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AIR CONDITIONING SYSTEM

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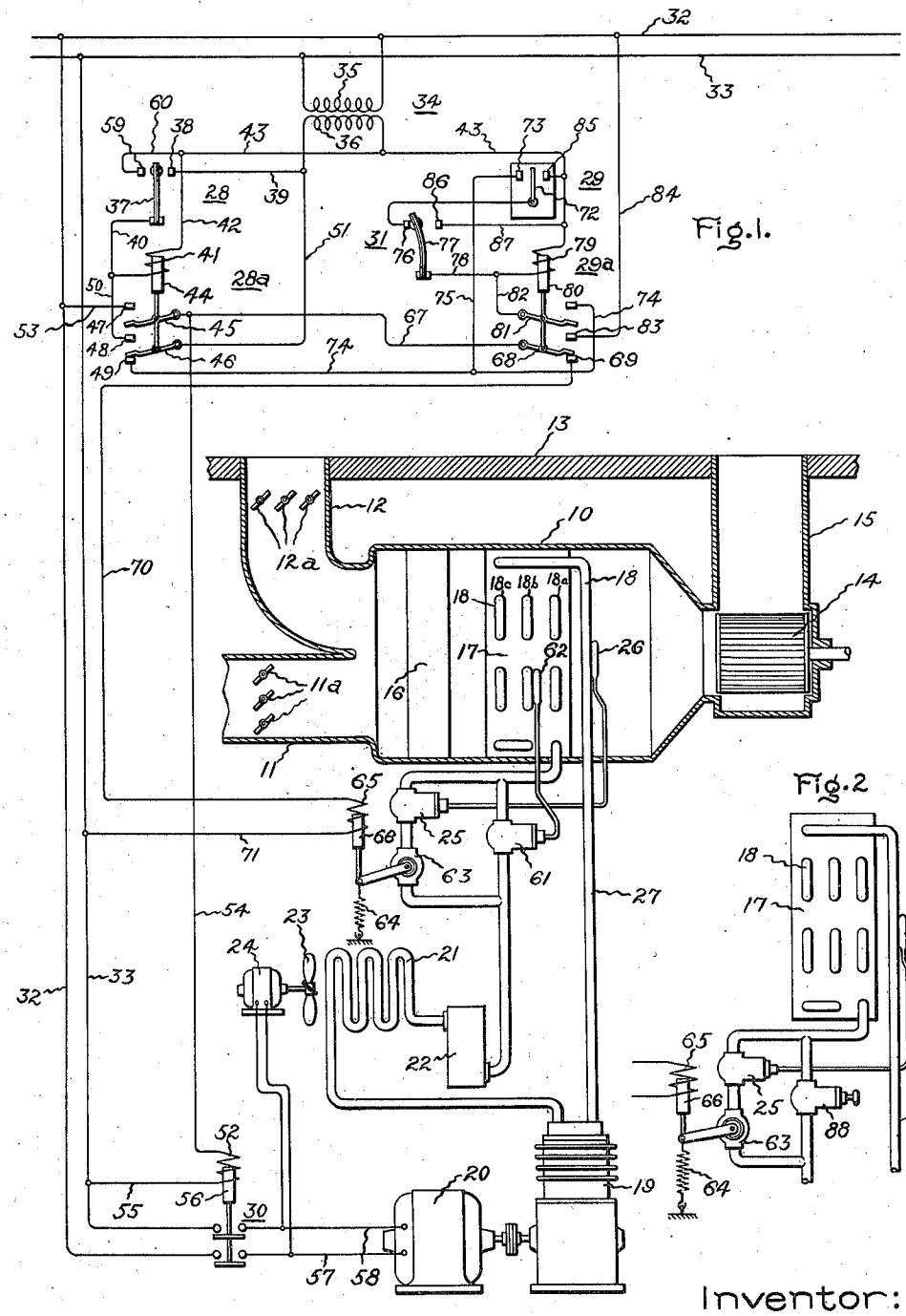

Fig. 1.

Fig. 2

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AIR CONDITIONING SYSTEM

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Renewed December 11, 1937

9 Claims. (Cl. 62—6)

My invention relates to air conditioning systems for cooling and dehumidifying the air within auditoriums, rooms and other enclosures.

It is an object of my invention to provide a system for cooling and dehumidifying the air within an enclosure including a cooling coil and a plurality of valves for controlling the admission of cooling medium to the coil and having an arrangement for selecting any one of the valves dependent upon the desired effective cooling surface of the coil as determined by the temperature and humidity of the air in the enclosure.

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 drawing in which Fig. 1 shows diagrammatically an air conditioning system embodying my invention, and Fig. 2 shows a modified arrangement of the controlling valves shown in Fig. 1.

Referring now to the drawing, in Fig. 1 I have shown an air conditioning system comprising a casing 10 arranged to receive fresh air through a duct 11 and air from the room to be conditioned through a duct 12 which passes through a wall 13 of the room. The fresh air and the room air are drawn into the casing 10 by operation of a fan 14, arranged at the discharge side of the casing, and the conditioned air is conducted to the room through a duct 15 passing through the wall 13. The quantity of fresh air utilized is controlled by adjustable dampers 11*a*, and the quantity of room air is controlled by adjustable dampers 12*a*. A filter 16 is provided in the casing 10 to remove dust and other impurities from the air, and the air is cooled by passing through a cooling element 17 arranged in the casing and comprising a sinuous coil 18 having a plurality of turns extending entirely across the casing in the path of the air. The coil 18 is preferably of the type having a plurality of fins providing a large surface area in the path of the air passing through the cooling element. The coil 18 is connected in the circuit of a mechanical refrigerating machine including a compressor 19 driven by a motor 20, a condenser 21 and a liquid receiver 22. Gaseous refrigerant is compressed in the compressor 19 and is discharged into the condenser 21 where it is cooled and liquefied by air circulated thereover by a fan 23. The fan 23 is driven by a motor 24 connected across the motor 20. The condensed refrigerant flows into the liquid receiver 22 and is supplied to the coil 18 under normal conditions by operation of a thermostatic expansion valve 25, provided with a thermostatic bulb 26 arranged in contact with the suction side of the coil 18. The valve is, therefore, operated in response to the temperature of the vaporized refrigerant withdrawn from the coil 18. The refrigerant is preferably admitted to the coil 18 so that it flows through the banks 18*a*, 18*b*, and 18*c* of the coil in succession in the opposite direction from that of the flow of air through the duct 10. The air thus passes from the least cold to the coldest portion of the coil. Refrigerant vapor is withdrawn from the coil 18 through a conduit 27 and is returned to the compressor.

The refrigerating machine is controlled under normal conditions by a thermostat 28 having a relay 28*a*. Under conditions of excess humidity of the air in the enclosure the refrigerating machine may be controlled by a room humidostat 29 having a relay 29*a*. The thermostat 28 is arranged to control a switch 30 in the power supply line of the motor 20. Should the humidity of the air in the room be abnormally high it is possible that the temperature of the air may be reduced sufficiently to satisfy the thermostat 28 before the humidity has been reduced the desired amount to provide maximum comfort for the occupants in the room. In such cases it is desirable further to dehumidify the air, but any substantial decrease of the temperature of the air in the room must be avoided in order to maintain a comfortable temperature for the occupants of the room. However, it may be permissible to continue the cooling action at a reduced rate in order that the humidity may be reduced further.

In most air conditioned spaces some of the heat which must be removed by the air conditioning system originates within the room itself. For example, occupants, electric lights, motors and other heat producing appliances and also the sun's rays entering through the windows, all generate heat within the room. It is necessary that the heat from such internal sources be removed from the room before any reduction of the temperature in the room below that of the outdoor air can be accomplished. It is evident, therefore, that part of the capacity of the cooling system must be devoted to the removal of heat from these internal sources. In air conditioning systems in which the internal heat of the

space to be conditioned must be removed, a small portion of cooled air may be circulated continuously without reducing the total sensible heat of the air in the space to be conditioned. It is possible in such systems to produce a substantial amount of dehumidification with only sufficient sensible cooling to offset the effect of the internal heat sources in the room so that dehumidification may be accomplished without reduction of the dry bulb temperature of the air in the room.

If the thermostat 28 be satisfied due to the reduction of the temperature of the air of the room to a predetermined low value before the humidity has been reduced sufficiently to satisfy the humidostat 29, the humidostat will take over the control of the motor 20. The motor will continue to operate under the control of the humidostat until the humidity has been reduced the desired amount or until a minimum permissible temperature has been reached as determined by a low temperature limit thermostat 31.

When the motor is under the control of the humidostat the supply of refrigerant to the coil is reduced and, consequently, an increased percentage of the total coil length is filled with superheated refrigerant gas. With the flow of refrigerant restricted, the balance of heat transfer capacity between the coil and the compressor is changed so that a lower refrigerant pressure is maintained in the coil. At this lower pressure the saturation temperature of the refrigerant is lower and the surface temperature of the coil is, therefore, lower in that portion of the coil in which the gas is not superheated. The dehumidification accomplished by this cold portion of the coil is increased as compared with the dehumidification during the normal operation of that portion, but the total sensible heat removed from the air by the coil is reduced.

The above described system for effecting a control of temperature and humidity by modifying the operation of the refrigerant supply controlling device in accordance with the humidity of the air in an enclosure, is not my invention, but is the invention of Edward W. Roessler and is described and claimed in his copending application, Serial No. 77,949, filed May 5, 1936, and assigned to the General Electric Company, assignee of my present invention.

When it is desired to operate the air conditioning system illustrated in Fig. 1, electric energy is supplied to lines 32 and 33. This energizes a transformer 34 having a primary winding 35 and a secondary winding 36. If the temperature of the air in the room rises to a predetermined value a bimetallic strip 37 of the thermostat 28 engages a contact 38 and closes a circuit from one side of the primary 36 through a connection 39, the strip 37 and a connection 40 to a coil 41 of relay 28a and thence back to the other side of the primary 36 through a connection 42 and a line 43. The coil 41 will thereby be energized and will pick up an armature 44 of the relay 28a, raising arms 45 and 46 of the relay into engagement with contacts 47 and 48, respectively, and breaking engagement between the arm 46 and a contact 49. The raising of arm 46 closes a holding circuit for the coil 41 through connections 50 and 51 thereby maintaining the coil energized even though the strip 37 should move out of engagement with the contact 38. The raising of the arm 45 closes a circuit of a coil 52 of the switch 30 from line 32 through a connection 53, the arm 45, a line 54 to the coil and thence back to line 33 through a connection 55. The energization of coil 52 picks up an armature 56 of switch 30 thereby closing the switch and connecting motor leads 57 and 58 to lines 32 and 33, respectively. This starts the motor 20 and thereby operates the compressor 19 to supply refrigerant to the coil 18, and also starts the condenser fan motor 24. The operation of the motors will continue until a predetermined low temperature of the air in the room has been reached, when the bimetallic strip 37 will engage a contact 59; this short-circuits the relay coil 41 through connections 42 and 60, strip 37 and connection 40 thereby deenergizing the coil and causing relay 28a to drop out and break the circuit of the coil 52 to open the switch 30. The operation of the compressor 19 and fan motor 24 is thereby stopped and the supply of refrigerant to the coil 18 discontinued.

When the air conditioning system is operating as just described the supply of liquid refrigerant is controlled by the valve 25 which maintains a minimum temperature of the refrigerant withdrawn from the coil 18. By operation of the valve 25 a minimum length of the coil is maintained filled with superheated refrigerant vapor while the remainder of the coil contains liquid refrigerant or liquid refrigerant and saturated vapor and is effective for dehumidifying the air passing over the coil and for substantially reducing the sensible heat of the air.

It has been pointed out above that by operating only a portion of the cooling coil at low temperature while the remainder of the coil contains superheated refrigerant vapor the humidity may be decreased without substantially decreasing the sensible heat of the air in the room. This further reduction of humidity is accomplished as has already been stated by arranging the room humidostat so that it will take over the operation of the refrigerating machine in the event that the humidity is still too high after the room thermostat is satisfied.

I, therefore, provide a second valve 61 arranged in parallel with the valve 25 and provide a solenoid or motor-operated valve 63 in series with the valve 25 to cut out the valve 25 when desired. The second refrigerant controlling valve 61 is set to maintain a higher temperature of the refrigerant vapor withdrawn from the coil 18 and thereby to maintain a greater length of the coil filled with superheated refrigerant vapor. Whenever the control of the refrigerating machine is taken over by the humidostat the valve 25 is cut out and the cooling coil is supplied with refrigerant through the second valve 61.

I have shown the second thermostatic controlling valve 61 connected in parallel with the valve 25 and having a thermostatic bulb 62 secured to the cooling coil 18 intermediate the ends thereof. It will readily be apparent that if the valves 25 and 61 are both set to maintain the same temperature of the coil at the places where their respective thermostatic bulbs are attached then the valve 61 will maintain only a small portion of the coil 18 at a low temperature, as compared with the portion operating at a low temperature under the control of the valve 25. In series with the valve 25 is arranged the solenoid control valve 63 which is biased by a spring 64 to its closed position, shown in the drawing. The valve 63 is opened by energization of a coil 65 which raises an armature 66 whenever the refrigerating machine is controlled in response to the ther-

mostat 28. The circuit for the coil 65 may be traced from line 32 through connection 53, arm 45 of relay 28a, a connection 67, an arm 68 of relay 29a, a contact 69 and a line 70 to the coil 65 and back to the line 33 through a connection 71. When the valve 63 is open the supply of refrigerant to the coil 18 is controlled solely by the valve 25. This is apparent since the operation of the valve 25 will maintain a minimum temperature of the refrigerant withdrawn from the coil 18 making it impossible for the valve 61 to be opened, because the temperature of the coil 18 at the point where the bulb 62 is connected cannot rise sufficiently to open the valve 61.

During the operation of the air conditioning system shown, should the humidity of the room still be above the desired value after the thermostat 28 has been satisfied, the humidostat 29 will be in a position to operate the relay 29a to shift the control of the refrigerant supply for the coil 18 from valve 25 to valve 61 by closing valve 63, and will also maintain the refrigerating machine in operation. When the humidity is too high a movable member 72 of the humidostat 29 engages a contact 73 establishing a circuit from one side of the secondary 36 of the transformer through the connection 51, the arm 46 of relay 28a, a line 74, a connection 75, the member 72, a contact 76 and a bimetallic strip 77 of the limit thermostat 31 and a connection 78 to a coil 79 of relay 29a and back to the other side of the secondary 36 through a line 43. This energizes the coil 79, raises an armature 80 of the relay 29a and lifts the arm 68 and an arm 81, thereby breaking the circuit of the solenoid 65 and closing a holding circuit for the coil 79. The holding circuit includes a connection 51 from one side of the secondary 36 of the transformer, arm 45, line 74, arm 81 and a connection 82 to one side of the coil 79, and from the other side thereof through line 43 to the other side of the transformer secondary 36. This holding circuit maintains the relay 29a in its raised position even though the movable member 72 moves out of engagement with the contact 73. In its raised position the arm 68 engages a contact 83 closing a circuit from line 32 through a connection 84, arm 68, the connection 67 and line 54 to coil 52 and thence to line 33 through the connection 55, thereby energizing coil 52 and operating switch 30 to start the motor 20 of the refrigerating machine and supply refrigerant to the coil 18 through the valve 61.

The operation under the control of the humidostat of the refrigerating machine, supplying refrigerant to the coil 18 through the valve 61 will thus maintain a higher temperature of the refrigerant withdrawn from the coil 18, thereby reducing the rate of sensible cooling of the air, but continuing the dehumidification of the air since a small portion of the coil 18 is maintained at a sufficiently low temperature for this purpose. Further moisture will, therefore, be abstracted from the air with less than normal decrease in the sensible heat of the air in the room.

The operation of the refrigerating machine under the control of the humidostat will continue until the humidity has been reduced to a desired value or until the temperature of the air has reached a minimum permissible value consistent with comfort. Should the humidostat be satisfied the movable member 72 will engage a contact 85 thereby short-circuiting the coil 79 through connection 78, strip 77, movable member 72 and a portion of line 43. The relay 29a will then drop out and discontinue operation of the motor 20 by opening switch 30. Should the temperature of the air in the room reach the minimum permissible temperature before the humidostat 29 is satisfied, the strip 77 will engage a contact 86 and short-circuit the coil 79 through connection 78, strip 77, and a connection 87, thereby deenergizing the relay 29a and stopping the operation of the refrigerating machine.

Should the temperature of the room increase until the thermostat 28 again calls for cooling before the humidity has been reduced the desired amount the control of the refrigerating machine will be transferred from the humidostat 29 to the thermostat 28 since the operation of the thermostat will raise the arm 46 of the relay 28a thereby breaking the circuit to humidostat 29. The control of the system in response to the room thermostat, therefore, takes precedence over the control in response to the humidostat.

In Fig. 2, I have shown a modification of my invention, in which I utilize a pressure responsive valve 88 in parallel with the valve 25 in order to maintain a greater length of coil 18 filled with superheated vapor. The valve 88 is arranged to open in response to a predetermined low pressure in the coil 18. This pressure is lower than the pressure obtaining in the coil when the refrigerating machine is supplying refrigerant through the valve 25. The valve 88, therefore, remains closed as long as the valve 25 is in operation. However, when the solenoid valve 63 operates to cut off the valve 25 in response to the room humidostat, the pressure in the coil 18 becomes lower and the valve 88 operates to supply refrigerant to the coil. The supply of refrigerant through the valve 88 is restricted so that only a small portion of the coil is maintained at a low temperature, due to the presence of liquid refrigerant, while a greater portion is filled with superheated refrigerant vapor. It is readily apparent that this arrangement of valves will operate in the same manner as that shown in Fig. 1 to maintain either one of two predetermined temperatures of the refrigerant withdrawn from the coil 18.

While I have disclosed particular embodiments of my invention, various modifications will occur to those skilled in the art and I do not, therefore, desire my invention to be limited to the construction shown and described, and I intend in the appended claims to cover all modifications that do not depart from 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. A system for conditioning the air within an enclosure including a cooling element, means for supplying cooling medium to said element and for withdrawing cooling medium from said element, means including a valve and arranged to control the supply of cooling medium to said cooling element for maintaining a predetermined substantially constant temperature of the cooling medium withdrawn from said element, means including a second valve connected in parallel with said first valve and arranged to control the supply of cooling medium to said cooling element for maintaining a different substantially constant temperature of the cooling medium withdrawn from said cooling element, means for rendering only one of said supply controlling means effective at the same time, and means responsive to the humidity of the air within said enclosure for shifting from one of said valves to the other the

control of the supply of cooling medium to said cooling element.

2. A system for conditioning the air within an enclosure including a cooling element, means for supplying cooling medium to said element and for withdrawing cooling medium from said element, means including a valve arranged to control the supply of cooling medium to said cooling element for maintaining a predetermined substantially constant temperature of the cooling medium withdrawn from said element, means including a second valve connected in parallel with said first valve and arranged to control the supply of cooling medium to said cooling element for maintaining a different substantially constant temperature of the cooling medium withdrawn from said cooling element, means for rendering said first valve only effective to control the supply of cooling medium to said cooling element during normal operation of said system, means including a third valve for controlling the supply of refrigerant to said first valve, and means responsive to the humidity of the air within said enclosure for closing said third valve to shift to said second valve the control of the supply of cooling medium to said cooling element.

3. A system for conditioning the air within an enclosure including a cooling coil, means for supplying liquid refrigerant to said coil and for withdrawing vaporized refrigerant from said coil, means including a valve arranged to control the supply of liquid refrigerant to said coil for maintaining superheated the vaporized refrigerant in a predetermined length of said coil, means including a second valve connected in parallel with said first valve and arranged to control the supply of liquid refrigerant to said coil for maintaining superheated the vaporized refrigerant in a different predetermined length of said coil, means for rendering said first valve only effective to control the supply of liquid refrigerant to said coil during normal operation of said system, means including a third valve for controlling the supply of refrigerant to said first valve, and means responsive to the humidity of the air within said enclosure for closing said third valve to shift to said second valve the control of the supply of liquid refrigerant to said coil.

4. A system for conditioning the air within an enclosure including a cooling coil, means for supplying liquid refrigerant to said coil and for withdrawing vaporized refrigerant from said coil, said means including a supply conduit having parallel branches, means including a valve in each of said branches for controlling the flow of liquid refrigerant through said branches to said coil, means including a temperature responsive element associated with each of said valves for maintaining superheated the vaporized refrigerant in different lengths of said coil, one of said valves being operable to control the supply of liquid refrigerant to said coil during normal operation of said system, and means responsive to the humidity of the air in said enclosure for transferring to another one of said valves the control of the supply of liquid refrigerant to said coil.

5. A system for conditioning the air within an enclosure including a cooling coil, means for supplying liquid refrigerant to said coil and for withdrawing vaporized refrigerant from said coil, said means including a supply conduit having two parallel branches, means including a valve in each of said branches for controlling the supply of liquid refrigerant to said coil, means responsive to the temperature of the vaporized refrigerant near the outlet end of said coil for actuating one of said valves, means dependent upon a predetermined low pressure of the refrigerant in said coil for actuating the second of said valves to control the supply of liquid refrigerant to said coil, means for rendering only one of said valves effective at the same time to control the supply of refrigerant to said coil, and means dependent upon the humidity of the air within said enclosure for selecting one of said valves for operation to control the supply of liquid refrigerant to said coil.

6. A system for conditioning the air within an enclosure including a cooling coil, means for supplying liquid refrigerant to said coil and for withdrawing vaporized refrigerant from said coil, said means including a supply conduit having two parallel branches, means including a valve in each of said branches for controlling the supply of liquid refrigerant to said coil, means responsive to the temperature of vaporized refrigerant near the outlet end of said coil for actuating the first of said valves, means responsive to the temperature of the vaporized refrigerant at a point intermediate the inlet and outlet ends of said coil for actuating the second of said valves, means for rendering said first valve only effective during normal operation of said system, means including a third valve for controlling the supply of liquid refrigerant to said first valve, and means responsive to the humidity of the air in said enclosure for closing said third valve to transfer from said first valve to said second valve the control of the supply of liquid refrigerant to said coil.

7. A system for conditioning the air within an enclosure including a cooling coil, means for supplying liquid refrigerant to said coil and for withdrawing vaporized refrigerant from said coil, said means including a supply conduit having two parallel branches, means including a valve in each of said branches for controlling the supply of liquid refrigerant to said coil, means responsive to the temperature of vaporized refrigerant near the outlet end of said coil for actuating the first of said valves, means dependent upon a predetermined low pressure of the refrigerant in said coil for actuating the second of said valves to control the supply of liquid refrigerant to said coil, means for rendering said first valve only effective during normal operation of said system, means including a third valve for controlling the supply of liquid refrigerant to said first valve, and means responsive to the humidity of the air in said enclosure for closing said third valve to transfer from said first valve to said second valve the control of the supply of liquid refrigerant to said coil.

8. A system for conditioning the air within an enclosure including a cooling element, means for supplying cooling medium to said element and for withdrawing cooling medium from said element, means including a valve arranged to control the supply of cooling medium to said cooling element for maintaining a predetermined substantially constant temperature of the cooling medium withdrawn from said element, said cooling medium supplying means including a conduit having a portion comprising two branches arranged in parallel, means including a second valve connected in one of said parallel branches and arranged to control the supply of cooling medium to said cooling element for main-

taining a different substantially constant temperature of the cooling medium withdrawn from said cooling element, means including a third valve and arranged in the other of said parallel branches for rendering only one of said supply controlling means effective at the same time, and means responsive to the humidity of the air within said enclosure for operating said third valve to transfer the control of the supply of cooling medium from one of said supply controlling means to the other.

9. A system for conditioning the air within an enclosure including a cooling element, means for supplying cooling medium to said element and for withdrawing cooling medium from said element, said cooling medium supplying means including a conduit having a portion comprising two branches arranged in parallel, means including a valve arranged in said conduit and having a thermostatic control member arranged on said cooling element for controlling the supply of cooling medium to said cooling element, means including a second valve connected in one of said parallel branches and having a thermostatic control member on said cooling element for controlling the supply of cooling medium to said cooling element, means including a third valve arranged in the other of said parallel branches for rendering only one of said supply controlling means effective at the same time, and means responsive to the humidity of the air within said enclosure for operating said third valve to transfer the control of the supply of cooling medium from one of said supply controlling means to the other.

DAVID W. McLENEGAN.

DISCLAIMER

2,112,039.—*David W. McLenegan*, Caldwell, N. J. AIR CONDITIONING SYSTEM. Patent dated March 22, 1938. Disclaimer filed July 27, 1940, by the assignee, *General Electric Company*.

Hereby enters this disclaimer of Fig. 2 of the drawing of said patent and of that part of the specification of said patent appearing in lines 21 to 46 inclusive in the second column on page 3 thereof, and hereby enters disclaimer of claims 5 and 7 of said patent.

[*Official Gazette September 3, 1940.*]