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AIR CONDITIONING SYSTEM

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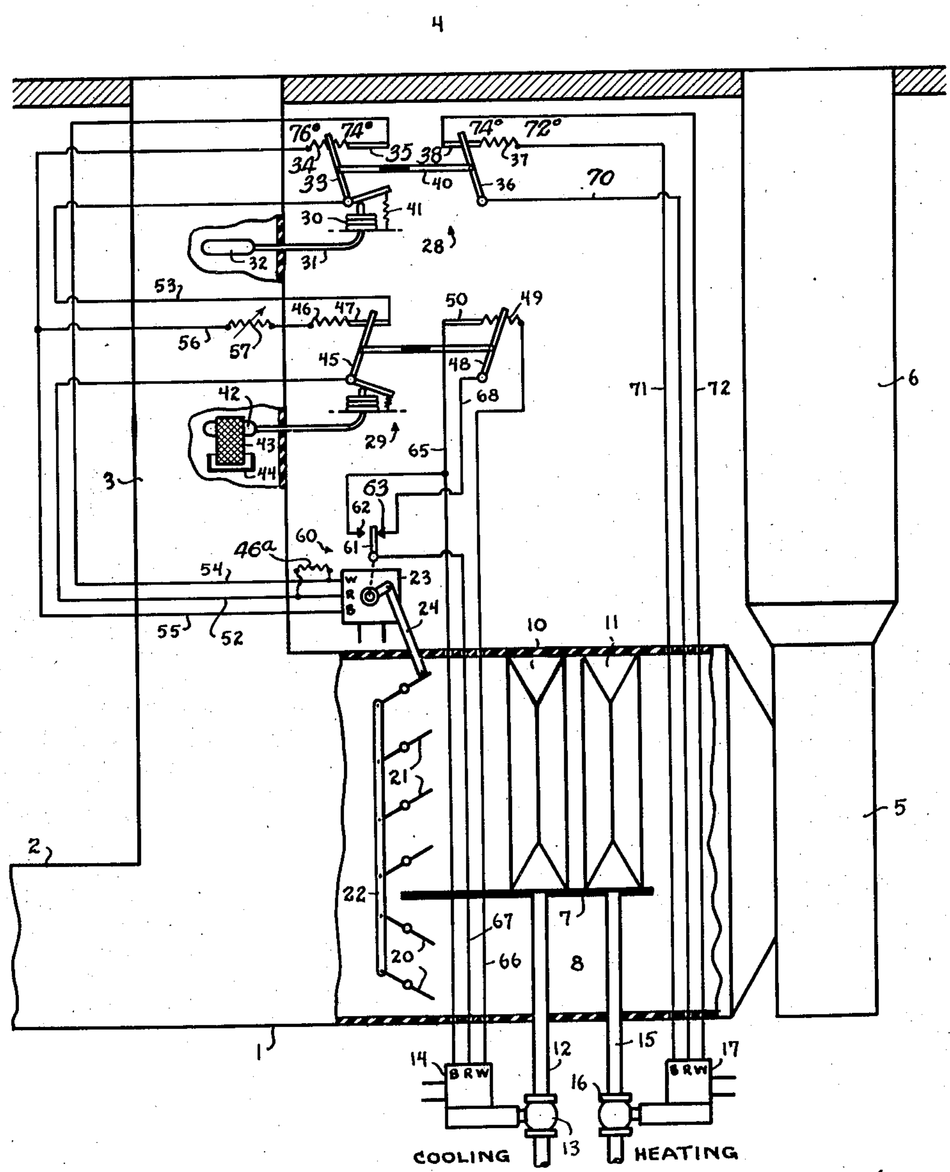

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AIR CONDITIONING SYSTEM

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8 Claims. (Cl. 257—3)

This invention relates in general to air conditioning and is concerned particularly with automatic controls for apparatus of this type.

It is an object of this invention to provide an air conditioning control system which controls the temperature of a cooling and dehumidifying device and which also controls the flow of air in contact with such device in a manner to maintain the desired temperature and relative humidity in the conditioned space, irrespective of the relationship between the cooling and dehumidifying loads.

Other objects of this invention will become apparent from the following description and the appended claims.

For a full disclosure of this invention reference is made to the following detailed description and to the accompanying drawing, the single figure of which illustrates diagrammatically a preferred embodiment of the invention.

Referring to the drawing, reference character 1 indicates an air conditioning chamber which may be provided with a fresh air inlet duct 2 and the usual return air duct 3 leading from a conditioned space 4. This chamber is also connected to a fan 5 which serves to draw air through the chamber and to discharge it into the space 4 through a discharge duct 6. Located within the conditioning chamber is a partition 7 which divides the chamber into a by-pass passage 8 and a space for receiving a cooling coil 10 and a reheat coil 11. The cooling coil 10 receives a suitable cooling medium through pipe 12, the flow of this medium being controlled by a valve 13 which is positioned by a proportioning motor 14. The heating coil 11 receives a suitable heating medium through pipe 15, the flow of heating medium being controlled by a valve 16 which is positioned by a proportioning motor 17. The flow of air through the by-pass 8 and through coils 10 and 11 is controlled by a by-pass damper formed of damper blades 20 and by a face damper formed of blades 21. These blades are connected together by a member 22 which causes the by-pass damper blades to be actuated in unison with the face damper blades but in the opposite manner. The face and by-pass damper formed of blades 20 and 21 is positioned by a proportioning motor 23 which is shown as being connected by a link 24 to one of the damper blades.

The proportioning motors 14, 17, and 23 are preferably of the type shown and described in Patent No. 2,028,110 issued to Daniel G. Taylor. These motors are controlled by means of a dry bulb thermostat generally indicated as 28 and by a wet bulb thermostat or humidity responsive device generally indicated as 29. Referring to the dry bulb thermostat 28 this thermostat may be of any suitable construction and is diagrammatically illustrated as including a bellows 30 which is connected by a capillary tube 31 to a bulb 32 located in the return duct 3. This bellows 30 actuates a bell-crank lever having a control arm or slider 33 which cooperates with a resistance 34 and a contact 35. The thermostat 28 also includes a second potentiometer controller comprising a slider 36 which cooperates with a resistance 37 and a contact 38. The slider 36 is also actuated by the bellows 30 through a suitable means such as an insulated link 40. This instrument may be so designed and adjusted as by varying the tension of a biasing spring 41 as to cause slider 33 to engage the left-hand end of resistance 34 when space dry bulb temperature is at or above 76°. At this time, the slider 36 engages the left-hand end of contact 38. As the space dry bulb temperature falls below 76°, the slider 33 travels to the right across resistance 34 and the slider 36 travels in the same direction across contact 38. When the space temperature falls to 74°, the slider 33 engages the right-hand end of resistance 34 and the slider 36 engages the left-hand end of resistance 37. Upon continued fall in space temperature the slider 36 travels across resistance 37 and reaches its right-hand end when space temperature falls to 72°. At this time the slider 33 remains in engagement with the contact 35. By this arrangement the two potentiometer controllers of the thermostat are in effect actuated sequentially.

The wet bulb thermostat 29 may be similar in construction to the dry bulb thermostat 28 excepting that the bulb 42 of this wet bulb thermostat is provided with a wick 43 which is kept saturated with water by a water pan 44. This wet bulb thermostat includes a first potentiometer controller formed of slider 45, resistance 46, and contact 47. The wet bulb thermostat 29 also includes a second potentiometer controller formed of slider 48, resistance 49, and contact 50.

Upon reference to the Taylor patent referred to, it will be found that the proportioning motor disclosed in this patent is provided with a three-wire control circuit. In the drawing the motor terminals for the three-wire control circuits are indicated as R, W, and B. The position assumed by a motor of this type is dependent upon the relative values of resistance connected between terminals R and W and terminals R and B. Thus, if the resistance between terminals R and

W is equal to the resistance between terminals R and B, the motor will assume its intermediate position. If the resistance between terminals R and W is increased without corresponding increase in resistance between terminals R and B the motor will travel in one direction an amount proportionate to the unbalancing of the resistances. Similarly, if the resistance between terminals R and B is decreased without corresponding decrease in resistance between terminals R and W, the motor will travel in the opposite direction an amount proportionate to the resistance unbalancing. A motor of this type is therefore adapted to be controlled by a potentiometer type controller and will assume intermediate positions corresponding to the position of a potentiometer slider upon its resistance.

The damper motor **23** is controlled by both the dry bulb thermostat **28** and the wet bulb thermostat **29**. It will be noted that terminal R of this motor is connected by a wire **52** to the slider **45** of thermostat **29**. Under normal conditions the slider **45** engages the contact **47** as shown. This contact **47** is in turn connected by wire **53** to the slider **33** of the thermostat **28**. Terminal W of the motor **23** is connected by wire **54** to the contact **35** of the thermostat **28** and terminal B of this motor is connected by wire **55** to the left-hand end of resistance **34**. The wire **55** is also connected by wire **56** to the left-hand end of resistance **46** of the thermostat **29**. From the foregoing it will be noted that when the slider **45** of thermostat **29** engages contact **47**, the thermostat **28** is in complete control of the damper motor **23**. As shown, the slider **33** is engaging the center of resistance **34** which divides the resistance **34** equally between terminals R and W and between terminals R and B of motor **23**. This causes the motor **23** to assume the intermediate position as shown wherein the face and by-pass dampers are each half open. If the space temperature should rise, the bellows **30** will expand thus causing the slider **33** to travel to the left on resistance **34** which decreases the portion of this resistance between terminals R and B and increases the portion between terminals R and W. The motor **23** due to this action will rotate clockwise thereby opening the face damper and closing the by-pass damper for increasing the flow of air through the cooling coil **10**. This increases the amount of cooling performed and thus tends to maintain the space temperature substantially constant. If the space temperature should fall, the slider **33** will travel to the right across resistance **34** which movement will be followed up by motor **23** rotating counter-clockwise for closing the face damper and opening the by-pass damper. Therefore, under normal conditions when the slider **45** of the thermostat **29** engages contact **47** the thermostat **28** controls the position of the face and by-pass dampers and varies the flow of air across the cooling coil in a manner to maintain a constant space temperature.

In the event that the relative humidity should rise to an unusually high value, the wet bulb temperature of the return air will increase to a point at which the slider **45** of thermostat **29** begins travelling to the left across resistance **46**. It will be noted that this action places a portion of the resistance **46** in circuit with the slider **33** of thermostat **28** and thus reduces the effect of this thermostat on the motor **23**. This same action also reduces the portion of resistance **46** which is in circuit between terminals R and B of the motor **23** and thus causes clockwise rotation of this motor for opening the face damper **21** and closing the by-pass damper **20**. It should now be apparent that the wet bulb thermostat **29** serves to place the thermostat **28** in control of the proportioning motor when the relative humidity is below a predetermined value and serves to open the face damper and close the by-pass damper independently of thermostat **28** when the relative humidity begins rising above a predetermined value. It will be noted that a resistance **46*a*** is connected between terminals R and W of the motor **23**. This resistance should be equal in value to resistance **46** of thermostat **29**. This resistance **46*a*** serves to balance out the effect of resistance **46** in the control circuit, the resistance **46** being normally connected directly between terminals R and B of the motor.

The proportioning motor **14** which controls the cooling valve **13** is controlled by the wet bulb thermostat **29** and also by an auxiliary switch **60** which is actuated by the damper motor **23**. This auxiliary switch **60** is diagrammatically illustrated as including a switch arm **61** operated by motor **23** and cooperating with contacts **62** and **63**. As long as the face damper is not completely open, the switch arm **61** engages the contact **63** as shown. However, when the motor **23** rotates clockwise to a position at which the face damper is wide open, the switch arm **61** disengages contact **63** and engages contact **62**. Terminals B and W of the proportioning motor **15** are connected by wires **65** and **66** to the contact **50** and resistance **49** of thermostat **29**. Terminal B of the motor is connected also to switch contact **62**. Terminal R of this motor is connected by wire **67** to switch arm **61** of the auxiliary switch **60**. The contact **63** of this auxiliary switch is connected by wire **68** to the slider **48**. Thus as long as the face damper is not completely open, the cooling coil valve **13** is controlled by the wet bulb thermostat **29**. When, however, switch arm **61** engages contact **62**, the R and B terminals of the motor are connected to cause the motor to move valve **13** to wide open position. The purpose of this will be explained in a later portion of the specification.

Under normal conditions the slider **48** of thermostat **29** engages the resistance **49** as shown. Upon an increase in wet bulb temperature, which indicates an increase in relative humidity, the slider **48** travels to the left across resistance **49** which causes motor **14** to open valve **13** a greater extent. This admits more cooling medium to the cooling coil which causes the temperature of this coil to be lowered. This action increases the dehumidifying effect of the coil. Upon fall in relative humidity the slider **48** travels to the right across resistance **49** which causes the temperature of the cooling coil to be raised which decreases the amount of dehumidification performed by this coil.

The proportioning motor **17** for the reheater valve **16** is controlled by the dry bulb thermostat **28**. Terminal R of this motor is connected by wire **70** to the slider **36** and terminals B and W are connected respectively to the resistance **37** and contact **38** by wires **71** and **72**. Under normal conditions reheat is not required and the slider **36** engages the contact **38** as shown. This short circuits terminals R and W of the motor **17** which causes this motor to completely close valve **16** for maintaining the reheater out of operation.

Operation

With the parts in the positions shown the dry bulb temperature is approximately 75° as indicated by slider **33** engaging the center of resistance **34**. At this time the slider **36** engages contact **38** which maintains the reheat valve **16** completely closed. The wet bulb temperature is also at a value indicating that the relative humidity is at an intermediate value as indicated by the slider **48** engaging the center of resistance **49**. This causes the valve **13** to be half open for maintaining the temperature of coil **10** at an intermediate value. Due to the slider **45** engaging the contact **47**, the thermostat **28** is in complete control of the damper motor **23** and this motor is positioned for causing the face and by-pass dampers to be in mid position. If the dry bulb temperature increases, the thermostat **28** will cause motor **23** to rotate clockwise for increasing the air flow across coil **10** thereby increasing the amount of cooling performed. Conversely, if the dry bulb temperature decreases the thermostat **28** will cause movement of motor **23** in the opposite direction for reducing the flow of air across coil **10**. If the wet bulb temperature should decrease, indicating a decrease in humidity the wet bulb thermostat **29** will cause the valve **13** to move towards closed position for reducing the temperature of coil **10** thereby decreasing the dehumidifying effect of this coil. This will also have the effect of decreasing the amount of cooling performed which will result in the dry bulb temperature beginning to rise. The dry bulb thermostat in response to this rise in temperature will cause motor **23** to position the dampers so as to increase the amount of air flowing across coil **10**. This increases the amount of cooling performed and thus checks the rise in temperature which tends to occur due to the change in temperature of coil **10** made for the purpose of obtaining humidity regulation. If the relative humidity should increase, the slider **48** will travel to the left along resistance **49** which causes motor **14** to open valve **13** wider thereby lowering the temperature of coil **10** and increasing its humidifying effect. This will result in the dry bulb temperature falling slightly which causes the thermostat **28** to operate the damper motor **23** for decreasing the flow of air across the coil **10** thereby decreasing the amount of cooling performed. Thus under normal conditions the reheater is out of operation and the wet bulb thermostat or humidity controller varies the temperature of the coil in a manner to maintain a constant relative humidity and the dry bulb thermostat **28** controls the face and by-pass dampers in a manner to maintain the dry bulb temperature relatively constant.

It will be observed that as the relative humidity increases the cooling coil temperature is reduced to a minimum. If the cooling load happens to be quite light the space temperature will fall to a point wherein the thermostat **28** reduces the air flow across coil **10** to a minimum value. If this reduction in air flow fails to prevent the dry bulb temperature from falling below 74°, the slider **36** of thermostat **28** will begin traversing resistance **37** which opens the reheat valve **16** thereby placing the reheater into operation for preventing the dry bulb temperature from falling too low.

If the dehumidifying load is quite heavy, the minimum flow of air across the coil **10** may not provide sufficient dehumidification. If this occurs the slider **45** of the controller **29** will begin traversing the resistance **46** which will cause motor **23** to operate for increasing the air flow across coil **10** thereby securing sufficient air flow across this coil to obtain the necessary dehumidification. It will be noted that this action occurs entirely independently of the dry bulb thermostat **28**, and that the degree that damper **21** may be opened by controller **29** is limited by rheostat **57**. This dry bulb thermostat **28** at this time will control the reheat valve motor **17** in a manner to provide the proper amount of reheat for maintaining the dry bulb temperature at the desired value.

Under conditions wherein the dehumidifying load is relatively light and the sensible cooling load is heavy, the temperature of the coil **10** will be increased to a maximum by the controller **29**. This high temperature of the coil **10** may not be sufficient to perform the necessary amount of cooling. In such case the dry bulb temperature will rise until the thermostat **28** causes the face damper **21** to be wide open. When this occurs the switch arm **61** of the auxiliary switch **60** will disengage contact **63** and engage contact **62** which short-circuits terminals R and B of the valve motor **14** which causes the valve **13** to be opened wide for thus reducing the coil temperature to a minimum for securing the necessary amount of cooling.

From the foregoing it will be apparent that the present invention provides a simplified control system for varying the temperature and air flow across a cooling coil for maintaining temperature and humidity at proper values irrespective of the relationship between the cooling and the dehumidifying loads. While the invention is shown applied to a cooling coil receiving a cooling medium such as cold water or brine, it is equally adaptable to control of other types of cooling means such as direct expansion coil. Also while the invention is illustrated as applied to a system in which the flow of cooling medium through the coil is throttled it will be understood that the temperature of the coil may be controlled by means of a mixing valve or other suitable control means. If desired, a humidity controller of known form may be substituted in place of the wet bulb thermostat.

While I have shown and described a preferred form of the invention, it will be understood that various modifications may be made without departing from the scope of the invention. I therefore desire to be limited only by the scope of the appended claims.

I claim as my invention:

1. In an air conditioning system, in combination, a heat exchanger located so as to be contacted by a stream of air for a space being conditioned, a damper for varying the flow of air through said heat exchanger, thermostatic means influenced by the temperature of said space for controlling said damper in a manner to increase or decrease the flow of air in contact with said heat exchanger upon rise or fall in space temperature for thereby maintaining the space temperature at a desired value, means influenced by the humidity of the air in the space for raising or lowering the temperature of the heat exchanger upon decrease or increase in relative humidity, and means for increasing the air flow in contact with said heat exchanger independently of said thermostatic means when the relative humidity in said space rises to a predetermined value.

2. In an air conditioning system, in combination, a heat exchanger located so as to be con-

tacted by a stream of air for a space being conditioned, means for supplying cooling medium to said heat exchanger, a first controller for controlling the flow of air in contact with said heat exchanger, a second controller for controlling the temperature of said heat exchanger, thermostatic means influenced by the temperature of said space for controlling one of said controllers in a manner tending to maintain a predetermined space temperature, and moisture responsive means influenced by the humidity in said space for sequentially controlling both of said controllers, said moisture responsive means acting upon a rise in humidity first to cause operation of the controller not controlled by the thermostatic means to increase the dehumidifying effect of said system and then to cause operation of the other controller independently of said thermostatic means to further increase the dehumidifying effect of said system.

3. In an air conditioning system, in combination, a heat exchanger located so as to be contacted by a stream of air for a space being conditioned, means for supplying cooling medium to said heat exchanger, a first controller for controlling the flow of air in contact with said heat exchanger, a second controller for controlling the temperature of said heat exchanger, thermostatic means influenced by the temperature of said space for controlling said first controller in a manner tending to maintain a constant space temperature, and moisture responsive means responsive to the humidity in said space for controlling both controllers in sequence, said moisture responsive means acting upon rise in humidity to first cause actuation of said second controller to reduce the temperature of the heat exchanger to a predetermined minimum and then to cause actuation of said first controller for increasing the flow of air in contact with said heat exchanger independently of said thermostatic means.

4. In an air conditioning system, in combination, a heat exchanger located so as to be contacted by a stream of air for a space being conditioned, means for supplying cooling medium to said heat exchanger, a first controller for controlling the flow of air in contact with said heat exchanger, a first motor for positioning said first controller, a second controller for controlling the temperature of said heat exchanger, a second motor for positioning said second controller, a first motor control device connected to said first motor for controlling the same, a second motor control device connected to said first motor in a manner to cause increase in flow of air independently of said first motor control device, a third motor control device for controlling said second motor, space temperature responsive means for controlling said first motor control device, and space humidity responsive means for sequentially controlling said third and second motor control devices, said humidity responsive means acting upon rise in humidity to first act through said third motor control device and hence said second motor to cause actuation of said second controller to reduce the temperature of the heat exchanger to a predetermined minimum and then to act through said second motor control device and hence said first motor to cause actuation of said first controller for increasing the flow of air in contact with said heat exchanger independently of said thermostatic means.

5. In an air conditioning system, in combination, a cooling and dehumidifying device located so as to be contacted by a stream of air for a space being conditioned, a reheat device for reheating the air which is cooled by the cooling and dehumidifying device, a first controller for varying the flow of air through said cooling and dehumidifying device, a second controller for varying the temperature of the cooling and dehumidifying device, a third controller for controlling said reheat device, temperature responsive means influenced by the temperature of the space, humidity responsive means influenced by the humidity of the space, one of said responsive means controlling said first and third controllers in sequence in a manner to decrease the flow of air to a minimum and place the reheat device into operation, and the other of said responsive means controlling said first and second controllers in a manner to decrease the temperature of the cooling and dehumidifying device to a minimum and then to increase the flow of air through said cooling and dehumidifying device independently of said one responsive means.

6. In an air conditioning system, in combination, a cooling and dehumidifying device located so as to be contacted by a stream of air for a space being conditioned, a reheat device for reheating the air which is cooled by the cooling and dehumidifying device, a first controller for varying the flow of air through said cooling and dehumidifying device, a second controller for varying the temperature of the cooling and dehumidifying device, a third controller for controlling said reheat device, temperature responsive means influenced by the temperature of the space for controlling said first and third controllers in sequence, said temperature responsive means acting upon fall in temperature to reduce the flow of air to a minimum and to then place the reheat device into operation, and humidity responsive means influenced by the humidity in said space for sequentially controlling said first and second controllers, said humidity responsive means acting upon rise in humidity to reduce the temperature of the cooling and dehumidifying device to a minimum and then to increase the flow of air through said cooling and dehumidifying device independently of said temperature responsive means.

7. In an air conditioning system, in combination, a cooling and dehumidifying device located so as to be contacted by a stream of air for a space being conditioned, a reheat device for reheating the air which is cooled by the cooling and dehumidifying device, a first controller for varying the flow of air through said cooling and dehumidifying device, a first motor for positioning said first controller, a second controller for varying the temperature of said cooling and dehumidifying device, a second motor for positioning said second controller, a third controller for controlling said reheat device, a third motor for positioning said third controller, a first motor control device connected to the first motor for controlling the same, a second motor control device connected to said first motor in a manner to cause increase in flow of air independently of said first controller, a third motor control device for controlling said second motor, a fourth motor control device for controlling said third motor, means responsive to the temperature in said space, means responsive to humidity in said space, one of said responsive means sequentially actuating said first and fourth motor control devices and the other of said responsive means

sequentially actuating said second and third motor control devices.

8. In an air conditioning system, in combination, a cooling and dehumidifying device located so as to be contacted by a stream of air for a space being conditioned, a reheat device for reheating the air which is cooied by the cooling and dehumidifying device, a first controller for varying the flow of air through said cooling and dehumidifying device, a first motor for positioning said first controller, a second controller for varying the temperature of said cooling and dehumidifying device, a second motor for positioning said second controller, a third controller for controlling said reheat device, a third motor for positioning said third controller, a first motor control device connected to the first motor for controlling the same, a second motor control device connected to said first motor in a manner to cause increase in flow of air independently of said first controller, a third motor control device for controlling said second motor, a fourth motor control device for controlling said third motor, means responsive to the temperature in said space for sequentially controlling said first and fourth motor control devices in a manner to decrease the air flow and to place the reheat device into operation upon fall in space temperature, and means responsive to the humidity in said space for sequentially controlling said second and third motor control devices in a manner to reduce the temperature of the cooling and dehumidifying device to a minimum and to increase the flow of air htrough said cooling and dehumidifying device upon rise in humidity.

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