaporator including a portion, and including a second portion connected with the first portion for receiving refrigerant therefrom, means responsive to the relative humidity of the air to be conditioned for controlling the heat exchange between the air and the evaporator, and means intermediate said portions for controlling the flow of refrigerant from the first to said second mentioned portions of the evaporator in response to changes in the relative humidity of the air to be conditioned.

8. The process of cooling and dehumidifying air which comprises causing air, which is to be conditioned, to circulate in heat exchange relation with a portion of an evaporator of a mechanical refrigerator, and in heat exchange relation with another portion of the evaporator, causing refrigerating medium to flow from one of the portions to the other, and while refrigerating medium flows through the evaporator, varying the flow of refrigerating medium from said one portion to said other portion in accordance with the change in the relative humidity of the air to be conditioned.

9. The process of cooling and dehumidifying air which comprises causing air, which is to be

conditioned, to circulate in heat exchange relation with a portion of an evaporator of a mechanical refrigerator, and in heat exchange relation with another portion of the evaporator, causing refrigerating medium to flow from one of the portions to the other, and while the refrigerating medium is flowing through the evaporator, varying the flow of refrigerating medium from said one portion to said other portion in accordance with changes in the relative humidity and temperature of the air to be conditioned.

10. An air conditioning system comprising, in combination, a refrigerating system including an evaporator, said evaporator including a first portion and a second portion connected with the first portion for receiving refrigerant therefrom, and means intermediate said portions responsive to changes in the relative humidity and the temperature of the air to be conditioned for varying the flow of refrigerant from the first to the second mentioned portion.

11. An air conditioning system comprising, in combination, a refrigerating system including an evaporator, said evaporator including a first portion and a second portion connected with the first portion for receiving refrigerant therefrom, and means responsive to the relative humidity and temperature of the air to be conditioned for controlling the heat exchange between the air and the evaporator, and means intermediate said portions responsive to the relative humidity and temperature of the air to be conditioned for varying the flow of refrigerant from the first to the second mentioned portion of the evaporator.

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