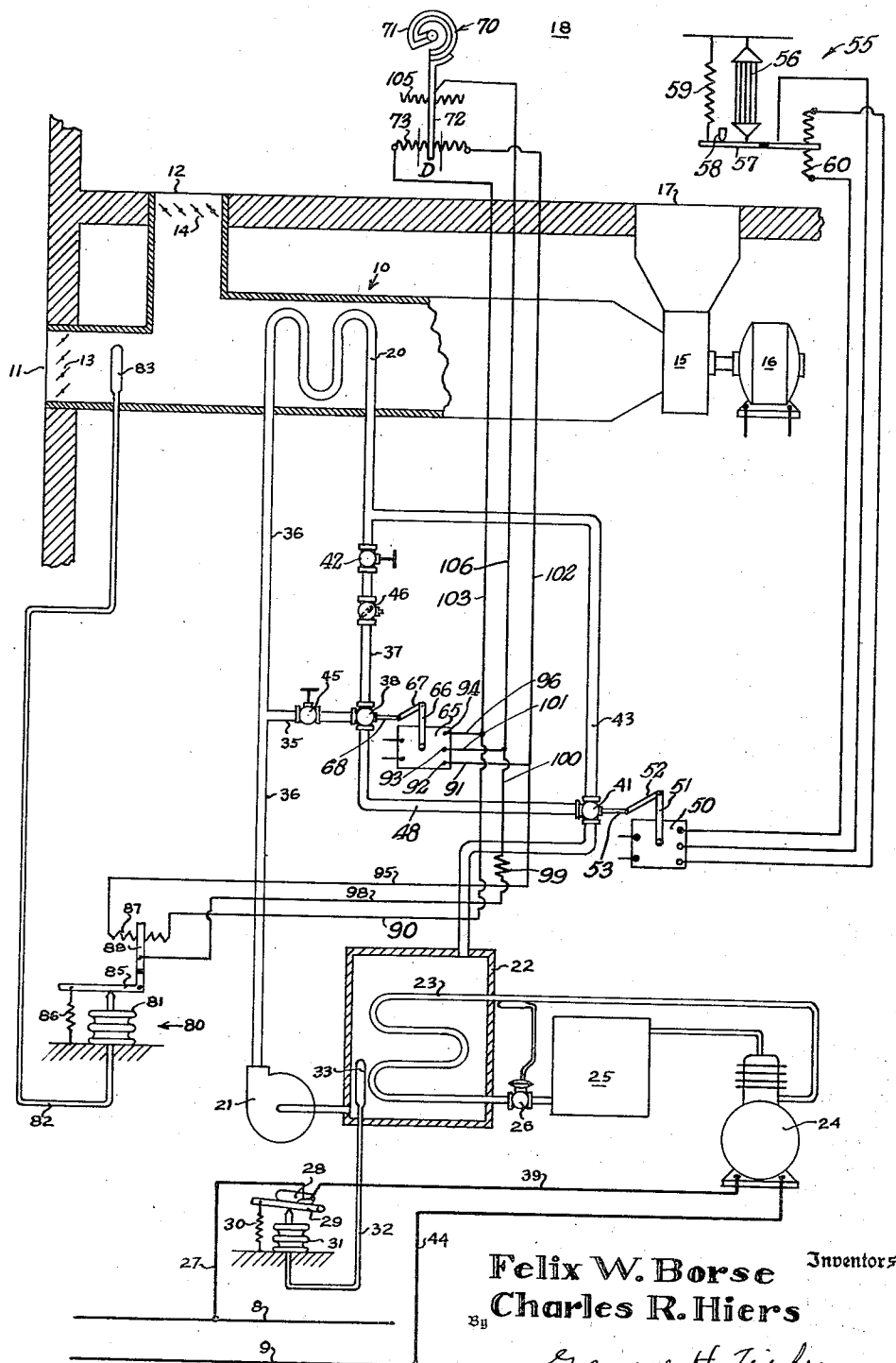


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AIR CONDITIONING SYSTEM

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AIR CONDITIONING SYSTEM

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This invention relates to an air conditioning system and more particularly to a cooling and dehumidifying system.

In accordance with our invention, the temperature and humidity of a space is controlled by passing air being circulated thereto over a coil or coils through which a suitable cooling medium is circulated, the amount of dehumidification and sensible cooling that is effected being controlled by controlling the rate of flow of the cooling medium through the coil. The flow of the cooling medium is so controlled that when there is a call for maximum sensible cooling only, the rate of flow through the coil may be less than when there is a call for maximum dehumidification only. In other words, while the rate of flow is controlled both in accordance with the demand for sensible cooling and the demand for dehumidification, an increase in the demand for dehumidification may cause a greater increase in the rate of flow than a like increase in demand for sensible cooling. Since a considerably greater amount of heat must be removed from the air to effect dehumidification thereof than to effect sensible cooling, by properly proportioning the rates of flow in accordance with the above, it is possible to more effectively control the temperature and humidity of the air than is possible where the temperature and humidity responsive devices exercise the same influence on the flow controlling means.

It is therefore an object of our invention to provide a novel control means for a coil through which a cooling medium is circulated to cool and dehumidify the air being circulated through a space whose temperature and humidity is to be controlled.

Other objects and advantages will become apparent upon a study of the specification, claims, and appended drawing, the single figure of which is a schematic view of an air conditioning system embodying the principles of our invention.

Referring now to the drawing, an air conditioning chamber is represented by the reference character 10, this chamber being provided with a fresh air inlet 11 and a return air inlet 12. Dampers 13 and 14 positioned in the fresh and return air inlets, respectively, may be provided for controlling the proportions of fresh and return air admitted to the chamber 10 and may be controlled in any suitable well known manner. A fan 15 driven by a motor 16 is provided for drawing air through the chamber 10 and discharging it through the outlet 17 into the space 18 whose condition is being controlled.

Located within the chamber 10 are suitable cooling coils 20 through which a cooling medium is circulated by means of a pump 21. A cooling tank 22 is provided for cooling the water or other cooling medium and this tank is illustrated as being cooled by an evaporator 23 of a refrigeration system. This refrigeration system may include a compressor 24, a condenser 25, and an expansion valve 26, these elements being connected together and operating in the manner well known in the art. The operation of compressor 24 may be controlled by a mercury switch 28 mounted on a lever 29, this lever being biased by means of a spring 30 into engagement with a bellows 31. Bellows 31 is connected by means of a capillary tube 32 with a bulb 33 located within the cooling tank 22, this tube, bulb, and bellows being provided with a suitable volatile fill whereby the bellows expands and contracts in response to variations in temperature of the water in the tank 22. Switch 28 controls the current to the compressor motor from lines 8, 9 connected to a suitable source of power (not shown), current flowing from line 8 through wire 27, switch 28, wire 39, motor 24, and wire 44 to line 9, and when the temperature of the fluid in the tank 22 drops to a predetermined value, the bellows 31 will contract and cause the switch 28 to be tilted in the opposite direction from that shown thus interrupting the current to the compressor motor and stopping the operation of the refrigeration system.

The fluid circulated by the pump 21 may follow several different paths. A pipe 35 connects the pipe 36, leading to the inlet of the cooling coil 20, to a pipe 37 which is connected to the outlet of the coil 20. The flow of water through the by-pass 35 and the pipe 37 is controlled by a three-way mixing valve 38 whereby the proportion of water flowing through the by-pass 35 and through the pipe 37 from the coil 20 depends upon the position of the valve 38. A pipe 43 is connected to the pipe 37 and forms a by-pass around the valve 38, the flow of water through this pipe being controlled by a three-way mixing valve 41. With the three-way valve 38 in a position to prevent flow of water through the pipe 37, water may still be permitted to flow through the coil 20 if the three-way valve 41 is in proper position, the amount of water which is permitted to flow through the coil depending upon the position of this valve member. A hand operated valve 42 is provided in the pipe 37 to control the maximum amount of water that may flow through the coil 20 when the

inlet from pipe 43 to the three-way valve 41 is entirely closed and when the inlet from the pipe 37 to the three-way valve 38 is entirely open, or in other words, to control the maximum flow of water through pipe 37. A second manually operated valve 45 may be positioned in the pipe 35 to control the amount of water that may flow through the pipe 35 and the three-way valve 38 for any position of the valve 38. A check valve 46 is provided in the pipe 37 to prevent flow of water through the pipes 36, 35, valve 38, and pipe 37 to the outlet of the coil 20.

The position of the three-way valve 41 may be controlled by a motor 50 having an arm 51 connected by means of a link 52 to the valve stem 53. This motor may be a proportioning motor of the type illustrated in Patent 2,028,110 issued to D. G. Taylor on Jan. 14, 1936, and controlled by humidity responsive device 55 mounted in the space 18, this device including a humidity responsive element 56 connected to a lever 57 pivoted at 58. A spring 59 is connected to the left end of the lever 57 and biases the opposite end of the lever in a downward direction. A resistance 60 is provided over which the right end of the lever 57 moves in response to variations in humidity in the space 18. Upon an increase in humidity in the space the humidity responsive element 56 will become elongated and the lever 57 will move downwardly over the resistance 60 under the influence of the biasing spring 59. Upon a decrease in relative humidity in the space, the humidity responsive element 56 will contract thus causing the lever 57 to move upwardly over the resistance 60. The position of the lever 57 with respect to the resistance 60 controls the position of arm 51 driven by motor 50 as will be apparent upon a study of the aforementioned patent. As the humidity in the space rises the motor operates to move the arm 51 in a direction to cause an increased flow of cooling fluid through the pipe 43 and a decreased flow through the pipe 48 and when the humidity reaches a predetermined high value there will be no flow through the pipe 48 and a maximum flow through the pipe 43. As the humidity drops to a predetermined low value the valve will be operated to close the inlet from pipe 43 so that no water flows through this pipe and the flow through pipe 48 will be at a maximum.

A motor 65 similar to the motor 50 is provided for controlling the position of the three-way valve 38. An arm 66 driven by this motor is connected by means of a link 67 with the valve stem 68. This motor may be controlled by a device 70 responsive to the temperature of the air in the space 18. Temperature responsive device 70 may include a bimetallic element 71 carrying an arm 72 which sweeps over a resistance 73 in response to temperature changes in the space 18 whereby the position of arm 66 driven by motor 65 is controlled in accordance with the temperature in the space. The operation of motor 65 may be compensated by the outdoor temperature so that as the temperature of the air outside of the building rises, a higher temperature will be maintained in the space 18 in order to secure proper temperature conditions within the space. For this purpose a controller 80 is provided, this controller including a bellows 81 connected by means of a capillary tube 82 to a bulb 83 which may be located in the fresh air inlet 11 of the chamber 10. This tube, bulb, and bellows may be provided with a suit-

able volatile fill so that the bellows 81 expands or contracts in accordance with variations in outdoor temperature. A bell crank lever 85 has one leg thereof biased into engagement with the bellows 81, the other arm 88 of this lever being arranged to sweep over a resistance 87 which is connected to the motor 65 in such a way as to compensate the effect of the temperature responsive device 70. As the outdoor temperature rises, the arm 88 of lever 85 is moved to the right over the resistance 87 by reason of the expansion of the bellows 81 and this arm moves in the reverse direction in response to a drop in outdoor temperature. The left end of this resistance is connected by means of conductors 95 and 91 to the terminal 92 of the motor 65. The opposite end of the resistance 87 is connected by means of conductors 90 and 96 to the terminal 94 of the motor 65. The arm 88 of lever 85 is connected by means of conductors 98, resistance 99, and conductors 100 and 101 to the terminal 93. As the arm 88 moves to the right in response to an increase in outdoor temperature the valve 38 is operated by motor 65 to reduce the flow of water through the pipe 37 and accordingly through the coil 20 by way of this valve. Arm 72 of thermostat 70 moves toward the right end of resistance 73 in accordance with a rise in the temperature in the space 18 and this side of the resistance is connected by means of conductors 102 and 91 to the motor terminal 92. The opposite end of the resistance towards which the arm 72 moves in response to a temperature drop in the space is connected by means of conductors 103 and 96 to the motor terminal 94. The arm 72 is connected by means of the center tapped resistance 105 and conductors 106 and 101 to the motor terminal 93. It will now be noted that by reason of the relative arrangements of the resistances 73 and 87 that if movement of arm 88 to the right in response to an increase in outdoor temperature causes movement of arm 66 by the motor 65 in a direction to cause a decrease in flow of water through pipe 37, that upon a movement of arm 72 to the right over resistance 73 in response to an increase in room temperature the motor 65 will be operated in the opposite direction and will accordingly cause an increase in the flow of water through the pipe 37. By reason of the resistance 99 in the circuit to the arm 88 this arm will have less effect on the operation of motor 65 for a given range of movement thereof than will the arm 72. In other words, for a movement of arm 72 through the range indicated by D the motor 65 may be operated from one extreme position to the other whereas in order to give the same movement to the motor the arm 88 must operate from one end to the other of resistance 87. Thus the effect of a change in outdoor temperature is to shift the control range of the arm 72 so as to maintain a different temperature in the space as the outdoor temperature varies. The center tapped resistance 105 serves to maintain the length of the operating range of arm 72 the same at all times regardless of the location of this operating range as determined by the controller 80.

When the temperature in the space is at a predetermined low value the thermostat 70 will cause motor 65 to position the three way valve 38 so as to close this valve to pipe 37 and open it to the by-pass pipe 35. If the relative humidity is low, the humidity controller 55 will

cause the motor 50 to position valve 41 so that this valve closes completely to pipe 43 and opens wide to pipe 48. Thus, when both space temperature and relative humidity are low, the valves 38 and 41 will be positioned for preventing flow of cooling fluid through pipe 37 and pipe 43. This will prevent any flow of cooling fluid through the cooling coil 20. At this time, it will be noted that valve 38 is wide open to by-pass pipe 35 and valve 41 is wide open to pipe 48. The pump 21 will therefore circulate cooling fluid from the cooling tank 22 through pipe 36, pipe 35, valve 38, pipe 48, valve 41, and the return pipe back to cooling tank 22. Therefore, when no cooling fluid is allowed to circulate through the cooling coil 20, this cooling fluid is permitted to circulate through the by-pass pipes. This arrangement has the advantage of avoiding churning by the pump 21 when the flow through the cooling coil is prevented. This arrangement also permits circulation of the cooling fluid across the heat exchange surface in cooling tank 22. This circulation prevents stratification of the fluid in cooling tank 22 and thus insures that the cooling fluid stored in this tank will be of maximum effectiveness when required for use.

Assume now that the space temperature is still low but that the relative humidity rises to a value requiring dehumidification. Under these conditions, the three way valve 38 will remain positioned for preventing flow through pipe 37 and directly connecting pipes 35 and 48. Due to the rise in relative humidity, the motor 50 will position valve 41 so as to permit flow of cooling fluid through pipe 43. Consequently, cooling fluid circulated by the pump 21 will divide into two branches, one branch passing through the pipes 35 and 48 back to cooling tank 22 and the other branch passing through the cooling coil 20, pipe 43 and valve 41 back to the cooling tank 22. It will be apparent that as the relative humidity continues to rise, the controller 55 will cause motor 50 to position valve 41 for gradually increasing the flow of cooling fluid through the coil 20 and decreasing the flow through the by-pass pipes 35 and 48. When the relative humidity rises to a maximum value, the valve 41 will be positioned for opening wide to pipe 43 and closing completely to pipe 48. At this time, the flow of cooling medium through coil 20 will be at a maximum.

Assume now that the relative humidity is at a low value wherein dehumidification is not required but that the space temperature rises to a value requiring cooling. At this time, due to the relative humidity being low the valve 41 will be positioned so as to close completely to pipe 43 and open completely to the pipe 48. As the space temperature rises, the thermostat 70 will cause the motor 65 to position valve 38 so as to permit flow of cooling fluid from pipe 37 to pipe 48, this cooling fluid joining the cooling fluid passing through the by-pass pipe 35. This opening of valve 38 to the pipe 37 and closing of this valve to the by-pass pipe 35 causes cooling fluid to now flow through the cooling coil 20. It will be apparent that when the space temperature rises to a predetermined maximum value, the thermostat 70 will cause motor 65 to position valve 38 to close this valve completely to pipe 35 and open it wide to pipe 37. At this time, the flow of cooling medium under the demand of the thermostat 70 will be at a maximum. As pointed out previously, the valve 42 serves to restrict the

flow of fluid through the pipe 20 under the control of valve 38. Preferably this valve 42 is adjusted so that when the valve 38 is positioned for supplying the maximum flow of cooling fluid, this maximum flow will amount to only 40 per cent of the maximum flow which can be caused by the valve 41 which is controlled by the humidity controller 55. In other words, valve 42 is adjusted so that when the valve 41 is positioned to prevent flow of cooling medium through coil 20, the maximum flow through this coil which can be caused by valve 38 is only 40 per cent of the flow which can be caused by valve 41. By this arrangement, the humidity controller is able to increase the flow of cooling fluid to a maximum when necessary for dehumidification, while the flow that can be caused by the thermostat is considerably less. This arrangement is highly desirable for the reason that it is necessary to maintain the over all coil temperature considerably lower in order to obtain dehumidification than is necessary in order to obtain sensible cooling. By limiting the effect of the thermostat in this manner, this thermostat is prevented from lowering the coil temperature to a value which would perform too much dehumidification.

While for convenience in description the operation of the temperature control mechanism and the humidity control mechanism have been described separately, it will be obvious that when both sensible cooling and dehumidification are required at the same time, the two sets of controls will cooperate to provide a resultant flow of cooling fluid through the cooling coil 20 which is proper for obtaining the desired sensible cooling and dehumidifying effects.

It should be noted that in the arrangement described, the valve 38 controlled by the thermostat 70 handles considerably less cooling fluid than is required to be handled by the valve 41. This valve 38 for this reason may be made considerably smaller than the valve 41.

By reason of the fact that only enough fluid as is required for dehumidification and cooling is circulated through the coil 20 and the rest of the fluid is by-passed through pipe 35, the cooling requirements of the evaporator 23 in the tank 22 are kept at a minimum for any given condition and the compressor 24 will be operated only long enough and often enough to maintain a predetermined temperature of the water in tank 22.

It will thus be seen that we have devised a very simple and effective system for controlling the cooling coil to effectively maintain proper conditions of temperature and humidity within a space, compensating the temperature in accordance with outdoor temperature with the use of a single cooling coil and with the provision of a minimum number of parts.

Having described a preferred form of our invention, many modifications may become apparent to those skilled in the art and it should be understood that our invention is limited only by the scope of the appended claims.

We claim as our invention:

1. In an air conditioning system, a cooling coil, means for circulating a cooling fluid through said coil, a by-pass connected between the inlet and outlet of said coil, a three-way valve connected to the outlet of said coil and controlling the relative flows through said coil and said by-pass, a second by-pass around said valve connected to the outlet of said coil and the outlet of said valve, a second three-way valve for controlling the relative flows

from said first three-way valve and said coil, temperature responsive means controlling the position of said first three-way valve, humidity responsive means in control of said second three-way valve, the first three-way valve being incapable of passing as large a flow of cooling fluid through said coil as can be passed by the second three-way valve.

2. In an air conditioning system, a cooling coil for removing heat from the air in a space, pump means for circulating a cooling fluid through said cooling coil, a by-pass for permitting flow of fluid by said pump means without flowing through said coil, valve means controlling the relative flows of fluid through said coil and said by-pass, means responsive to the space temperature in control of said valve means, a second by-pass for permitting a flow of fluid through said coil and around said valve means, a second valve means controlling the relative flows of fluid through said coil and through said first valve means, and means responsive to the humidity of the space in control of said second valve means.

3. In an air conditioning system, a cooling coil for removing heat from the air in a space, pump means for circulating a cooling fluid through said cooling coil, a by-pass for permitting flow of fluid by said pump means without flowing through said coil, valve means controlling the relative flows of fluid through said coil and said by-pass, means responsive to the space temperature in control of said valve means, a second by-pass permitting a flow of fluid through said coil and around said valve means, a second valve means controlling the relative flows of fluid through said coil and through said first valve means, and means responsive to the humidity of the space in control of said second valve means, said first valve means being incapable of passing as large a flow of cooling fluid through said coil as can be passed by said second valve means.

4. In an air conditioning system, a cooling coil for removing heat from the air in a space, pump means for circulating a cooling fluid through the cooling coil, a by-pass for permitting flow of fluid by said pump means without flowing through the coil, first valve means for controlling the relative flows of fluid through said coil and said by-pass, a second by-pass for permitting a flow of fluid through the coil and around said first valve means, a second valve means controlling the relative flows of fluid through said coil and through said first valve means, temperature responsive means, humidity responsive means, one of said responsive means controlling said first valve means and the other of said responsive means controlling said second valve means.

5. In an air conditioning system, a cooling coil for removing heat from the air in a space, pump means for circulating a cooling fluid through the cooling coil, a by-pass for permitting flow of fluid by said pump means without flowing through the coil, first valve means for controlling the relative flows of fluid through said coil and said by-pass, a second by-pass for permitting a flow of fluid through the coil and around said first valve means, a second valve means controlling the relative flows of fluid through said coil and through said first valve means, temperature responsive means, humidity responsive means, one of said responsive means controlling said first valve means and the other of said responsive means controlling said second valve means, the valve means controlled by the temperature responsive means being incapable of passing as large a flow of cooling fluid through the coil as can be passed by the valve means controlled by the humidity responsive means.

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