

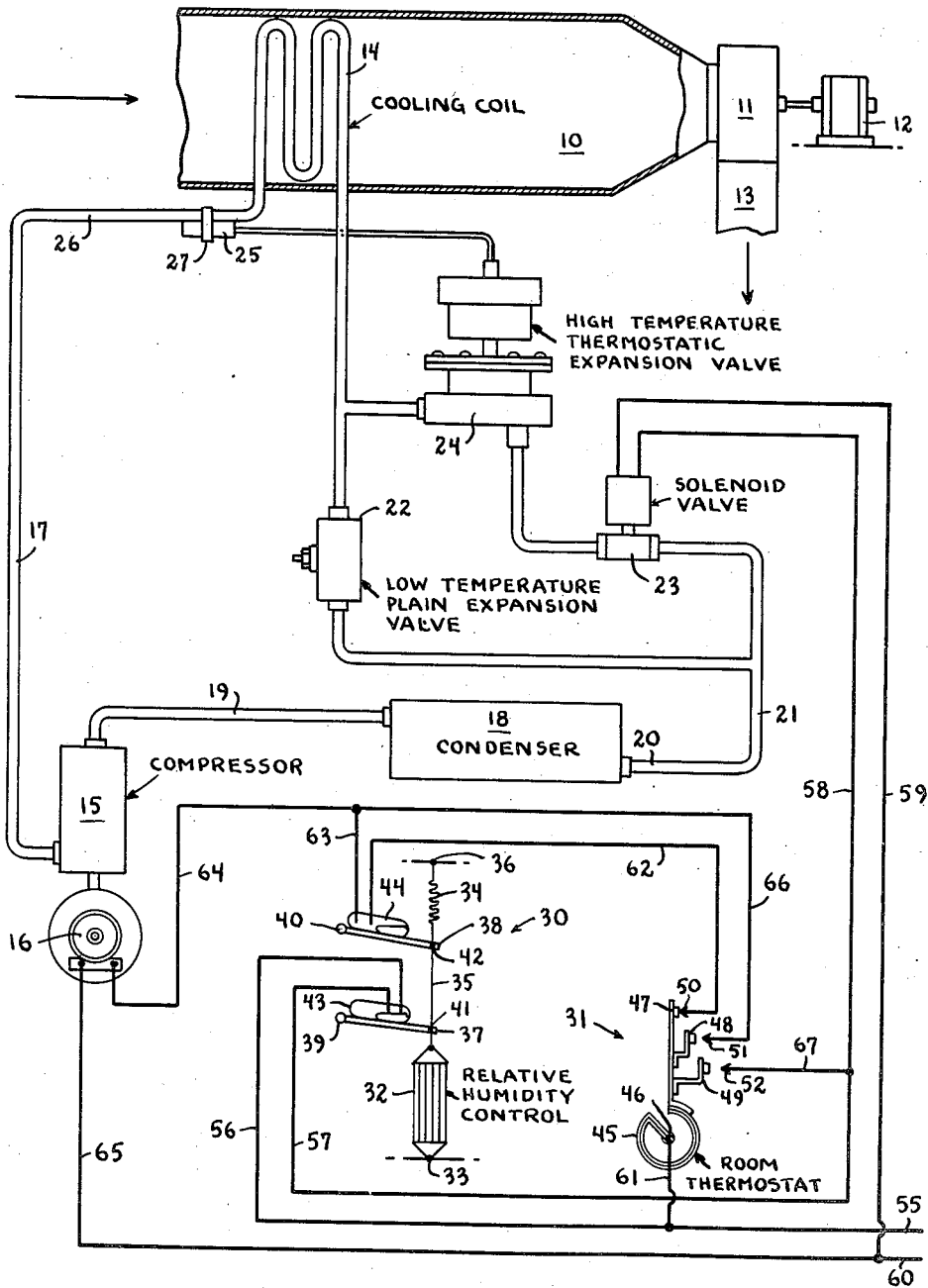
July 6, 1943.

W. R. MILLER

2,323,408

AIR CONDITIONING SYSTEM

Original Filed Nov. 18, 1935



INVENTOR.

Wayland R. Miller

BY

George H. Fisher
Attorney

UNITED STATES PATENT OFFICE

2,323,408

AIR CONDITIONING SYSTEM

Wayland R. Miller, Milwaukee, Wis., assignor to
Minneapolis-Honeywell Regulator Company,
Minneapolis, Minn., a corporation of Delaware

Original application November 18, 1935, Serial No.
50,291. Divided and this application February
7, 1942, Serial No. 429,902

6 Claims. (Cl. 62—6)

The present invention relates to the cooling and dehumidifying of air by a direct expansion refrigeration system. This application is a division of my co-pending application Serial No. 50,291, filed November 18, 1935.

It is an object of the present invention to provide a cooling and dehumidifying system in which the evaporator of a direct expansion refrigeration system is selectively operated at high temperature or low temperature under the control of relative humidity and space temperature in such manner that the evaporator will be used to best advantage considering the relative values of the relative humidity and space temperature.

More specifically, it is an object of the present invention to operate such an evaporator coil at low temperature upon excessive relative humidity provided the space temperature is not too low, while preventing any operation of the evaporator coil, irrespective of the value of the relative humidity, if the space temperature should be at a value lower than desired.

A further object of the present invention is to operate the evaporator at high temperature upon excessive space temperature irrespective of the relative humidity demand. It will thus be seen that space temperature dominates both upon excessive temperature and low temperature.

A further object of the invention is to operate the evaporator at a high or low temperature, when the space temperature is between an excessive value and a low value, the high and low temperature operation of the evaporator depending upon the relative values of the space temperature and relative humidity.

A further object of the invention is to accomplish any or all of the above objects by supplying refrigerant to the evaporator through two different paths, the temperature of the evaporator being maintained at a high value when refrigerant is supplied thereto through one of the paths whereas the temperature of the evaporator is maintained at a low value when the refrigerant is supplied thereto through the other of the paths.

Further objects of the invention will be found in the single drawing which is illustrative of one form of the invention, in the detailed description and in the appended claims.

Referring to the drawing, the air to be conditioned is passed through an air conditioning chamber 10 by means of a fan 11 which may be driven in any suitable manner, as by the electric motor 12. This air is then passed to the room or space to be conditioned by means of

a duct 13. The air passing through the air conditioning chamber 10 is cooled by a cooling coil 14, located in the air conditioning chamber 10, which cooling coil is adapted to be supplied with refrigerant by a suitable mechanical refrigeration system.

This refrigeration system includes a compressor 15 that is driven by an electric motor 16. Refrigerant is returned from the coil 14 to the compressor 15 by means of a pipe 17. This refrigerant is thereupon compressed after which it is passed to a condenser 18 by means of a pipe 19. The condenser 18 may be of any of the well-known types and operates to liquify the compressed gaseous refrigerant delivered thereto by the compressor 15. This liquid refrigerant is then delivered to the cooling coil 14 through two different paths, both of which include pipes 20 and 21. One of these paths includes a plain expansion valve 22 of any well known construction which operates to maintain a constant pressure on the coil 14. As is well known in the art, such a plain expansion valve is in reality nothing more than a pressure reducing valve which is operated by the pressure on its suction side. The liquid refrigerant may also pass from pipe 21 to the cooling coil 14 through two series connected valves 23 and 24. The valve 23 may be any suitable type of on or off valve and is herein shown as comprising a solenoid valve. The valve 24 is a thermostatic expansion valve which may be of any usual construction and includes a thermostatic bulb 25 which responds to the temperature of the refrigerant leaving the coil 14. The bulb 25 is herein shown as clamped to a pipe 26, by means of a clamp 27, the pipe 26 being connected to the end of the coil 14 and to pipe 17.

Whenever liquid refrigerant is available, if the solenoid valve 23 is closed, then refrigerant can pass through the coil 14 only by way of the plain expansion valve 22. This expansion valve is so set that the temperature of the coil 14 is maintained well below the dew-point temperature of the air passing thereover. If the solenoid valve 23 is open however, then liquid refrigerant can also pass through the coil 14 by way of the thermostatic expansion valve 24. Since the thermostatic bulb 25 thereof responds to the temperature of the refrigerant leaving the coil 14, this valve may be and is set so that the coil 14 is always flooded and is maintained at a relatively high temperature which may well be above the dew-point of the air passing over the same or slightly below the dew-point thereof.

The generation or supplying of liquid refriger-

ant may be controlled in any desirable manner and is herein shown as controlled by starting and stopping the compressor motor 16. This compressor motor 16 and the solenoid valve 23 are controlled by the cooperative action of a room or space responsive humidity controller, generally indicated at 30, and a room or space responsive temperature controller, or thermostat, generally indicated at 31.

The humidity responsive controller 30 comprises an actuator 32 that expands and contracts in response to changes in relative humidity and may well take the form of a plurality of strands of hair. One end of the actuator 32 is secured as indicated at 33, and its other end is connected to a suitable tension spring 34 by means of a cable 35. The other end of tension spring 34 is suitably fixed as indicated at 36 whereby the actuator 32 is maintained under tension at all times. A pair of switch carriers 37 and 38, which are respectively pivoted at 39 and 40, are secured to the cable 35 at points indicated at 41 and 42. The switch carrier 37 supports a mercury switch 43 which is arranged to be moved to circuit closed position when the relative humidity of the air to which the actuator 32 responds falls to some predetermined minimum. The switch carrier 38 supports a mercury switch 44 which is so arranged that it moves to circuit closed position when the relative humidity of the air to which the actuator 32 responds rises to some predetermined maximum. For the purposes of this explanation, it will be assumed that the mercury switch 43 is in closed circuit position for all relative humidity values below 50% and is in open circuit position for all relative humidity values thereabove. Likewise, it will be assumed that the mercury switch 44 is closed when the relative humidity rises to 60% and is opened for all relative humidity values therebelow.

The temperature responsive thermostat 31 includes an actuator 45 which is herein shown as comprising a bimetallic element having one of its ends fixed as indicated at 46. The other end of bimetallic element 45 controls three switch arms 47, 48 and 49 which respectively cooperate with three relatively fixed contacts 50, 51 and 52. The arrangement is such that switch arm 47 first engages contact 50, then switch arm 48 engages contact 51 and thereafter switch arm 49 engages contact 52 as the temperature to which actuator 45 responds increases. For the purposes of this explanation, it will be assumed that switch arm 47 engages contact 50 when the temperature rises to 72° F., the switch arm 48 engages contact 51 when the temperature rises to 75° F., and the switch arm 49 engages contact 52 when the temperature rises to 78° F. It will be understood that the temperature values set forth for the temperature responsive device 31 and the relative humidity values set forth for the relative humidity control 30 may be varied according to the conditions of any particular installation and that the examples given hereinabove are merely illustrative.

Operation

With the parts in the position shown, the relative humidity of the space to be controlled is below 50% so that the mercury switch 43 is closed and the mercury switch 44 is open. Also, the temperature of the space to be controlled is between 72° F. and 75° F. so that switch arm 47 is in engagement with contact 50 but the switch arms 48 and 49 are disengaged from their re-

spective contacts 51 and 52. Under these conditions, the solenoid valve 23 is energized by a circuit as follows: line wire 55, wire 56, mercury switch 43, wire 57, wire 58, solenoid valve 23 and wire 59 to line wire 60. However, the compressor motor 16 is deenergized under these conditions so there is no available supply of liquid refrigerant. Under these conditions, no refrigerant is passing to the coil 14 so that the air passing thereover and being delivered to the room or space to be controlled is neither being cooled or dehumidified. These conditions of temperature and humidity are the desired normal conditions.

If the relative humidity of the room or space to be controlled should rise to 60%, then mercury switch 44 will be moved to closed circuit position, it being noted that mercury switch 43 will thereby be opened. Opening of mercury switch 43 deenergizes solenoid valve 23 by interrupting the circuit just described. Closure of mercury switch 44 energizes compressor motor 16 by the following circuit: line wire 55, wire 61, actuator 45, switch arm 47, contact 50, wire 62, mercury switch 44, wire 63, wire 64, compressor motor 16 and wire 65 to line wire 60. A supply of liquid refrigerant will thereupon be provided and this supply of liquid refrigerant can reach the cooling coil 14 only by passing through the plain expansion valve 22 since the solenoid valve 23 has been deenergized. The expansion valve 22 will thereupon maintain a pressure upon the coil 14 such that the temperature thereof will be well below the dew-point temperature of the air passing thereover. This air is therefore not only cooled but the moisture therein is condensed so as to lower its relative humidity. The relative humidity of the room or space to be controlled is thereby lowered. This cooling of the air below its dew-point will also result in cooling of the space or room to be controlled, and if the temperature thereof drops below 72° F., the switch arm 47 of the temperature controller 31 will disengage contact 50, whereupon the circuit for compressor motor 16 will be interrupted. In this manner, no more liquid refrigerant will be furnished to the cooling coil 14 so that no further cooling or dehumidification of the air passing thereover can be accomplished. Thus, the switch comprised by switch arm 47 and contact 50 operates as a minimum temperature control to prevent a lowering of the temperature of the room or space to be controlled below some desired minimum irrespective of the relative humidity.

Now if the relative humidity should return to 50% or therebelow so as to again open mercury switch 44 and reclose mercury switch 43, and if the temperature of the room or space rises to 75° F., so as to move switch arm 48 into engagement with contact 51, then solenoid valve 22 will again be energized by the circuit set forth above and, in addition, the compressor motor 16 will be energized by a circuit as follows: line wire 55, wire 61, bimetallic element 45, switch arm 48, contact 51, wire 66, wire 64, compressor motor 16, and wire 65 to line wire 60. The compressor 16 is thereupon again operated to furnish liquid refrigerant and this refrigerant now passes to the cooling coil 14 through the thermostatic expansion valve 24. The bulb 25 of the thermostatic expansion valve 24, in responding to the temperature of the refrigerant leaving the cooling coil 14, maintains the cooling coil temperature relatively high and perhaps above the dew-point of the air passing thereover,

whereby the refrigeration will be used substantially entirely for cooling purposes and no appreciable dehumidification will take place.

If this should result in a rise in relative humidity so that the relative humidity again rises above 50%, then the mercury switch 43 will be opened. This opening of mercury switch 43 will deenergize solenoid valve 23, whereupon the cooling coil 14 will be controlled by the plain expansion valve 22 so that the temperature of cooling coil 14 will be lowered below the dew-point temperature of the air passing thereover. Under these conditions, a dehumidifying action as well as some cooling will be obtained. The proportion of cooling and dehumidification that is obtained under these conditions will depend on how far below the dew-point temperature of the air passing over the coil 14 the temperature of such coil is maintained.

If the temperature of the room or space to be controlled should rise to 78° F. so that switch arm 49 is brought into engagement with contact 52, then the solenoid valve 23 will be energized and the compressor motor 16 will be operated irrespective of the relative humidity. This energizing circuit for the solenoid valve 23 is as follows: line wire 55, wire 61, bimetallic element 45, switch arm 49, contact 52, wire 67, wire 58, solenoid valve 23 and wire 59 to line wire 60. Therefore, under conditions of excessive temperature, the cooling coil 14 is maintained at a high temperature so that the whole effect of the refrigeration apparatus, or the greater part thereof, is utilized in cooling such air and substantially none of it is utilized in dehumidification. In this manner, the temperature of the room or space to be controlled can be maintained below an undesired maximum irrespective of the relative humidity conditions.

To recapitulate, the compressor motor 15 is operated whenever the room temperature rises to 75° F. and closes the switch defined by switch arm 48 and contact 51. Whether or not the liquid refrigerant thus supplied is utilized entirely for cooling or both for cooling and dehumidification depends upon the relative humidity. If the relative humidity is at 50% or therebelow, the mercury switch 43 is closed so that solenoid valve 23 is opened and under these conditions all cooling will be effected. On the other hand, if the relative humidity is above 50% so that mercury switch 43 is opened, then solenoid valve 23 will be deenergized and the coil 14 will be maintained below the dew-point of the air passing thereover so that dehumidification is effected, of course, being accompanied by a certain amount of cooling. If the relative humidity becomes excessive by rising to 60% or thereabove, the compressor motor 16 is operated even though the room temperature is below 75° F., but when switch arm 47 moves from engagement with contact 50 no further dehumidification can take place since the compressor motor 16 is thereby deenergized. Further, if the room temperature reaches some excessive value such as 78° F., the compressor motor 16 is operated and the solenoid valve 23 is opened irrespective of relative humidity conditions so that only cooling can be obtained to the exclusion of dehumidification.

It is to be understood that the single form of the invention herein disclosed in detail is only one of the many manners in which my invention may be carried out and is susceptible of many changes in form without departing from the spirit of my invention. I therefore intend to be

limited only by the scope of the appended claims.

I claim as my invention:

1. The combination with a refrigerating coil over which air to be conditioned is passed before being delivered to a space to be controlled and a compressor for supplying refrigerant to said coil, of an expansion valve for maintaining the coil temperature below the dew-point of the air, a second expansion valve for maintaining the coil at a higher temperature than the valve first mentioned, moisture responsive means for placing said first valve in operation when the humidity increases, and for placing said second valve in operation when the humidity decreases, and temperature responsive means for placing said second expansion valve in operation when the temperature of the air rises above a predetermined maximum, regardless of the humidity.

2. The combination with a refrigerating coil over which air to be conditioned is passed before being delivered to a space to be controlled and a compressor for supplying refrigerant to said coil, of an expansion valve for maintaining the coil temperature below the dew-point of the air, a second expansion valve for maintaining the coil at a higher temperature than the valve first mentioned, moisture responsive means for placing said first valve in operation when the humidity increases, and for placing said second valve in operation when the humidity decreases, temperature and moisture responsive means for causing operation of the system whenever either the temperature or humidity of the air exceeds predetermined limits, and temperature responsive means for placing said second valve in operation regardless of humidity whenever the temperature of the air exceeds a predetermined maximum.

3. In an air conditioning system, in combination, a cooling coil, means for supplying refrigerant thereto, said means including an expansion valve arranged to maintain a relatively low pressure in said coil, a second expansion valve arranged to permit a relatively high pressure in the coil, and by-passing said first valve, cut-off means for preventing flow through said second valve, moisture responsive means in control of said cut-off means for permitting flow through said second valve upon decrease in humidity and for preventing flow through said second valve upon increase in humidity, and temperature responsive means for permitting flow through said second valve irrespective of humidity when the air temperature exceeds a predetermined value.

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 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.

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 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.

6. In a direct expansion cooling system for cooling air, in combination, cooling means including direct expansion cooling means and refrigerant supply means, means to control said cooling means to provide relatively high or relatively low temperatures, and means responsive to temperature and humidity to control said last-named means in a manner to produce a high cooling means temperature either upon a high temperature value regardless of the humidity or upon a lower temperature value upon low humidity and to provide a low cooling means temperature upon high humidity if the temperature is not at or above said high value.

WAYLAND R. MILLER.