April 22, 1947. T. W. BINDER 2,419,477

AIR CONDITIONING

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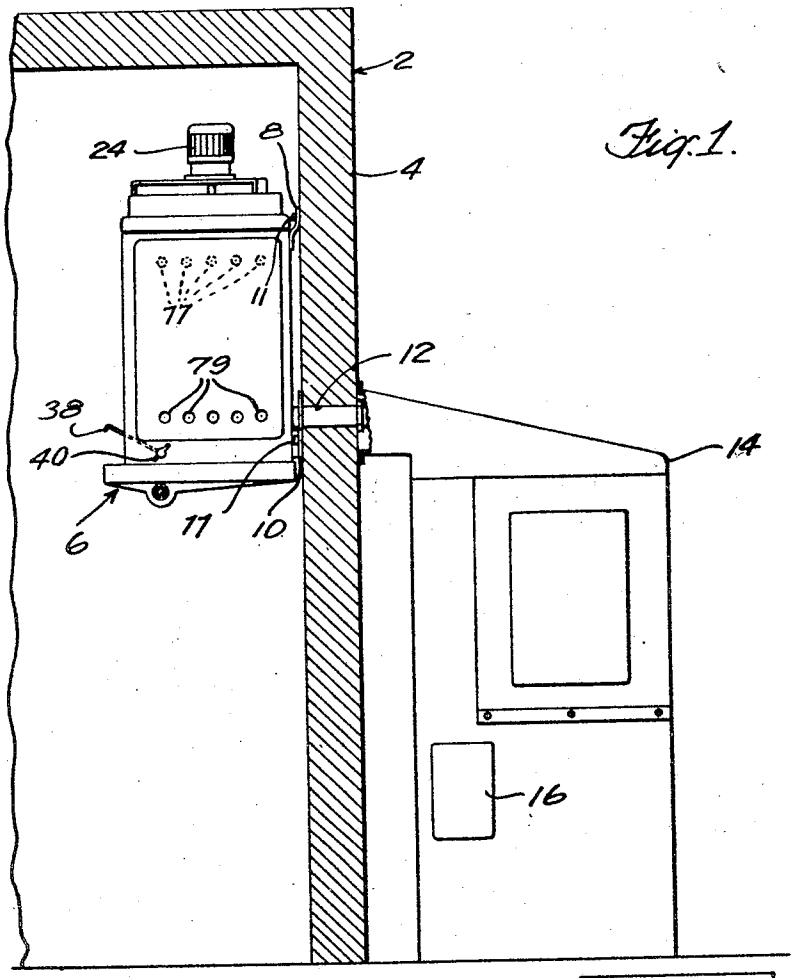

Fig. 1.

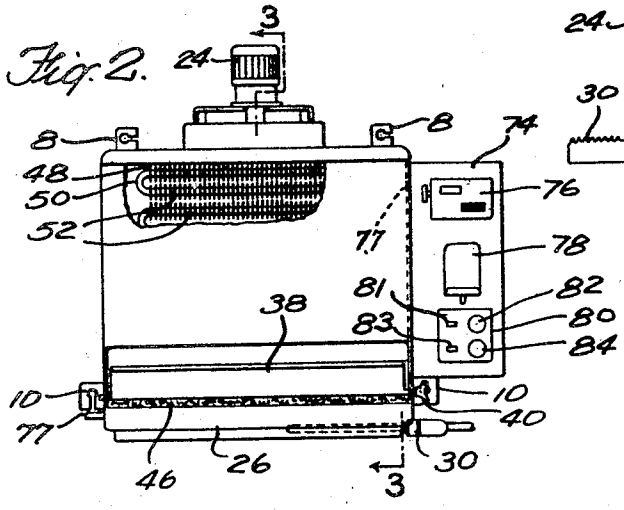

Fig. 2.

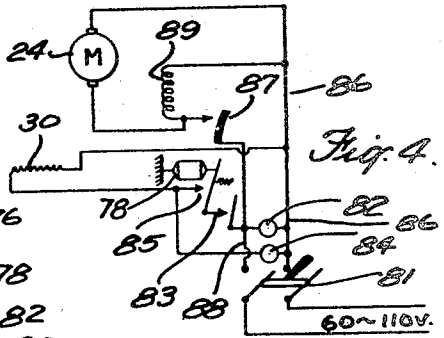

Fig. 4.

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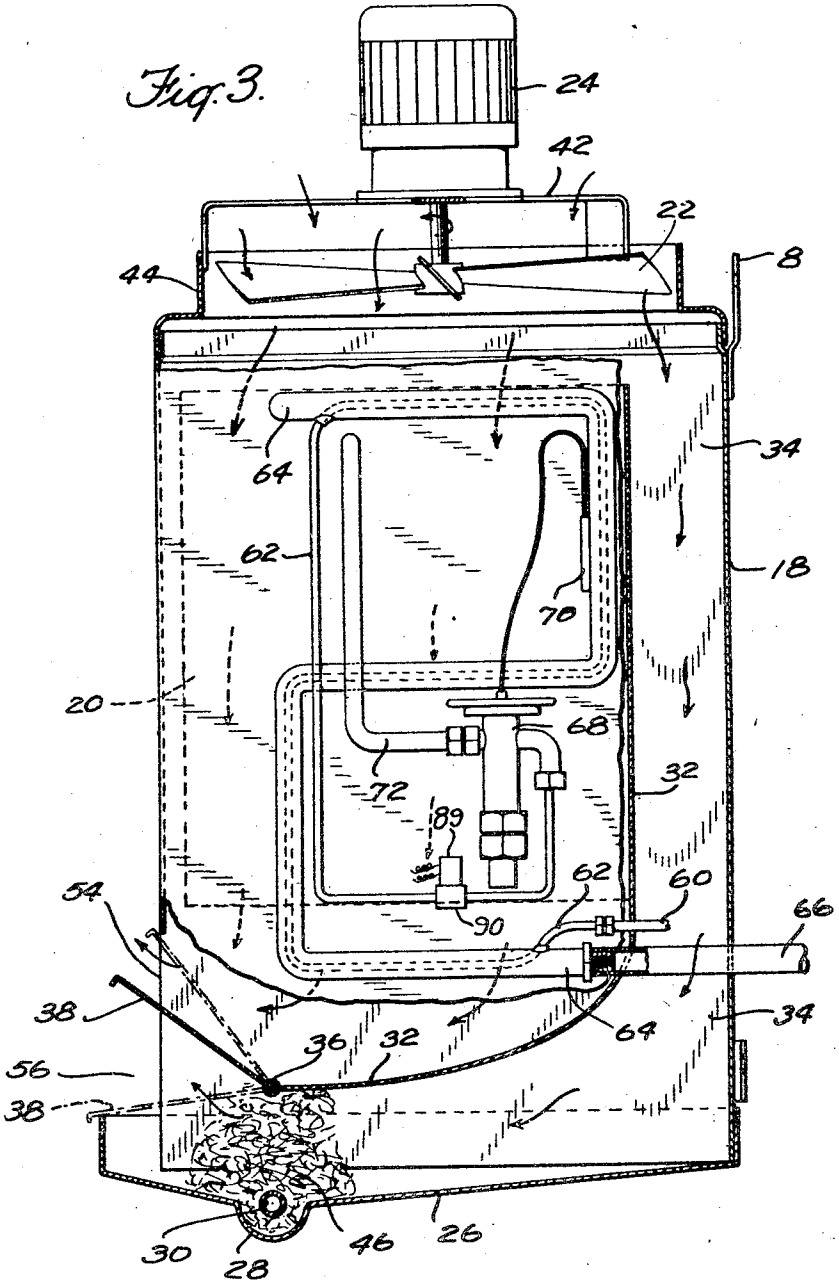
Fig. 3.



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AIR CONDITIONING

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16 Claims. (Cl. 257—3)

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This invention relates to humidity and temperature control, and more particularly to the maintaining of food in proper condition by circulating the air through a conditioning unit where the air is subjected to controlled humidity and refrigerating effects.

An object of this invention is to provide for the dependable and accurate control of the temperature and humidity conditions within a chamber. A further object is to provide a refrigerating and humidifying system where the air is circulated and maintained within predetermined limits of temperature and humidity. A still further object is to provide for the circulation of air and to control its movement selectively along two paths, one of which subjects the air to a humidifying action and the other of which subjects the air to a cooling action. A still further object is to provide apparatus for a complete system of the above character which is compact and sturdy in construction and which is readily installed in a refrigerated chamber to condition the air. A further object is to provide apparatus of the above character which is efficient and economical to operate and yet is easily manufactured and installed at a minimum of cost. 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 side elevation of one embodiment of the invention showing a portion of the refrigerated cabinet in section;

Figure 2 is a front elevation of the air circulating and conditioning unit;

Figure 3 is a sectional view along the line 3—3 of Figure 2; and

Figure 4 is a wiring diagram of the electrical control circuits.

As conducive to a clear understanding of the invention it seems desirable to point out a number of problems which are met with in the installation where the illustrative embodiment of the invention is used. In large food chambers such as the walk-in refrigerating rooms in butcher shops and storage rooms in provision houses, it is important that the temperature and humidity throughout the refrigerating chamber be

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maintained within predetermined limits. The operator should be able to vary these limits in accordance with the requirements for the particular food being stored. That is, a particular humidity and temperature combination may be ideal for a particular food, but when another food is stored the temperature or humidity may be too high or too low: thus, these two characteristics should be independently controllable and the system should automatically maintain conditions as nearly ideal as is consistent with commercial practice.

It is important to note that each installation is a distinct problem because the storage chambers vary in size and use. For example, one installation may be unique in that it is opened frequently so that there is a constant change of air, and the cold food may be constantly removed and replaced by warm food. Another installation may be unique in that it is to be used for storing a particular food which requires a very high humidity. It is important that the operator have available to him sufficient refrigerating and humidifying equipment to maintain the desired conditions in the storage chamber at all times. Furthermore, the system should be easily installed and should be adaptable to a wide range of demands so that the apparatus can be standardized. It is an object of this invention to meet these demands in a practical manner.

In the illustrative embodiment of the invention the air is cooled and humidified to standards set by the operator by a single unit which has a fan for circulating the air past cooling and humidifying apparatus. The air is drawn into the top of a closed casing by the fan and directed downwardly through the casing; the major portion of the casing is occupied by the evaporator of a refrigeration system and the main stream of air is directed toward this evaporator. At one side of the evaporator a partition in the casing provides a vertical passageway through which a portion of the air stream is directed by the fan, and this air is subjected to the humidifying necessary to maintain the proper standards of humidity within the refrigerating chamber. The refrigerated stream of air from the evaporator and the humidified stream of air are discharged together, and the relative amount of air flowing in the two streams is controlled at the outlet.

Temperature and humidity responsive controls are mounted on an end wall of the casing and the entire casing with the controls is referred to as the "food conditioner." The food conditioner is installed in the food chamber as a unit

by mounting it upon the side wall of the food chamber. The evaporator of the food conditioner is part of a refrigeration system which also includes, exterior of the food cabinet, a motor-driven compressor, a condenser, a receiver for condensed refrigerant, and controls for the motor. Prior to mounting the food conditioner on the side wall of the chamber, suitable holes are provided in the wall to accommodate the refrigerant pipes and the electrical wires.

Referring particularly to Figure 1 of the drawings, a food storage compartment, indicated at 2, has a side wall 4 upon which a food conditioner 6 is removably mounted. The conditioner is attached at the top by two hangers 8 (see also Figure 2); similarly attached at the bottom are two hangers 10. Hangers 8 and 10 are hooked onto screws 11 carried by the wall. Wall 4 has an opening 12 through which refrigerant and electrical connections extend to the conditioner. Mounted at the right of wall 4 is a compressor-condenser unit 14, of which only the casing is shown; this unit includes an electric motor-driven compressor, a condenser, a receiver for condensed refrigerant, and a motor starter the casing of which is indicated at 16. The food conditioner 6 and the compressor-condenser unit 16 are separate "package" units, completely assembled at the factory.

In installing the system, a suitable recess such as 12 is made in the side wall and the supporting screws 11 are put in place; the compressor-condenser unit 16 is placed upon a suitable foundation or upon a supporting frame, and then the electrical and refrigerant connections are made through the recess 12. No auxiliary wires or fittings are necessary, except to provide a connection to an appropriate electrical outlet. The construction is such that the system may be installed in any type of storage compartment either during construction of the storage compartment or later. Due to the simplified electrical and refrigerant connections, the system is easily installed where there are various thicknesses of the compartment side wall.

The details of construction of the food conditioner are shown best in Figure 3. The food conditioner is provided with a casing 18 which encloses the evaporator 20 and has at the top a fan 22 driven by an electric motor 24. The bottom of casing 18 is closed by a water pan 26 which has a longitudinal trough 28 in one end of which (see also Figure 2) is mounted an electric heater 30; as will be explained more fully below, heater 30 evaporates water for humidifying the air. Surrounding heater 30 and filling the space above trough 28 is metal wool 46. This metal wool is heated by contact with heater 30 and assists in evaporating the water as the air flows over the water in pan 26 and through the metal wool.

Evaporator 20 is mounted to the left (Figure 3) of the center of the casing and extending along the right-hand side of the evaporator and down under the evaporator is a partition 32. This partition provides a passageway indicated at 34 which extends down along the side of the evaporator and over the top of pan 26. Pivoted at the extreme lower end of partition 32 is a deflector 38. At its ends, deflector 38 is fixed to and pivoted on two studs 36 which extend through holes in the end walls of casing 18. Deflector 38 may be secured in any desired position, between the upper and lower positions shown in broken line by a thumb screw 40 (Figures 1 and 2) on one of studs 36.

During operation the controls are so adjusted that the system defrosts at the end of each running cycle. The water from the evaporator during defrosting flows to the left along partition 32 to the edge of the partition where it drips down onto the metal wool and into pan 26. The water dripping down onto the metal wool is heated when humidifying of the air is called for because heater 30 is then energized and the metal wool is heated. The air which is directed down passageway 34 passes through the metal wool and over the body of water in pan 26 so that the air carries away a substantial amount of water.

As shown best in Figure 2, evaporator 20 is constructed of finned horizontal pipes 48 each of which carries its own fins 52 and is connected to another similar pipe by a return bend 50. Fins 52 are vertically positioned so as to provide a plurality of parallel vertical paths for the air which is directed downwardly by fan 22. After being cooled by contact with pipes 48 and fins 52 the air passes from the bottom of the evaporator where it is deflected (see Figure 3) to the left by partition 32. The cooled air passes from casing 18 over the top of deflector 38 through an outlet 54.

The humidified air passing from the left-hand side of pan 26 is discharged beneath deflector 38 through an outlet 56. The relative amount of air passing from outlets 54 and 56 is controlled by the position of deflector 38. With deflector 38 in an intermediate position such as that shown in full lines, the outlet from beneath the evaporator is restricted and a substantial amount of air passes down passageway 34 and out through outlet 56. However, considerable cooling takes place because the fan directs the main body of air toward the evaporator and the air flows freely through the evaporator. If deflector 38 is swung to the lower broken line position, outlet 56 is closed and a large amount of air flows through the evaporator at a rapid rate. Evaporator 20 is "deep" in the sense that air passing through it is cooled below the dew-point and moisture is given up. By providing the variable restriction at the outlet from the evaporator, sufficient moisture is removed from the air to permit accurate humidity control by merely adding water vapor to the humidifying stream of air.

When it is desirable to perform very little or no cooling and to humidify at a rapid rate, deflector 38 is moved near the upper broken line position. This partially closes outlet passageway 54 from the evaporator 20 and causes more air to flow along the humidifying path. Particularly for use under these circumstances, the system may include means to add water to pan 26 and to maintain a predetermined water level in the pan. As shown best in the lower left-hand portion of Figure 2, pan 26 is provided with a horizontal drain pipe 77 which limits the water level in the pan. If considerable water is being condensed and a lesser amount of humidifying is being carried on, the water level rises in the pan 26 and flows from the pan through pipe 77. However, a reserve supply of water is maintained in the pan so that if there is a demand for humidification water is available.

Liquid refrigerant is received as shown at the lower right-hand portion of Figure 3 through a liquid supply pipe 60 which is connected to the inside pipe 62 of a heat exchanger having an outside pipe 64. The return refrigerant gas from the evaporator passes through pipe 64 from the upper left-hand corner of the evaporator in

counter-current to the incoming liquid refrigerant in pipe 62, and thence passes from pipe 64 at the lower right-hand corner of the figure, through suction pipe 66 to the compressor (not shown). Pipe 62 is connected to a control valve 68 which is controlled by a thermal responsive element 70 having its bulb attached to pipe 64 and therefore responsive to the temperature of the return gas. The refrigerant from valve 68 passes through a pipe 72 to the evaporator. Thermal responsive element 70 is so regulated that during each refrigerating cycle frost tends to form upon the evaporator, but, as indicated above, the refrigerating cycle is such that the frost is melted off and flows down to pan 26 before the starting of the next refrigerating cycle.

As shown in Figure 2, the temperature and humidity controls are located on the end wall of casing 18 in a control box 74. Within control box 74 is a thermostat 76 which is provided with a manual adjustment for setting the temperatures at which the refrigerating apparatus is turned off and on. Beneath the temperature control unit is a humidostat 78 which is also provided with a manual adjustment to set the limits of humidity to be maintained within the refrigerated chamber.

Beneath humidostat 78 is mounted a control assembly 80 including a main switch 81, a humidostat switch 83, a red light 82 and a green light 84. Switch 81 is manually operated to put the system into and out of service; this switch also turns the red light 82 on and off so that when the light switch 81 is closed the light is lighted to indicate to operator that the system is "on." Switch 83 is normally closed but is opened when it is desirable to operate the system without using the humidifying apparatus. Light 84 is lighted only when heater 30 is receiving current, thereby indicating that humidification of the air is taking place.

It is desirable to insure that thermostat 76 and humidostat 78 register the exact conditions within the storage chamber. In accordance with the present invention, this result is obtained by causing fan 22 to replace the air in control box 74 constantly with air from the storage chamber. Accordingly, as shown in broken lines in Figure 1, near the top of casing 18 and opening into the control box are holes 77 through which air from fan 22 passes. At the bottom of control box 74 are five vent holes 79 through which the air escapes from the control box; thus, fan 22 provides one stream of air which is cooled and dehumidified, another stream of air which is humidified to the extent necessary, and a third stream of air which acts as a "control" for the operation of the system.

The electrical control circuit for the food conditioner is shown in Figure 4. The closing of the main switch 81 connects lines 86 and 88 directly to the power supply, and turns the system on; this lights light 82 which is connected directly across lines 86 and 88 and renders the system operative upon demand. Heater 30 has one side connected to line 86 and the other side connected to the humidostat switch 85 of humidostat 78; the other side of switch 85 is connected through the normally closed manual switch 83 to line 88. Thus, when humidification is called for by the humidostat, switch 85 is closed and heater 30 is energized. The green light 84 is connected in parallel with heater 30 so that it is energized and de-energized simultaneously with the heater.

In this embodiment, the supply of refrigerant to the food conditioner is controlled by a solenoid 89 which is energized to supply refrigerant by opening a valve 90 in pipe 62, and de-energized to close the valve and cut off the supply of refrigerant. Solenoid 89 and fan 22 are connected in parallel with one side of each connected to line 86 and the other side of each connected to the thermostat switch 87 of thermostat 76; the other side of switch 87 is connected to line 88. Thus, when refrigeration is called for, the closing of switch 87 energizes fan 22 and solenoid 89, and the circulation and cooling of air is started.

In the present embodiment, the compressor motor is controlled independently of the food conditioner by starting and stopping it in accordance with the pressure of the returning refrigerant. In this way the food conditioner is an independent complete unit even with respect to the electrical control mechanism. Furthermore, the compressor is started only when the pressure of the returning refrigerant indicates that defrosting of the evaporator has been completed. It will be seen that under some circumstances, the fan 22 might be started and solenoid 89 might be energized by the closing of switch 87 without the starting of the compressor. In such cases, fan 22 will direct air over the evaporator and thus cool the air and at the same time hasten the defrosting operation.

With this unitary construction, a food conditioner may be placed in service wherever a suitable supply or refrigerant is available. Furthermore, two or more food conditioners may be connected to a single compressor-condenser unit. Due to the standardized construction, two or more complete units of small size may be used where one unit is too small to handle the load and yet the systems will cooperate in maintaining the predetermined desired conditions.

As various possible embodiments might be made of the above invention, and as many changes might be made in the embodiment above set forth without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In an air conditioning unit, a casing having an air inlet in its top, a fan positioned at the top of said casing and adapted to direct air downwardly through said air inlet into the top of said casing, an evaporator positioned within said casing in the path of the air flow from said fan and adapted to cool the air, partition means forming a vertical passageway at the side of said evaporator for air to pass from said fan to the bottom of said casing without passing into contact with said evaporator, a humidifying pan at the bottom of said casing to collect water which is condensed on said evaporator from the air, means defining an air outlet from said casing at the side of said pan opposite the lower end of said passageway whereby the air from said passageway moves across said pan and from said outlet, and means including an air deflector in said outlet separating the stream of air flowing through said evaporator from the stream of air flowing from the bottom of said passageway, said deflector being adapted to be positioned to constrict the outlet of air from said passageway and from said evaporator.

2. In a system for maintaining predetermined temperature and humidity conditions, the combination of, an air-cooling means with which the air comes in contact, supply means to supply a

cooling medium to said cooling means, an electrically operated fan to direct air into contact with said cooling means, means forming a bypass air path around said cooling means for air from said fan, means to evaporate water by the introduction of heat into the air flowing along said bypass air path, air control means to control the flow of air as it passes from said cooling means including means constituting a variable restrictive outlet, control means responsive to a demand for cooling to start said fan, and independent control means for starting said supply means when the temperature of said cooling means rises above a predetermined temperature.

3. In an air cooling and humidifying unit, a casing having an air inlet and an air outlet at one side near the bottom thereof, an air circulating fan to direct air through said casing, partition means dividing said casing into two passageways along which the air flows from the inlet to the outlet, a cooling unit at one side of said partition means to cool the air passing along one of said paths, humidifying means on the other side of said partition means to add water to the air passing along the other of said paths, a vane swingably mounted at the edge of said partition means adjacent said air outlet to swing from one extreme position where it closes one of said paths to the other extreme position where it closes the other of said paths, means to control the relative amount of air passing along said paths, supporting means on the side of said casing opposite said outlet and adapted to support said casing, and connecting means constituting the connections for a cooling medium for said cooling means and extending from said casing on the side of said casing opposite said outlet.

4. Apparatus as described in claim 3 wherein said supporting means is in the form of four ears adapted to be hooked onto screws in a supporting wall with the ears positioned at the two upper and two lower corners of the side of the casing.

5. Apparatus as described in claim 3 wherein said humidifying means is in the form of a pan forming the bottom of said casing and having a longitudinal trough in which is positioned an electric heater, and wherein the water condensed from the air by said cooling means is received by said pan for vaporizing into the air.

6. In the art of conditioning air in a storage compartment, the steps of, circulating the air along two parallel paths, testing the air being circulated to determine the amount of cooling and humidifying necessary, cooling the air which passes along one of said paths to reduce its moisture content below the desired amount and thereby remove condensate, and flowing the condensate along a heating path in a large number of small streams, heating the condensate along said path in accordance with the necessity for humidifying of the air thereby to add to the air flowing along the other of said paths sufficient moisture in vaporized form to attain the desired humidity.

7. In apparatus for maintaining predetermined conditions of temperature and humidity, the combination of, a cooling coil assembly of substantial depth whereby the air passing through it is subjected to substantial cooling with the result that condensate is condensed from the air, means forming a recirculation path parallel to the path of air passing through said cooling coil assembly, temperature responsive means positioned to be responsive to air from said recirculation path to control the cooling effect of said cooling coil assembly, means to collect the condensate and to deliver it to said recirculation path, electric heating means to evaporate said condensate, means constituting a source of power for said heating means, and humidity responsive means to connect said heating means to said source thereby to initiate the process of adding water to the air moving along said recirculation path upon the reduction in relative humidity below a predetermined amount.

8. In a system for maintaining predetermined temperature and humidity conditions, the combination of, an air cooling means with which the air comes in contact, supply means to supply a cooling medium to said cooling means, an electrically operated fan to direct air into contact with said cooling means, means forming a recirculation path for directing air from said fan along the recirculation path out of contact with said cooling means, humidifying means along said recirculation path including means for receiving water condensed from the air by said cooling means and to vaporize said water in a controlled manner into the air flowing along said recirculation path, air control means to control the flow of air as it passes from said cooling means including means constituting a variable restrictive outlet, control means responsive to a demand for cooling to start said fan, and independent control means for rendering effective said supply means when the temperature of said cooling means rises above a predetermined temperature.

9. In apparatus for maintaining predetermined temperature and humidity conditions in a storage chamber, the combination of, means for passing a first stream of air along a cooling path to cool the air and to remove as condensate a substantial portion of the moisture which it contains, cooling means along said cooling path to cool the air, means to pass a second stream of air along a humidifying path parallel to said cooling path, humidifying means along said humidifying path adapted to receive said condensate and to evaporate said condensate in the air passing along said humidifying path, means to pass a third stream of air along a control path parallel to said cooling path and said humidifying path, and control means positioned along said control path to be responsive to the conditions of the air passing therealong comprising thermal responsive means to control the supplying of a cooling medium to said cooling means and humidity responsive means to control said humidifying means.

10. In apparatus for maintaining predetermined temperature and humidity conditions in a storage chamber, the combination of, a sheet metal casing forming a vertical passageway, an electric fan and cowl assembly closing the top of said passageway and adapted to direct air through said passageway, a pan closing the bottom of said passageway and providing with one wall of said casing a horizontally directed air outlet over one edge of said pan, a sheet metal partition positioned vertically in said casing and dividing said vertical passageway into two separate air paths one of which extends down along one side of said casing and across said pan to the lower portion of said air outlet and the other of which extends from the top of said casing to the upper portion of said air outlet, a cooling coil positioned along said other path and adapted to cool the air passing to the upper portion of said air outlet sufficiently to remove moisture

from the air in the form of condensate, means in said pan to receive said condensate and to cause the condensate to flow in a plurality of small streams to the bottom of said pan traversing the air flowing toward the lower portion of said air outlet, and an electric heater positioned in said pan to heat the condensate.

11. Apparatus as described in claim 10 wherein an auxiliary casing is mounted on a side wall of said casing, and control means within said auxiliary casing comprising thermal responsive means to control the supplying of a cooling medium to said cooling coil and humidity responsive means to control the energization of said electric heater in response to a demand for an increase in humidity, said auxiliary casing being open adjacent the fan to receive a stream of air from the fan so that a stream of the incoming air is directed to the control means.

12. Apparatus as described in claim 10 wherein said casing is removably attached to the side wall of the storage chamber by a plurality of ears, and a pair of pipes forming a connection between said cooling coil and a source of volatile refrigerant.

13. In an air-conditioning unit, the combination of, a casing having one wall in which is formed an air inlet and another wall in which is formed an air outlet, a fan positioned to cause air to flow through the casing entering through said air inlet and exiting through said air outlet, partition means forming two separate passageways for the air passing through said casing whereby the air is divided into a first stream flowing along a first passageway and a second stream flowing along a second passageway, an evaporator positioned within said casing along said first passageway whereby the air passing along said first stream is cooled and water is condensed from the air, a humidifying pan positioned along said second passageway and adapted to receive the water which is condensed by said evaporator from the air, and heating means positioned along said second passageway to vaporize the water in said humidifying pan.

14. In apparatus for maintaining predetermined conditions of temperature and humidity in an air space, the combination of, a cooling coil assembly of substantial depth forming an air-cooling path whereby during operation air passing through the cooling coil is subjected to substantial cooling with the result that condensate is condensed from the air, means forming a recirculation path parallel to said air-cooling path, means to collect the condensate from said cooling coil assembly and to deliver it to said recirculation path, electric heating means to evaporate said condensate along said recirculation path, and means to control the energization of said electric heating means.

15. In the art of conditioning air in a storage compartment, the steps of, passing a stream of air along a cooling path to cool the air thereby to remove in the form of condensed water a substantial portion of the moisture which it contains, passing a second stream of air along a humidifying path substantially parallel to said cooling path, supplying said condensate water along said humidifying path, supplying heat whereby said water is evaporated with the result that water in vapor form is added to the air in said second stream, and controlling the supplying of heat to evaporate water along said second path in accordance with the relative humidity of the air in the storage compartment.

16. In the art of maintaining predetermined temperature and humidity conditions in a storage chamber, the steps of, producing a series of cooling cycles each comprising a cooling step and a rest step by supplying a cooling medium intermittently to a cooling path, passing a stream of air along said cooling path in heat-exchange relationship with the cooling medium to cool the air and to remove a substantial portion of the moisture which the air contains, passing a second stream of air along a measuring path, passing a third stream of air along a humidifying path where water is evaporated by means of heat, controlling the supply of the cooling medium in accordance with the temperature along said measuring path with the result that during each cycle of operation the rest step is continued for a sufficient time to permit the temperature along the cooling path to rise sufficiently to melt ice or frost formed herealong, passing the melted frost or ice and other condensate from said cooling path to said humidifying path, and controlling the supply of heat to evaporate water along said humidifying path and thereby humidify the air in accordance with the humidity along said measuring path.

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