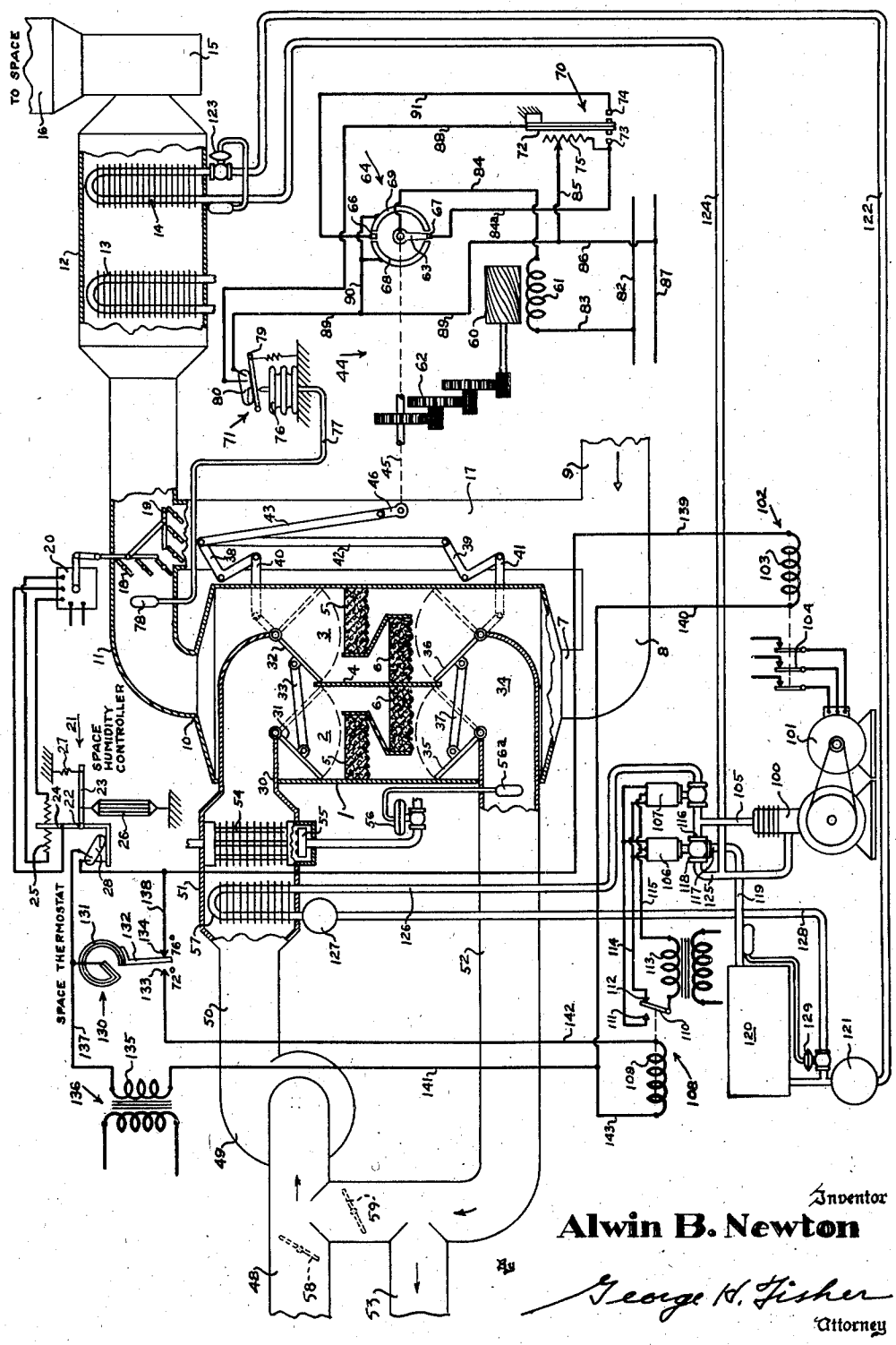
Sept. 30, 1941. A. B. NEWTON 2,257,478

AIR CONDITIONING SYSTEM

Filed Oct. 22, 1938



Inventor
Alwin B. Newton
By
George H. Fisher
Attorney

Patented Sept. 30, 1941

2,257,478

UNITED STATES PATENT OFFICE

2,257,478

AIR CONDITIONING SYSTEM

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

Application October 22, 1938, Serial No. 236,472

9 Claims. (Cl. 183—4)

This invention relates to air conditioning systems and more particularly to systems of the type utilizing absorption or adsorption type dehumidifiers for dehumidifying the air.

In systems of this type which utilize silica-gel or other hygroscopic dehumidifying material for condensing the water from the air, it is necessary to provide for reactivating the dehumidifying material at intervals in order that the material may continue its dehumidifying action. This is done by heating the material for driving off the collected water vapor. Due to the fact that a single bed of dehumidifying material cannot remain in use continuously but must be reactivated, it has become usual to provide a pair of separate beds and to reactivate and place these beds in operation in alternation. Thus while one bed is being reactivated, the other bed of material is dehumidifying the air being conditioned.

Heretofore it has been customary to reverse the operation of the dehumidifier by means of a timer which operates to reverse the operation periodically. This type of control, while being satisfactory for certain load conditions on the system is wasteful during periods of light load, and may not provide for sufficient reactivation during periods of heavy load. This wasteful operation of the system during light load periods is due to the fact that in order to reactivate a bed of material it is necessary to heat the bed sufficiently for driving off the water contained therein. This requires, in the first place, the supplying of a considerable quantity of heat to the bed. Then due to the bed being hot at the end of its reactivating period, it must be cooled which involves an additional loss. If this bed is cooled by passing cooled air therethrough the bed will act to dehumidify this cooling air and thus pick up water, thus losing a portion of its dehumidifying effect. On the other hand if the bed is not cooled before passing the air being dehumidified therethrough, the bed will heat this air excessively thereby throwing an additional load upon the cooling system. Therefore, each time that the dehumidifying apparatus is changed from dehumidifying to reactivating, a definite loss occurs. If this reversal is controlled by a timer, the reversals will occur more frequently than necessary, thus causing the efficiency to be lowered. Also, unless the timer is set to provide for reversing the dehumidifier at a sufficient rate to carry the maximum load, the system will not provide sufficient dehumidification during heavy load periods. On the other hand if the timer is set to provide for carrying maximum load, then the system efficiency for lighter loads will be lowered still further.

It is an object of this invention to provide a control system for dehumidifiers of this type which provides for reactivating the dehumidifying material in accordance with the actual load upon the dehumidifier, thereby reducing reversal losses of the dehumidifier to a minimum, while at the same time obtaining the necessary amount of dehumidification for all load conditions.

More specifically it is an object of this invention to provide a control system for controlling a dehumidifier of this general type in accordance with the temperature of the dehumidified air leaving the dehumidifier.

Another object of this invention is the provision of a reactivating control arrangement for a dehumidifier which controls the supply of reactivating heat in accordance with the condition of the material being reactivated, thereby supplying just enough reactivating heat to efficiently obtain the necessary reactivation.

A further object of this invention is the provision of a reactivating arrangement for a dehumidifier which secures the reactivation by passing heated air through the dehumidifying material, and which recirculates a portion of this reactivating air thus reducing to a minimum the amount of heat necessary for reactivation of the material.

Still another object of this invention is the provision of an air conditioning system utilizing the type of dehumidifier mentioned, and which utilizes the air cooling system for supplying additional reactivating heat when the dehumidifying load becomes excessive while the cooling load is light.

Other objects of this invention lie in various combinations and sub-combinations of the control system and will become apparent from the following description and appended claims.

For a full disclosure of my invention reference is made to the following detailed description and to the accompanying drawing, the single figure of which illustrates diagrammatically an air conditioning system embodying the novel features of my invention.

Referring to the drawing, reference character 1 indicates a conventional type silica-gel dehumidifying unit. This unit consists of a casing which is divided into passages 2 and 3 by means of a partition 4. These passages 2 and 3 each contain perforated or screen bottom pans 5 and 6 for retaining the silica-gel or other drying medium. At the bottom of the dehumidifying

unit is an inlet 7 for air to be conditioned, and this inlet is connected by duct 8 to a duct 9 which supplies the air to be dehumidified to the dehumidifying unit. This duct 9 may either supply all outside air to the unit or may supply to this unit a mixture of outside air and air withdrawn from the space being conditioned. At the top of the dehumidifying unit 1 is an outlet 10 for discharging dehumidified air. This outlet 10 is connected by a duct 11 to a conditioning chamber 12 which contains a precooling coil 13 and a direct expansion cooling coil 14. This conditioning chamber 12 is connected to a fan 15 which acts to draw air to be conditioned through the dehumidifying unit 1 and the conditioning chamber 12, this fan discharging the air to the space being conditioned through a discharge duct 16.

In order to control the relative humidity within the space, a by-pass duct 17 is provided between the supply duct 9 and the duct 11 for thereby permitting air to be by-passed around the dehumidifying unit 1. The proportions of air passed through the dehumidifying unit and by-passed therearound are controlled by means of dampers 18 and 19 which may be actuated by means of a proportioning motor 20. This motor may be of the type shown and described in the Taylor Patent 2,028,110 issued January 14, 1936, and is adapted to be controlled by means of a potentiometer controller, assuming intermediate positions in accordance with the position of the potentiometer slider upon its resistance. In the present case, this motor 20 is controlled by means of a potentiometer type space relative humidity controller 21. This controller may be of any suitable construction and is diagrammatically illustrated as comprising a bell crank lever pivoted at 22 and having an actuating arm 23 and a control arm or slider 24 which cooperates with a resistance 25 to form a control potentiometer for the motor 20. The actuating arm 23 may be connected to a humidity responsive device 26 which may comprise a plurality of strands of hair or other moisture responsive material. Upon an increase in relative humidity within the space, the strands 26 will increase in length for permitting movement of slider 24 to the left across resistance 25 under the action of a spring 27, this action causing the proportioning motor 20 to move damper 19 towards closed position while moving damper 18 towards open position. This will increase the proportion of the air passed through the dehumidifying unit, this tending to counteract the rising space relative humidity. Upon a decrease in relative humidity the strands 26 will decrease in length which will cause movement of motor 20 in the opposite direction for decreasing the amount of air passed through the dehumidifier.

The space relative humidity controller 21 is also provided with an auxiliary switch which is diagrammatically illustrated as comprising a mercury switch 28 which is arranged so as to remain in open position as long as the slider 22 is not engaging the left hand end of resistance 25. However when the relative humidity rises to an excessive value which causes the slider 22 to engage the left hand end of resistance 25, the mercury switch 28 will be tilted sufficiently for bridging its electrodes. The purpose of this auxiliary switch will become apparent as this description proceeds.

Referring again to the dehumidifying unit 1 it will be understood that the dehumidifying substance accumulates water and must occasionally or periodically be reactivated in order that it may continue its dehumidifying action. In order to provide for continuous dehumidification it is necessary to provide at least two separate beds of dehumidifying material and reactivate one of these beds while the other is in use for dehumidifying the air. In order to provide for reactivating the dehumidifying material the dehumidifying unit 1 is provided with an inlet duct 30 which conveys heated air for reactivation into the unit 1. This inlet duct 30 extends to the center of the casing and is provided with dampers 31 and 32 which are connected together by means of a link 33. At the lower part of the dehumidifying unit is an outlet duct 34 for the reactivating air. This outlet duct extends into the casing and is provided with dampers 35 and 36 which are connected together by a link 37. All of these dampers are actuated in unison through any suitable linkage which is diagrammatically illustrated as including bell crank levers 38 and 39 and links 40, 41, 42, and 43 by means of a motor generally indicated as 44. This motor is provided with an operating shaft 45 carrying a lever 46 to which the link 43 is attached. When the lever 46 is in the position shown the dampers will assume their full line positions which causes air for reactivation to pass from inlet duct 30 through the passage 2 to the outlet duct 34, while causing air to be dehumidified to flow from inlet 7 through the passage 3 to the outlet 10. When the lever 46 assumes a position 180° from the position shown the dampers will be shifted to their dotted line positions which will cause the air for reactivation to pass downwardly through the passage 3 to the outlet duct 34, while causing air to be dehumidified to flow from inlet 7 around duct 34 through passage 2 and around duct 30 to the outlet 10. The motor 44 therefore acts to reverse the operation of the dehumidifying unit for alternately causing the material in one passage to be reactivated while the material in the other passage dehumidifies the air being conditioned, and vice versa.

Referring now to the arrangement for providing reactivating air for the dehumidifying unit 1, reference character 48 indicates a duct which supplies outside air, this duct being connected to the inlet of a fan 49. This fan in turn discharges air through a duct 50 into a heating chamber 51 which in turn is connected to the inlet duct 30 of the unit 1. The outlet duct 34 within the unit 1 is connected to a duct 52 which leads back to the inlet of fan 49. A discharge duct 53 is connected to the duct 52 so as to discharge a portion of the air passing through this duct. Located within the heating chamber 51 is a heater 54 which may be of any suitable type including a gas burner 55 which is controlled by means of a thermostatic valve 56 which is responsive to the temperature of the reactivating air passing through the duct 52, this valve 56 having a thermostatic bulb 56a located within the duct 52. The heating chamber 51 also includes an auxiliary heating coil 57. In operation the fan 49 draws fresh air through the heating chamber 51 where it is heated to a temperature which is sufficiently high for driving off the water from the dehumidifying material within the unit. The air after passing through the dehumidifying unit passes through the duct 52 back to the inlet of the fan 49 and

is thus mixed with the fresh air being passed into the heating chamber 51. A portion of this air, however, is discharged through the discharge duct 53. The amount of air which is recirculated in this manner may be varied as desired by means of dampers 58 and 59 located in ducts 48 and 52, respectively. Due to this recirculation of a portion of the reactivating air, the fresh air being supplied for reactivation is preheated. This preheating is obtained without a proportionate reduction in reactivation effect of the air, as the recirculated air is still capable of absorbing considerable water. This recirculating of the reactivating air thus provides for decreasing the operating expense of the system.

A further economy in operation is obtained by the control of the heater 55 in accordance with the temperature of the reactivating air leaving the dehumidifier. When the dampers are positioned for reactivating a bed of dehumidifying material which has just been in operation, this bed will be relatively cool and consequently the temperature at the thermostat bulb 57 will decrease which will open valve 56 wide for operating the heater 54 at maximum capacity. At this time the bed of dehumidifying material being reactivated will be saturated with water and consequently this water will evaporate rapidly which will cause the reactivating air to be cooled considerably as it passes through the bed. As the reactivation continues, the amount of water in the gel bed being reactivated is progressively decreased and consequently less cooling of the reactivating air occurs as it passes through the gel bed. This will cause the temperature of the reactivating air leaving the dehumidifier to tend to rise. However in response to this rise in temperature the valve 56 will decrease the supply of gas to the burner 55 and thereby decrease the amount of heat supplied to the reactivating air. Thus the valve 56 acts to prevent the reactivating air from being discharged from the unit at a temperature higher than necessary to secure efficient reactivation and thus materially conserves on operating expenses of the system. It will be apparent that by controlling the heater 54 in accordance with the temperature of the air being discharged from the heater, and the recirculation of the reactivating air provides for materially reducing the operating expense of the system as compared to systems heretofore utilized in which no recirculation is provided and in which the heater operates continuously at the same rate.

Referring now to the motor 44 which drives the dampers from one position to another, this motor may comprise a rotor 60 and a field coil 61 which together form an induction motor. The rotor 60 drives the operating shaft 45 through a gear train 62. This shaft 45 in addition to actuating the operating lever 46 also actuates the switch arm 63 of a switching mechanism generally indicated as 64. This switching mechanism comprises a pair of contact buttons 66 and 67 which are located 180° apart, and contact segments 68 and 69. This motor 44 is controlled by the conjoint action of a timer 70 and a thermostat 71. Referring to the timer 70, this timer may include bimetallic element 72 which is fixedly secured at its upper end, and which carries contacts at its lower end cooperating with contacts 73 and 74. The bimetallic element 72 is subjected to the influence of a heating element 75 which may be adjustable as indicated. When the heating element 75 is energized, the bimetallic element 72 will warp to the left for contacting the contact 73. However, when the heating element 75 is deenergized, the bimetallic element 72 will cool which causes it to warp to the right for engaging contact 74.

Referring to the thermostat 71, this thermostat may be of any suitable type and is illustrated as comprising a bellows 76 which is connected by a capillary tube 77 to a control bulb 78 located within the duct 11. The bellows 76 actuates a switch carrier 79 which carries a mercury switch 80. When the temperature of the dehumidified air leaving unit 1 is above a predetermined value such as 100° F. the bellows 76 will be expanded sufficiently for tilting the mercury switch 80 to open position. However, when the temperature of the dehumidified air falls below this value the bellows will contract for tilting mercury switch 80 to closed position.

When the air being dehumidified passes through the dehumidifying material, the hygroscopic effect of this material causes the water vapor in the air to condense, thus causing the latent heat of evaporation of the condensing water vapor to be transferred to the air. This latent heat of evaporation causes the air to be considerably raised in temperature and consequently the air leaving the dehumidifying unit will be quite hot and above the setting of thermostat 71 as long as the dehumidifying material is operating satisfactorily. However as air continues to flow through the dehumidifying material this material gradually becomes saturated with water and consequently does not absorb as much water vapor from the air. Consequently less latent heat of evaporation will be transferred to the air and this will cause the temperature of the air leaving the dehumidifying unit to gradually fall. When the temperature of the dehumidified air falls to a value indicating that the dehumidifying material requires reactivation, the bellows 76 of the thermostat 71 will contract sufficiently for causing closing of the mercury switch 80.

With the parts in the positions shown, the dampers of the dehumidifying unit have just recently been shifted for passing the air being dehumidified through the passage 3. At this time the dehumidifying material within the passage 3 is quite active and the temperature of the dehumidified air is sufficiently high for causing the thermostat 71 to open its mercury switch 80. At this time the heating element 75 of timer 70 is energized as follows: line wire 82, wire 83, motor field coil 61, wire 84, switch arm 63, contact button 67, wire 84a, heater 75, wire 85, and wire 86 to line wire 87. It will be noted that this energizing circuit is through the motor field coil 61. However, due to the resistance of the heater 75, the current flow through this circuit will be insufficient for operating the motor. The heating element 70 will gradually heat up and after a period of time, such as two minutes, will cause the bimetallic element 72 to engage contact 73. At this time no action will occur and the heating element will remain energized and the bimetallic element 72 will remain engaged with contact 73. Eventually the dehumidifying material within the passage 3 of unit 1 will become saturated and the temperature of the dehumidified air will fall below the setting of thermostat 71. Due to the resulting closure of mercury switch 80 an energizing circuit for the motor 44 will be established as follows: line wire 82, wire 83, field coil 61, wire

84, switch arm 63, contact button 67, wire 84a, contact 73, bimetallic element 72, wire 88, mercury switch 80, wire 89, and wire 86 to line wire 87. This energization of field coil 61 will cause rotation of the shaft 45 in a clockwise direction and the switch arm 63 will engage the contact segment 68 while disengaging the contact button 67. Due to the engaging of switch arm 63 with contact segment 68 the field coil 61 will remain energized as follows: line wire 82, wire 83, field coil 61, wire 84, switch arm 63, contact segment 68, wire 90, wire 89, and wire 86 to line wire 87. The operating shaft 45 of motor 44 will thus rotate through 180° at which time the switch arm 63 disengages the contact segment 68 and engages the contact button 66. At this time the field coil 61 will become deenergized and the motor will stop with the dampers in their dotted line positions. Due to the air being dehumidified now flowing through a freshly reactivated bed of dehumidifying material the temperature of the dehumidified air will rise in a short period of time for causing the thermostat 71 to reopen its mercury switch 80. Also due to the switch arm 63 now being disengaged from the contact button 67 the energizing circuit for the heater 75 will be broken and consequently this heater will now be deenergized. This will permit cooling of the bimetallic element 72 for permitting it to engage contact 74. Eventually the dehumidifying material within the passage 2 will become saturated and the mercury switch 80 of thermostat 71 will close. This will establish an energizing circuit for motor field 61 as follows: line wire 82, wire 83, motor field coil 61, wire 84, switch arm 63, contact button 66, wire 91, contact 74, bimetallic element 72, wire 88, mercury switch 80, wire 89, and wire 86 to line wire 87. This will cause rotation of the shaft 45 again in a clockwise direction and the switch arm 63 will disengage contact button 66 and engage the contact segment 69. Engagement of switch arm 63 with the contact segment 69 will establish a holding circuit for maintaining the motor energized until its shaft 45 is rotated through an angle of 180° at which time the switch arm 63 disengages contact segment 69 and reengages the contact button 67. This will cause the dampers within the dehumidifying unit to be repositioned to their full line positions as shown, and will also reestablish the energizing circuit for heater 75 which will cause the bimetallic element 72 to reengage the contact 73. This cycle of operation will be repeated continuously.

From the foregoing it should be noted that the thermostat 71 and the timer 70 cooperate to control the damper motor 44 in a manner to shift the dampers of the dehumidifying unit only when the dehumidifying material in operation becomes saturated or ineffective to dehumidify the air. This arrangement further provides for decreasing the operating expense of the system. It will be apparent that with a dehumidifying system of this type a certain amount of heating load must be thrown upon the cooling system, and a certain amount of additional heat for reactivation must be supplied each time that the operation of the dehumidifying unit is reversed, while one bed of dehumidifying material is in operation for dehumidifying the space, the other bed is being highly heated in order to drive the water vapor therefrom. When the dampers are reversed, the relatively cool bed must be heated to this relatively high temperature for reactivation while the other bed of dehumidifying material is quite hot and imposes a substantial cooling load upon the system due to the air being first passed through this hot bed and then into contact with the cooling apparatus. In systems heretofore in use this reversing of the dehumidifying unit has been controlled by means of a timer which reverses the dampers periodically regardless of the load upon the system. Thus during light dehumidifying load conditions the dehumidifier is reversed considerably more than necessary thus imposing an unnecessary cooling load upon the system and also consuming an unnecessary amount of gas or other heating medium for heating the reactivating air. By controlling the dampers in accordance with the actual condition of the dehumidifying material in operation, the losses due to reversal of operation of the dehumidifying unit are reduced to a minimum.

Also by controlling the dampers in this manner, it is assured that the dampers will be shifted frequently enough during periods of maximum load for properly carrying the load. In this connection, it should be noted that before the dampers can be shifted, the timer 70 must either heat or cool. This provides for a positive minimum time period for each cycle and thus prevents the system from cycling too often.

It should be noted that during light dehumidifying load conditions the bed of material which is being reactivated will become fully reactivated a considerable time before the bed of material in operation becomes saturated. At this time the reactivated bed of dehumidifying material will absorb no more heat and consequently the thermostatic valve 56 will close substantially for reducing the supply of gas to the burner 55. Due to the feature of recirculating a portion of the reactivating air only a relatively small portion of heated air will be discharged through the discharge duct 59. Consequently during the period following completion of the reactivation of one bed and preceding the saturation of the other, the burner 55 will be operated at a very low rate thus further increasing the economy of the system. The automatic damper control thus cooperates with the thermostatic control for the heater, and the reactivating air recirculating arrangement for decreasing the operating expense of the system to a minimum.

In accordance with my invention I also provide for supplying additional heat for reactivation when the dehumidifying load upon the system becomes very heavy and the cooling load upon the system is light. Preferably this supplying of additional reactivating heat is performed by the cooling system which is operated upon the reverse cycle for thus supplying heat when the cooling system is not necessary for cooling the space. Referring now to the refrigeration system and controls, reference character 100 indicates a compressor which may be driven by a motor 101 under the control of an automatic starter 102. This automatic starter may be of the usual type including a relay coil 103 which actuates the switch arms 104. When this coil is energized the switch arms 104 will be brought into engagement with their respective contacts for completing a power circuit to the motor 101, while when coil 103 is deenergized the motor 101 will be stopped. The discharge of the compressor is connected by pipe 105 to the inlets of valves 106 and 107. The valve 107 is of the two-position motorized type, and the valve 106 is similar but is a three-way valve. These valves 106 and 107

are controlled by means of a relay 108 which consists of a relay coil 109 which actuates a switch arm 110 cooperating with contacts 111 and 112. When the relay coil 109 is deenergized the switch arm 110 will engage contact 112, which will complete a circuit from the transformer secondary 113 through wire 114 to the valves 106 and 107 and back to the transformer secondary 113 through wire 115. This will cause the valve 107 to close and will cause valve 106 to assume a position for placing port 116 into communication with port 117 while blocking off the port 118. If the compressor is in operation at this time refrigerant will pass from the outlet 117 through pipe 119 into condenser 120, then into receiver 121 and through liquid line 122 to the expansion valve 123 located at the inlet of cooling coil 14. The evaporated refrigerant will then flow from the cooling coil 14 through suction line 124 to the suction header 125 which is connected to the inlet of the compressor. Thus with the relay coil 109 deenergized, the compressor will operate to cause chilling of the cooling coil 14 in the usual manner. Now if the relay coil 109 is energized it will cause switch arm 110 to engage contact 111 which will shift valves 106 and 107 to their other positions in which the valve 107 will be closed, and the valve 106 will be positioned for blocking off port 116, and placing ports 117 and 118 into communication. Now refrigerant will flow from the compressor through pipe 105 and valve 107 and through pipe 126 to the preheating coil 57 located in the heating chamber 51. This coil will now act as a condenser and liquid refrigerant will pass from this coil into receiver 127, and from this receiver through liquid line 128 to the expansion valve 129 and will pass from the outlet of this expansion valve through the heat exchanger 120 which acts as an evaporator and absorbs heat from the water or other heat exchange medium supplied thereto. The evaporated refrigerant then passes from heat exchanger 120 through pipe 119 and valve 106 to the suction header 125 and back to the inlet of the compressor. From the foregoing description it should be apparent that when relay coil 109 is deenergized the refrigeration system will operate on the cooling cycle for cooling the air in the space. However, when the relay coil 109 is energized, the refrigeration system will operate on a reversed cycle for supplying additional heat to the reactivating air, and at this time the cooling coil 14 in the air conditioning chamber is placed out of operation.

Reference character 130 indicates a space thermostat which may consist of a bimetallic element 131 which actuates a switch arm 132 cooperating with contacts 133 and 134. This thermostat may be so designed and adjusted as to cause the switch arm 132 to engage the contact 134 when the space temperature rises to 76° F. When the space temperature falls slightly below this value the switch arm 132 will remain disengaged from both contact 134 and contact 133. When the space temperature falls to 72° F. the switch arm 132 will engage contact 133.

Assuming now that the space temperature rises to 76° F. the switch arm 132 of thermostat 130 will engage contact 134 which will energize the coil 103 of the compressor starter as follows: secondary 135 of transformer 136, wire 137, switch arm 132, contact 134, wire 138, wire 139, coil 103, wire 140, and wire 141 to secondary 135. This will place the compressor into operation for cooling the space, as the relay coil 109 of the relay 108 controlling the valves 106 and 107 will be deenergized at this time. Air from the space will flow through the dehumidifying unit 1 and through the by-pass 17 in proportions determined by the space relative humidity, and the heated and dehumidified air will pass into the conditioning chamber 12 and will be precooled by the coil 13 and further cooled by the direct expansion cooling coil 14. The compressor 100 will continue to operate until the space is cooled sufficiently for causing the switch arm 132 of thermostat 130 to disengage the contact 134. Thus the compressor will be started and stopped for maintaining a predetermined temperature and the dampers 18 and 19 will be positioned for maintaining a desired relative humidity within the space. Meanwhile the dampers within the dehumidifying unit will be shifted from one position to another each time that a bed of dehumidifying material becomes sufficiently saturated to require reactivation, and the heater 54 will be controlled for supplying just the proper amount of heat necessary for obtaining the necessary reactivation.

During relatively damp and cool weather the dehumidifying load upon the system will be quite heavy while at this time the cooling load upon the system will be sufficiently light as to make operation of the direct expansion cooling coil 14 unnecessary. Under such conditions the relative humidity will rise to a point for causing the by-pass 17 to be closed for thereby passing all of the air being conditioned through the dehumidifying unit. If this fails to carry the prevailing humidifying load, the relative humidity will increase which will cause the mercury switch 28 of the humidity controller 21 to be closed. This switch, it will be noted, is connected in parallel with the switch arm 132 and contact 134 of the thermostat 130, and consequently places the compressor into operation independently of the space thermostat. If this operation of the compressor is not necessary for carrying the cooling load upon the system, the space temperature will begin falling and finally the switch arm 132 will engage the contact 133. This will energize the coil 109 of relay 108 as follows: transformer secondary 135, wire 137, switch arm 132, contact 133, wire 142, coil 109, wire 143, and wire 141 to secondary 135. This will cause the switch arm 110 to engage contact 111 which will position the valves 106 and 107 in a manner to place the cooling coil 14 out of operation and to operate the heating coil 57 as a condenser for thereby additionally heating the reactivated air. At this time, due to the heavy dehumidifying load on the beds of dehumidifying material, these beds will require reactivation at frequent intervals and consequently the bed being reactivated must be reactivated in a short period of time. This utilization of the compression refrigeration system for providing additional heat during periods when the cooling load is light and the dehumidifying load is heavy provides for supplying the necessary additional heat for reactivation in an inexpensive manner. While the heating coil 57 is shown in chamber 56, this coil may be located in fresh air duct 48 if so desired.

From the foregoing description it should be apparent that my invention provides a control system for air conditioning systems utilizing absorption or adsorption type dehumidifiers and provides for reducing the losses involved in systems of this type to a minimum and also provides for utilizing the refrigeration system of the air conditioner for supplying additional heat to

the reactivating air under conditions wherein the dehumidifying load is heavy while the cooling load is light. While I have shown and described my system as applied to a dehumidifier of the type wherein the air is shifted from one bed of material to another it will be apparent that my invention is equally adaptable to a system utilizing a single bed of material, and to systems utilizing an arrangement for mechanically withdrawing the dehumidifying material from the air path when it requires reactivation. Also while I prefer to control the operation of the dehumidifier by means of a thermostat responsive to the dehumidified air it will be apparent that my invention is of broader scope and includes the control of the dehumidifier reversals in accordance with the actual dehumidifying load upon the system. As many modifications and adaptations of my improved control apparatus will occur to those skilled in the art I desire to be limited only by the scope of the appended claims.

I claim as my invention:

1. In an air conditioning system for controlling the temperature and humidity in a space to be conditioned, in combination, a pair of dehumidifying chambers containing a dehumidifying material requiring reactivation, means for passing dehumidified air from said chambers to said space being conditioned, a cooling device for cooling said dehumidified air, fan means for discharging air for reactivation to said chambers, selective control means for alternately supplying air for reactivation and air to be dehumidified to said chambers in a manner to pass air for reactivation through one of said chambers while passing air to be dehumidified through the other of said chambers, heating means located between said fan means and said chambers for heating the reactivation air, means for returning said reactivation air from said chambers to said fan means, means for discharging a portion of said reactivation air and replacing said discharged portion with fresh air, a compressor connected to said cooling coil, and to said heating means, change-over valve means for selectively causing said compressor to operate said cooling device for cooling said space or to operate said heating means for heating the reactivation air, means responsive to space temperature and humidity for placing said compressor into operation when either the space temperature or humidity becomes excessive, means responsive to a low space temperature for actuating said change-over valve means in a manner to operate said heating means, and means responsive to the temperature of the dehumidified air for controlling said selective control means.

2. In an air conditioning system, in combination, a dehumidifier of the type utilizing a hygroscopic material for dehumidifying the air being passed to a space being conditioned, said dehumidifier requiring heat for reactivating said material, means including a refrigeration system for cooling the dehumidified air, means responsive to space temperature and humidity for placing said refrigeration system into operation when either space temperature or relative humidity becomes excessive, and means for causing said refrigeration system to supply heat for reactivating said dehumidifying material when space temperature falls to a predetermined low value.

3. In an air conditioning system, a space to be conditioned, means for conveying air to said space, dehumidifying means of the type utilizing a hygroscopic material associated with said conveying means to dehumidify the air being passed to said space, said dehumidifying means being of a type utilizing heat for reactivation of said material, means for varying the effect of said dehumidifier on the total volume of air going to said space, a refrigeration system having an evaporator in heat transfer relation with the air being passed to said space and a condenser in heat transfer relation with said hygroscopic material to reactivate the same, means independent of said condenser to heat said hygroscopic material, and means responsive to the humidity in said space for controlling said varying means and said refrigeration system and operable as the space humidity increases to cause said varying means gradually to increase to its maximum capacity the effect of said dehumidifier on the air going to the space without causing operation of said refrigeration system and thereafter to cause operation of said refrigeration system.

4. In an air conditioning system, a space to be conditioned, means for conveying air to said space, dehumidifying means of the type utilizing a hygroscopic material associated with said conveying means to dehumidify the air being passed to said space, said dehumidifying means being of a type utilizing heat for reactivation of said material, a refrigeration system having an evaporator in heat transfer relation with the air being passed to said space, a condenser, and a heat exchanger adapted to act as an evaporator, means for placing said condenser in heat transfer relation with said hygroscopic material to reactivate the same, means for placing said evaporator into operation upon demand for cooling, and means for placing said condenser into operation and for operating said heat exchanger as an evaporator upon demand for dehumidification which is unaccompanied by a demand for cooling.

5. In an air conditioning system, a space to be conditioned, means for conveying air to said space, dehumidifying means of the type utilizing a hygroscopic material associated with said conveying means to dehumidify the air being passed to said space, said dehumidifying means being of a type utilizing heat for reactivation of said material, a refrigeration system having an evaporator in heat transfer relation with the air being passed to said space, a condenser, and a heat exchanger adapted to act as an evaporator, means for placing said condenser in heat transfer relation with said hygroscopic material to reactivate the same, means for placing said evaporator into operation and operating said heat exchanger as a condenser upon demand for cooling, and means for placing said condenser into operation and for operating said heat exchanger as an evaporator upon demand for dehumidification which is unaccompanied by a demand for cooling.

6. In an air conditioning system, a space to be conditioned, means for conveying air to said space, dehumidifying means of the type utilizing a hygroscopic material associated with said conveying means to dehumidify the air being passed to said space, said dehumidifying means being of a type utilizing heat for reactivation of said material, a reverse cycle refrigeration system operable in a first phase of operation to cool the air being passed to said space and in a second phase of operation to supply heat to said hygroscopic material without cooling said space, change-over means associated with said refrig-

eration system for selectively rendering said refrigeration system operable in its first phase or its second phase, and means responsive to a condition influencing the effective temperature of the space for controlling said changeover means.

7. In an air conditioning system, a space to be conditioned, means for conveying air to said space, dehumidifying means of the type utilizing a hygroscopic material associated with said conveying means to dehumidify the air being passed to said space, said dehumidifying means being of a type utilizing heat for reactivation of said material, a reverse cycle refrigeration system operable in a first phase of operation to cool the air being passed to said space and in a second phase of operation to supply heat to said hygroscopic material without cooling said space, changeover means associated with said refrigeration system for selectively rendering said refrigeration system operable in its first phase or its second phase, means influenced by humidity for controlling the effect of said dehumidifying means on the air flowing to said space, and means influenced by temperature for controlling said changeover means.

8. In an air conditioning system, a space to be conditioned, means for conveying air to said space, dehumidifying means of the type utilizing a hygroscopic material associated with said conveying means to dehumidify the air being passed to said space, said dehumidifying means being of a type utilizing heat for reactivation of said material, a reverse cycle refrigeration system operable in a first phase of operation to cool the air being passed to said space and in a second phase of operation to supply heat to said hygroscopic material without cooling said space, changeover means associated with said refrigeration system for selectively rendering said refrigeration system operable in its first phase or its second phase, means influenced by humidity for controlling the effect of said dehumidifying means on the air flowing to said space and for placing the refrigeration system into operation upon demand for dehumidification, and means influenced by temperature for placing said refrigeration system into operation upon demand for cooling and for controlling said changeover means in a manner to render the refrigeration system operable in its first phase when cooling is desirable while rendering the system operable in its second phase when cooling is undesirable.

9. In a system of the class described, in combination, absorbing means including two bodies of absorbing material for absorbing vapor from a gas, control means operative in a first position to place one of said bodies into absorbing operation and to place the other body upon reactivation, a motor for operating said control means between said first and second positions, means responsive to a condition affected by the moisture content of the body then in operation in control of said motor and operative to shift said control means between its two positions whenever said condition assumes a value indicative of the need for reactivation of the body then in operation, a timing device, and means for causing said timing device also to control said motor to prevent too frequent cycling of the motor.

ALWIN B. NEWTON.