

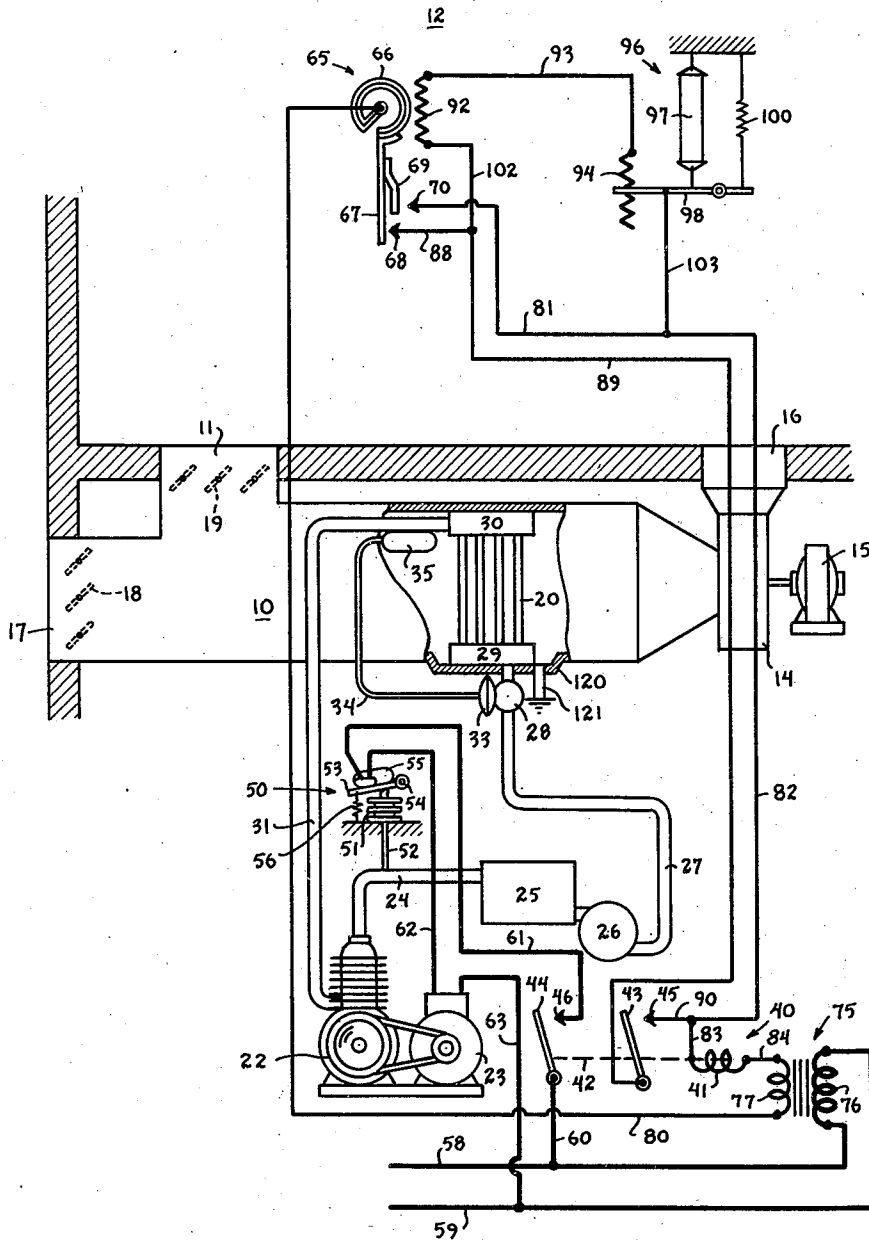
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A. B. NEWTON

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AIR CONDITIONING

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Inventor

Alwin B. Newton

By

George H. Fisher

Attorney

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AIR CONDITIONING

Alwin B. Newton, Minneapolis, Minn., assignor to
Minneapolis-Honeywell Regulator Company,
Minneapolis, Minn., a corporation of Delaware

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This invention relates to air conditioning systems and more particularly to systems for cooling and dehumidifying the air in a space.

One of the objects of my invention is to operate a cooling coil over which air to be conditioned is circulated, in such a manner that substantially complete drainage of moisture from the coil is periodically effected.

More specifically, it is an object of the present invention to vary the periods during which the coil is in operation and out of operation in accordance with the humidity of the space in such a manner that drainage of moisture from the surface of the coil is assured during periods of high humidity, and during periods of low humidity, the moisture deposited on the surface of the coil will re-evaporate, thus increasing the sensible cooling effect of the coil.

Another object of the invention is the provision of a temperature responsive means for controlling conditioning apparatus, the temperature responsive means having a variable differential, and adjusting the differential in accordance with the humidity of the space.

Another object of the invention is the provision of a temperature responsive means having means for anticipating a change in temperature in a space, and varying the effectiveness of the means for anticipating the effect of a change in temperature in accordance with another condition in the space.

Other objects and advantages will become apparent upon a study of the specification, claims, and appended drawing wherein is illustrated a preferred embodiment of my invention.

Referring more particularly to the drawing, an air conditioning chamber represented by the reference character 10 is connected by means of the inlet opening 11 with the space 12 to be conditioned. Air is drawn through the chamber 10 by means of the fan 14 driven by a motor 15, the air being discharged into the space through the outlet 16. For ventilation purposes, fresh air may also be drawn into the chamber 10 through the fresh air inlet 17 and the proportions of fresh and return air drawn into the chamber 10 may be regulated by means of the dampers 18 and 19.

Located within the chamber 10 is a cooling coil 20 over which the air flowing through the chamber passes. This cooling coil may comprise an evaporator of a refrigeration system, which system is shown to comprise a compressor 22 driven by a motor 23. Compressed refrigerant flows from the compressor through the discharge

pipe 24 into a condenser 25 wherein the refrigerant is condensed, the refrigerant then flowing into the receiver 26 and thence by way of the pipe 27 and expansion valve 28 into the distributing header 29 of the evaporator 20, which is illustrated as being of the multiple pass type. The evaporated refrigerant from the evaporator 20 flows into the collector 30 and through the suction pipe 31 into the low pressure side of the compressor 22. The expansion valve 28 is illustrated as being of the thermostatic expansion valve type, the operating mechanism for the valve including a diaphragm or bellows 33, one side of which is connected by means of the capillary tube 34 with a bulb 35 located in contact with the pipe 31 leading from the evaporator 20, in the manner well known in the art. If desired, the valve may be provided with an external equalizer connection as is common in the art. The expansion valve thus controls the flow of refrigerant into the evaporator 20 in a manner to prevent liquid refrigerant from flowing back into the compressor 22. The operation of such a refrigeration system is well known in the art and further description thereof is believed to be unnecessary.

The compressor motor 23 is under the control of a relay designated by the reference character 40 and which relay comprises a relay coil 41, an armature 42, switch arms 43 and 44 connected to the armature 42, these switch arms cooperating with fixed contacts 45 and 46, respectively. When the relay coil 41 is energized, the switch arms 43 and 44 move into engagement with their respective contacts, and upon deenergization of the relay coil the switch arms move out of engagement with their respective contacts under the influence of gravity or any suitable biasing means (not shown). The circuit to the compressor motor also includes a pressure responsive device 50 which comprises a bellows 51 connected by a tube 52 into the pipe 24 connected to the discharge side of the compressor. The bellows 51 controls the position of an arm 53 pivoted at 54 and carrying a mercury switch 55, the arm being biased downwardly by means of the spring 56. As long as the pressure of the refrigerant leaving the compressor is not excessively high the mercury switch will be in the circuit closing position as illustrated. Should the pressure on the high pressure side of the compressor become excessively high however the expansion of the bellows 51 caused thereby will move the mercury switch 55 into the circuit breaking position. Line wires 58 and 59 supply power to the compressor

motor 23 when the relay 41 is energized and the mercury switch 55 is closed, the circuit being as follows: from the line wire 58 through conductor 60, switch arm 44, contact 46, conductor 61, mercury switch 55, conductor 62, motor 23 and conductor 63 to the line wire 59, the line wires being connected to a suitable source of power, not illustrated. It will therefore be seen that when the relay 40 is energized and the pressure on the high pressure side of the compressor is not excessive, the compressor will be placed in operation to circulate refrigerant through the evaporator 20.

The energization of the relay 40 is under the control of a temperature responsive device 65 which, for purposes of illustration, is shown to comprise a bimetallic element 66 carrying a flexible contact arm 67 for cooperation with a fixed contact 68. The arm 67 carries a second contact arm 69 for cooperation with a fixed contact 70. As the temperature in the space 12 rises, the bimetallic element 66 causes the arm 67 to move towards the contact 68 and the contact arms 67 and 69 are so arranged with respect to their respective contacts that arm 67 will first engage contact 68 and upon a further rise in temperature at the thermostatic element the arm 69 will engage the contact 70, the resiliency of the arm 67 permitting movement of arm 69 into engagement with contact 70.

Power is supplied to the relay 40 by means of the step-down transformer 75 which includes a high tension primary 76 connected across the line wires 58 and 59, the transformer also including a low tension secondary 77. When the temperature at the thermostat 65 is sufficiently high so that contact arm 69 is in engagement with contact 70, relay coil 41 will be energized as follows: from one side of the transformer secondary 77 through conductor 80, bimetallic element 66, contact arm 69, contact 70, conductors 81, 82, 83, relay coil 41, and conductor 84 to the other side of the secondary 77. Energization of the relay moves the arms 43 and 44 into engagement with the contacts 45 and 46, respectively, causing operation of the compressor as heretofore described and also completing a holding or maintaining circuit for the relay coil 41 which is independent of engagement of arm 69 of the thermostat with contact 70, this maintaining circuit being as follows: from one side of the transformer secondary 77 through conductor 80, bimetallic element 66, switch arm 67, contact 68, conductors 88, 89, switch arm 43, contact 45, conductors 90, 83, relay coil 41, and conductor 84 to the other side of the secondary 77. It will accordingly be seen that after the relay 40 has been energized by engagement of arm 69 with contact 70, it will remain energized until the arm 67 moves out of engagement with the contact 68 due to a sufficient reduction in temperature at the thermostat 65.

Associated with the bimetallic element 66 is an electrical heating element 92 for raising the temperature at the bimetallic element 66 above the space temperature at certain times during operation of the system. One side of the heating element 92 is connected by a conductor 93 to an adjustable resistance 94 whereby the heating effect of heater 92 may be adjusted. A humidity responsive device 96 which may be of any suitable construction and is shown to comprise a hygroscopic element 97 which expands and contracts in response to variations in humidity of the air in the space 12, has the movable end

thereof connected with the pivoted arm 98 which cooperates with the resistance 94. A spring 100 causes movement of the arm 98 in a direction to maintain the humidity responsive device 97 under a desired amount of tension. As the humidity in the space increases, the element 97 will expand, thus permitting downward movement of the left end of arm 98 which increases the effectiveness of the resistance 94. Conversely, upon a decrease in the space humidity the arm 98 moves upwardly to decrease the amount of the resistance 94 in series with the heating element 92.

As the temperature in the space 12 rises and arm 67 of the thermostat engages contact 68 a circuit is completed through the heating element 92 as follows: from one side of the transformer secondary 77 through conductor 80, bimetallic element 66, contact arm 67, contact 68, conductors 88, 102, heating element 92, conductor 93, resistance 94, arm 98, conductors 103, 82, 83, relay coil 41, and conductor 84 to the other side of the secondary 77. Sufficient current does not flow through this circuit to energize the relay coil 41 but the heating element 92 will start to heat up, and the degree to which it will heat up will depend upon the amount of the resistance 94 that is in series therewith. Thus if the humidity in the space is low and the amount of the resistance 94 in series with the heating element 92 is low, the element 92 will heat up to a greater extent than when the humidity in the space is high. The energization of the heater 92 causes the temperature of the bimetallic element to increase more rapidly than the space temperature increases, with the result that the contact 69 will engage the fixed contact 70 sooner and at a lower temperature of space 12 than it normally would were the heater 92 not present. As the contact arm 69 engages the contact 70 and the relay 40 is energized to operate the compressor, the above described maintaining circuit for the relay which includes the arm 43 and the fixed contact 45 effectively shunts out the heating element 92 so that practically no current now flows through this element and it will cool down. Since the bimetallic element 66 has been heated to a higher temperature than the temperature to which the space 12 has risen by the time contact 69 engages fixed contact 70 to start the compressor, the temperature of element 66 will drop rather rapidly when the heater 92 is deenergized. At some time before the space temperature drops to the temperature setting at which contact 67 disengages fixed contact 68, the temperature of the bimetallic element will have become equal to the space temperature so that the temperature to which the space is cooled at the end of a period of operation of the compressor will be the same regardless of the heater 92. The effect of the heater, then, is to reduce the effective operating differential of the thermostat.

Assume that the thermostat is so adjusted that contacts 69 and 70 do not make until the bimetallic element 66 is five degrees warmer than the temperature at which contacts 67 and 68 make and that the compressor has been shut down due to disengagement of contacts 67 and 68. On a rise in temperature causing contacts 67 and 68 to engage, the heater 92 will be energized. The temperature of the space 12 will continue to rise but the temperature of the bimetallic element will rise at a greater rate so that when contacts 69 and 70 engage to start the compressor and deenergize heater 92, the space tempera-

ture will not have risen five degrees as has the thermostatic element but some lesser amount, for example two to four degrees, depending on the setting of the rheostat 94 as positioned by the humidity responsive element 97. Accordingly the operating differential of the thermostat will be varied in accordance with the humidity of the air in the space and when the humidity in the space is low the operating differential of the thermostat will be small but as the humidity in the space increases, the operating differential of the thermostat will be likewise increased.

The air passing through the air conditioning chamber 10 and over the evaporator 20 will have its temperature reduced and the evaporator 20 may also remove latent heat from the air as will be evidenced by condensation of moisture on the evaporator coils. If the compressor is operated for a sufficiently long period of time so much water will be deposited on coils 20 that it will run off. As shown by the drawing, the chamber 10 may be provided with a sump 120 located below the evaporator coils 20, a suitable drain 121 being connected to the sump for removing the water of condensation as it drains from the evaporator.

Under conditions of high humidity substantially all of the resistance 94 will be connected in series with heater 92 thereby lessening the supply of heat to the thermostatic element 66 during the period when the space temperature is rising. Since little artificial heat is being supplied to the thermostatic element, contacts 69 and 70 will not make until the space temperature has risen through substantially the full differential of the thermostat. Consequently when the compressor is started, considerable time will be required to bring the space temperature down to the point where contacts 67 and 68 will break to shut down the compressor. During the first portion of the operating period of the compressor moisture will be condensed out of the air onto the evaporator coils 20. Continued operation of the compressor will cause more water to be condensed than can remain on the evaporator coils and the water will flow from the coils to the sump 120 and the drain 121 thus permanently removing moisture from the air.

Under conditions of low humidity the heater 92 will be heated to a greater extent due to lessening of the effective value of resistance 94 as adjusted by the humidity responsive element 97. When the compressor is shut down and the contacts 67 and 68 are in engagement the space temperature will be rising but considerable artificial heat will be supplied to the bimetal element 66 by the heater 92. The effect will be that long before the space temperature has risen sufficiently to cause contacts 69 and 70 to make, heater 92 will have raised the temperature of the bimetal element 66 to this point. Since the compressor has been energized at a temperature very little above the temperature at which the thermostat will be satisfied, it will not have to operate very long to bring the space temperature down to this point. As pointed out hereinbefore, the first effect of operation of the compressor is to cause precipitation of moisture from the air on the evaporator coils 20. If the operating cycle is sufficiently short the compressor will be shut down before sufficient moisture has been precipitated on the evaporator coils to cause drainage therefrom. Under conditions of low humidity the period of operation of the compressor is so shortened that little if any moisture is permanently removed from the air. Once the com-

pressor is shut down, air flowing past the evaporator will reevaporate any moisture which has not passed to the drain 120. This is not undesirable when the humidity is low because this reevaporation of moisture causes additional sensible cooling.

It will be seen that I have provided a control system for a cooling and dehumidifying apparatus which controls the amount of moisture removed from the air by varying the length of the cooling cycle, which is in turn controlled by varying the operating differential of the thermostat by means of a humidostat.

Having described a preferred form of my invention, many modifications may become apparent to those skilled in the art, for example, instead of using a direct expansion refrigerating system for cooling the air any other suitable form of system such as a brine system may be employed. Also while I have shown the compressor being controlled only by head pressure and the space thermostat, it will be understood that other suitable controls therefor such as a suction pressure controller might be added. It should therefore be understood that my invention is to be limited only by the scope of the appended claims.

I claim as my invention:

1. In an air conditioning system for a space, means for reducing the temperature of the air in the space, said means including an evaporator of a refrigeration system, means for causing a circulation of air past said evaporator and through the space to be conditioned, means controlling the operation of the refrigeration system, said means including a space temperature responsive means having a variable operating differential, and means responsive to the moisture condition of the air in the space for increasing the operating differential of the temperature responsive means as the moisture condition increases and decreasing the operating differential of the temperature responsive means as the moisture condition decreases, without substantially changing the value of the temperature maintained by said temperature responsive means.

2. In an air conditioning system for a space, means for reducing the temperature of the air in the space, said means including an evaporator of a refrigeration system, means for causing a circulation of air past said evaporator and through the space to be conditioned, means controlling the operation of the refrigeration system, said means including a space temperature responsive means having a variable operating differential, and means responsive to the humidity of the air in the space for increasing the operating differential of the space temperature responsive means as the humidity increases and decreasing the operating differential of the space temperature responsive means as the humidity decreases, without substantially changing the value of the temperature maintained by said temperature responsive means.

3. In an air conditioning system for a space, means for reducing the temperature of the air in the space, said means including an evaporator of a refrigeration system, means for causing a circulation of air past said evaporator and through the space to be conditioned, means controlling the operation of the refrigeration system, said means including a space temperature responsive means having a variable operating differential, means for causing the temperature adjacent said temperature responsive means to fall more rapidly than the space temperature

after operation of the refrigeration system has been initiated, and means responsive to the humidity of the air in the space for varying the operation of said last named means.

4. In an air conditioning system for a space, means for reducing the temperature of the air in the space, said means including an evaporator of a refrigeration system, means for causing a circulation of air past said evaporator and through the space to be conditioned, means controlling the operation of the refrigeration system, said means including space temperature responsive means having two pairs of sequentially engageable contact members, means responsive to engagement of both pairs of contact members due to a rise in temperature adjacent said temperature responsive means to initiate operation of said refrigeration system, means causing said refrigeration system to remain in operation until both pairs of contact members have been disengaged, local heating means adjacent said thermostatic means, means causing energization of said heating means only when the first of the pairs of contact members to engage are in engagement and the refrigerating apparatus is shut down, and means responsive to the humidity of the space being conditioned in control of the heating effect of said heating means.

5. In a system of the class described, space cooling means, temperature responsive means in control of said space cooling means, said temperature responsive means having a variable operating differential, and humidity responsive means for increasing the operating differential of the temperature responsive means when the space humidity is relatively high and for decreasing the operating differential of the temperature responsive means when the space humidity is relatively low, without substantially changing the value of the temperature maintained by said temperature responsive means.

6. In a system of the class described, space cooling means, temperature responsive means in control of said space cooling means, said temperature responsive means having a variable operating differential, and means responsive to increases or decreases in the humidity of the air in the space for increasing or decreasing, respectively, the operating differential a proportionate amount, without substantially changing the value of the temperature maintained by said temperature responsive means.

7. In a system of the class described, a cooling coil, means for causing a circulation of a cooling medium through said cooling coil, means for causing a circulation of air over said coil and through a space to be conditioned, said cooling coil effecting a removal of both sensible and latent heat from the air passing thereover, space temperature responsive means in control of the flow of cooling medium through said cooling coil, said temperature responsive means including

means for varying the operating differential thereof, and means responsive to the humidity of the space being conditioned in control of said last named means to increase the operating differential of the temperature responsive means as the humidity increases and to decrease the operating differential of the temperature responsive means as the humidity decreases, without substantially changing the value of the temperature maintained by said temperature responsive means.

8. In a system of the class described, a cooling coil, means for causing a circulation of a cooling medium through said cooling coil, means for causing a circulation of air over said coil and through a space to be conditioned, said cooling coil effecting a removal of both sensible and latent heat from the air passing thereover, space temperature responsive means in control of the flow of cooling medium through said cooling coil, local temperature changing means adjacent said temperature responsive means, means under the control of said temperature responsive means operative to render said local temperature changing means more effective when said temperature responsive means is in one position than when said temperature responsive means is in another position to vary the operating differential of said temperature responsive means, and humidity responsive means for varying the effect of said local temperature changing means to increase said operating differential as the humidity increases and to decrease said operating differential as the humidity decreases.

9. A method of conditioning air for a space which comprises removing sensible and latent heat by passing unconditioned air at substantially constant velocity over an evaporator of a refrigerating system which is continually supplied during effective periods of operation with refrigerant passing serially through said entire evaporator and at such a rate of flow as to maintain a substantially constant degree of superheat at the outlet of said evaporator, intermittently rendering said evaporator effective and ineffective over a period of time during which said space requires cooling and regulating the total time consumed by said effective periods in accordance with the sensible heat load on said space during said period of time for maintaining the dry bulb temperature in said space substantially constant, increasing the duration of said effective periods upon an increase in space humidity and decreasing the duration of said effective periods upon a decrease in space humidity without affecting the average temperature of the air leaving said evaporator, or the total time consumed by said effective periods, whereby the amount of sensible heat removed from the air by said evaporator over said period of time will be unaffected by the humidity in said space.

ALWIN B. NEWTON.