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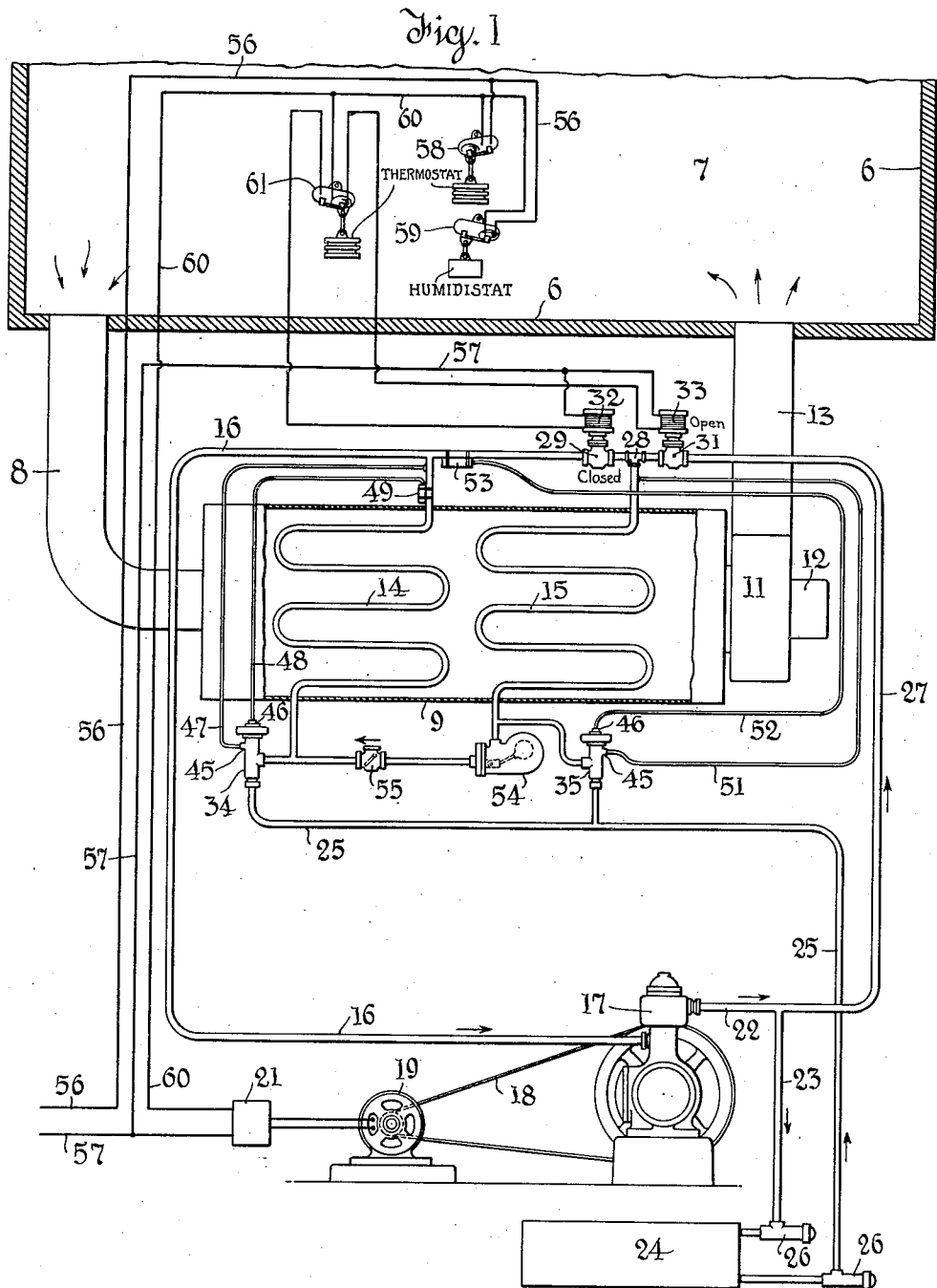
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2,195,781

AIR CONDITIONING

Filed Sept. 29, 1936

2 Sheets-Sheet 1



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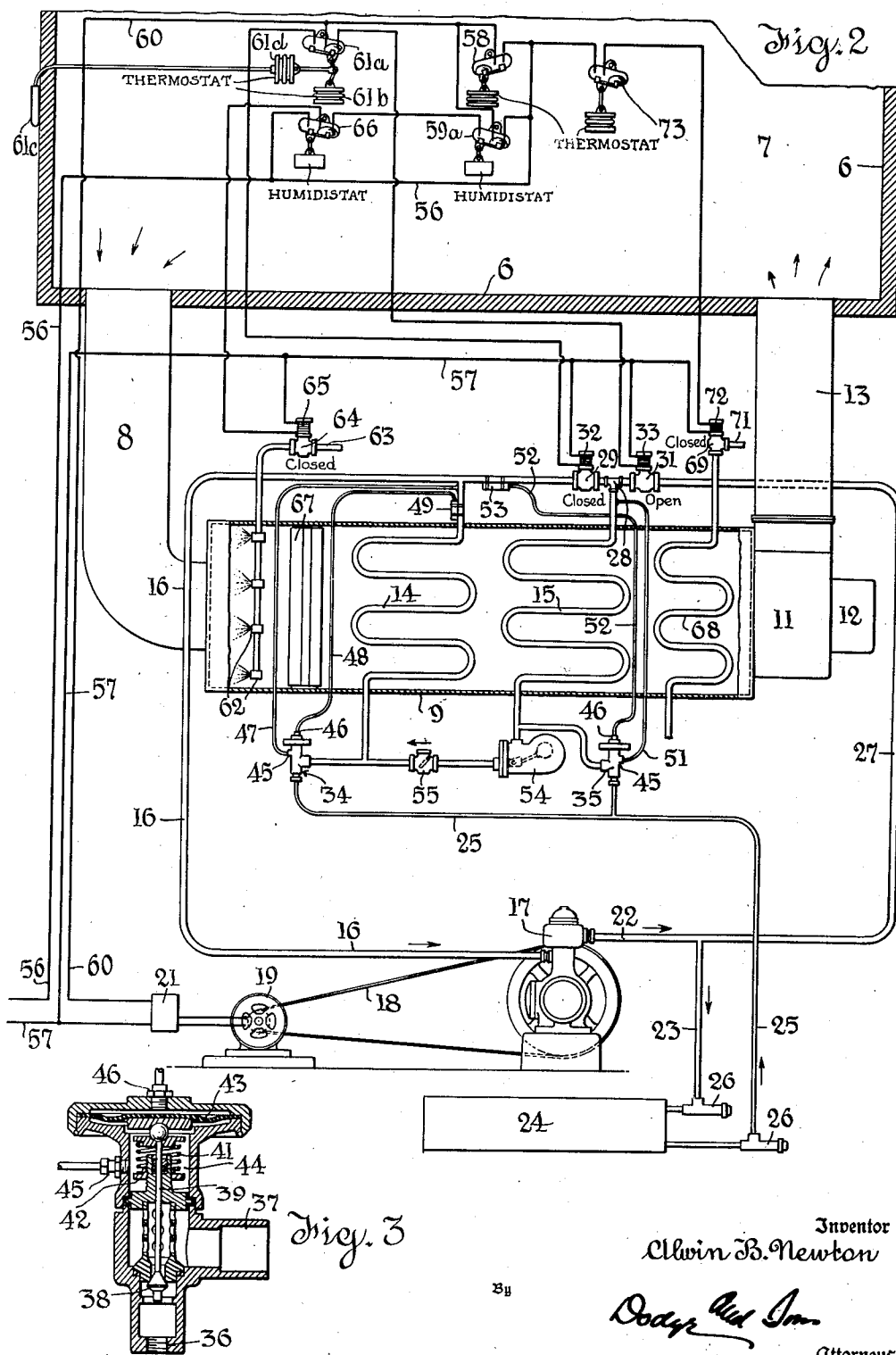
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UNITED STATES PATENT OFFICE

2,195,781

AIR CONDITIONING

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26 Claims. (Cl. 257—3)

This invention relates to air conditioning and more particularly to cooling and dehumidification under summer conditions.

Prior to my invention it has been proposed to pass the air to be conditioned successively over two refrigerative evaporators from which refrigerant is drawn by a constant speed compressor and to which refrigerant is admitted through automatic expansion valves of the superheat control type. When there is demand for cooling, or for dehumidification or both, the compressor is kept in operation, but whenever the demand is for dehumidification alone one of the evaporators is cut out of the refrigerative circuit. The effect is to evaporate less refrigerant, but at a lower suction pressure, so that not only is the total cooling effect on the air less than when both evaporators operate, but more moisture is condensed from the air because the single evaporator operates at a lower temperature. In other words, the sensible cooling diminishes not only because of the reduction of total refrigerant evaporated, but also because a larger proportion of the refrigeration then effective is devoted to the extraction of latent heat from the water vapor carried by the air.

Regulation of this sort is commercially satisfactory but has the disadvantage that some sensible cooling is a necessary incident to dehumidification, whereas it is preferable to secure dehumidification without sensible cooling when humidity alone is high.

According to the present invention, the air preferably contacts the evaporators serially and in such case the second evaporator is the one cut out during simple dehumidification. At such times the second evaporator is temporarily converted into a condenser for at least a part of the refrigerant compressed by the compressor. While it so operates it serves as a reheater for the air cooled by the first evaporator, and restores to the air at least a part of the heat extracted by the first evaporator. The air thus is first cooled and then reheated, the temperature dip serving to remove moisture without substantial final change in sensible heat, or at any rate with less reduction than is had with the described prior art arrangements.

In the present invention the use of a constant speed compressor is preferred because it is the simplest way known to applicant, to reduce evaporator temperature and increase the dehumidifying effect when evaporative capacity is reduced. Other functionally equivalent means for reducing evaporative temperature are known and may

be substituted, within the scope of this invention. Moreover, since some dehumidification is secured at normal evaporator temperature, reduction of evaporator temperature is not essential to practice of the invention in its broadest aspects.

While the principal feature of novelty is that above described, there are ancillary features, particularly as to the arrangement of the automatic expansion valve, the control connections, etc., which will be appreciated as the detailed description proceeds.

The system is also favorably constituted for the inclusion in the installation of means for heating and humidifying under winter conditions, and can be made to operate with success between seasons when conditions shift back and forth between heating and cooling requirements. Such an arrangement will be disclosed as a modified embodiment.

In the drawings,

Fig. 1 is a diagram of a very simple embodiment of the invention intended solely for conditioning in summer.

Fig. 2 is a diagram of a similar system including means for conditioning in winter, and controls which will operate between seasons to select and regulate the action of the system according to demand.

Fig. 3 is a section of an automatic expansion valve used in both embodiments above described.

For simplicity the invention will be described as embodied in a system in which air withdrawn from the room is conditioned and returned to the room, but nothing in the invention precludes its use with air circuits in which all or any part of the air supplied to the conditioner is fresh air. In other words, these various well known arrangements are equivalents, so far as the invention is concerned.

Similarly, the controls responsive to room condition are shown located in the room, but their location at any point at which they would respond to room conditions, for example in the return air duct, falls within the scope of the invention.

Further, while particular electrical controls will be described in some detail, temperature and humidity control systems different in structure but essentially similar in effect are well known and substitution is possible. For example, thermostats of the pneumatic type are highly developed and can be arranged to parallel the functions of the electrical type chosen for illustration. Since the invention resides in the way the con-

trols are applied so as to be properly coordinated, and not in the mechanics of the control devices themselves, applicant is entitled to a considerable range of equivalents.

5 In the embodiments shown the air passes serially over the two evaporators, and this arrangement is preferred, because when dehumidifying without substantial ultimate cooling substantially all the air is first dehumidified and then substantially all is reheated so that the desired effects
10 are secured in the maximum degree. It should be understood, however, that a useful result may be secured without adhering to this arrangement, for if one stream is cooled and dried and another heated, mixture of the streams in the fan
15 results in reheating of the first stream after moisture has been rejected.

Referring now to Fig. 1.

The walls 6 enclose a room 7, or other space to
20 be conditioned. The return air duct 8 leads from the room to the intake end of the conditioner housing 9, from which a total volume fan 11, driven by motor 12, draws air and returns it to the room through the duct 13. Mounted in the
25 housing 9 are two coils 14 and 15, conventionally represented as sinuous coils. It is immaterial to the invention what particular type of coil is used. In the air conditioning art it is customary to use finned tubes so as to get a large heat
30 transfer surface.

The suction line 16 of a refrigerative circuit, leads to the suction of compressor 17 which is driven through a belt 18 by an electric motor 19. This motor is started and stopped by an electrically controlled starting switch, diagrammatically indicated at 21. The compressor discharges
35 through the pipe 22 and branch pipe 23 to a combined condenser and receiver 24, from which the liquid line 25 leads. The fittings indicated at 26 are normally-open stop valves.

Branch pipe 27 leads from the discharge pipe 22. The discharge end of the coil 14 is permanently connected with the suction line 16. The discharge end of the coil 15 leads to a T or junction
45 28 which is selectively connected with the suction line 16 or with the high pressure branch line 27 by valves 29 and 31, so arranged that when one is opened the other is closed. The valve 29 is actuated by the energization and deenergization
50 of a winding 32, while the valve 31 is similarly actuated by a winding 33. The valves are each biased in closing direction and each is opened only when its related coil is energized. The two windings 32 and 33 are selectively energized by a
55 switch mechanism, hereinafter described.

When the valve 29 is open and the valve 31 is closed, coil 15 is connected to suction line 16, but when the valve 31 is opened and the valve 29 is closed coil 15 is connected to the high pressure
60 branch pipe 27. The liquid line 25 leads to two automatic expansion valves, 34 which controls the supply of refrigerant to the coil 14, and 35 which controls supply of refrigerant to the coil 15. Since these two valves are structurally identical it will suffice to describe the valve as illustrated in section in Fig. 3, and then describe its connections, the connections for the two valves being different.

Liquid refrigerant is supplied through line 25
70 to the connection 36 and is delivered to the connected evaporator coil through the connection 37. Flow from connection 36 to connection 37 is controlled by a poppet valve 38 which seats in the direction of flow. This valve is connected to a
75 stem 39 and is urged in a valve closing direction,

by a coil compression spring 41. The stress on this spring is adjustable by means of nut 42 which is threaded on a portion of the housing, as clearly shown in Fig. 3. The stem 39 is in thrust relation with a flexible diaphragm 43 which is subject
5 on its lower face to fluid pressure in the chamber 44. The chamber 44 is isolated from the discharge connection 37, a packing gland being arranged to seal the stem 39, as clearly indicated in the drawings.

The chamber 44 is subject to pressure arriving through a pressure connection 45. The space above the diaphragm 43 is subject to fluid pressure arriving through the connection 46, the temperature connection.

Reverting now to Fig. 1, it will be observed as to the valve 34 that a pipe 47 leads from the pressure connection 45 to the discharge of coil 14, so that the chamber 44 in valve 34 is always subject to suction pressure. The pipe 48 leads from the temperature connection 46 to a thermostatic bulb
20 49 in thermal conducting relation with the outlet of the coil 14. It will be observed, therefore, that the valve 34 functions in response to superheat at the outlet of the coil 14.

The connections for the valve 35 are slightly different. A pipe 51 leads from the pressure connection 45 to the outlet of the coil 15, from which it results that if valve 29 is opened and valve 31 closed, the chamber 44 of valve 35 is at the suction pressure in the system, but if valve 31 is opened and valve 29 is closed, the chamber 44 is subject to the discharge pressure in the system, with the result that valve 38 then will be held continuously closed. Pipe 52 leads from the temperature connection 46 of valve 35 to a thermostatic bulb 53 which is not placed adjacent the discharge of coil 15 but is in thermal conducting relation with the suction line 16 beyond the valve 29. The purpose of this is to locate the thermostatic bulb 53 where it will be subjected to the suction temperature of the system and never subjected to the much higher discharge temperature. It will be observed, however, that when valve 29 is opened and valve 31 closed, the flow resistance between the point of connection of the pipe 51 and the location of the thermostatic bulb 53, is negligible so that when the valve 35 is operative to supply liquid refrigerant to the coil 15 the control will be substantially in response to
50 superheat at the outlet of the coil.

The arrangement described protects the thermostatic bulb against overheating, prevents it from tending to open the expansion valve 35 when the valve 29 is closed, while the location of the connection of the pipe 51 insures that the expansion valve 35 will be maintained closed when the suction connection valve 29 is closed.

With the compressor 17 running and the valve 29 closed and valve 31 opened, coil 15 serves as a
60 condenser. Refrigerant then liquefied in the coil 15 is fed to the coil 14 by way of the high side float valve 54 and the check valve 55.

Leads 56 and 57 from any suitable current source provide electric current for operating the electrically actuated valves 29 and 31 and the motor control switch 21 which starts and stops motor 19.

Lead 57 is connected with a terminal of the control switch 21 and with one terminal of each of the windings 32 and 33. Lead 56 is connected to the right hand contact of the thermostatic mercury tube switch 58 which tilts clockwise to close when dry bulb temperature rises above a chosen value assumed for discussion to be 80° F.
75

Lead 56 is also connected to the right hand contact of the humidostatic mercury tube switch 59 which tilts clockwise to close when relative humidity is above a chosen value, here assumed to be 50%. In Fig. 1 the parts are shown in positions assumed when temperature is below 80° and humidity is above 50%.

The other terminals of switches 58 and 59 are connected to line 60 which leads to the second terminal of control switch 21 which therefore runs motor 19 unless both switches 58 and 59 are open.

Valves 29 and 31 are biased to closed position and open only if their respective windings 32 or 33 be energized. The tilting thermostatic mercury tube switch 61 energizes these windings selectively, but only when line 60 is energized by the closure of at least one of the switches 58 or 59. Line 60 is connected to the middle contact of switch 61, winding 32 to the lefthand contact and winding 33 to the righthand contact. Thermostatic switch 61 is set to a control point not above, and preferably a few degrees below the control point of thermostatic switch 58. For discussion 74° is assumed as the control point of switch 61. Below this temperature it tilts clockwise to energize winding 33 and deenergize 32 as shown in Fig. 1, while above this temperature it tilts counterclockwise and reverses this effect.

Assuming that the thermostats and the humidostats are set for the values mentioned, which values are merely illustrative, and that dry bulb temperature is above 80°, the compressor will run and will run whether or not humidity is above or below 50%. Inasmuch as the dry bulb temperature is above the setting of the thermostat 61, valve 29 is opened and valve 31 is closed. Consequently both coils are connected to the suction line and both operate at a normal suction pressure to cool the air passing through the housing 9. The amount of dehumidification which will occur will depend on humidity conditions in the room, but under these conditions both cooling and humidification will occur.

Suppose now the dry bulb temperature in the room falls below 80° while the relative humidity is above 50%. This amounts to saying that thermostatic switch 58 opens but humidostatic switch 59 remains closed. The compressor will continue to run and the conditioning effect will be unchanged. This action, however, can continue only until dry bulb temperature falls to the setting of the thermostatic switch 61, i. e., 74°. If at this time the relative humidity is still above 50% so that the humidostatic switch 59 is still closed, the compressor will continue in action, and the thermostatic switch 61 will shift to close the valve 29 and open valve 31. This disconnects coil 15 from suction line 16 and connects it with the discharge line 21. Warm high pressure refrigerant from the compressor 17 will then flow through valve 31 to the coil 15 in which it is condensed. The high pressure thus established in coil 15 will be transmitted through pipe 51 to chamber 44 of expansion valve 35, and will hold valve 38 to its seat preventing the supply of liquid refrigerant through liquid line 25 to coil 15. The thermostatic bulb 53 will not interfere with this action because it is still subject to temperature in the suction line. Liquid refrigerant condensed in the coil 15 will flow through the expansion valve 54 and the check valve 55 to coil 14, but the refrigerant so flowing will be insufficient to supply all the refrigerant required by the coil 14. Consequently the expansion valve

34 will supply the remainder under the control of the superheat at or near the bulb 49.

Thus both coils will operate to cool the air and to an extent to dehumidify the air when dry bulb temperature is high. If dry bulb temperature falls to normal value and the system is kept in operation because humidity is high, the dry bulb temperature can be only slightly reduced before low-limit thermostat 61 responds and converts the second coil 15 from an evaporator coil to a condenser coil. When this occurs the suction pressure in the system drops because the compressor operates at constant speed and the total amount of refrigerant fed through the coil 14 is less than the amount of refrigerant fed through both coils 14 and 15 when they were both operating as evaporators. Consequently less heat is abstracted from the air but it is abstracted at a lower temperature so that more latent heat and less sensible heat is abstracted. This intensifies the dehumidifying effect and diminishes, but does not eliminate, the cooling effect of the coil 14. However, the sensible cooling caused by the coil 14 is counteracted by the reheating effect of the coil 15 which operates as a condenser and consequently rejects heat into the air stream.

The above operative sequences are mentioned merely as examples of operative characteristics. Since accessions of heat and moisture to the room depend on factors some of which are independent of one another, various control cycles too numerous to recount in detail will occur from time to time. Such control cycles can be readily deduced and will conform to the requirements imposed.

An important point is that the system can operate to dehumidify without substantial reduction in dry bulb temperature. This results in important economies. The humidity control is in response to "relative" humidity which is a function of dry bulb temperature. To secure the desired relative humidity, but at a lower dry bulb temperature entails an unnecessary and wasteful removal of atmospheric moisture for it does not improve comfort conditions. Hence, maintenance of the dry bulb temperature, reduces the latent heat load and improves the operative efficiency as compared to a system in which relative humidity is held constant and dry bulb temperature is reduced as an incident to dehumidification.

A further development of this idea by the use of a modifying control subject to outdoor temperatures to secure the maximum practicable economy under varying summer conditions, is a feature of the elaborated embodiment shown in Fig. 2.

Fig. 2 shows all the components of Fig. 1 with certain additions and refinements particularly in the automatic controls.

Identical parts in Fig. 2 are given the same reference numerals as in Fig. 1. Modified control elements are given the same number with the letter *a*. New components are distinctively numbered.

In this figure the thermostatic switch 61*a* is of the remote readjustable type. The thermostatic cell 61*b* is the main thermostatic element and subject to room temperature. An outdoor thermostatic bulb 61*c* modifies the control point of switch 61*a* as operated by cell 61*b*, by affecting motor 61*d*. The operating range of 61*c* may be from a low limit approximating the lowest outdoor temperature at which cooling is needed, to

a high summer temperature. The resulting adjustment of the control point is from a low value, say 74° when outdoor temperature is low, to a value slightly below the control point of thermostat 58, say 79° when outdoor temperature is high.

Thus on hot days the controls are set to take the utmost practicable advantage of the economy secured by limiting dehumidification to that essential for comfort, while on cooler days cooling and dehumidification are allowed to continue to lower values of temperature. The readjustment can, of course, be made manually, if preferred.

At the entrance end of conditioner housing 9 spray heads 62 are added. These are supplied with water under pressure through connection 63 under control of valve 64 which is biased to closed position and opened by energizing winding 65, one of whose terminals is connected to lead 57. The other terminal of the winding is connected with the middle terminal of the low limit humidostat mercury tube switch 66, whose left-hand terminal is connected with lead 56. The control point of humidostat 66 is low, say 40% relative humidity, below which value the switch shifts from the position shown in Fig. 2, counterclockwise to close a circuit from 56 to 57 through winding 65 thus opening valve 64 and operating the spray heads.

The humidostat 59a differs from humidostat 59 of Fig. 1 only in that it has a third (left-hand) contact which is connected to the right hand contact of low limit humidostatic switch 66. Thus if temperature is high, so that switch 58 energizes line 60 and humidity is low so that switch 59a is tilted counterclockwise, there will be a circuit from 56 to 60 (via switch 58) through left contact of switch 59a to right contact of switch 66 through winding 65 to line 57. This operates the sprays whenever they would perform adiabatic cooling because of high air temperature and low relative humidity.

Eliminators 67 are used to remove entrained water droplets from the air stream. A heater coil 68 is mounted in the exit end of housing 9. It might be of any controllable type, but is assumed to be a steam coil controlled by the normally closed valve 69 fed with steam by line 71 and opened by energizing winding 72. One terminal of this winding is connected with lead 57, the other with the right hand contact of thermostatic mercury tube switch 73 whose other contact is connected with lead 56. This switch closes the circuit and admits steam to coil 68 if temperature falls below a chosen point, say 70° F.

The system disclosed in Fig. 2 has the same functions as the system of Fig. 1 and certain added functions in addition to the readjustment feature above discussed. The thermostat 73 controls heating means. The low limit humidostat 66 operates the sprays 62 whenever humidity falls below a chosen low value, or whenever thermostat 58 calls for cooling and humidostat 59 does not call for dehumidification. Thus some adiabatic sensible cooling is secured by the use of the sprays during the cooling season whenever dehumidification is not required. The same sprays maintain a minimum relative humidity during the heating season.

Two specific embodiments have been described and others within the scope of the invention can be evolved by the exercise of mechanical skill.

The valves 29 and 31 conjointly perform the function of a three-way valve arranged to connect

the discharge of coil 15 selectively with lines 16 and 27, as will be obvious to those skilled in the art.

What is claimed is:

1. The method of controlling an air conditioning plant of the refrigerative circuit type in which air to be conditioned exchanges heat with two surface heat exchangers connected in said circuit, which comprises operating both exchangers as evaporators when cooling is chiefly required, and when dehumidification is chiefly required operating one exchanger as an evaporator and the other as a condenser.

2. The method of controlling an air conditioning plant of the refrigerative circuit type in which air to be conditioned exchanges heat with a first surface heat exchanger and then with a second surface heat exchanger both connected in said circuit, which comprises operating both exchangers as evaporators when cooling is chiefly required, and when dehumidification is chiefly required operating said first exchanger as an evaporator and said second exchanger as a condenser.

3. The method of controlling an air conditioning plant of the refrigerative circuit type in which air to be conditioned exchanges heat with two surface heat exchangers capable of operating as evaporators, which comprises operating both exchangers as evaporators at a normal suction pressure when cooling is chiefly required, and when dehumidification is chiefly required operating one exchanger as an evaporator at a lower suction pressure than said normal and at the same time operating the other heat exchanger as a condenser.

4. The method of controlling an air conditioning plant of the refrigerative circuit type in which air to be conditioned exchanges heat with two surface heat exchangers serially, both said exchangers being capable of operating as evaporators, which comprises operating both exchangers as evaporators at a normal suction pressure when cooling is chiefly required, and when dehumidification is chiefly required operating the exchanger first affecting the air as an evaporator at a lower suction pressure than said normal, and the other exchanger as a condenser.

5. The method of controlling an air conditioning plant of the refrigerative circuit type in which air to be conditioned exchanges heat with two surface heat exchangers capable of operating as evaporators, which comprises operating both exchangers as evaporators when cooling is chiefly required, and when dehumidification is chiefly required operating one exchanger as an evaporator and at the same time operating the other heat exchanger as a condenser, and supplying refrigerant so condensed to the exchanger which operates as an evaporator.

6. The method of controlling an air conditioning plant of the refrigerative circuit type in which air to be conditioned exchanges heat with two surface heat exchangers serially, the exchangers forming parts of said circuits, which comprises operating both exchangers as evaporators when cooling is required; when temperature in the conditioned space is depressed below normal and humidity in the conditioned space is above normal, operating the exchanger first affecting the air as an evaporator and the other exchanger as a condenser; and adjusting the permissible depression of temperature below normal according to outdoor temperature.

7. In an air conditioning system, the combi-

5 nation of a refrigerating circuit having an evaporator, and means for circulating air to be conditioned thereover, said circuit serving to absorb heat from air being conditioned through said
 10 evaporator and reject said heat; means responsive to temperature and to humidity for keeping said circuit in operation when temperature or humidity or both exceed chosen values; and temperature responsive means controlling the operative characteristics of said circuit and effective
 15 at a limiting temperature below the above named chosen value, to reduce the temperature of at least a portion of said evaporator and cause the circuit to reject heat to the conditioned air.

20 8. In an air conditioning system, the combination of a refrigerating circuit having an evaporator, and means for circulating air to be conditioned thereover, said circuit serving to absorb heat from air being conditioned through said
 25 evaporator and reject said heat; means responsive to temperature and to humidity for keeping said circuit in operation when temperature or humidity or both exceed chosen values; temperature responsive means controlling the operative characteristics of said circuit and effective
 30 at a limiting temperature below the above named chosen value, to reduce the temperature of at least a portion of said evaporator and cause the circuit to reject heat to the conditioned air; and means responsive to outdoor temperature for varying said limiting temperature.

35 9. In an air conditioner, the combination of means for circulating air to be conditioned; a refrigerative circuit including a heat exchanger in the path of circulating air; converting means for selectively establishing two operative conditions in one of which the exchanger serves as a refrigerative evaporator to abstract heat and in the other of which a portion of the exchanger
 40 serves as a refrigerative evaporator to abstract heat, and another portion serves as a condenser to reject heat to the circulating air; and means responsive to the temperature of conditioned air for controlling said converting means.

45 10. In an air conditioner, the combination of means for circulating air to be conditioned; a refrigerative circuit including a heat exchanger in the path of circulating air; converting means for selectively establishing two operative conditions in one of which the exchanger serves as a refrigerative evaporator to abstract heat and in the other of which a portion of the exchanger serves as a refrigerative evaporator to abstract heat, and another portion serves as a condenser
 50 to reject heat to the circulating air; means responsive to the temperature of conditioned air for controlling said converting means; and means responsive to outdoor temperature serving to vary the temperature at which the last-named means
 55 actuates said converting means.

60 11. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a constant speed compressor; a condenser; and means for connecting said exchangers in circuit with said compressor and condenser, in two relations, in one of which both exchangers operate as evaporators, and in the other of which one operates as an evaporator
 65 and the other as a condenser.

70 12. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchanging relation with one of said conditioners and then with the other thereof; a constant speed compressor;
 75

a condenser; and means for connecting said exchangers in circuit with said compressor and condenser in two relations, in one of which both exchangers operate as evaporators, and in the other of which the exchanger which first affects the air operates as an evaporator and the other exchanger operates as a condenser.

13. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a constant speed compressor; a condenser; means for connecting said exchangers in circuit with said compressor and condenser in two relations, in one of which both exchangers operate as evaporators, and in the other of which one operates as an evaporator and the other as a condenser; and means for supplying refrigerant condensed in the last-named exchanger to the other exchanger.

14. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a compressor; a condenser into which said compressor discharges; a suction line connecting one of said exchangers with the suction of the compressor; valve means for selectively connecting the other of said exchangers with the suction and with the discharge of said compressor; and two automatic expansion valves arranged to feed liquid refrigerant from said condenser to respective exchangers, said expansion valves including temperature responsive means subject to temperature in the suction line and pressure responsive means subject to pressure in the respective related exchangers.

15. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a constant speed compressor; a condenser into which said compressor discharges; a suction line connecting one of said exchangers with the suction of the compressor; valve means for selectively connecting the other of said exchangers with the suction and with the discharge of said compressor; two automatic expansion valves arranged to feed liquid refrigerant from said condenser to respective exchangers, said expansion valves including temperature responsive means subject to temperature in the suction line and pressure responsive means subject to pressure in the respective related exchangers; and means for feeding liquid refrigerant from said other exchanger to the first named exchanger.

16. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a compressor; a condenser into which said compressor discharges; a suction line connecting one of said exchangers with the suction of the compressor; valve means for selectively connecting the other of said exchangers with the suction and with the discharge of said compressor; two automatic expansion valves arranged to feed liquid refrigerant from said condenser to respective exchangers, said expansion valves including temperature responsive means subject to temperature in the suction line and pressure responsive means subject to pressure in the respective related exchangers; and a high side float valve for discharging liquid refrigerant condensed in said other exchanger to the first named exchanger.

17. In an air conditioner, the combination of two surface heat exchangers; means for circu-

lating air to be conditioned in heat exchange relation with said exchangers; a compressor; a condenser; means for connecting said exchangers in circuit with said compressor and condenser in two relations, in one of which both exchangers operate as evaporators and in the other of which one operates as an evaporator and the other as a condenser; controlling means responsive to temperature and to humidity, arranged to stop said compressor when humidity and temperature are both normal and to run said compressor when either or both humidity and temperature are high; and temperature responsive means functionally related to said controlling means and in conjunction therewith controlling the means for connecting the exchangers to establish the second-named relation when humidity is high and temperature concurrently falls below normal and to establish the first-named relation at other times.

18. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a constant speed compressor; a condenser; means for connecting said exchangers in circuit with said compressor and condenser in two relations, in one of which both exchangers operate as evaporators and in the other of which one operates as an evaporator and the other as a condenser; controlling means responsive to temperature and to humidity, arranged to stop said compressor when humidity and temperature are both normal and to run said compressor when either or both humidity and temperature are high; and temperature responsive means functionally related to said controlling means and in conjunction therewith controlling the means for connecting the exchangers to establish the second-named relation when humidity is high and temperature concurrently falls below normal and to establish the first-named relation at other times.

19. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a compressor; a condenser; means for connecting said exchangers in circuit with said compressor and condenser in two relations, in one of which both exchangers operate as evaporators and in the other of which one operates as an evaporator and the other as a condenser; controlling means responsive to temperature and to humidity, arranged to stop said compressor when humidity and temperature are both normal and to run said compressor when either or both humidity and temperature are high; temperature responsive means functionally related to said controlling means and in conjunction therewith controlling the means for connecting the exchangers to establish the second-named relation when humidity is high and temperature concurrently falls below normal and to establish the first-named relation at other times; and means responsive to outdoor temperature, and serving to adjust the control point of the last-named temperature responsive means.

20. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a compressor; a condenser; means for connecting said exchangers in circuit with said compressor and condenser in two relations, in one of which both exchangers operate as evaporators and in the other of which one operates as an evaporator and the other as

a condenser; controlling means responsive to temperature and to humidity, arranged to stop said compressor when both humidity and temperature do not exceed normal and to run said compressor at other times; temperature responsive means functionally related to said controlling means and in conjunction therewith controlling the means for connecting the exchangers to establish the second-named relation when humidity is above normal and temperature concurrently is below normal and to establish the first-named relation at other times at least when the compressor runs; normally inactive means for spraying water into the air approaching said heat exchangers; and means responsive to humidity and serving when humidity is abnormally low to cause said spraying means to operate.

21. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a compressor; a condenser; means for connecting said exchangers in circuit with said compressor and condenser in two relations, in one of which both exchangers operate as evaporators and in the other of which one operates as an evaporator and the other as a condenser; controlling means responsive to temperature and to humidity, arranged to stop said compressor when both humidity and temperature do not exceed normal and to run said compressor at other times; temperature responsive means functionally related to said controlling means and in conjunction therewith controlling the means for connecting the exchangers to establish the second-named relation when humidity is above normal and temperature concurrently is below normal and to establish the first-named relation at other times at least when the compressor runs; normally inactive means for spraying water into the air approaching said exchangers; and means responsive to humidity and operatively related to said controlling means for operating said sprays when humidity is abnormally low and also when humidity is normal and temperature is high.

22. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a compressor; a condenser; means for connecting said exchangers in circuit with said compressor and condenser in two relations, in one of which both exchangers operate as evaporators and in the other of which one operates as an evaporator and the other as a condenser; controlling means responsive to temperature and to humidity, arranged to stop said compressor when both humidity and temperature do not exceed normal and to run said compressor at other times; temperature responsive means functionally related to said controlling means and in conjunction therewith controlling the means for connecting the exchangers to establish the second-named relation when humidity is above normal and temperature concurrently is below normal and to establish the first-named relation at other times at least when the compressor runs; normally inactive means for supplying heat to the circulating air; and means responsive to an abnormally low temperature for rendering the last-named means active.

23. In an air conditioner, the combination of two surface heat exchangers; means for circulating air to be conditioned in heat exchange relation with said exchangers; a compressor; a condenser; means for connecting said exchangers

in circuit with said compressor and condenser in two relations, in one of which both exchangers operate as evaporators and in the other of which one operates as an evaporator and the other as a
 5 condenser; controlling means responsive to temperature and to humidity, arranged to stop said compressor when both humidity and temperature do not exceed normal and to run said compressor at other times; temperature responsive means
 10 functionally related to said controlling means and in conjunction therewith controlling the means for connecting the exchangers to establish the second-named relation when humidity is above normal and temperature concurrently is below normal and to establish the first-named relation at other times at least when the compressor runs; normally inactive means for spraying water into the air approaching said heat exchangers; means responsive to humidity and serving when humidity is abnormally low to cause said sprays to operate; normally inactive means for supplying heat to the circulating air; and means responsive to an abnormally low temperature for rendering the last-named means active.

24. In an air conditioning system, the combination of a refrigerating circuit including a compressor operated at substantially uniform capacity, an evaporator and means for circulating air to be conditioned thereover, said circuit serving to absorb heat from the air being conditioned through said evaporator and reject said heat; means responsive to relative humidity arranged to cause and suspend the operation of said circuit as relative humidity passes above and below a chosen value; means operable to limit the total liquid refrigerant supplied to said evaporator, whereby at least a portion of the evaporator will be caused to operate at an abnormally low suction pressure; and means responsive to reduction of temperature of the conditioned air below a limiting temperature serving to cause the circuit to deliver rejected heat to the air after its heat exchange with the evaporator, and serving also to operate said liquid refrigerant supply limiting means.

25. In an air conditioning system the combination of a refrigerating circuit including a compressor operated at substantially uniform capacity, an evaporator and means for circulating air
 50 to be conditioned thereover, said circuit serving

to absorb heat from the air being conditioned through said evaporator and reject said heat; means responsive to temperature and to relative humidity arranged to cause operation of said circuit when temperature or relative humidity or both exceed chosen values and to suspend the operation of said circuit when both are below such values; means operable to limit the total liquid refrigerant supplied to said evaporator, whereby at least a portion of the evaporator will be caused to operate at an abnormally low suction pressure; and means responsive to reduction of temperature of the conditioned air below a chosen temperature lower than the above-named temperature value to cause the circuit to deliver
 10 rejected heat to the conditioned air and serving also to operate said liquid refrigerant supply limiting means.

26. In a system for conditioning air in an enclosed space, the combination of means forming
 20 an air conditioning passage leading from and back to said space; means for passing air to be conditioned therethrough; a refrigeration system including an evaporator arranged to withdraw heat from air flowing through said passage, condensing means including an exchanger operable to return a part of the heat rejected from the system to air flowing through said passage, controllable operating means for withdrawing refrigerant from said evaporator and delivering it at
 25 higher pressure to said condensing means; means operable to cause said evaporator to operate at an abnormally low pressure and to cause said exchanger to deliver heat to the air; control means responsive to conditions in said space and comprising temperature responsive and humidity responsive means; and connections whereby said control means controls the operating means for the refrigerating system and also controls the means to cause the evaporator to operate at abnormally low pressure and the exchanger to deliver heat to the air, so arranged that the refrigerating system operates when either temperature or humidity is high, and the evaporator is operated at abnormally low pressure and the exchanger delivers heat to the air when the humidity is high and temperature is below a chosen value lower than that at which the control means causes the refrigerating system to operate.

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