

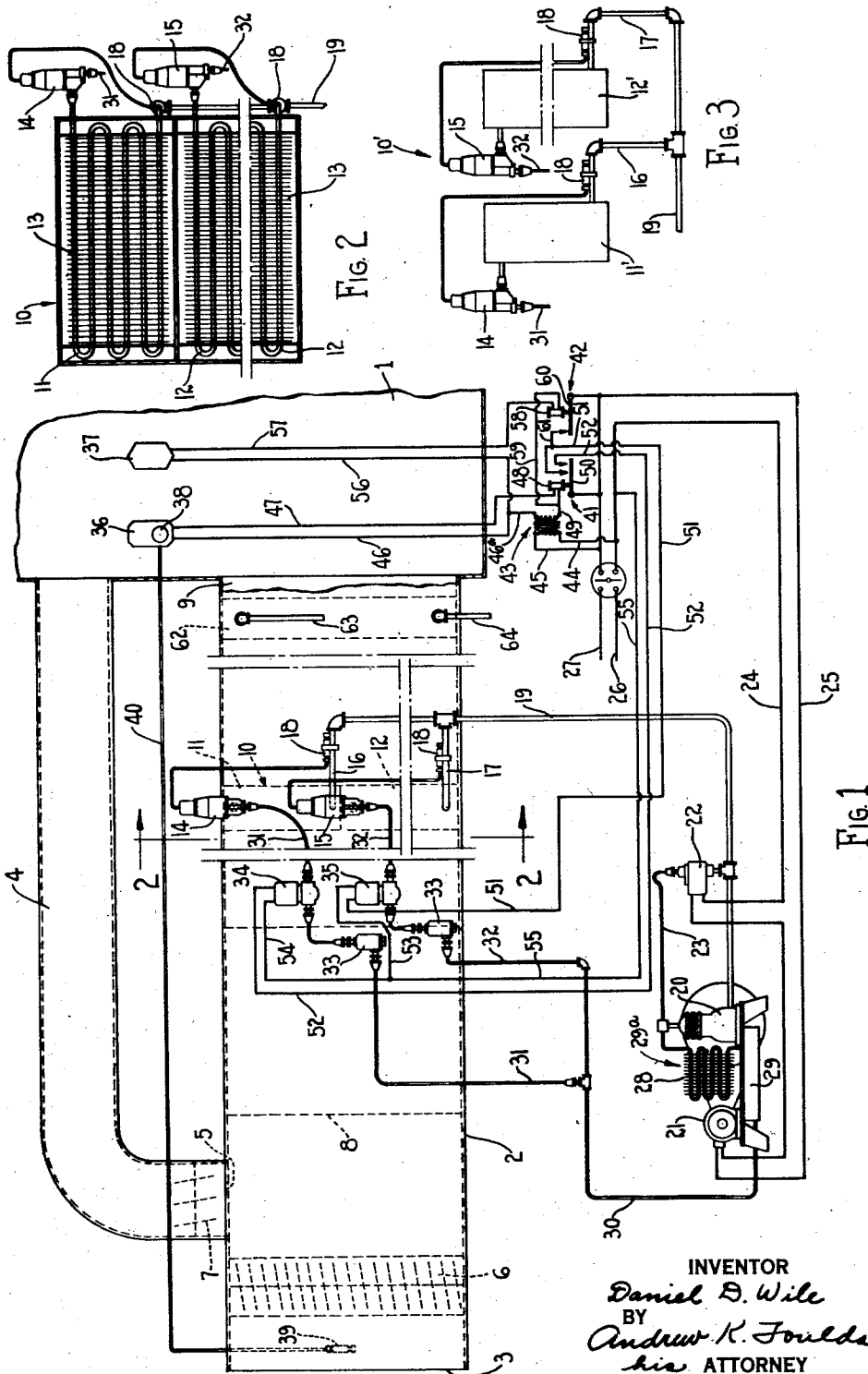
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APPARATUS FOR CONDITIONING AIR

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APPARATUS FOR CONDITIONING AIR

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This invention relates to the treatment of air for supply to an enclosed space or room for human occupancy, and more particularly to an apparatus for controlling the cooling and dehumidification of the air.

In cooling the air within a room, it is desirable to keep the room air temperature within a predetermined increasing differential and below the temperature of the outside air as the outside air temperature rises, so that upon entering or leaving the space individuals will not be subjected to too great a temperature change, and this is accomplished by the herein disclosed apparatus.

It is also desirable to maintain the moisture content of the air below a predetermined relative humidity to avoid a damp cold in the room and it is therefore another object of the invention to eliminate moisture from the air supplied to the room by the use of cooling means affecting a portion only of the supplied air stream.

Another object of the invention is to provide means for automatically maintaining the air within the room at a predetermined increasing differential of temperature below the temperature of the outside air as the outside air temperature rises, and to regulate automatically the removal of excess moisture from the supplied air.

Another object is to provide for dehumidification of a portion of an air stream without resort to mechanical means for dividing the stream.

Another object is to provide both controlled cooling and controlled dehumidification of an air stream by means of refrigeration.

The invention consists of a novel apparatus for controlling the temperature and moisture content of the air in an enclosed space, all of which will be more particularly described hereinafter and the novelty of which will be particularly pointed out and distinctly claimed.

In the accompanying drawing, to be taken as a part of this specification, certain apparatus by which the method can be performed is fully and clearly illustrated, in which drawing—

Figure 1 is a diagrammatic view of an air conditioning apparatus embodying the invention and having certain parts shown in side elevation;

Fig. 2 is a detail view in section on the line 2—2 of Fig. 1, and

Fig. 3 is a detail, partially diagrammatic view of a modified conditioning means.

Referring to the drawing by characters of reference, the numeral 1 designates a room or other enclosed space for human occupancy which is provided with an air supply duct or conduit 2 having an inlet 3 for outside or fresh air and

having an outlet return air duct or conduit 4 leading from the room and discharging into the supply duct 2, as at 5. The supply duct 2, anterior to its connection with the return duct 4, is provided with a control damper 6 which may be manually or automatically operated and may be operated differentially with a control damper 7 in the return duct 4. Duct 2 contains an air impelling means 8 such as a fan or blower for drawing air from the inlet 3 and return duct 4 and discharging it through the outlet 9 of conduit 2 into the room 1. Also within the duct 2 and on the discharge side of the means 8 there is a heat abstracting means generally designated 10, which is more clearly shown in Fig. 2. This means 10 comprises the low side or evaporator of a refrigerating apparatus and preferably includes two separate coils 11, 12, each of which has heat absorbing fins or extended surfaces 13. The coil 11 is positioned above and in the plane of the coil 12 and the coils together extend across and preferably substantially fill the interior of the duct 2 so that all of the air supplied to the room 1 passes through and in heat exchange relation with the coils. The coil 12 is the moisture removing coil and its capacity for dehumidification is determined in accordance with air conditioning practice so as to have the temperature of the dehumidifying coil 12 maintained just above freezing temperature. This design will give the maximum of moisture removing capacity with the minimum of sensible cooling of the air, although the efficiency of the condensing unit to be hereinafter described may be somewhat lower while operating on coil 12 alone. Coil 11 is so designed that when used in conjunction with coil 12 the maximum sensible cooling and maximum efficiency of the condensing unit is reached. With this arrangement, on a hot day the system will satisfactorily cool the space 1 while on a relatively cooler day, but one having high relative humidity, the space or room 1 will be maintained at a desired, predetermined, relative humidity and temperature. The coils 11, 12 are provided with thermostatic expansion valves 14, 15 respectively for controlling the supply of refrigerant or refrigerant medium to the coil inlets. Each valve is controlled by the pressure of the refrigerant medium in its respective coil and the temperature of the refrigerant medium adjacent the evaporator outlet in the respective return line or conduits 16, 17, as reflected by a temperature responsive volatile liquid containing bulb element 18. The conduits 16, 17 are communicatively connected to a common return or suction con-

duit 19 which is connected to the inlet of compressor 20 driven by an electric motor 21. The operation of the compressor 20 is under the control of a suction-pressure responsive, electric switch 22 having a pressure responsive element (not shown) subject to pressure in the refrigerant return conduit 19 and operable to prevent refrigerant from going below a predetermined minimum temperature. The switch 22 has a high pressure cutout for opening the switch if the high side or discharge pressure of the compressor 20 becomes too high, a pressure line 23 being shown for this purpose. This switch 22 may be of the type shown in the patent to Dillman, No. 2,080,169, dated May 11, 1937, for example. The motor 21 is supplied with electrical energy by lead wires 24, 25, the switch 22 controlling current flow through the wire 24 and being in series circuit with the motor. The wires 24, 25 are connected to the service line wires 26, 27 respectively or to any other suitable source of electrical energy supply. The compressor 20 discharges the high pressure vapor into a condenser 28, wherein it is cooled and liquefied and the liquid flows into a receiver 29. The compressor 20, motor 21, condenser 28 and receiver 29 form a condensing unit 29^a which is the means for refrigerating the coils 11, 12 by removing the refrigerant vapor and by supplying the liquid refrigerant from receiver tank 29 through a liquid refrigerant outlet line or conduit 30 communicating with and supplying liquid refrigerant to branch conduits or pipes 31, 32. The expansion valves 14, 15 have their inlets connected respectively to the branch conduits 31, 32, each of which conduits contains a strainer element 33. Refrigerant flow through the branch conduits is controlled by automatically operable remote control valves 34, 35 respectively, these valves preferably being electrically energized, solenoid type cut-off valves and which are in closed position when deenergized.

The supply of refrigerant medium to the coils 11 and 12 is under the control of a differential temperature responsive switch 36, the supply to coil 12 also being under the control of a humidistat or hygroscopic switch 37, which switches are positioned in the room 1. The switch 36 may be such as is shown in the patent to Eggleston and Dillman, No. 2,044,729, dated June 16, 1936, and the switch 37 may be such as is shown in the patent to Eggleston, No. 2,031,408, dated Feb. 18, 1936. The switch 36 has a power element 38 responsive to dry bulb temperature in the room 1 and a second power element responsive to the dry bulb temperature of the inlet air in the duct 2 as reflected by a thermostatic bulb or feeler element 39 positioned in the inlet portion of duct 2 and communicating with the switch 36 by a pressure conveying tube 40 so that the switch 36 is operated in accordance with changes in the differential between the dry bulb temperatures within the room 1 and the outside atmosphere. The switch 36 operates to make circuit when the indoor temperature reaches a predetermined degree, for example, 77° F. when the outdoor temperature is at 85° F., but will make circuit at a lower indoor temperature with a lower outdoor temperature, such for example as 75° F. indoor temperature and 77° F. outside temperature. The hygroscopic switch 37 may be set for about 50% relative humidity and will operate to make circuit if there is an increase in relative humidity above this setting of 50% within the room 1. The valves 34, 35 are controlled for simultaneous operation by a relay switch 41 controlled by the

thermostatic switch 36. The valve 35 is also operable independently of the valve 34 under the control of a relay switch 42 which is controlled by the hygroscopic switch 37. The relay switches are supplied with electrical energy by a transformer 43 having its primary connected across the service line wires 26, 27 by lead wires 44, 45 respectively. A lead wire 46 and its extension 46^a connects the transformer secondary to one side of switch 36 and from the other side of the switch 36 the lead wire 47 connects to the relay coil 48 from which a lead wire 49 extends to the transformer secondary. The relay switch 41 has an armature 50 connected to the service wire 27 and which is simultaneously engageable upon energization of coil 48 with contacts or lead wires 51, 52 which are connected respectively to the solenoid coils of valves 35 and 34 from which lead wires 52, 54 respectively are connected to a common return wire 55 which is electrically connected to the service wire 26. Leading from the transformer secondary lead wire 46^a to one side of the hygroscopic switch 37 there is a lead wire 56, and connected to the other side of the switch there is a lead wire 57 which connects to the coil 58 of relay 42, a wire 59 being connected from the coil to the lead wire 49 thus completing the circuit to the transformer secondary. The relay 42 has an armature 60 connected to the service wire 27 and cooperable with the terminal of a lead wire 61 connected to the lead wire 51 of valve 35.

In the duct 2 on the outlet side of the heat abstracting means 10 there may be provided a heat exchanger 62 having supply and return pipes 63, 64 respectively for flow of steam or other suitable heating medium through the coils of the exchanger 62. This heating means 62 is provided in order to increase the temperature of the dehumidified air should its temperature become too low.

In Fig. 3, the coils of the heat abstracting means 10' are designated 11', 12' respectively, and are set in tandem relation so that all of the air passing through the duct will pass through each of the coils as distinguished from the showing in Fig. 1 wherein part of the air flows over the coil 11 and the remainder flows over the coil 12. As in Fig. 1, the coil 12' is here shown as of variable size to provide the proper amount of surface area for dehumidification.

The method of operation of the apparatus of Figs. 1 and 2 is as follows: With the blower 8 in operation and the switches 36 and 37 satisfied, that is, each in open circuit position, the valves 34, 35 will be closed and the reduction in return line 19 of the refrigerant medium pressure by compressor operation will have operated switch 22 to stop the compressor motor 21. If now the temperature in the room 1 should increase or the outdoor temperature affecting the bulb element 39 should decrease, the switch 36 will be closed, completing the circuit through lead wires 46, 47 to relay coil 48 from the transformer secondary, thereby completing the circuit at relay armature 50 through parallel lead wires 51, 52 and return wire 55 to energize the solenoid valves 34, 35 and permit refrigerant medium to flow through the expansion valves 14, 15 to the coils 11, 12. The heat abstracting means 10 will thus be refrigerated and will sensibly cool the air fed by blower 8 and discharged through outlet 9 into the room 1. When the valves 34, 35 open, the low side pressure will increase due to evaporation of the refrigerant

in the heat abstracting means 10 and when the pressure in the return line 19 reaches the desired cut-in pressure, the switch 22 will close and start operation of the compressor 20, the refrigerating apparatus then continuing to function so long as the pressure in the line 19 is above that for which the control is set to stop the operation of the compressor 20. If during the time that the switch 36 is calling for a decrease of temperature of the air in room 1, the humidostat or switch 37 sensitive to the relative moisture content of the room air should be closed by the occurrence of predetermined relative humidity, no change in operation results but if the humidostat 37 remains closed when the switch 36 is opened by reaching the predetermined air temperature for which switch 36 is set to operate, then the valve 35 will remain open and the refrigerating apparatus will remain in operation, with refrigerant medium being supplied only to the coil 12. The operation of the refrigerating apparatus on coil 12 alone will by reason of the capacity of the coil 12 and of the compressor 20 be at a substantially lower temperature than when both coils 12 and 11 are in use. The air flowing through coil 12 will have more moisture or latent heat removed therefrom because of the low temperature at which the coil 12 is operating than would be removed from the entire air stream should both coils be cooling at the higher temperature and by remixing the air streams the temperature of the outlet air through outlet 9 is above the temperature and contains less moisture than it would contain if both coils were operating. When the relative humidity of the air in the room 1 drops to the desired predetermined percentage, the humidostat or switch 37 will open and thereby open the relay switch 42 to allow the solenoid valve 35 to close and stop further flow of refrigerant to the coil 12. This will stop further abstraction of heat from the air supplied to room 1 and the switch 22 will operate to stop the compressor 20. Should the thermostatic switch 36 be satisfied when the relative humidity of the room increases sufficiently to close switch 37, then this closure of switch 37 will act through its relay 42 to open the valve 35 and start operation of the refrigerating apparatus in the manner above described.

The operation of the apparatus shown in Fig. 3 will be apparent from the foregoing description of Fig. 1. However, in this form the air stream is not divided and therefore there is no reheating of the dehumidified air by mixture of the dehumidified air with a portion of the air stream which by-passes the dehumidifying coil. During the dehumidifying operation, the air flowing through the operating coil 12' and non-operating coil 11' of the heat abstracting means 10' will be in heat abstracting relation with means 10' for a shorter period of time and consequently the total air will be cooled to a lesser extent. The air flowing through the coil 12' may be considered as being composed of a number of separate layers or streams adjacent one to the other. The layer or stream coming directly in contact with the coil 12' of the abstracting means 10', which is operating at a lower temperature than when coil 11' is operating, will be in good heat exchange relationship with the coil 12' and the moisture will be removed from this layer to a great extent. The air which is further away from the cooling surfaces, that is, which is separated therefrom by the dehumidi-

fied layer, has a greater resistance of heat transfer and this insulated layer or stream of air will not be cooled as much as will the air in direct contact with the coil 12'. As the streams or layers mix after leaving the abstracting means 10', they will form an air stream containing less moisture and the stream will be at a higher temperature than would be the case with coils 11' and 12' both operating.

With the above described arrangement, I can automatically maintain comfortable air conditions within an enclosed space efficiently and economically with a minimum of equipment and operating expense, regardless of the variation of temperature and relative humidity of the supplied air.

What I claim and desire to secure by Letters Patent of the United States is:

1. In an air conditioning system, in combination, a refrigeration system including compressor means and a pair of evaporators for removing sensible and latent heat from air to be conditioned, means for circulating air past said evaporators, a first valve for controlling the flow of refrigerant into one evaporator, a second valve for controlling the flow of refrigerant into the other evaporator, temperature responsive means for opening both of said valves upon demand for cooling, humidity responsive means connected to open one only of said valves upon maximum demand for dehumidification, both of said valves being closed when there is no demand for cooling or dehumidification.

2. In an air conditioning apparatus, duct means for supplying air to an enclosed space, a plurality of cooling coils extending across the interior of said duct means, said coils jointly having sufficient cooling surface to reduce the sensible heat of the air passing through said duct means, a main conduit for supplying refrigerant medium to said coils and having a plurality of branch conduits connected respectively one to each of said coils, a valve in each of said branch conduits, thermostatic means for controlling said valves and having one portion exposed to the air in said space and a second portion exposed to the air outside of said space, said thermostatic means being arranged to open said valves upon a rise in temperature of the air on one of said portions, one of said coils having a predetermined surface of sufficient extent to dehumidify the air passing through said duct means, means responsive to the relative humidity of the air in the space and operatively connected to the valve controlling the refrigerant medium supply to said one coil and acting when the relative humidity of the air is above a desired percentage to open said one valve, means to supply refrigerant medium to said main conduit, suction conduit means connecting the outlet of said coils to said supply means, and pressure responsive means sensitive to the pressure in said suction conduit means to control the operation of said supply means.

3. In an air conditioning system, in combination, a refrigeration system including compressor means and a pair of evaporators for removing sensible and latent heat from air to be conditioned, means for circulating air past said evaporators, a first valve for controlling the flow of refrigerant into one of said evaporators, a second valve for controlling the flow of refrigerant into the other of said evaporators, temperature responsive means for opening both of said valves

upon demand for cooling, humidity responsive means connected to open one only of said valves upon maximum demand for dehumidification, both of said valves being closed when there is no demand for cooling or dehumidification, and means responsive to the opening of one of said valves for placing said compressor into operation, said last-named means acting to place said compressor out of operation when both of said valves are closed.

4. In an air conditioning system, in combination, a refrigeration system including compressor means and a pair of evaporators for removing sensible and latent heat from air to be conditioned, means for circulating air past said evaporators, a first valve for controlling the flow of refrigerant into one evaporator, a second valve for controlling the flow of refrigerant into the other evaporator, temperature responsive means for opening both of said valves upon demand for cooling, humidity responsive means connected to open one only of said valves upon maximum demand for dehumidification, both of said valves being closed when there is no demand for cooling or dehumidification, and means operable in response to increased pressure of evaporated refrigerant subsequent to opening of one or both of said valves to start operation of said compressor means.

5. In an air conditioning system, in combination, an air supply duct, a refrigeration system including compressor means and a pair of evaporators positioned side by side in said duct for removing sensible and latent heat from air to be conditioned, one of said evaporators extend-

ing across a portion of said duct and the other of said evaporators extending across the remaining portion of said duct, means for circulating air through said evaporators, a first valve for controlling the flow of refrigerant into one evaporator, a second valve for controlling the flow of refrigerant into the other evaporator, temperature responsive means for opening both of said valves upon demand for cooling, humidity responsive means connected to open one only of said valves upon maximum demand for dehumidification, both of said valves being closed when there is no demand for cooling or dehumidification.

6. In an air conditioning system, in combination, a refrigeration system including compressor means and a pair of evaporators for removing sensible and latent heat from air to be conditioned, means for circulating air past said evaporators, a first valve for controlling the flow of refrigerant into one evaporator, a second valve for controlling the flow of refrigerant into the other evaporator, temperature responsive means for opening both of said valves upon demand for cooling and having a pair of control elements, one of said elements being positioned in the space to be cooled and the other of said elements being positioned external of the space, humidity responsive means connected to open one only of said valves upon maximum demand for dehumidification, both of said valves being closed when there is no demand for cooling or dehumidification.

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