

Nov. 7, 1950

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2,528,720

AIR CONDITIONING APPARATUS FOR HEATING AND COOLING

Filed July 3, 1946

3 Sheets-Sheet 1

Fig. 1.

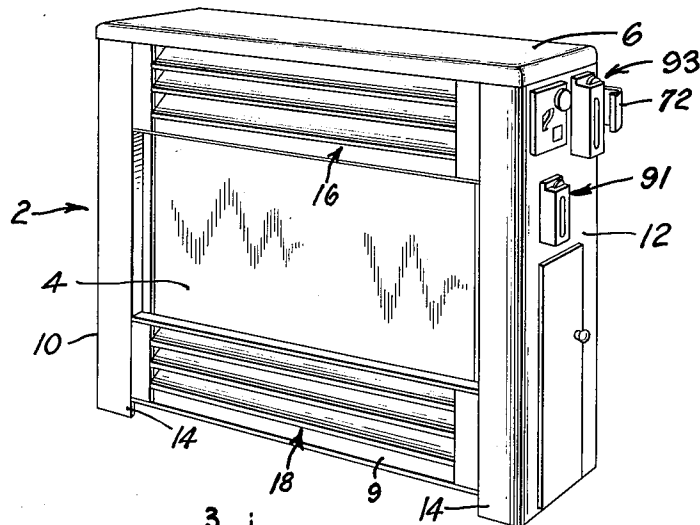
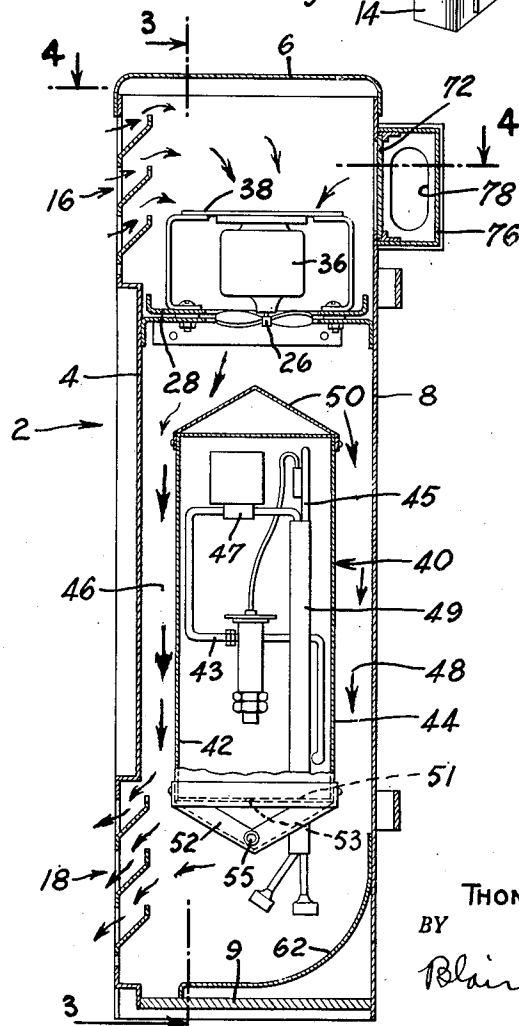


Fig. 2.



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3 Sheets-Sheet 2

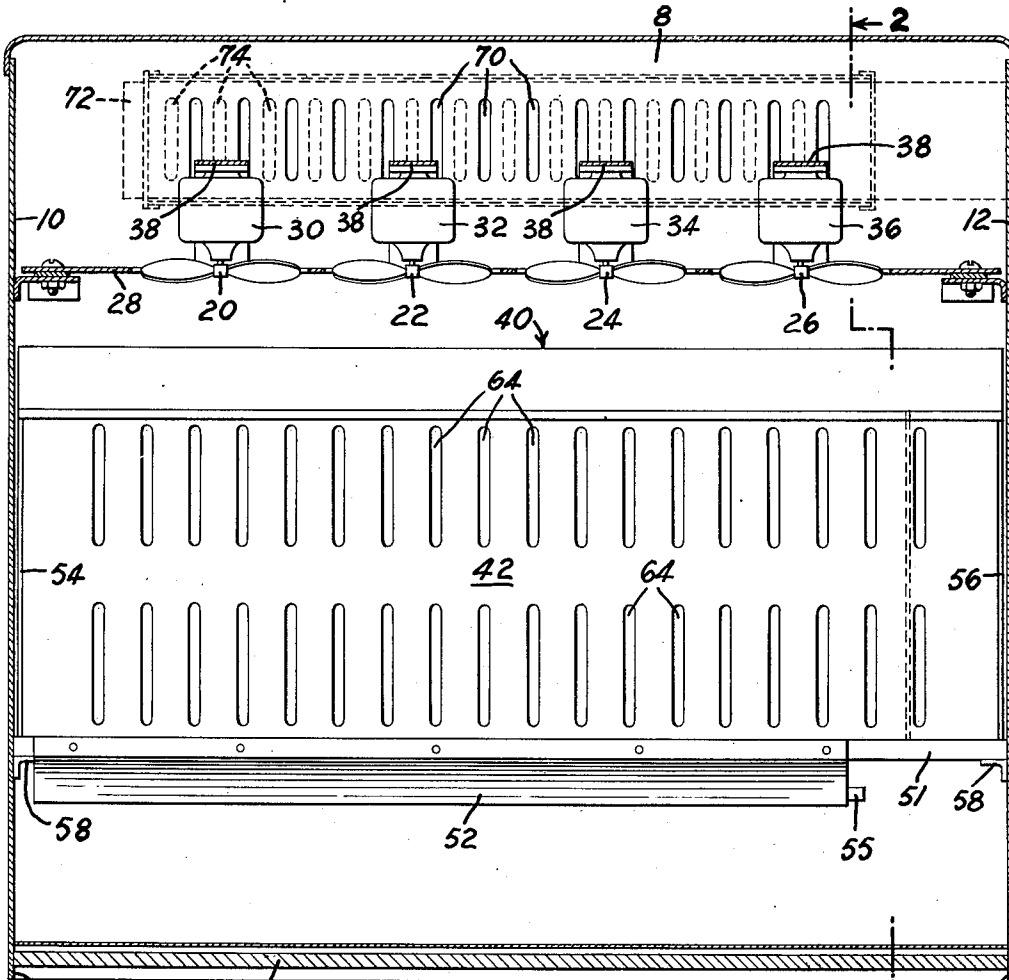


Fig. 3.

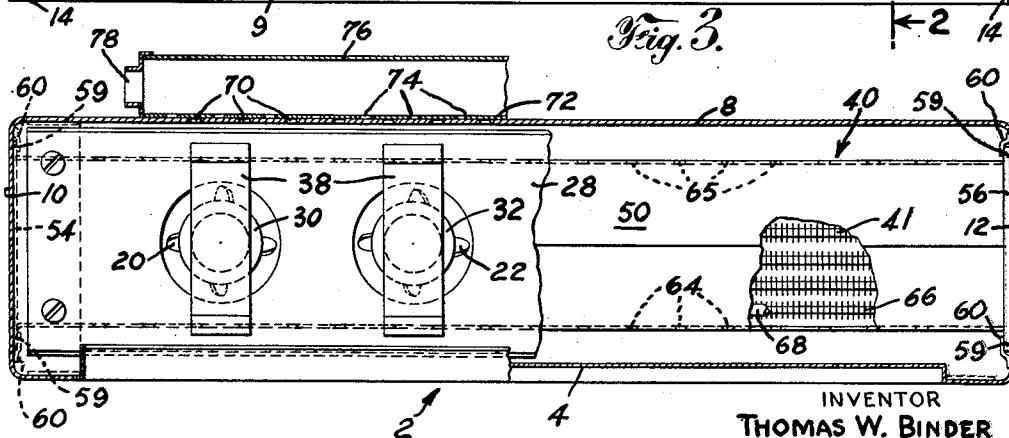


Fig. 4.

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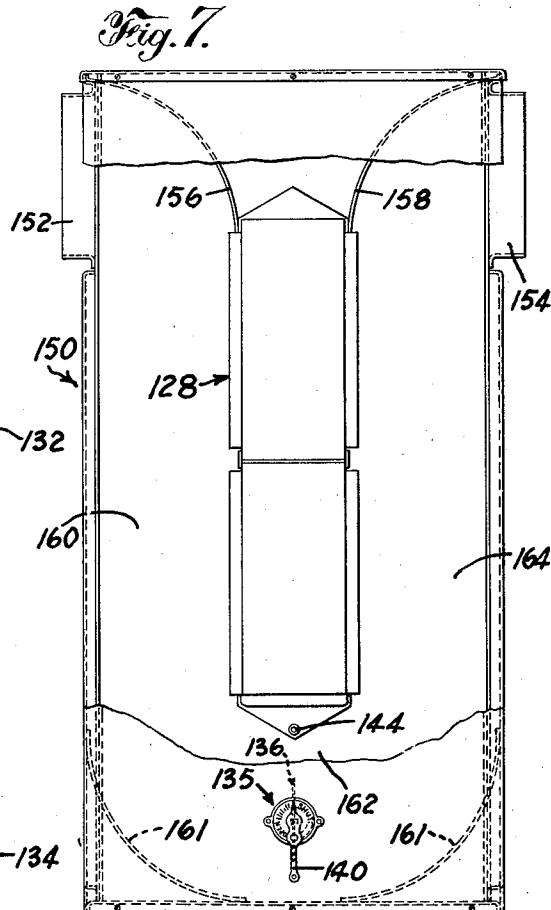
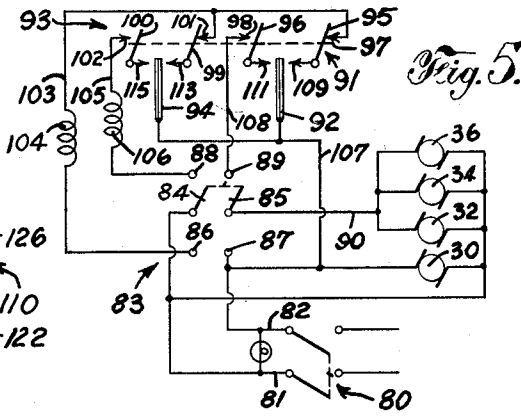
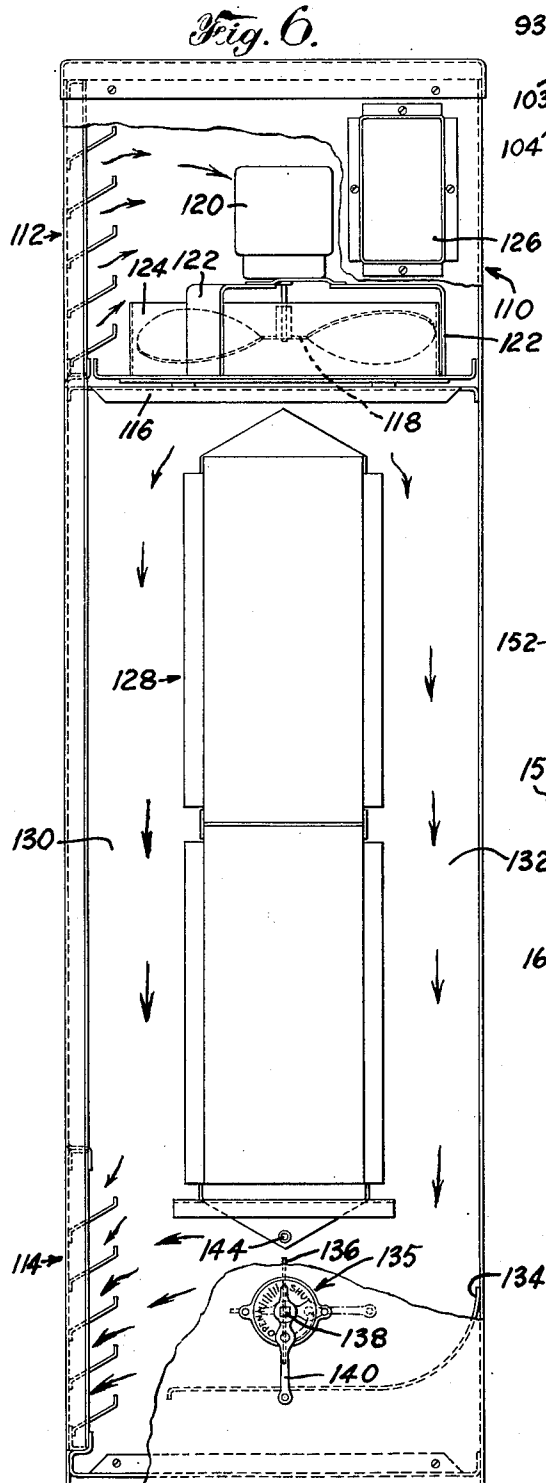
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AIR CONDITIONING APPARATUS FOR HEATING AND COOLING

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3 Sheets-Sheet 3



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## UNITED STATES PATENT OFFICE

2,528,720

AIR CONDITIONING APPARATUS FOR  
HEATING AND COOLING

Thomas W. Binder, Maplewood, N. J.

Application July 3, 1946, Serial No. 681,239

17 Claims. (Cl. 257—3)

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This invention relates to air conditioning, and, more particularly, to controlling the humidity and temperature conditions in an enclosed space.

An object of this invention is to provide for the independent control of humidity and temperature conditions in a room or other enclosure, for example, by units which are positioned within the enclosure. A further object is to provide a unified control system for air conditioning units, such, for example, as where the humidity or temperature, or both, are controlled. A further object is to provide for the alternative heating or humidifying of the air. A still further object is to provide in such a system for the addition of a fresh stream of outside air; that is, air taken from outside the conditioned space. A further object is to provide a method and apparatus for carrying out the above which are practical, efficient and dependable. These and other objects will be in part obvious and in part pointed out below.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the drawings:

Figure 1 is a perspective view of one embodiment of the invention;

Figure 2 is a vertical section on the line 2—2 of Figure 3;

Figure 3 is a vertical section on the line 3—3 of Figure 2;

Figure 4 is a stepped horizontal with parts broken away section on the line 4—4 of Figure 2;

Figure 5 is a schematic electrical circuit diagram of the control system of the embodiment of Figures 1 to 4; and

Figures 6 and 7 are vertical sections of the heat-exchange and dehumidifying units of two other embodiments of the invention.

The invention herein disclosed relates to the invention disclosed in my copending application, Serial Number 538,042, filed May 30, 1944, now Pat. No. 2,405,812, granted August 13, 1946, of which the present application is a continuation-in-part. The present application is concerned primarily with compact, self-contained air conditioning units of the types which are positioned in and outside the air conditioned space. With the illustrative embodiments of the invention a stream of air is passed through the air conditioning unit, and this stream may be derived wholly

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from the air conditioned space or partially from the outside.

The term "air conditioning" has been loosely applied to many methods of treating air but it is more commonly applied to applications where air is cooled and its humidity is regulated. Even though it is recognized that humidity is a very important factor in obtaining comfort, far too little emphasis has been given to humidity control. In practice it is known that the average person is comfortable even though the temperature and humidity vary over a rather wide range. However, the humidity and temperature should be considered together in order to stay within the "comfort zone"; that is, a rather high temperature will appear comfortable to the average person if the humidity is low, whereas a much lower temperature will appear uncomfortable at high humidity.

As the temperature rises in a room where there are people, the evaporation of perspiration and the expelled vapor causes a rise in humidity, and in order to maintain a condition of comfort the moisture should be removed from the air; it is true that cooling alone will give some temporary relief but the moisture must be removed if continued comfort is desired. In the past, temperature and humidity have been considered together and it has been conventional with some systems to simultaneously cool air and dehumidify it by passing it into direct contact with cold surfaces or liquids. These prior systems are costly to install and operate and they are often quite unsatisfactory because they give excessive cooling when, for example, dehumidification only is desirable.

It is an object of the present invention to provide a solution to the above problems with a simple system wherein the temperature and humidity of the air are controlled independently. By doing this primary consideration may be given to the control of the humidity so that moisture can be removed from the air without any substantial cooling of the air. Furthermore, with the illustrative systems the air may be dehumidified and cooled with the same apparatus that is used for dehumidifying the air and yet complicated controls are unnecessary. In the illustrative embodiments of the invention the moisture is removed from the air by creating a low vapor-pressure zone to which the moisture passes and in which it is condensed. This low vapor-pressure zone is produced in a refrigerated cold chamber where the air is more or less stratified, and the moisture enters this stratified air due to the low vapor-pressure condition. The cold chamber

has an opening or a number of openings through which the moisture passes from the high-humidity, warm air to the low vapor-pressure stratified air in the cold chamber but the air which is being dehumidified does not pass through the cold chamber. The cold chamber may be positioned within the air conditioned chamber, or it may be positioned outside the air conditioned chamber and connected thereto by air ducts through which air is directed by a suitable fan. The air is passed in a stream along the side of the cold chamber and the moisture leaves the warm air and passes into the cold chamber.

In accordance with the present invention, the air in the air conditioned space may be dehumidified, cooled, heater, or humidified, all in accordance with the need. For example, normally during the summer months the main effect is that of dehumidifying, but there is some sensible cooling of the air; and in the winter months, the main effect is heating, but the air is humidified as desired. The present invention contemplates that two or more air conditioning units may be positioned in an air conditioned space with all of the units operating together to perform the desired air conditioning functions. Under some circumstances, a single condensing unit may condense the refrigerant which is used by several air conditioning units to perform the cooling and dehumidifying functions.

Illustratively, humidostat and thermostat controls are provided, but these controls may merely open and close refrigerant valves and they need not control the starting and stopping of the condensing unit which condenses the refrigerant. Thus, when dehumidifying or cooling is needed a solenoid valve is opened to permit the flow of liquid refrigerant to the evaporator. The temperature of the evaporator is controlled by an expansion valve having a thermostatic bulb at the outlet of the evaporator. The refrigerant condensing unit is controlled by a refrigerant pressure switch so that a constant pressure is maintained on the "low side" of the refrigerant circuit; that is, on the refrigerant in the evaporator. Thus, the compressor of the condensing unit is operated when the pressure on the "low side" rises above a predetermined value. By this arrangement the control system for the compressor is entirely independent of the temperature and humidity control system in the air-conditioned space.

During a dehumidifying cycle moisture from the air is condensed upon the cold surfaces of the evaporator and conditions might be such that this moisture will collect in the form of frost (or ice). In the illustrative embodiments of the invention any such frost or ice is removed at the end of each cooling period; that is, during the "off" period. In this way the evaporator is free of excessive frost accumulation and the operation is efficient and dependable.

Referring particularly to Figure 1 of the drawings, a upright rectangular sheet metal casing 2 is adapted to reset upon the floor in a room or other air-conditioned space. Casing 2 has a front wall 4 a top wall 6, a rear wall 8 (see Figure 2), a bottom wall 9 and end walls 10 and 12 (see Figure 3), and the casing is supported at its two ends by legs 14. At the top of front wall 4 is a set of louvres 16 (Fig. 2) which provide for the flow of a stream of air to be conditioned into the top of the casing, and at the bottom of wall 4 is a similar set of louvres 18 through which the conditioned air flows from the casing. As shown

best in Figure 3, four air circulating fans 20, 22, 24 and 26, are mounted in circular openings in a horizontal partition 28 which extends across the casing directly beneath the lower edge of louvres 16 (Figure 2). These fans are fixed to the vertical shafts (Figure 3) of their motors, 30, 32, 34 and 36, and (Figures 2 and 4) each of the motors is mounted on a C-frame 38, the ends of which are bolted to the horizontal partition 28.

Directly beneath the fans is a rectangular evaporator shell 40 (Figures 2 and 4), which encloses and supports on a cross-frame an evaporator 41 of the direct-expansion, finned-tube type. Evaporator 41 receives liquid refrigerant through a liquid-inlet tube 43, and the gas refrigerant is withdrawn through an outlet tube 45. The liquid inlet is controlled by a solenoid valve 47, and the incoming liquid passes through a heat-exchanger 49 in heat exchange relationship with the outgoing gas. Shell 40 has a front wall 42 and a rear wall 44 which are spaced respectively from the front and rear walls of casing 2 to provide front and rear vertical passageways 46 and 48, respectively. Shell 40 has an arched top wall 50 which deflects the down-flowing stream of air from the fans to passageways 46 and 48. The bottom wall 51 of the shell has a number of spaced, central openings 53 and beneath these openings is a trough-like drip pan 52. Thus, the condensate from evaporator 41 flows through openings 53 into drip pan 52 and thence to waste through a drain outlet 55 (shown at the right in Figure 3).

As shown best in Figure 3, shell 40 has end walls 54 and 56 which abut the respective casing end walls 10 and 12 of casing 2, and welded to the casing end walls beneath the ends of shell 40 are bracket bars 58 upon which the shell rests. Referring to the right-hand side of Figure 4, each of the vertical side edges of the shell end walls 54 and 56 extends beyond the sides of the shell so as to provide vertical flanges 59 along the vertical edges of the shell; and these vertical flanges are snugly received beneath flange strips 60 which are welded to the inside corner walls of casing 2. Thus, during assembly, shell 40 is lowered into the top of casing 2 prior to the assembly of the horizontal partition 28 and its associated parts, and flanges 59 are guided into the slots formed by flange strips 60. The shell is then further lowered to the position shown where it rests upon bracket bars 58.

Referring again to Figure 2, positioned beneath the evaporator shell is a deflector 62 which directs the down-flowing stream of air from passageways 46 and 48 toward louvres 18. It is thus seen that air is drawn into the top of the casing through louvres 16 and passes downwardly through passageways 46 and 48 past the sides of the evaporator shell and thence from the casing through louvres 18.

Front wall 42 of shell 40 is provided (see Figure 3) with a row of vertical slot openings 64, and wall 44 has a similar row of slot openings 65. These slot openings provide openings between passageways 46 and 48 and the refrigerated interior of evaporator shell 40. Evaporator 41 is effectively isolated from a heat-exchange standpoint from the front and rear walls 42 and 44 of the shell so that the shell walls are not materially cooled by the evaporator. This arrangement permits the air to pass the evaporator without any substantial cooling of the air. However, the cooling of the air within shell 40 condenses the vapor therein and thereby creates a low partial-

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vapor pressure zone wherein the air is relatively stratified. Therefore, when the air in passageways 46 and 48 carries any substantial amount of vapor, there is an appreciable difference between the partial-vapor pressure of the vapor in the air streams and that of the vapor in the air in the refrigerated space in shell 40. This difference in the partial-vapor pressures is sufficient to cause the vapor to flow from the air in passageways 46 and 48 through openings 64 and 65 into shell 40. The continued refrigeration effect in shell 40 condenses the vapor which enters the shell in this manner so as to maintain the low partial-vapor pressure in the shell. Thus, the moisture is removed from the air without any substantial sensible cooling of the air. There is a tendency for the vapor which flows into shell 40 to carry with it a small amount of air so that a slight pressure condition builds up within the shell. It has been found that this does not interfere materially with the above-described operation.

With any given set of conditions, the partial-vapor pressure within shell 40 depends upon the temperature maintained in the evaporator, whereas, the partial-vapor pressure in the streams of air in passageways 46 and 48 depends upon the amount of moisture in the air and this is a function of the temperature and relative humidity of the air. Therefore, as the relative humidity in the air-conditioned space is reduced, there is a reduction in the difference in the partial vapor-pressures in the shell and in the air streams; therefore, less vapor flows from the air streams into the shell and less moisture is removed from the air streams. In this way the humidifying effect is reduced automatically as the optimum humidity condition is approached. The arrangement is such that even with continued operation, the humidity will not be reduced materially below the optimum value. Furthermore, as the humidity falls and the condensation of moisture is reduced, the cooling effect on the air may increase, but at all times there is assurance that the air will not be cooled excessively.

Passageways 46 and 48 are rectangular in cross-section and small in width so that the air is spread out into two relatively thin streams. In this way, the moisture can pass from the down-flowing streams of air through openings 64 and 65 in an efficient and dependable manner. The unrestricted outlet through louvres 18 at the lower ends of these passageways 46 and 48 insures an even flow of the air so as to avoid objectionable turbulence within the passageways at openings 64 and 65. Furthermore, any tendency for the air flowing through passageway 46 to disturb the relatively stratified condition of the air in shell 40 is balanced by the equal and opposite effect of the air flowing in passageway 48. Therefore, the air in shell 40 is in effect stratified to the extent that there is no great tendency for the air to flow from or into the shell.

As shown best in the lower right-hand portion of Figure 4, positioned within shell 40 adjacent front wall 42 is a steam coil 66 which is supplied with steam to heat the air passing through the unit. Directly over coil 66 is a spray pipe 68 through which water may be sprayed in a slow stream on coil 66 when humidification of the air is desired. In this way the air may be humidified in an efficient manner during the time that it is heated.

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As indicated above, it is desirable to provide for the addition of outside or fresh air to the recirculated air which enters casing 2 through louvres 16. Accordingly, as shown best in Figures 3 and 4, near the top of rear wall 8 of casing 2 is a horizontal row of parallel vertical slots 70; and, directly over this row of slots is a slide 72 which has a mating row of similar slots 74. Slide 72 has limited sliding movement and when in the extreme right-hand position slots 74 are in alignment with slots 70 so as to provide for the flow of air through the slots into the top of casing 2. However, when slide 72 is in the extreme left-hand position shown the slots are out of alignment with the result that the slide covers all of slots 70 and air can not enter casing 2 through the slots. Fixed to wall 8 and enclosing the area of slots 70 is a rectangular casing 76 which has at its left-hand end an oval air inlet connection 78. Inlet connection 78 is connected through a conduit (not shown) to a source of clean outside air. Thus, when slide 72 is in the right-hand position, fresh air is drawn into casing 2 through the inlet connection along with the recirculating air which is drawn in through louvres 16. By adjusting slide 72 to an intermediate position, accurate control is obtained on the proportion between the amount of air which is recirculated and the amount of fresh air which is drawn in through inlet connection 78. Thus, when the fans are operated the air which they direct downwardly past shell 40 is made up of a stream of recirculated air from louvres 16 and an added stream of fresh air from inlet connection 78 and the amount of this added fresh air is controlled by adjusting slide 72.

Referring now to Figure 5 of the drawings wherein the electrical circuit for the embodiment of Figures 1 to 4 is represented schematically, power is received from a two-wire source, indicated at the bottom of the figure, through a main switch 80 which is closed to energize a pair of lines 81 and 82. At the right of the figure the four fan motors 30, 32, 34 and 36 are represented, and of these motor 30 is connected directly across lines 81 and 82 so that it operates continuously when switch 80 is closed. The system is adapted for either summer or winter operation; for summer operation the air is mainly dehumidified but partially cooled, and for winter operation the air is heated and humidified as desired. Accordingly, there is provided a double-pole double-throw switch 83, the poles 84 and 85 of which are swung to the upper position for winter operation and are swung to the lower position for summer operation. When positioned for summer operation, poles 84 and 85 engage respectively contacts 86 and 87 and when positioned for winter operation, these poles engage respectively contacts 88 and 89. Contact 87 is connected to line 82 and pole 85 is connected through a line 90 to one side of each of fan motors 32, 34 and 36. The other side of each of these motors is connected to line 81 so that with switch 80 closed and switch 83 positioned for summer operation, these motors are connected across lines 81 and 82 and they operate continuously along with motor 30.

At the top of the figure is represented a thermostat switch assembly 91 which has a temperature-responsive element 92 and adjacent this switch assembly is a humidostat switch assembly 93 which has a humidity-responsive element represented with its electrical contacts at 94. Switch assembly 91 has a pair of armatures 95

and 96 which are rockably mounted to swing between the right-hand position shown where armature 95 engages a contact 97 and a left-hand position where armature 96 engages a contact 98. Switch assembly 93 has a similar pair of armatures 99 and 100 which are similarly mounted so that when in the right-hand position, armature 99 engages a contact 101 and when in the left-hand position armature 100 engages a contact 102.

Contact 97 of switch assembly 91 and contact 101 of switch assembly 93 are both connected through a line 103 to a refrigerant solenoid 104, the other side of which is connected to contact 86 of switch 83. Contact 102 is connected through a line 105 to a solenoid 106, the other side of which is connected to contact 88 of switch 83 and when this solenoid is energized a water valve is opened to supply water to pipe 68 (Figure 4) for the purpose of humidifying the air. Contact 98 of the thermostat switch assembly is connected through a line 108 to contact 89 of switch 83 so that when pole 85 is positioned for winter operation, the left-hand side of each of motors 32, 34 and 36 is connected to contact 98. Temperature-responsive element 92 and the electrical contacts of humidity-responsive element 94 are connected together and thence through a line 107 to line 82 so that with switch 80 closed, the potential of line 82 is carried by the condition-responsive elements 92 and 94.

Element 92 has a normal intermediate position wherein it does not engage either its right-hand contact 109 or its left-hand contact 111. However, when the temperature rises above a predetermined value, the element moves to the right and engages a contact 109 and when the temperature falls below a predetermined value, the element moves to the left and engages its contact 111. The humidity-responsive element 94 is similarly provided with a right-hand contact 113 and a left-hand contact 115 so that when the humidity is above a predetermined value, the element engages contact 113 and when the humidity is below a predetermined value, the element engages contact 115. Therefore, when the temperature is such that cooling is desirable, element 92 connects line 82 through line 107 to armature 95; and, when the temperature is such that heating is desirable, line 82 is similarly connected to armature 96. Likewise, when the humidity is such that either dehumidifying or humidifying is desirable, line 82 is connected through line 107, respectively, to armature 99 or to armature 100. For each of elements 92 and 94 there is an operating range for each setting so that even a momentary rise or fall in the temperature or humidity of sufficient magnitude to close one set of contacts will result in the contact staying closed for a substantial period of time.

As indicated above, for summer operation poles 84 and 85 of switch 83 are in the lower position engaging contacts 86 and 87, and armatures 95, 96, 99 and 100 of the switch assemblies 91 and 93 are positioned to the right as shown. Thus, with pole 84 engaging contact 86, line 81 is connected to solenoid 104, and, with armatures 95 and 99 engaging their contacts 97 and 101, circuits are set up from the other side of solenoid 104 to the right-hand contact of temperature-responsive element 92 and to the right-hand contact of humidity-responsive element 94. Therefore, when the temperature rises to a predetermined value, element 92 engages its right-hand contact 109 and connects line 82 through line 107

to armature 95 and thence through contact 97 and line 103 to solenoid 104 so that the solenoid is thereby energized. The energization of solenoid 104 opens the refrigerant valve 47 so as to supply refrigerant to evaporator 41. Similarly, a rise in humidity of sufficient magnitude to close the right-hand contacts of the humidity-responsive element 94 completes a circuit from lines 82 and 107 to armature 99 and thence through contact 101 and line 103 to energize solenoid 104.

Thus, when the unit is set for summer operation all of the fan motors are operated continuously and refrigerant is supplied to the evaporator whenever either the humidity or the temperature is within predetermined operating ranges. As indicated above, the major effect of the unit is to remove moisture from the air, but there is some sensible cooling particularly when the humidity is relatively low, and in no event does the humidity fall below a minimum desirable value. When the unit is set for winter operation, steam is supplied continuously to steam coil 66 and variable heating is provided by varying the air circulation. During this time the switches are so set that poles 84 and 85 engage contacts 88 and 89 and armatures 95, 96, 99 and 100 are positioned to the left so that armatures 96 and 100 engage their contacts 98 and 102. When the switches are thus positioned, the left-hand side of each of motors 32, 34 and 36 is connected through line 90, pole 85, contact 89, line 108 and contact 98 to armature 96; and, when the temperature-responsive element 92 moves to the left because of a fall in temperature, this circuit from the left-hand side of these motors is completed from armature 96 through contact 111 to thermostat element 92 and thence through line 107 to line 82 with the result that fan motors 32, 34 and 36 are operated along with fan motor 30. However, when the temperature rises to the desired value, the thermostat element moves to the right thereby opening the circuit and stopping motors 32, 34 and 36, but motor 30 operates continuously so as to give continuous air circulation through the unit. With this mode of operation there is some continued warming of the air and outside air is circulated by the fan operated by motor 30. When the room temperature drops, the temperature-responsive element 92 starts motors 32, 34 and 36 so as to give rapid circulation and heating of the air.

With pole 84 engaging with contact 88, line 81 is connected to one side of solenoid 106 which controls the supplying of water to pipe 68 for humidifying purposes. The other side of this solenoid is connected through line 105 and contact 102 to armature 100 so that when the humidity drops sufficiently to cause the humidity-responsive element 94 to close its left-hand contacts, a circuit is completed from armature 100 and line 107 to line 82. This energizes solenoid 106 so that water is supplied to pipe 68 and this water is vaporized on the steam coil 66 and the vapor passes into the air stream. It should be noted that the continuous air circulation provided by operating fan motor 30 insures the efficient dispersing of moisture into the room even though the other fan motors are not then operating. In this way the water supplied to pipe 68 is quickly added to the air in the room so that the humidity is raised to the desired value. Therefore, the humidostat will soon become satisfied and solenoid 106 will be deenergized before an excessive amount of water has been supplied to the unit.

As indicated above, under some circumstances it is desirable to provide for substantial cooling of the air as it passes through the unit and provision is made for this in the embodiments of the invention shown in Figures 6 and 7. The construction of the embodiment of Figure 6 is somewhat similar to that of Figures 1 to 4 although in Figure 6 there is no provision for heating and humidifying air. In this embodiment the casing is represented at 110 and has a set of air inlet louvres 112 at the top and a set of air outlet louvres 114 at the bottom. Directly beneath louvres 112 is a partition 116 upon which is mounted four fans 118 (one of which is shown in broken lines) which are driven by motors 120 mounted on brackets 122. Each of the fans is surrounded by a cowl 124 so that when the motors are operated air is directed downwardly in an efficient manner. Fresh air admitted through an inlet 126 joins the air from louvres 112 and the combined stream of air is directed downwardly by the fans.

Centrally positioned beneath partition 116 is an evaporator shell 128 which has vertical slot openings (not shown) in its side walls similar to slot openings 64 and 65 in shell 40. The space within shell 128 is occupied by finned evaporator coils and during operation a low vapor pressure zone is maintained within this shell in the manner explained above. Shell 128 forms with the front and rear walls of casing 110 a front air passageway 130 and a rear air passageway 132 and at the bottom of these passageways is an air deflector plate 134 which directs the air horizontally toward louvres 114.

Mounted directly beneath shell 128 is a damper assembly 135 which includes a damper plate 136 carried at its ends by a pair of pivots 138 extending through the end walls of the casing. One of the pivots 138 has a squared end which carries an adjusting handle 140 by means of which the damper plate 136 may be swung between the vertical position shown and the horizontal position indicated in broken lines. The position of the damper plate is indicated on a fixed bearing plate carried by the end wall of the casing. When in the horizontal position the damper does not interfere with the free flow of air from fans 118 downwardly through passageways 130 and 132 and thence from the unit through louvres 114. However, when the damper is in its vertical position the flow of air through passageway 132 is restricted so that air which tends to flow down passageway 132 is deflected through shell 128 and thus flows in direct contact with the evaporator so that the air is cooled. This cool air joins the stream of air flowing down passageway 130 and is discharged through louvres 114.

When damper plate 136 is in the broken line position, the air is dehumidified in the manner explained above without any material cooling of the air. The moisture which is removed is condensed and flows from the bottom of shell 128 to waste through a drain pipe 144. When damper plate 136 is swung toward its vertical position the air is still dehumidified but there is an additional cooling due to the direct contact by air with the evaporator. Thus, in the embodiment of Figure 6 the air may be dehumidified as it flows downwardly along passageways 130 and 132, and by adjusting the damper assembly an additional predetermined cooling of the air may be obtained.

In the embodiment of Figure 7, provision is

made to condition the air in an air supply stream flowing in a large conduit such as is used in a central air conditioning system. Accordingly, an evaporator shell 128, identical with that of the embodiment of Figure 6, is centrally positioned within a rectangular casing 150. At the top of casing 150 are left and right conduit connections 152 and 154 which are adapted to connect the casing in an air conduit. At the right of connection 152 is a baffle 156, and assuming that a stream of air is entering connection 152, this baffle directs the air downwardly along the side of shell 128 through a passageway 160. At the bottom of the casing are two baffles 161 which direct the stream of air to the right under shell 128 through a passageway 162 and thence upwardly along the right-hand side of shell 128 through passageway 164. At the top of passageway 164 is a baffle 158 similar to baffle 156 which directs the air to the right through connection 154.

Positioned in passageway 162 is a damper assembly 135 which is similar in construction and operation to that of the embodiment of Figure 6. In Figure 7 the entire stream of air passes along the one path, that is, along passageways 160, 162 and 164, and therefore the restricting of passageway 162 tends to divert a large proportion of the air through the refrigerated shell 128. Thus, a very substantial cooling of the air is obtained by moving damper plate 136 to its vertical position and this cooling effect is diminished gradually as the damper plate is swung to the horizontal position. The dehumidifying effect is carried on in the manner explained above and the condensate is removed at the bottom of shell 128 through drain pipe 144.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In an air conditioning unit which is adapted to rest upon the floor in a space to be conditioned, the combination of, a casing having a horizontal partition with a fan opening therein dividing the casing into an upper compartment and a lower compartment, said casing having an air inlet adapted to admit air into said upper compartment and an air outlet through which air passes from said lower compartment, a plurality of fans having individual motors mounted in said upper compartment and adapted to direct air from said upper compartment downwardly into said lower compartment, a refrigerated shell centrally positioned in said lower compartment and forming with two opposite walls of said casing a pair of passageways along which the air flows as it passes said shell, said shell having walls along said passageways which have openings therein through which vapor may pass, refrigerating means to cool the air in said shell thereby to produce a low vapor-pressure zone with the result that air flowing along said passageways is subjected to the dehumidifying effect caused by vapor flowing into said shell through said opening to said low vapor-pressure zone, and means to direct the air out of said lower compartment through an air outlet.

2. Apparatus as described in claim 1, wherein

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said air inlet and said air outlet are at the top and bottom of one side wall of said casing, and louver means mounted on said side wall to direct the air into and from said casing.

3. Apparatus as described in claim 1, which includes, means forming a fresh air inlet to said upper compartment comprising, a horizontally disposed conduit fixed to a side wall of said casing and having an opening at one end through which fresh air is admitted, said side wall of the casing having a plurality of slots opening from the upper compartment into said conduit, and a slide positioned between said side wall and the interior of the conduit and having openings which are adapted to mate with the openings in said side wall thereby to permit air to flow from the conduit into said upper compartment and with the slide being movable longitudinally of the conduit so that the openings in the slide are out of alignment with the openings in the casing wall.

4. Apparatus as described in claim 1, which includes a damper assembly mounted within said lower compartment beneath said shell and comprising, a damper plate which is adapted to swing between a first position in which it obstructs the flow of air through one of said passageways and a second position wherein it does not obstruct such flow of air, and means to regulate the position of said damper plate.

5. Apparatus as described in claim 1, which includes, baffle means to direct the air from one of said passageways along a horizontal passageway beneath said shell, and a damper plate rockably mounted in said horizontal passageway and adapted to be moved between a first position wherein it obstructs the flow of air through said horizontal passageway and a second position wherein it does not obstruct the flow of air.

6. In an air conditioning system of the type wherein the humidity and temperature of the air is controlled, control means comprising, a double-pole double-throw switch which is adapted to be positioned with its poles engaging a first set of contacts when the system is conditioned for summer operation and which is adapted to be positioned with its poles engaging a second pair of contacts when the system is conditioned for winter operation, a pair of power lines connected to means constituting a source of power one of said power lines being connected to one of said first pair of contacts and the other of said power lines being connected to one of said poles, a refrigerant-control solenoid connected at one side to the other of said first pair of contacts, a fan motor assembly connected at its opposite sides to said poles, a pair of condition-responsive switch assemblies each of which includes a condition-responsive element and a pair of switches which are closed alternatively to condition the switch assemblies for summer or winter operation, each of the condition-responsive elements being adapted upon a rise in the value of the condition to which it is responsive to close a circuit through the one of its switches which is closed for summer operation and upon a fall in the value of the condition to which it is responsive to close the circuit through the other of its switches, one of said switch assemblies being temperature responsive and having a temperature-responsive element and the other being humidity responsive and having a humidity-responsive element, circuit means connecting said condition-responsive elements to said one of said power lines, circuit means connecting the other

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side of said refrigerant-control solenoid to the switch of each of said switch assemblies which is closed when the system is conditioned for summer operation, circuit means connecting the other switch of the temperature-responsive switch assembly to one of said second pair of contacts, a water-control solenoid which is energized to supply water for humidifying the air, and circuit means connecting said water-control solenoid at one side to the other of said second set of contacts and at its other side to the other contact of said humidity-responsive switch assembly.

7. In an air conditioning system of the type where the humidity and temperature of the air is controlled, control means comprising, a switch assembly having a plurality of poles which are adapted to have a first set of contacts engaged by their respective poles when the system is conditioned for summer operation and which is adapted to have a second pair of contacts engaged by their respective poles when the system is conditioned for winter operation, a pair of power lines connected to means constituting a source of electric power with one of said power lines being connected to one of said first pair of contacts and with the other of said power lines being connected to one of said poles, a refrigerant-control electrical device connected at one side to the other of said first pair of contacts, a fan motor assembly connected at its opposite sides to said poles, and a pair of condition responsive assemblies each of which includes a condition responsive element and switch means which are closed to condition said condition responsive assemblies for summer or winter operation, said control means being so constructed and arranged as to exert control in response to humidity and temperature conditions.

8. In air-conditioning apparatus, the combination of, a casing which is substantially rectangular in cross-section, a condensing shell positioned centrally within said casing and having side walls which are substantially parallel to and spaced from the respective side walls of said casing thereby to provide two passageways along the opposite sides of said shell and within said casing, said shell having said side walls along said passageways permeable to vapor whereby moisture from the air flowing along said passageways may flow into said shell, means to cool the air within said shell to condense the moisture therein, fan means positioned to direct air through said passageways, and means to supply fresh air to the inlet of said fans.

9. In an air-conditioning unit, a casing which is rectangular in horizontal cross-section and which has air inlet and outlet openings at the top and bottom respectively, a horizontal partition adjacent the top of said casing, fan means mounted in said partition and adapted to direct air downwardly through said casing, an adjustable fresh-air inlet in the top of said casing to provide for the addition of fresh air to the stream of air entering said casing from the air-conditioning space, a refrigerated shell centrally positioned within said casing and having side walls which are parallel to and spaced from the respective side walls of said casing whereby a pair of parallel vertical passageways are provided along the sides of said shell from the top to the bottom of said casing, the walls of said shell along said passageways having openings therein whereby vapor from air passing along said passageways may flow from said air into said shell and be

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condensed with the result that the air is dehumidified.

10. In an air conditioning system which is adapted to remove vapor from air and also to impart to the air a predetermined degree of cooling, the combination of, a casing having an inlet opening and an outlet opening, a refrigerated shell centrally positioned in said casing and forming with the side and bottom walls of said casing a pair of vertical passageways at opposite sides of said shell and a horizontal passageway beneath said shell, said shell having openings in its side walls along said vertical passageways whereby the passageways are open to the interior of the shell, refrigerating means within said shell to produce a low vapor-pressure zone with the result that vapor passes from air flowing along said passageways through said openings and into said low-pressure zone where it is condensed, and a damper positioned in said horizontal passageway and adapted to restrict the flow of air through said horizontal passageway with the result that air from one of said vertical passageways flows through said shell to the other of said vertical passageways.

11. Apparatus as described in claim 10, wherein said inlet and outlet openings are positioned respectively at the top and bottom of said casing, and fan means to direct a stream of air downwardly through said vertical passageways.

12. Apparatus as described in claim 10, wherein said inlet and outlet openings are positioned adjacent the top of said casing, and means to direct the air from said inlet opening downwardly through one of said vertical passageways and thence through said horizontal passageway and upwardly through the other of said vertical passageway to said outlet opening.

13. In the art of conditioning air, the steps of, cooling a body of air to a temperature below a predetermined dew point with the result that excess water vapor is condensed and a low vapor-pressure zone is maintained, passing two separate streams of air along spaced paths in contact with opposite sides of said body of air with the result that vapor tends to pass from the flowing air into the low vapor-pressure zone where it is condensed, and restricting the flow of air at the outlet of one of said paths with the result that the air is diverted through said low vapor-pressure zone and is materially cooled.

14. In the art of conditioning air, the steps of, cooling a body of air to a temperature below a predetermined dew point with the result that excess water vapor is condensed and a low vapor-

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pressure zone is maintained, passing air along two paths into contact with said body of air whereby vapor from the air flowing along said paths passes into said low vapor-pressure zone and is condensed with the result that the air flowing along the paths is dehumidified, and restricting the flow of air along one of said paths whereby the air tends to flow through said low vapor-pressure zone from one path to the other with the result that air is materially cooled.

15. In the art of conditioning air, the steps of, passing a stream of air from an inlet opening along a path to an outlet opening, cooling the air in a zone in contact with said path in response to a call for dehumidifying the air in the stream, and diverting a predetermined amount of air from said path through said zone and thence back to said path thereby to produce a cooling effect on the air in the stream.

16. In the art of conditioning air, the steps of, producing a continuous circulation of air at a slow rate through a conditioning zone, cooling a body of air which is in contact with the air flowing through said zone, and increasing the rate of flow of air through the zone simultaneously with the starting of the cooling operation.

17. In an air conditioning system of the type where the humidity and temperature of air are controlled, the combination of, means including a casing construction to pass a stream of air to be conditioned along a substantially closed path, means forming a cold chamber adjacent said path and having a vapor permeable opening to said path, cooling means to maintain the temperature within said cold chamber at a relatively low temperature whereby a low vapor pressure condition is maintained therein, and a movable baffle structure to divert a predetermined amount of air from said path and thence through said cold chamber and back to said path whereby the air diverted is subjected to a cooling effect.

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