July 26, 1938. W. E. STARK ET AL 2,124,932

AIR CONDITIONING SYSTEM

Filed Jan. 6, 1936 2 Sheets-Sheet 1

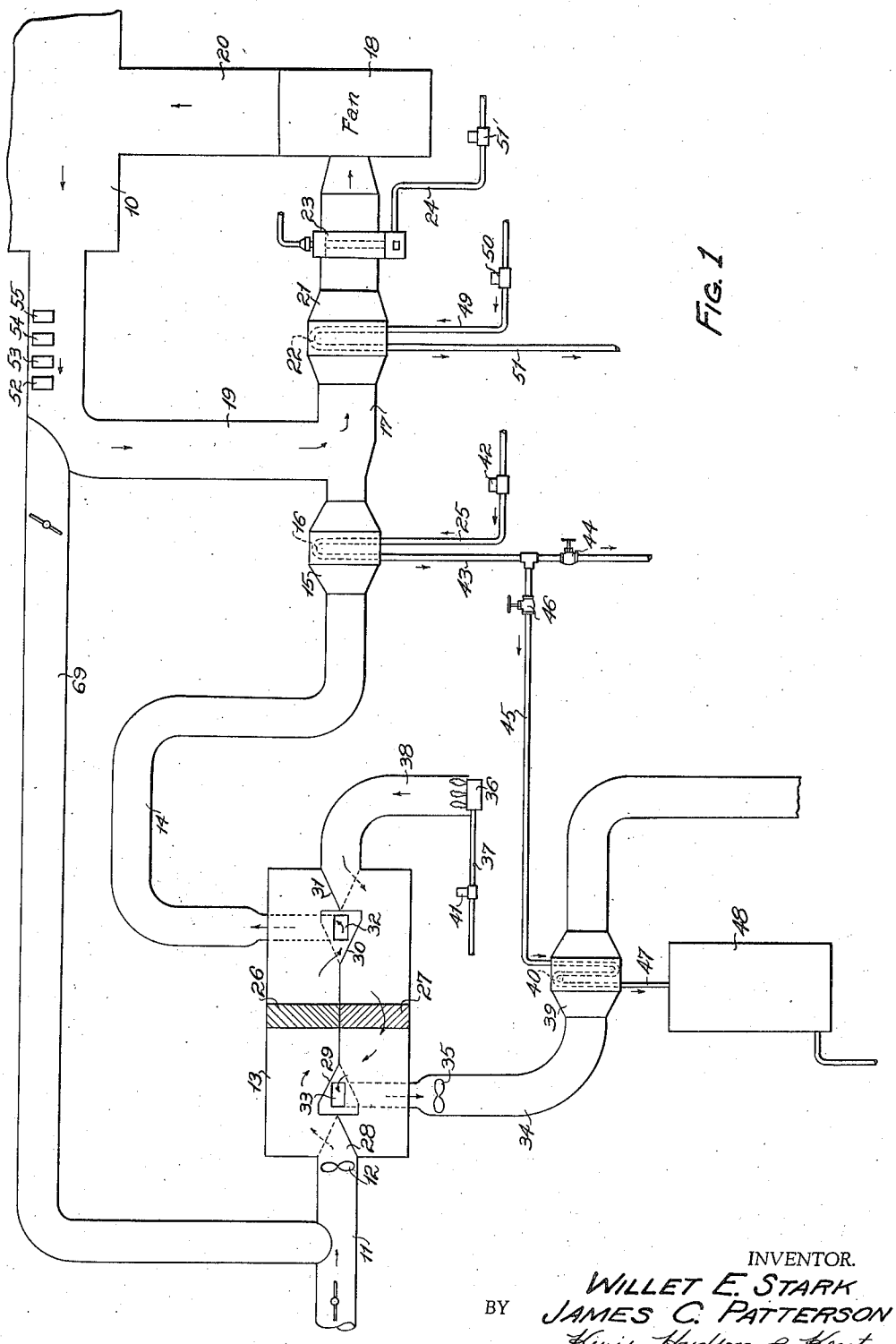


FIG. 1

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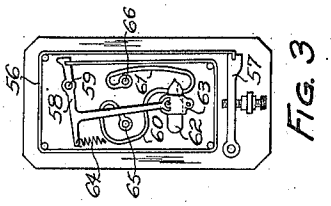


FIG. 3

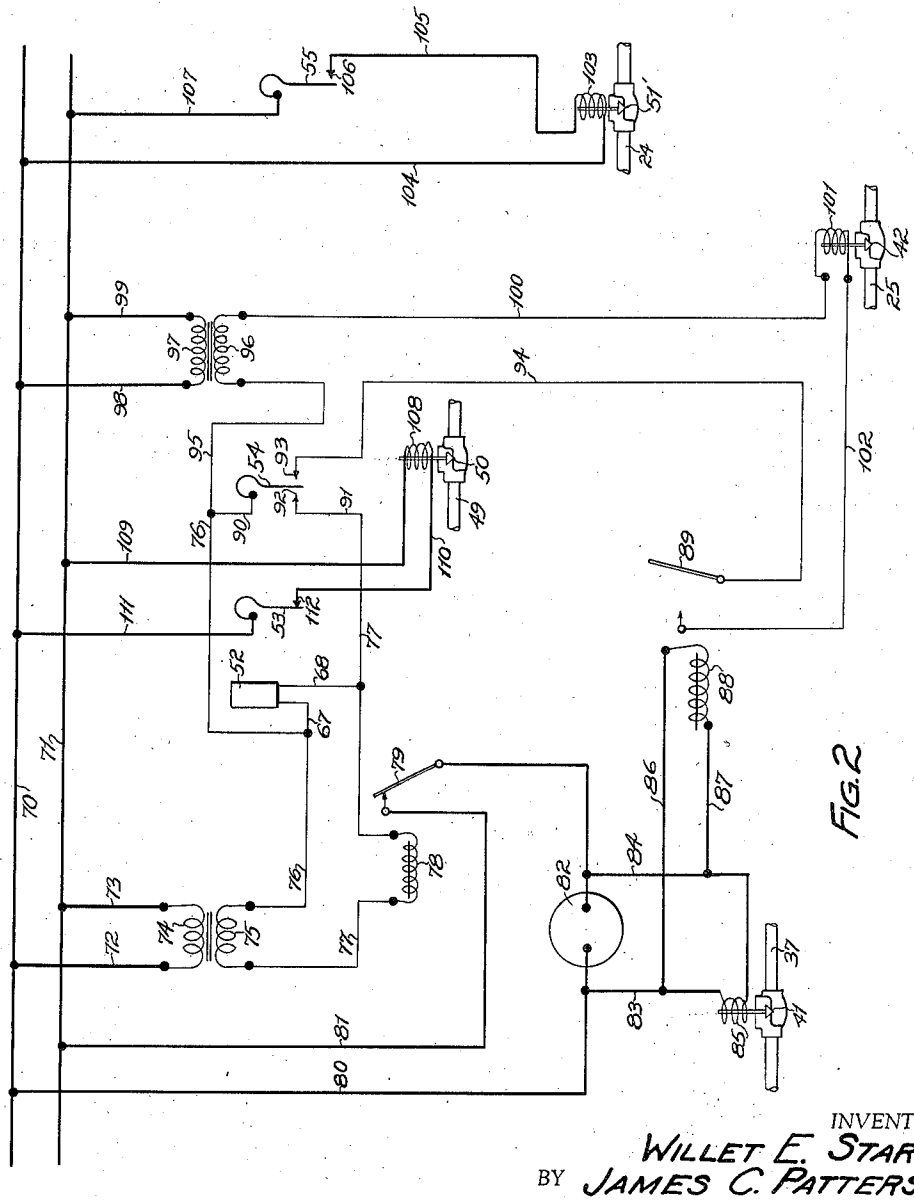


FIG. 2

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UNITED STATES PATENT OFFICE

2,124,932

AIR CONDITIONING SYSTEM

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Application January 6, 1936, Serial No. 57,668

11 Claims. (Cl. 257—3)

This invention relates to improvements in air conditioning systems, particularly systems employed in localities or climates where the principal requirement is for dehumidification with more or less cooling, and where heating requirements are infrequent, relatively small and of comparatively short duration.

One of the objects of the invention is the utilization of a dehumidifier as a means for heating the premises.

Another object is the provision of an air conditioning system which will respond quickly and automatically to changes in atmospheric conditions, and particularly to a system in which the small amount of occasional heating that is needed is accomplished by the same equipment that is ordinarily used for dehumidifying without in any way changing the operation of that equipment.

Another object is the provision of means for controlling automatically the operation of a dehumidifier of the adsorption type and associated apparatus, so as to cause the same to supply dry air cooled to room temperature when the temperature in the premises is high enough for comfort, or dry heated air when the temperature is below the desired standard, the heat being principally heat of vaporization converted into sensible heat by the dehumidifier.

A further object is the provision of means for utilizing heat resulting from the dehumidifying action and the reactivation process to heat water, or to perform other useful work.

Other objects and features of novelty will appear as we proceed with the description of that embodiment of the invention which, for the purposes of the present application, we have illustrated in the accompanying drawings, in which

Fig. 1 is a diagrammatic view of an air conditioning system employing a dehumidifier of the adsorption type and embodying the present invention.

Fig. 2 is a wiring diagram showing control circuits for the apparatus, and

Fig. 3 is a detail elevational view of a humidostat which may be used in connection with the invention.

The air conditioning system comprehended by this invention is designed to take care of all conceivable conditions and all conceivable rates and directions of change in temperature and humidity, but it is directed primarily toward those localities in which heating is required only very seldom and in which humidity is the principal factor contributing to discomfort. Our system includes as an essential part a dehumidifier of such character that heat is released in the process of dehumidification, so that the air passing through the dehumidifier emerges in a warm state. For this purpose we prefer to employ a dehumidifier of the adsorption type employing a solid adsorbent, such for instance as silica gel. Certain liquids, such as lithium chloride and calcium chloride may be used, instead of solid material if desired, the thermal changes taking place being of practically the same value. In the latter case the action is chemical rather than physical, and hence it is not strictly proper to refer to such a dehumidifier as of the absorption type, but it is to be understood that these two forms of dehumidifier are equivalent for the purposes of the present application.

Referring particularly to the action of a dehumidifier using silica gel, when air containing water vapor is brought into contact with the silica gel the water vapor is in effect condensed within the pores of the gel. This results in the liberation of the latent heat of the water vapor removed, so that the air issues from the gel dried, but with its sensible heat increased by an amount equal to the latent heat of the moisture removed, this being approximately 1,100 B. t. u. per pound of water vapor removed. In addition the heat of adsorption is liberated and goes to heat the air, this being of the order of 200 B. t. u. per pound of water vapor. In conventional dehumidification apparatus of this type this latent heat (transformed into sensible heat) is removed by passing the dried air over coils containing cooled water. However, if the air is not cooled after being dehumidified, but is discharged dry and hot into a given space, it will warm that space as well as lower its humidity. When using a dehumidifier of the adsorbent type in the usual manner, even more heat than is above indicated is in effect available for use. In practice, in a dehumidifier there are two or more bodies or beds of silica gel. While one of these beds is drying air, the other is itself being dried by the application of heat, as by passing through it a mixture of air and the products of combustion of a gas fire, sufficient air being used to give a mixture temperature of about 350°. This process is called reactivation. At its conclusion the gel will be rather warm, and when it is again used to adsorb moisture, some of this heat in the gel will be imparted to the air. In the actual dehumidification the dried air leaving the apparatus is at a temperature of about 150° F.

Referring to Fig. 1 of the drawings, 10 indicates a room or space which is to be air condi-

tioned. Fresh air in sufficient amounts to meet the ventilation needs of the space is drawn in through duct 11 by the action of a fan 12 mounted at the entrance to a dehumidifier 13. The dried air leaving the dehumidifier passes by way of a conductor 14 through an air cooler 15 in which is located a radiator, indicated diagrammatically at 16. In our system the cooler 15 may or may not operate, depending upon the temperature conditions in the space 10. The air delivered from the cooler 15 enters a mixing chamber 17, where it is mixed with a larger stream of recirculated air being drawn by a fan 18 through duct 19 from the space 10, and discharged back into the space through a duct 20. Immediately following mixing chamber 17 is an air cooler 21, in which there is located another radiator 22 through which we may cause to flow cool water or any available refrigerant. If desired, a heater 23 supplied with fuel through a pipe 24 may be placed in the duct following air cooler 21 for a purpose later to be described. This heater may be of any appropriate type, such as a gas heater indicated in the drawings, or a steam or hot water coil. Cooler 15 will usually be supplied with water from city mains or a well through pipe 25.

Returning now to the dehumidifier 13, which is shown diagrammatically, there are silica gel beds 26 and 27 which are used alternately as air driers. 28, 29, 30 and 31 are four swinging deflectors or valves which are caused to take the full line and dotted line positions alternately at regular intervals while the dehumidifier is in operation. The conduit 14 connects with the right side of the dehumidifier through an opening 32. A similar opening 33 in the left side connects with a conduit 34 in which is located a fan 35. A gas burner 36 fed by a fuel line 37 produces a flow of hot air and gas of a temperature approximating 350° F. upwardly through conduit 38 into the dehumidifier casing. This heated air and gas is the reactivating medium, and the conductor 34 is the exhaust pipe for that medium. It may include an enlarged section 39 in which is located a radiator 40 by means of which some of the heat of the exhausted reactivated medium may be absorbed.

When the valves of the dehumidifier are in the full line position fresh air is caused to flow through silica gel bed 26, by which it is dried, and then out through opening 32 and conduit 14, as indicated by the arrows. At the same time hot reactivating medium flows in the opposite direction through the lower part of the casing and through gel bed 27, driving out the moisture previously adsorbed by that bed, and passes out through opening 33 and conductor 34, the fan 35 assuring the flow. When this has continued for a predetermined length of time the valves are automatically thrown to the dotted line position, whereupon the fresh air flows toward the right through gel bed 27 and out to the recirculating system, while the hot air for reactivation flows toward the left through gel bed 26 and out through opening 33 and conductor 34.

In fuel pipe 37 we locate an electric valve 41. A similar valve 42 is used in pipe 25 leading to radiator 16. From that radiator there extends a pipe 43 in which there is a hand valve 44 which, when opened, permits the cooling water flowing through the pipe to pass to the drain. Another pipe 45 in which there is a hand valve 46 connects with pipe 43 and with radiator 40, so that when the valve 44 is closed and the valve 46 opened the warm water from radiator 16 is caused to flow also through radiator 40, where it is further heated and then carried by pipe 47 to a suitable storage tank 48, from which it may be drawn for use directly or for still further heating, as may be required.

The radiator 22 is fed by a pipe 49 having an electric valve 50 therein, and the cooling medium delivered from the radiator is discharged to the drain or otherwise through a pipe 51. Another electric valve 51' controls the flow of fuel to the heater 23.

The instruments by means of which the system is automatically controlled may be located as found desirable or convenient either in the space 10 or in a conductor forming part of the path for the recirculated air. In the drawing they are shown in the conduit 19. They consist of a humidostat 52 and three thermostats 53, 54 and 55. These instruments may be of conventional form. An example of a humidostat which is suitable for the purpose is illustrated however in Fig. 3, where 56 is a tape which expands and contracts as the humidity of the air in contact with it increases or decreases. This tape is secured at one end in an adjustable anchoring means 57, and at the other end in a lever 58 pivotally mounted at 59. 60 and 61 are flexible electrical conductors which have terminals in a mercury tube switch 62 which is tiltably mounted at 63 and is adapted to be swung to circuit closing position by the action of a spring 64 when the tape 56 expands to a predetermined extent due to a rise in humidity, and to a circuit opening position by the contraction of tape 56 when the humidity falls sufficiently. Terminals 65 and 66 of the humidostat are connected by electrical conductors 67 and 68 into the control system, as will presently be described.

A duct 69 may be provided with connections as shown if it is desired to direct some recirculated air to the dehumidifier during periods of extreme outdoor moisture, so as to lighten the load on the dehumidifier.

Referring to Fig. 2, two electric service wires are indicated at 70 and 71. Connected to these wires are two conductors 72 and 73, forming a circuit to supply energy to the primary coil 74 of a step-down transformer. The secondary coil 75 forms a part of a low voltage circuit including conductors 76 and 77 across which the conductors 67 and 68 are bridged. In this same circuit there is an electromagnet 78 controlling a switch 79 which is adapted to open or close a circuit comprising conductors 80 and 81 and a motor 82. The motor 82 is the dehumidifier motor which operates the fans 12 and 35, and by means of cams or other suitable mechanism shifts valves 28, 29, 30 and 31 back and forth at regular intervals between their full line and dotted line positions, respectively. Branch conductors 83 and 84 serve to energize a magnet coil 85, which opens gas valve 41. Other branch conductors 86 and 87 lead to an electromagnet 88 which controls a switch 89 to which we will refer again later.

Bridged across the low voltage conductors 76 and 77 in a line parallel with the line through humidostat 52 are two conductors 90 and 91 which are adapted to be connected together by thermostat 54 when the temperature in the premises falls to or below a predetermined point. It will be apparent therefore that the dehumidifier is arranged to be started either by the humidostat or by the thermostat 54, and that it will operate if the temperature becomes low enough,

whether or not the humidity conditions are such as would cause the humidostat to function.

The thermostat 54 is a double contact thermostat, one contact 92 being the terminus of conductor 91 and the other contact 93 being connected with a low voltage conductor 94 which extends to one side of switch 89. From the conductor 90 a conductor 95 extends to the secondary coil 96 of a step-down transformer, the primary coil 97 of which takes current from the line wires 70 and 71 through conductors 98 and 99. The other side of coil 96 is connected by means of a conductor 100 with an electromagnet 101 controlling the valve 42 in the cooling water line 25. Magnet 101 is also connected by a conductor 102 with the other side of switch 89. It will be apparent therefore that when the thermostat 54 moves to the right because of rising temperature, and engages contact 93, a current will be set up through electromagnet 101 provided that switch 89 is closed at the time. But the switch 89 is closed only when switch 79 is closed and the dehumidifier is in operation. Two conditions are therefore necessary before cooling water will flow through pipe 25, first the dehumidifier must be in operation, and second the temperature in the premises must be above a predetermined point. In some localities where the heat requirements are small, heater 23 may be omitted. When it is used the valve 51' is controlled by an electromagnet 103 which is connected on one side by a conductor 104 with line wire 70, and on the other side by a conductor 105 with a contact 106 adapted to be closed by thermostat 55 when the temperature in the premises falls below a predetermined point, the other side of the thermostat being connected by a conductor 107 with line wire 71. Through the pipes 49 and 51 any suitable refrigerant may be conducted to and away from radiator 22. The functioning of this radiator is controlled by valve 50, which may be opened electrically by a magnet 108 which is in circuit with line wire 71 through a conductor 109 and with line wire 70 through conductors 110 and 111 and the thermostat 53. When the room temperature rises above a predetermined point the thermostat 53 engages its contact 112, whereupon electromagnet 108 is energized and the valve 50 is opened permitting refrigerant to flow through the radiator.

By the proper selection or adjustment of the thermostatic control devices the range of action of the heater 23 and of the two cooling radiators 16 and 22 can be regulated to suit requirements. We prefer to so select and adjust the parts that the heater 23 will be turned on only when a relatively low temperature is reached in the premises, and will be turned off slightly before the desired temperature is attained. We also prefer to have the radiator 16 function normally as an intermediate range cooler for the dried air issuing from the dehumidifier, which cooler will be turned off automatically when small increases in temperature are called for. The radiator 22 in which refrigerant circulates we prefer to call into play only when the temperature is relatively high, that is, such that the radiator 16 is not able by itself to accomplish the desired result.

Variations from the described structure may be employed. Accordingly, we desire it to be understood that the scope of the invention is to be regarded as defined exclusively by the appended claims rather than by the foregoing description or the accompanying illustration.

Having thus described our invention, we claim:

1. In an air conditioning system, means for recirculating air, a dehumidifier of the adsorption type arranged to deliver air into said recirculating system, a cooling means for the air delivered by the dehumidifier, and thermostatic means responsive to temperature changes only for controlling said dehumidifier and said cooling means, acting to cut off the cooling means whereby the dehumidifier acts as a heater when the temperature of the system falls below a predetermined point.

2. In a combined heating and cooling system, means for recirculating air, means for cooling said air, an adsorption type dehumidifier arranged to deliver air to said system, and thermostatic means responsive to temperature changes only for disabling said cooling means when the temperature in the premises falls to a predetermined level and for starting said dehumidifier when the temperature falls to a lower predetermined level.

3. In an air conditioning system, means for recirculating air, a dehumidifier of the adsorption type arranged to deliver air to said system, means for heating the recirculating air, and thermostatic means responsive to temperature changes only for starting said dehumidifier when the temperature in the premises falls to a predetermined level and for starting said air heating means when the temperature falls to a lower predetermined level.

4. In an air conditioning system, means for recirculating air, a dehumidifier of the adsorption type arranged to deliver air to said system, a heater and a cooler for the recirculating air, and thermostatic means responsive to temperature changes only for disabling said cooler when the temperature in the premises falls to a predetermined level, for starting said dehumidifier when the temperature falls to a lower predetermined level, and for starting said air heater when the temperature falls to a still lower predetermined level.

5. In an air conditioning system, means for recirculating air, a dehumidifier of the adsorption type arranged to deliver air to said system, a humidostat and a thermostat arranged in parallel for causing said dehumidifier to function, not only when the humidity in the premises is high, but also when the temperature in the premises is low irrespective of the humidity.

6. In an air conditioning system, means for recirculating air, a dehumidifier of the adsorption type arranged to deliver air to said system, a cooler for the air delivered by the dehumidifier, a humidostat adapted to start said dehumidifier when the humidity in the system rises to a predetermined percentage, and a thermostat acting in conjunction with said humidostat for controlling said cooling means adapted to set it in operation only when the dehumidifier is in operation and the temperature of the premises is at or above a predetermined point.

7. In an air conditioning system, means for recirculating air, a dehumidifier of the adsorption type arranged to deliver air to said system, a cooler for the air delivered by the dehumidifier, and a double electrical control for said cooler, one element of said control opening and closing with the starting and stopping of the dehumidifier and the other element closing and opening with the rise and fall of the temperature in the premises with respect to a predetermined temperature level.

8. In a control system for air conditioning means, a dehumidifier, a control circuit therefor, two parallel lines bridged across said control circuit, each of said parallel lines having switches, a humidostat adapted to close one of said switches when the humidity rises above a predetermined point, and a thermostat adapted to close the other switch when the temperature falls below a predetermined point.

9. In an air conditioning system, means for recirculating air, a dehumidifier of the adsorption type arranged to deliver air into said recirculating system, a cooling means for the air delivered by the dehumidifier, humidity responsive means for controlling said dehumidifier, and thermostatic means for controlling said dehumidifier and said cooling means, said thermostatic means acting to start the dehumidifier and to prevent the cooling means from operating when the temperature of the system falls below a predetermined point, regardless of the condition of the humidity responsive means.

10. In an air conditioning system, means for recirculating air, a first cooling means for cooling said air, thermostatic means for starting said first cooling means at a relatively high temperature and stopping it at a slightly lower temperature, a dehumidifier of the adsorption type arranged to deliver air to said recirculating system, a second cooling means for the air delivered by said dehumidifier connected to operate only when the dehumidifier is operating, a humidity responsive device to start and stop said dehumidifier and second cooling means at predetermined relative humidities in the system, thermostatic means for disabling said second cooling means at a predetermined low temperature and for setting it in operation at a slightly higher temperature, and for starting said dehumidifier and holding said second cooling means disabled at said predetermined low temperature regardless of the condition of the humidity responsive device and for stopping it at a slightly higher temperature.

11. In an air conditioning system, means for recirculating air, a first cooling means for cooling said air, means for heating said air, thermostatic means for starting said first cooling means at a relatively high temperature and stopping it at a slightly lower temperature, thermostatic means for starting said heating means at a relatively low temperature and stopping it at a slightly higher temperature, a dehumidifier of the adsorption type arranged to deliver air into said recirculating system, a second cooling means for the air delivered by said dehumidifier connected to operate only when the dehumidifier is operating, a humidity responsive device to start and stop said dehumidifier and second cooling means at predetermined relative humidities in the system, intermediate temperature thermostatic means which will disable said second cooling means at a predetermined intermediate temperature and will cause it to operate at a slightly higher intermediate temperature, and which will also start said dehumidifier and hold said second cooling means disabled at said predetermined intermediate temperature regardless of the condition of the humidity responsive device, and stop it at a slightly higher intermediate temperature.

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